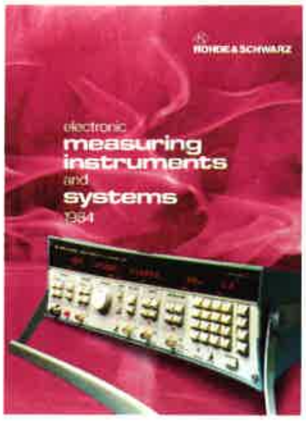
ROHDE & SCHWARZ

electronic
measuring instruments
and
systems
1984



The cover

shows the new Sweep Generator SWP for 0.1 to 2500 MHz, an R&S precision instrument combining three essential measurement capabilities: SWEEP GENERATOR, SIGNAL GENERATOR with modulation capability and SYNTHESIZER. Fields of application: general laboratory measurements, automatic measurements, component measurements, directional radio links and radar, and satellite television IF. The SWP is IEC-bus compatible and programmable in all its functions.
More details on page 126.

new

This identifies newly introduced products.

IEC 625 Bus

This identifies equipment compatible with the IEC bus (IEEE 488, GPIB, etc.), the worldwide standardized interface for automated instrumentation. More details in section 1.

MEASURING INSTRUMENTS MEASURING SYSTEMS

from Rohde & Schwarz are the subject of this catalog. The amount of information contained for each unit of equipment or system is approximately the same as in the separately available data sheets. For instructions on how to request these and other brochures, etc. please refer to the reader-service information on page 376.

The company's offices and representatives are always ready to deal with your enquiries. The experienced staff at the head office in Munich will gladly advise you on all measurement problems.

This catalog has a relatively long period of validity, so please ask for confirmation of all data when ordering or considering a purchase.

Explanations of the symbols used in the tables and text and of the ordering information are to be found on page 375.

Publisher: Rohde & Schwarz GmbH & Co. KG, dept. 5ZW

Editor: G. Strohbach

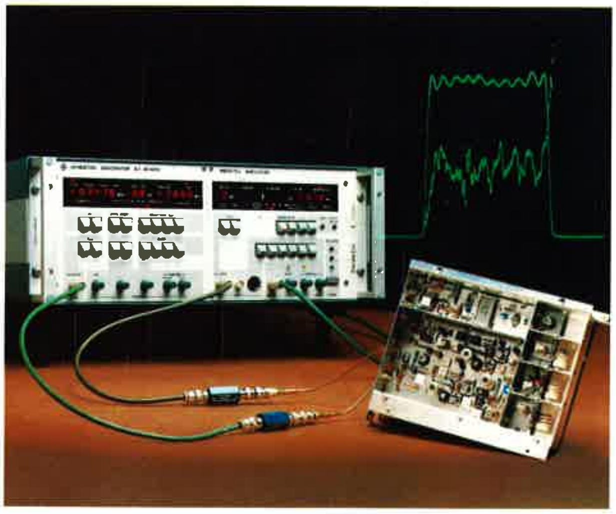
Translators: E. Märkl, C. Neumann, U. Renner, G. Koranyi

Printed in the Federal Republic of Germany

OTHER PRODUCTS

Sound/TV broadcasting

Details of R&S measuring instruments and equipment for sound and television broadcasting are given in a separate, 280-page catalog. If you would like to receive a copy, please use on of the reader-service cards (page 376). Examples of equipment from this division (2F) are presented in Appendix A1.



Radiocommunications

The R&S line of radio equipment – for shortwave, air-traffic control, radiomonitoring and radiocommunications – is described in system data sheets and specialized catalogs which will be supplied on request. For examples of equipment from these divisions (4F and 4P) see Appendix A1.

contents

ROHDE & SCHWARZ

Electronic precision

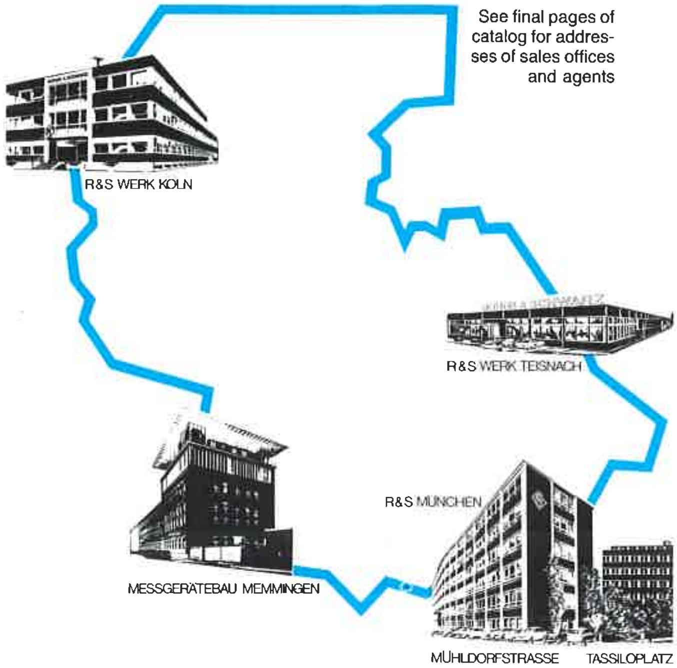
has been the Rohde & Schwarz hallmark during 50 years of developing and manufacturing electronic measuring and communications equipment. R&S is an independent concern, established as a physical and technical development laboratory in Munich in 1933 by the two physicists **Dr. Lothar Rohde** and **Dr. Hermann Schwarz.** Both are still active in the management of the company, and were joined in 1971 by **Friedrich Schwarz, Dipl.-Ing.,** representing the second generation of owners.

The company employs 4000 people worldwide and its sales network covers a total of 80 countries. R&S has manufacturing plants in Munich, Memmingen and Teisnach and two subsidiary operations Messgeraetebau GmbH and Rohde & Schwarz Vertriebs-GmbH. The company group has an annual turnover of DM 500 million with exports making up 50% of the total.

Rohde & Schwarz operates with four product- and thus user-defined divisions:

- measuring equipment and systems
- sound/television broadcasting
- radiomonitoring, radiolocation
- radiocommunications

Each of these financially autonomous divisions is responsible for its own product planning, development, construction and sales and is thus able to respond quickly to what is happening on the market.



Rohde & Schwarz development and production facilities and the R&S Cologne service centre

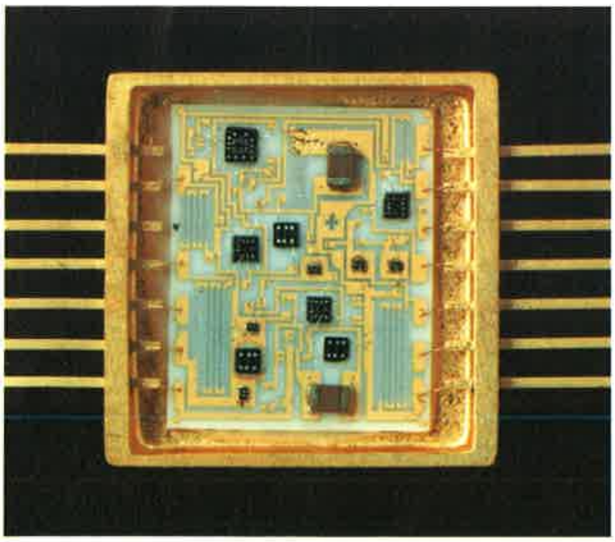
Assured quality

Advanced equipment design calls for modern circuit technology. R&S develops and manufactures microcircuits inhouse, using the latest computer aids to generate films for printed circuit boards to be assembled automatically.

In all stages of the creation of an R&S product there is close cooperation with quality assurance, which reports directly to the company management and is responsible for quality planning, reliability, environmental testing, component testing, incoming inspection and, at production level, for preproduction control, finish control, assembly control, final acceptance and manufacturing equipment studies. If requested, certificates are issued to document the compliance of equipment with its published technical data.

All phases from incoming inspection through production control and burn-in to servicing are watched over by a computer-based fault-acquisition system. The R&S quality-assurance system is approved by government authorities and civil organizations and complies with the NATO requirements to AQAP-1.

30 of these thin-film, high-speed pulse amplifiers from the R&S microelectronics department will fly in the NASA space probe Galileo to the planet Jupiter 600 million kilometers from the earth



Reliable service

Well-equipped facilities in Munich, Cologne and at domestic and foreign agencies provide the after-sales service for R&S products: preventive maintenance to keep equipment working properly and scrupulous repair if anything should go wrong. Our extensive, central spares depot with high availability and fast turn-around plus decentralized stocks, optimized on the basis of equipment statistics, help our personnel to repair fast and with minimal delay.

The detailed servicing instructions in our equipment manuals or in the handbooks that our documentation department produces at customer request in line with national and international standards provide the basis for successful equipment maintenance and repair by the user.

The Rohde & Schwarz Cologne works, being the largest industrial service centre in West Germany for electronic measuring and communications equipment with a qualified staff of more than 300 and a useful area of 12,000 m^2, offers a wide range of services:

The conveniently equipped demonstration bus for Europe of the measuring equipment and systems division is 12 m long and subdivided into a show room of 17 m^2 and a small conference room accommodating six persons

- maintenance and repair of electronic equipment and systems
- calibration and inspection on behalf of the Federal German Calibration Service (DKD)
- training in Germany and abroad
- equipment manuals and illustrated parts catalogs to TDV, GAF T.O., PANAVIA and customer specifications in German and English
- development, design and production of stationary and mobile electronic workshops and calibration laboratories
- system servicing of radio, radar and sonar

Training is given priority both in the R&S training centre Cologne and in the Munich divisions: presentation of new equipment, fundamental technical training, service courses, system briefing

Continuous flow of information

55,000 copies of the magazine **News from Rohde & Schwarz** are published quarterly in English, French and German and distributed free of charge to qualified readers. Besides interesting articles on new products, the magazine contains applications reports, test hints and refresher courses.

For every item of equipment produced by Rohde & Schwarz there is of course a data sheet available, in part with large, poster-like illustrations. Certain test assemblies, test systems and fields of measurement – and also families of communications equipment – are additionally dealt with in special **brochures** (infos), containing extra information and examples of applications.

Both R&S Munich and the R&S service centre in Cologne hold regular **seminars, training sessions and courses.** These keep people informed about what is new in the company's equipment range, impart the principles of maintenance and repair and provide instruction in the use of systems or even basic technical training.

Rohde & Schwarz shows its products annually at some 40 to 50 **trade fairs and exhibitions** all over the world. These are opportunities for demonstrating the latest developments and advising users, and also provide a forum for exchanging ideas and directly comparing one's products with those of the competition. The company's own specially equipped vans carry selections of both new and older products for demonstration on the customer's door-step.

A continuous flow of information between R&S central sales and field sales produces highly accurate forecasts for the development of products that are exactly right for the market, true to the company's motto of quality rather than quantity.

ROHDE & SCHWARZ

Measuring equipment and systems

The world-wide reputation of Rohde & Schwarz was established in the thirties with the development of measuring instruments. At a time when there was no such a thing as RF measurements in Europe, R&S came out with a precision heterodyne wavemeter, a capacitor sorter and a dissipation-factor meter for frequencies up to 10 MHz, as well as frequency standards and time measuring equipment. Other **pioneer efforts** were field-strength meters and the first series-produced power signal generator (1942). A considerable proportion (12% on average) of the annual turnover goes into the development of new promising products such as logic testers and highly convenient automatic test systems for components, modules and cables.

The use of microprocessors has become a routine: the first microcomputer-based, intelligent radio-set test assembly with standard IEEE 488/IEC 625 bus interface was already introduced in 1974. Since then the development of new, **system-compatible measuring instruments** which can be combined in computer-controlled test assemblies for the widest range of applications has been continued. A process controller specially developed by R&S for measurements optimizes the product line.

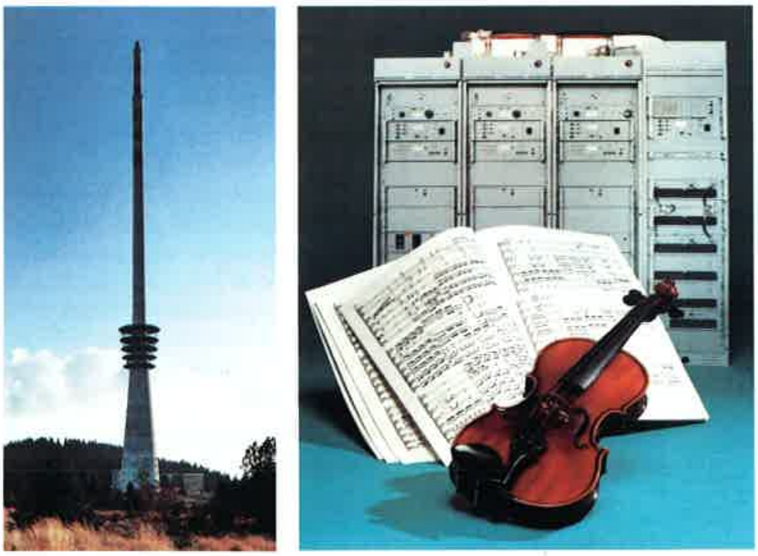
The **major product categories** of this division are: signal generators for AF through to microwaves, sweep testers and network analyzers, radio-set test assemblies, test receivers for interference and field-strength measurements, wave and modulation analyzers, logic testers, standard-frequency systems, voltmeters and power meters, and IEC-bus-compatible system components. The measuring equipment division has great experience in the field of hybrid test systems for automatic testing of all kinds of electronic modules. In-house services include suitable adapters and software programs as well as system engineering, training and maintenance.

Sweeper, signal generator and synthesizer all in one unit: Sweep Generator SWP for 100 kHz to 2.5 GHz

Sound/television broadcasting

The sound/television broadcasting division serves a very specialized kind of customer who looks for technically advanced and at the same time economic solutions to his needs. Here Rohde & Schwarz is able to offer **broadcasting technology and the related measurement engineering from a single source:** from solid-state, "plug-in-and-go" VHF transmitters through to turn-key, 20-kW TV transmitting systems (band IV/V) with standby transmitter, measuring equipment and antenna – if required, with customized horizontal and vertical patterns for optimal coverage of any shape of service area. Also available are transposers, relay receivers, combiners and the entire measuring and monitoring equipment needed for maintaining AF, VF and RF quality in all transmission devices.

Rohde & Schwarz supplied **Europe's first VHF soundbroadcast transmitter in 1949,** and in **1980** adapted the **world's first TV transmitter for dual-carrier/dual-sound** operation. The highly precise and internationally successful TV demodulator AMF first appeared in 1955, the first vision-transmitter test assembly in 1956 and at the beginning of the 70s the first test-line inserters and analyzers were marketed. Today the entire TV-broadcast network of the Federal German Postal Authority is automatically monitored by computer-controlled test equipment of the type UPKF from Rohde & Schwarz. VHF-UHF omnidirectional antennas with phase-rotation feeding were brought out in 1956, and the multiplex-polarizing VHF FM broadcast antennas introduced in 1975 have made a large contribution to improving car-radio reception.



VHF FM sound broadcasting transmitter system for three VHF programs, 10 kW power each, plus 1 kW standby

Radiomonitoring, radiolocation

As early as 1941 Rohde & Schwarz built the radar detection receiver Samos for AM and, for the first time, FM with an almost unheard-of frequency range extending to 1.6 GHz. Today the radiomonitoring and radiolocation division produces automatic receivers that can check a thousand frequency channels for occupancy in the space of one second, short microcomputer-controlled vehicle antennas, logarithmic-periodic short-wave antennas that can transmit up to 1000 kW rms power and remotely controlled triangulation DF networks with large-scale displays.

Radiomonitoring and radiolocation work concerns the four areas **receivers, direction finders, antennas and software** plus systems engineering from the design concept through to turn-key projects. The applications here are those of PTT radiomonitoring, military communications intelligence and security services, as well as traffic control and – in as much as antennas are concerned – radiocommunications and radiomonitoring from 10 kHz up to 40 GHz.

A DF network from Rohde & Schwarz for military airtraffic control covers the whole of West Germany, and Doppler direction finders from R&S are in use at all domestic and many foreign airports. Radiomonitoring systems from R&S are working in North and South America, Africa, the Near and Middle East, in most countries of Europe and, of course, are also operated by many civilian and military services in the Federal Republic of Germany.

VHF-UHF Broadband Doppler Direction Finder PA 005 for radiomonitoring systems covering 20 through 1000 MHz

Radiocommunications

Over several decades the radiocommunications division can offer an almost complete line of equipment for **radiocommunication in the RF, VHF and UHF range** for stationary, land-mobile, shipboard and airborne use.

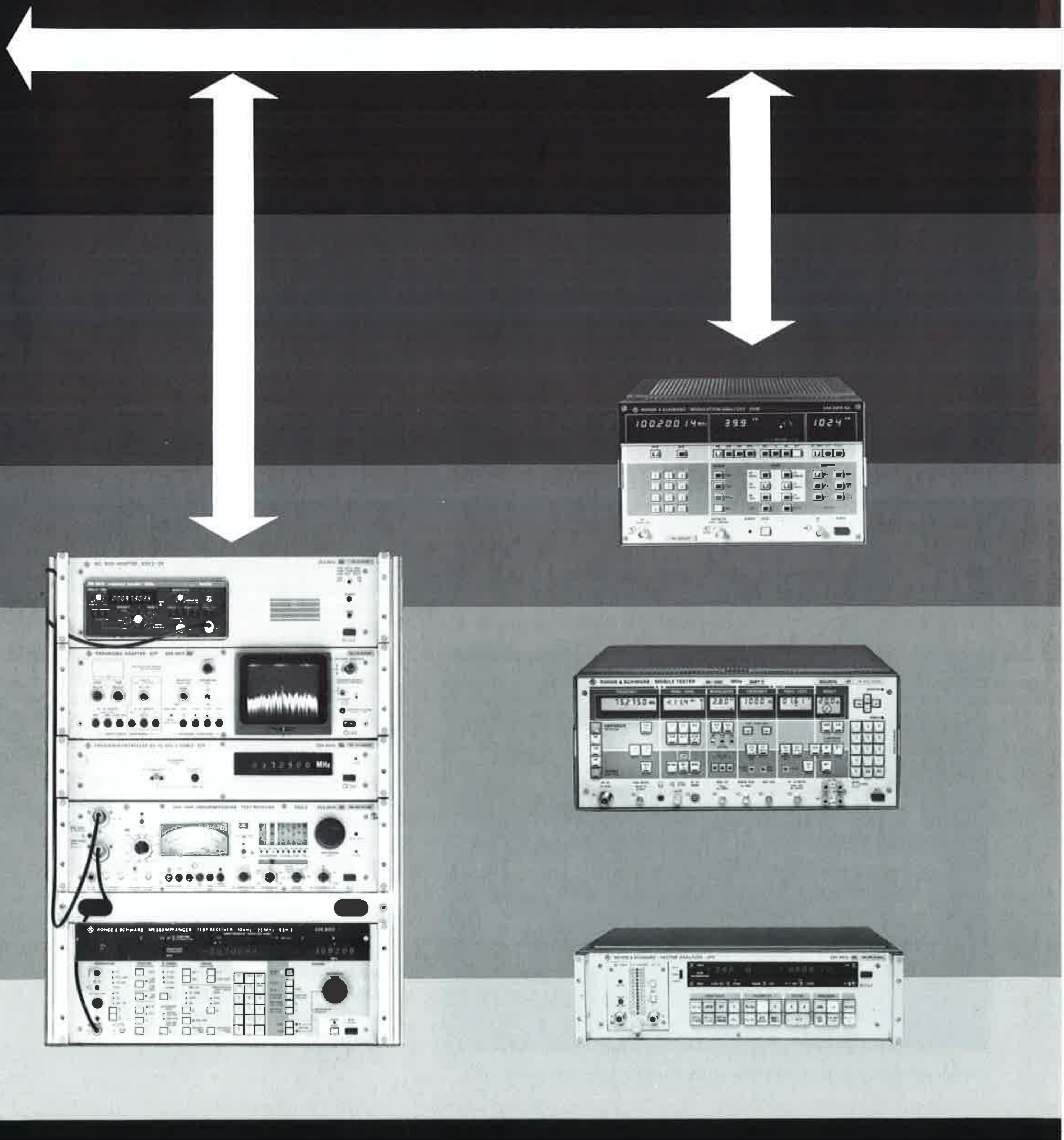
R&S radio systems are installed at all West German and innumerable foreign airports. Many airborne weapon systems use communications equipment from Rohde & Schwarz. Today the number of **computer-controlled radio systems** in use is steadily increasing. **Multifunction keyboards** simplify the operation and relieve the personnel on board ship and in aircraft from routine work. High reliability and **microprocessor-controlled test equipment** for fault location ensure a high availability and low life-cycle costs.

Modern command systems fully depend on a well-functioning communications system ensuring full mobility of the forces. The radio transmission of information therefore remains absolutely indispensable, but does of course not exclude any future transmission methods as being developed by the radiocommunications division. This division plans and produces complete radio systems for use on board ship, at civil and military airports, as well as mobile radio equipment and embassy networks.

The EK 070 is an **ultra-modern HF receiver** and is furthermore entirely remotely controllable. It is used in high-grade communication systems, for radio surveillance and in short-wave DF systems. It can be found increasingly with computer support even in smaller radio installations.

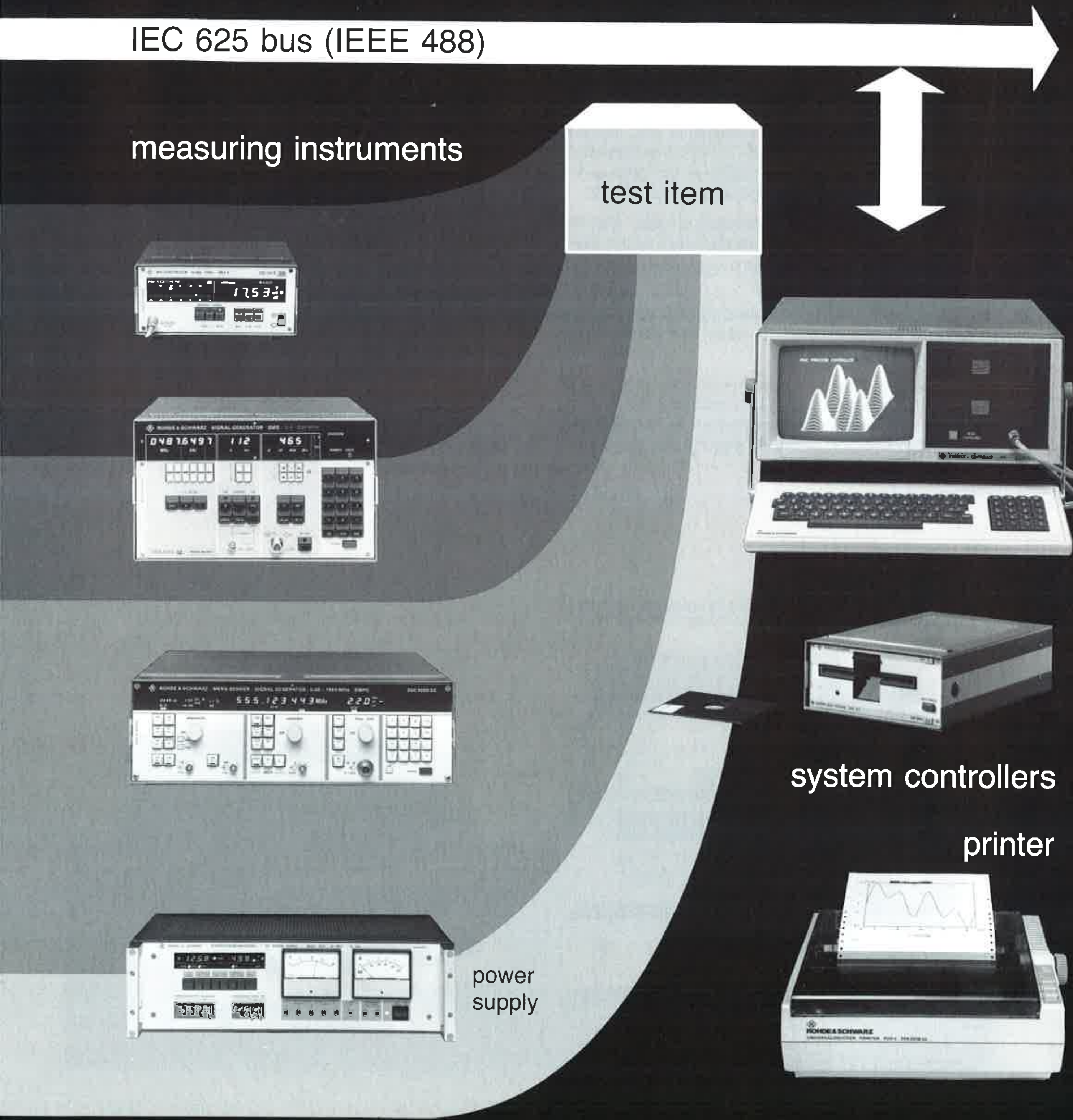
Remotely controllable VLF-HF receiving system made up of the Receivers EK 070 and EK 071

The new measuring instrument generation can be controlled via the IEC interface bus and combined to form test assemblies of any required size



1

automated testing
IEC bus test systems



The development of favourably priced control computers and itelligent measuring instruments has opened the way – both at the control and the measuring ends – for the implementation of automated measurements on a broad front. The application of automated instrumentation is no longer restricted to a few large-scale users – as it was before for financial reasons – but has become a cost-effective method available to all users of measuring instruments in development, production and quality control.

Exploitation of the full potential of this intelligent instrumentation is made possible by the IEC bus.

IEC bus or IEEE 488 or GPIB?

The IEC bus is a worldwide standardized data bus for use in test systems, permitting measuring instruments from different manufacturers to be combined at will with freely selectable computers without requiring an instrument-compatible interface or special data couplers.

Rohde & Schwarz measuring instruments with IEC-bus capability are generally designated as IEC-bus-compatible and marked by the symbol (IEC 625 Bus) in the catalog, the term "IEC bus" being based on the standard IEC 66.22.

In the USA the corresponding standard is IEEE 488; the acronym GPIB (general purpose interface bus) is also used. All these names designate the same bus system except for the connectors (see right).

Having become the international standard, IEC 625-1 applies for this bus system all over the world; this results in the designation: **IEC 625 bus.**

The IEC bus constitutes a teletype line between the individual units of a test system, enabling data transfer in either direction. The controllers both send commands to the measuring instruments and receive data from them via the IEC bus.

The IEC bus is designed such that combining the instruments into a system requires no **special knowledge** and is achieved by simply linking up the IEC bus connectors of the individual units. All other functions, such as monitoring the usually different data transfer rates of the individual instruments, are performed automatically. The code used for transmitting information via the IEC bus is ASCII (ISO 7-bit code), which normally also provides the communication between computers and their peripherals and delivers characters which can be written and read directly.

Small computing systems such as desktop models and process controllers featuring a favourable price/performance ratio are ideal for controlling IEC-bus-compatible equipment. In general they are smart enough to meet all usual requirements. Computers using standard programming languages such as BASIC are of special advantage since changing the computer then presents no problems. Even the speed of these models is generally sufficient for analog test systems.

IEC-bus connectors (differences)

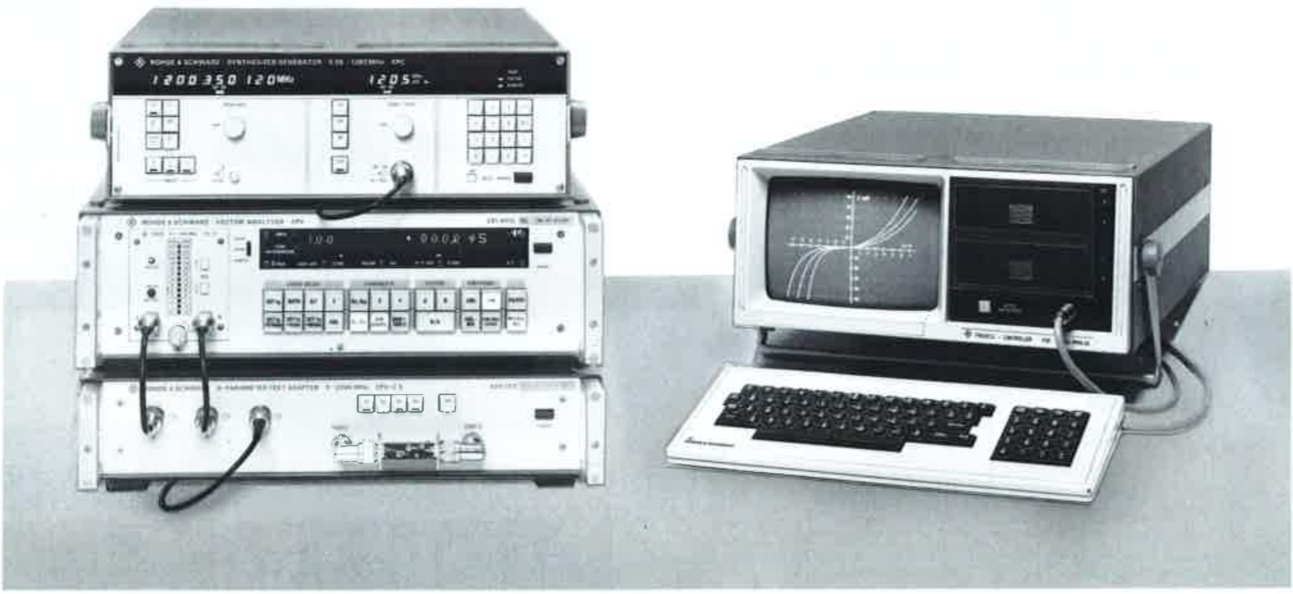
The development of the IEC bus has brought about two different connector systems:

24-way connector (Amphenol), original type, in accordance with US standard, at present most frequently used;

25-way connector (Cannon), included in the IEC standard.

Rohde & Schwarz instruments basically use the 24-way connector; they are thus compatible with the majority of the equipment on the market.

Application of IEC bus: automatic test assembly for s-parameter measurement (ZPV with S-parameter Test Adapter, XPC and Process Controller PUC)

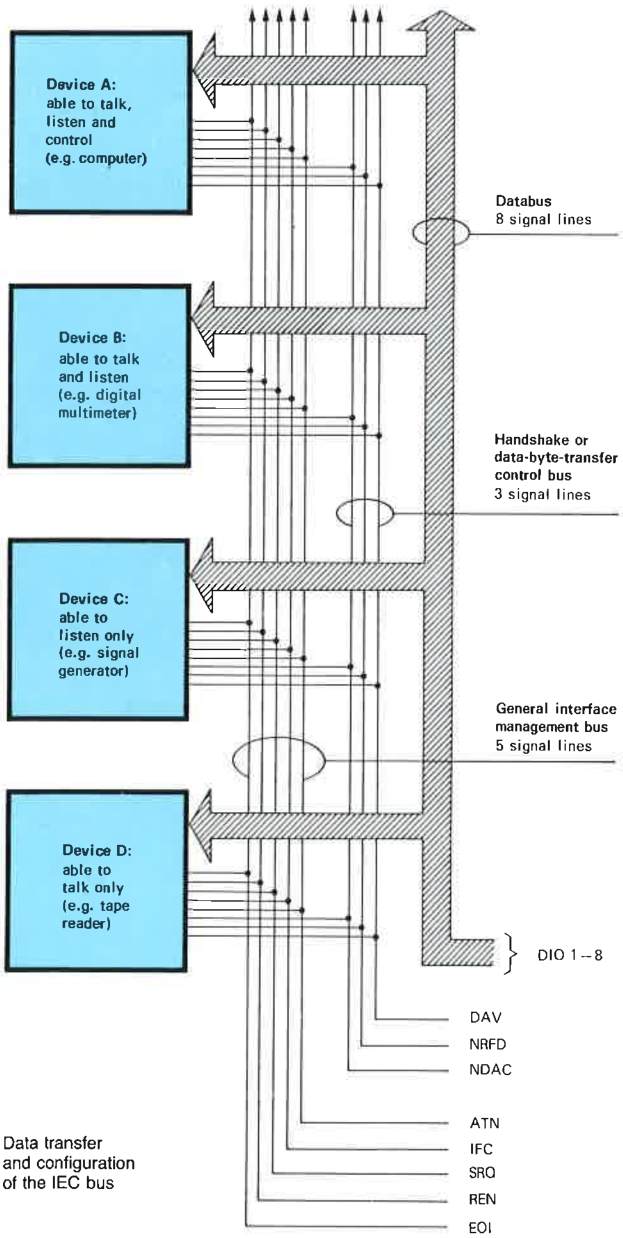


How does the IEC bus function?

The IEC bus consists of three parts: the data lines, the control lines for the timing of what occurs and the control lines necessary for the management of the system.

The actual data transfer is made over eight data lines **DIO** (data input/output) which carry all information and also addresses. The data bus is bidirectional, the data flowing in both directions.

As mentioned, the characters are in ISO 7-bit code (ASCII code), one complete character per clock being transferred over the data bus. The control line **ATN** (attention) serves for identifying whether instrument addresses, commands or data are being transferred.



Data transfer and configuration of the IEC bus

The other lines for system control are: **IFC** (interface clear) for resetting the system to a defined initial state, **SRQ** (service request) for interrupt control, which enables the instrument to request the attention of the control computer for delivering a test result or signalling an error, **REN** (remote enable) for putting the measuring devices into programmed operation and **EOI** (end or identify) for identifying the last character sent.

The timing of data transfer is controlled via the lines **DAV** (data valid), **NDAC** (not data accepted) and **NRFD** (not ready for data) by the handshake process, that is to say, the slowest device determines the speed of operation. Although this method is not the best from the point of view of speed, it ensures that the user does not have to worry about timing the data transfer. Any combination of IEC-bus-compatible instrumentation can be assembled and automatically adjusts to its own speed of data flow. In general the minimum data flow rate of Rohde & Schwarz instruments is very high, so that normally no noticeable delay of the programming speed is entailed. Since, moreover, in analog measurements the instruments need quite some time to settle to steady state, it can be assumed that even desktop-computer control does not reduce the physically feasible maximum test speed significantly.

The IEC bus is consequently a self-driving and self-controlling data bus enabling measuring instruments and computers to be put together easily.

How is an IEC-bus-compatible test system set up?

The most important criterion is the selection of suitable measuring instruments. Thus the configuration of an IEC-bus-compatible test assembly does not differ from that of a setup consisting of manually operated devices. The measuring instruments are selected for their specific technical characteristics to meet all the requirements involved. Next the necessary interconnections are made. Now the user is able to check in the manual mode whether the test assembly complies with his idea. All measuring functions and accuracy specifications are verified.

The step towards automation is taken by linking up the IEC-bus connectors located on the rear of the instruments and by connecting them to a control computer. Criteria for selecting this computer are the programming language, storage capacity, computing speed and operating convenience. The test assembly obtained in this way performs all test routines that are possible in the manual mode in fully automatic operation.

Thus in the **first stage** the IEC-bus-compatible test equipment is a configuration of instruments which are operated from a computer.

Set up of test system (cont'd)

In the **second stage,** efficient use of the computer capabilities permits optimizing the instrument characteristics. This can be achieved by suitable programs for error correction and self-calibration in accordance with standard curves. In this way, the accuracy can be increased considerably in most cases.

In the **third stage,** measurement evaluation can be expanded from simple test result logging to error statistics, error diagnosis, nominal-to-actual comparison and graphic display.

In practice, the configuration of IEC-bus systems is so easy that the user himself can take care of the assembly. However, Rohde & Schwarz naturally also offers comprehensive system consultancy and assistance for any questions or problems that may arise. Finally, ready-to-use systems are available on request.

For frequent standard applications, the Rohde & Schwarz line includes **complete IEC-bus systems** with data sheet specifications. The delivery comprises problem-oriented software enabling the user to operate these systems without any extra programming.

Instruments used in IEC-bus systems

The configuration of IEC-bus test systems requires not only **measuring instruments** but also different **system devices** to perform control and auxiliary functions. For the measuring instruments see the corresponding sections of this catalog; the system devices (and the temperature-measuring units) are described on the following pages.

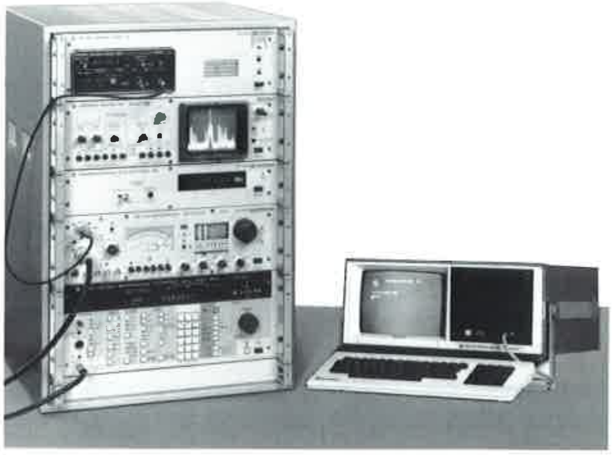
IEC 625 Bus

IEC-bus compatible instruments

System devices

IEC-bus-compatible measuring instruments for sound- and TV-broadcasting equipment are described in a separate catalog; see note on inside front cover.

Selection of the right controller to suit the task



Example of computer control: automatic VHF-UHF test assembly for wanted- and unwanted-signal measurements using Process Controller PUC

Desktop computer control

The desktop computer (process controller) provides an excellent means for controlling IEC-bus systems. It offers a particularly economic solution for small, decentralized automatic test systems.

Essential advantages are:

Low price. In addition to the actual computing system, the process controller combines in one unit the most important peripherals such as keyboard, magnetic store and display. In this way an especially favourable price/performance ratio is achieved.

High reliability. Integrating the computer and the peripherals in one cabinet ensures an extremely high reliability. Putting the system into operation presents no difficulties since there are no interface problems to be solved. The IEC-bus connector is fitted as standard.

Easy operation. The process controller is convenient and easy to operate. Program editing in particular is very easy.

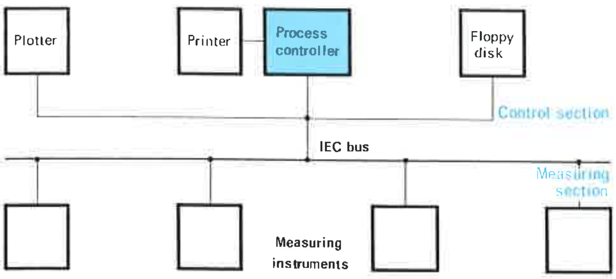
The high storage capacity and computing speed are sufficient for practically all analog testing applications.

Minicomputer control

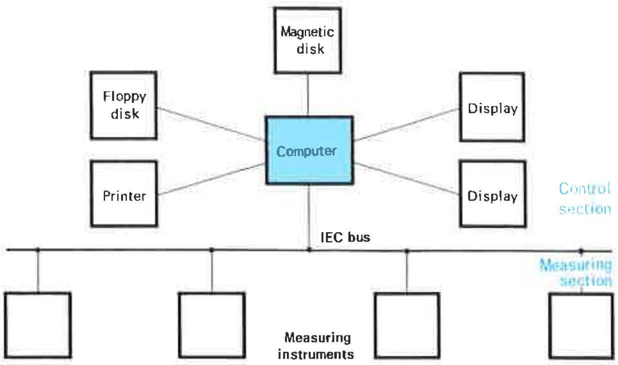
If a higher-capability control computer is required, a minicomputer can be used instead of the desktop computer or process controller. Any computer with IEC-bus connector is suitable for this purpose.

The advantages of this configuration are the higher data processing speed and the shorter access time to larger data stores such as the magnetic disk. Thus it is convenient to use minicomputers if, in addition to the actual measurement task, comprehensive data processing is required, for instance selection of test-item-dependent measuring parameters and collection of large amounts of data for statistical evaluation.

Rohde & Schwarz automatic test systems are controlled from the Process Controller PUC. In specific cases standard programs for other types of computers are also available.



Block diagram of automatic test assembly



Block diagram of test assembly with computer control

Programming

The programming effort required for an automatic test system is an essential criterion for its economic efficiency. Therefore a complete, technical ATS solution comprises both the realization of the hardware and the corresponding software.

Two different solutions are to be distinguished:

a) for users with higher programming knowledge wishing to make exhaustive use of their ATS capabilities, and

b) for users who have to change their programs very frequently and are not ready to accept a high programming effort.

Consequently there are two different modes of programming:

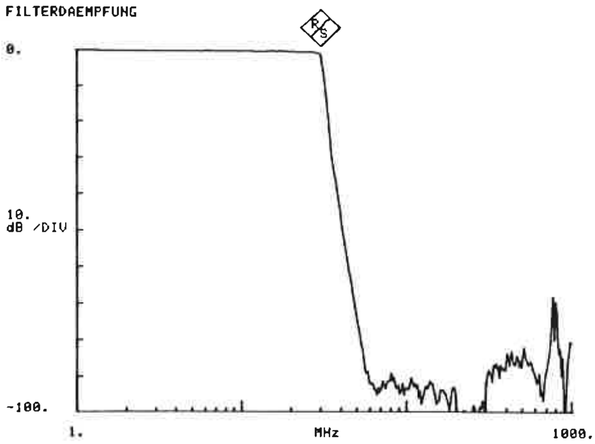
The direct mode using a programming language. The most universal method is to address the instruments directly. Setting and measuring commands are communicated to the instruments in a programming language and combined into test programs using logic functions. The basis is BASIC, the widely used programming language; it permits IEC-bus-controlled instruments to be directly addressed. With modern R&S measuring instruments of high intelligence it is even possible to enter the settings in ordinary language and to read the test results in the correct mathematical form. This means: instrument intelligence considerably simplifies individual test programs.

Using preprogrammed test routines (basic software).

Programming becomes very easy when preprogrammed test routines are used. In this case virtually no programming knowledge is required and the user is able to realize comprehensive test programs within a very short time. For this purpose, Rohde & Schwarz offers **basic software packages** containing ready preprogrammed test routines. These routines are linked in such a way that wrong programming is practically impossible.

Basic software packages are available for instance for all test programs required in RT technology for measuring AM, φM and FM equipment. Moreover, another software package available for the Process Controller PUC contains graphics routines which permit complex diagrams, such as the Smith chart, to be represented within a very short time. These software packages have proved valuable in many cases, their number being constantly extended with the appearance of new R&S measuring instruments. It is also of advantage that the packages can be expanded by individual test programs and that no loss in flexibility occurs.

The programming example below to the left shows the procedure executed when measuring a transceiver with the Mobile Tester SMFP 2, while the example to the right, relating to the Vector Analyzer ZPV, illustrates the programming required for graphic display of complex quantities.



Measured filter response output by computer

Programming examples

Transceiver measurement using SMFPZ

```
100 R=1:GOSUB 9000
110 R=40:GOSUB 9000
120 Y=2
130 R=6:GOSUB 9000
140 R=42:GOSUB 9000
150 PRINT"HF-FREQUENZ: ";Y;"[HZ]"
160 R=41:GOSUB 9000
170 PRINT"HF-LEISTUNG  ";Y;"[W]"
180 Y=300
190 R=17:GOSUB 9000
200 R=43:GOSUB 9000
210 PRINT"POS.MODULATION: ";Y;"[KHZ]"
220 INPUT"EMPFANGSFREQUENZ [MHZ]",X(1)
230 R=62:GOSUB 9000
240 Y=12
250 R=9:GOSUB 9000
260 Y=1
270 R=16:GOSUB 9000
280 Y=25
290 R=12:GOSUB 9000
300 R=28:GOSUB 9000
310 PRINT"NF-PEGEL: ";Y;" [MV]"
320 END
```

Start routine
Transmitter test
Modulation setting FM
Measurement RF frequency output
Measurement RF power output
300 mV AF level setting
Measurement deviation output
Setting RF synthesizer
Receiver test
RF level setting 12 μV
AF frequency setting
Int. modulation setting
Measurement AF level output

Measurement of complex quantities using ZPV

```
100 INIT
110 Y=1
120 GOSUB 1
130 Y=10
140 GOSUB 9
150 Y=900
160 GOSUB 10
170 Y=10
180 GOSUB 11
190 GOSUB 78
200 Y1=-60
210 Y2=0
220 S$="DB"
230 T$="KOPPELDAEMP. RICHTK."
240 GOSUB 90
250 GOSUB 97
260 Y1=-200
270 Y2=400
280 Y$="GR"
290 GOSUB 92
300 GOSUB 98
310 END
```

program start
sweep start frequency
sweep stop frequency
sweep step width
transmission factor measurement
cartesian diagram with scaling
display magnitude
additional scaling
display phase

Example for easy programming with preprogrammed test routines
Code numbers of Basic Software ZPV-K 10

1 program start

Y = 1	generator SMPU	Y = 4	generator SMS
Y = 2	generator SMLU	Y = 5	generator XPC/SMPC
Y = 3	generator SPN	Y = 6	generator SWP

Input data	**Physical unit**
2 test frequency	MHz
3 test level	dBm
6 shift of reference plane	cm
7 relative dielectric constant ε_r	
9 sweep start frequency	MHz
10 sweep stop frequency	MHz
11 sweep step width	MHz
13 number of markers	
14 frequency deviation for group-delay measurement	kHz

Operational settings
17 impedance of test setup 50 Ω
18 impedance of test setup 75 Ω
19 parameter measurement using directional couplers
21 parameter measurement without directional couplers
22 filter on
23 filter off
25 electrical length compensation on
26 electrical length compensation off

Calibration/reference values
27 store magnitude (real component) as reference value
29 store phase (imaginary component), group delay as reference value
30 calibrate parameter
31 calibrate for dynamic group delay measurement

Output of single-shot measurements

33 nominal/actual value comparison, output on display	H1 = upper limit of magnitude (real component) H2 = upper limit of phase (imaginary component) L1 = lower limit of magnitude (real component) L2 = lower limit of phase (imaginary component)
34 nominal/actual value comparison, output on printer	limit input same as under 33

Output of swept-frequency measurements

35 nominal/actual value comparison, output on display	limit input same as under 33
37 nominal/actual value comparison, output on printer	limit input same as under 33

Program execution
39 wait loop 1 s
41 wait loop 0.1 s
42 halt
43 print program

Individual measurements

Vector measurement		**Physical unit**
45 voltage measurement channel A	linear	mV, degrees
46 voltage measurement channel A	linear, relative	no dimension, degrees
47 voltage measurement channel A	log	dBm, degrees
49 voltage measurement channel A	log, relative	dB, degreees
50 voltage measurement channel B	linear	mV, degrees
51 voltage measurement channel B	linear, relative	no dimension, degrees
53 voltage measurement channel B	log	dBm, degrees
54 voltage measurement channel B	log, relative	dB, degrees

Vector measurement		**Physical unit**
55 voltage ratio measurement, channel B/A	linear	no dimension, degrees
57 voltage ratio measurement, channel B/A	linear, relative	no dimension, degrees
58 voltage ratio measurement, channel B/A	log	dB, degrees
59 voltage ratio measurement, channel B/A	log, relative	dB, degrees
Parameter measurement		
62 reflection coefficient measurement	linear by magnitude and phase	no dimension, degrees
63 reflection coefficient measurement	linear with real and imaginary components	no dimension
65 reflection coefficient measurement	log by magnitude and phase	dB, degrees
66 VSWR measurement		no dimension, degrees
67 impedance measurement by magnitude and phase		Ω, degrees
69 impedance measurement in terms of resistance and reactance		Ω
73 admittance measurement by magnitude and phase		mS, degrees
74 admittance measurement in terms of conductance and susceptance		mS
75 transmission factor measurement	linear by magnitude and phase	no dimension, degrees
77 transmission factor measurement	linear with real and imaginary components	no dimension
78 transmission factor measurement	log by magnitude and phase	dB, degrees
Group-delay measurement		
82 static group-delay measurement		µs
83 dynamic group-delay measurement		µs
DC voltage measurement		
84 voltage measurement at ADC input		V

Graphic display

Charts	
85 Smith chart	T$ = "(title, max. 20 characters)"
86 Smith chart +10 dB	T$ = "(title, max. 20 characters)"
87 Smith chart −10 dB	T$ = "(title, max. 20 characters)"
88 polar diagram	Y = outer circle T$ = "(title, max. 20 characters)"
89 additional scaling, polar	Y = outer circle
90 Cartesian diagram, linear frequency axis	Y1 = minimum vertical axis Y2 = maximum vertical axis S$ =v "(unit, max. 3 characters)" T$ = "(title, max. 20 characters)"
91 Cartesian diagram, log frequency axis	input same as under 90
92 additional scaling, Cartesian	input same as under 90

Graphic data output
96 in Smith chart or polar coordinates
97 magnitude (real component) in Cartesian coordinates
98 phase (imaginary component, group delay) in Cartesian coordinates

PUC

Process Controller PUC

- Compact IEC-bus controller
- Two built-in floppy-disk drives of 156 kbyte capacity each
- Programming in BASIC
- Standard IEC-bus data and instructions
- Efficient RF shielding minimizes unwanted interference
- Great flexibility due to different external keyboards
- Direct connection of Universal Printer PUD 2 (page 20) possible
- Compact 19″ design for easy rack-mounting

IEC 625 Bus

The **Process Controller PUC** is an economic control computer for the automatic measurement and control of IEC-bus operated systems. The PUC possesses numerous interfaces and functions. Modern **measuring techniques** make special demands on process controllers. Compact and reliable design, powerful interfaces and **low RF leakage** make the PUC outstanding for use in RF test systems. The main unit is accommodated in a 19″ cabinet which may easily be fitted into a 19″ rack (see illustration page 15, top).

Equipment configuration

Basic unit Even in its basic version (main unit with one floppy-disk drive, display of characters and symbols, no keyboard), the PUC fitted with no operating controls finds application in automatic production cycles, in the test department, incoming goods inspection and communications services. For the large majority of other applications the PUC can be supplied with a **standard keyboard, user keyboard** and a **footswitch.** From the simple responses to Yes-No prompts during program run to the writing of programs, all problems may thus be solved (see page 17).

Options Based on a series of retrofit options the performance of the PUC can be enhanced easily and cost-effectively for the special problem on hand.

The storage capacity can be enlarged with a **second floppy-disk drive** whereas a **serial interface** (RS 232 C) and an **I/O interface** are available in addition to the standard IEC and printer interfaces. The **Real-time Clock Option** allows the measurement of time, real-time reference and time-related control. The **High-resolution Graphics Option** provides the PUC with every possible graphic display. The option is indispensable in reproducing test curves (e.g. Smith charts) and in many other tasks. More details on options on pp. 17 and 18.

Characteristics

Memory The storage capacity of the PUC is 64 kbytes, half of which is available to the user as RAM space. The 32-kbyte memory is large enough even for very long BASIC programs. To produce machine language programs, the PUC allows direct addressing of the entire memory range. Program parts in machine code may easily be inserted into BASIC programs. There is a further 156-kbyte memory available from the built-in 5¼″ floppy-disk drive. A second floppy drive is supplied as an option or may be retrofitted. The floppy-disk drives access programs and data within seconds. The operating system of the PUC stores and loads programs also under program control. With the directory system, an overview of the floppy content can e obtained at any time. The operating system manages up to four floppy-disk drives making up a total storage capacity of 624 kbytes.

Interference immunity Due to the fast logic, computers generate interfering voltages and RF interference. The latter not only "pollutes" the environment but also leads to erroneous results of measurements. As a result of proper shielding the PUC has an extremely low interfering effect on power supply and environment. On the other hand, shielding makes the PUC also insensitive to strong external fields or interference from power lines. To prevent low-frequency interference, the monitor screen can be switched on and off within seconds on the entry of a command.

Process Controller PUC with user keyboard in 19" rack

VDU

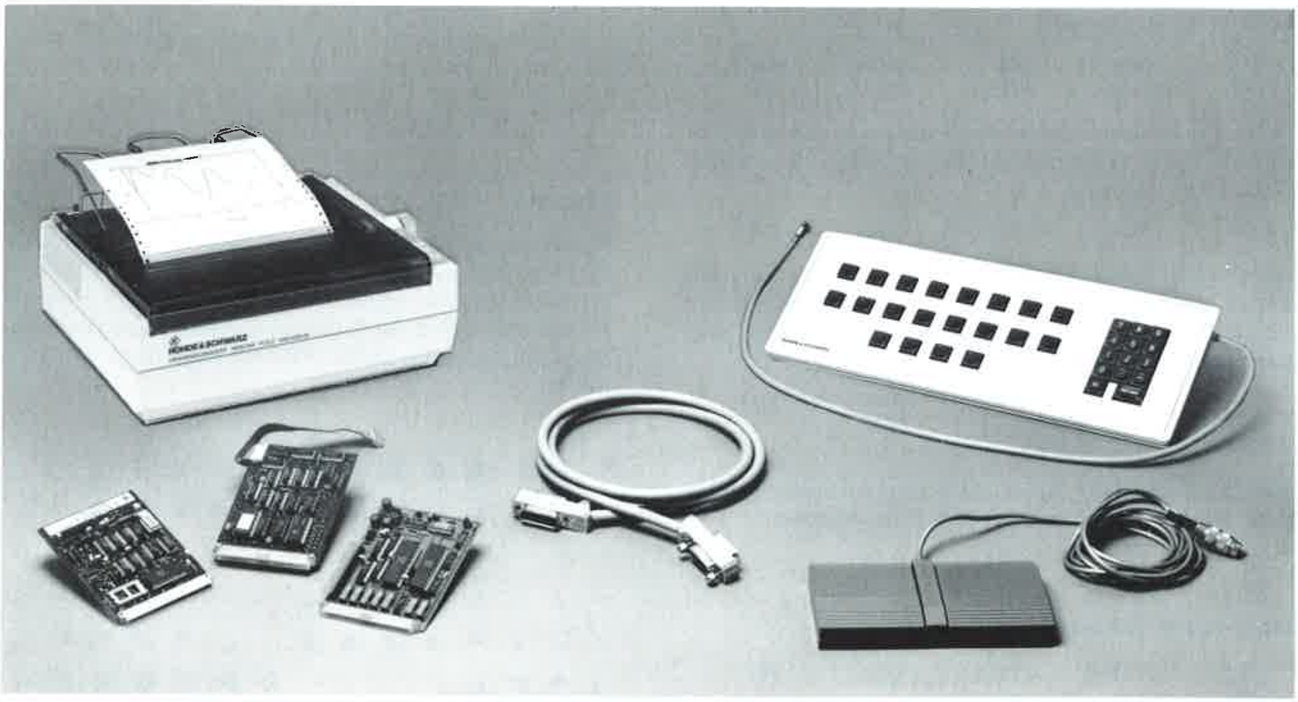
The 9" screen serves for the purpose of writing programs as well as for the display of results of measurements and calculations. The bright flicker-free display made up of 25 lines with 40 characters in each guarantees a relaxed working with the PUC. Program lines with more than 40 characters are displayed in two lines. In the operating mode GPH, upper-case characters and, together with the SHIFT key, graphic symbols are selected, whereas in the LTS mode both upper and lower case characters are enabled. Cursor shifts can be made also under program control.

Instruction set

PRINT	TAB	LTS	HOME	CURSOR ↑↓
SPC	GPH		CLEAR HOME	CURSOR ← →

For High-resolution Graphics Option see page 17.

Accessoires to the Process Controller PUC: Universal Printer PUD 2, user keyboard, footswitch, IEC-bus cable plus options (plug-in cards): RS 232 C Interface, High-resolution Graphics and I/O Interface



PUC – BASIC operating system

The **program language** of the PUC (BASIC) is simple to learn yet powerfull so that complex test programs can be set up. The BASIC in use is significantly extended and has a comprehensive set of editor commands. Program writing is therefore very much simplified. Important aids for program writing are:

Cursor controlled editing with repeat function
Autonumbering of lines
Renumbering of program lines
Searching and changing of single characters or texts in BASIC

The PUC can of course calculate directly or under program control. Execution times for the basic functions are listed in the following table. The functions contain elements of Boolean algebra so that complex flow charts and control of individual bits can be realized.

Functions	Execution time (ms)	Functions	Execution time (ms)
+	4.6	SQR	52.7
–	4.6	SIN	26.9
·	5.4	COS	27.2
⁒	6.8	TAN	52.1
> =		ATN	46.5
< =		LOG	22.6
AND	3.2	EXP	29.2
OR	3.25	a↑b	56.6
NOT	0.86	RND	3.68
SGN	0.45	DEF FN	
INT	0.9	FN	
ABS	0.13		

Program run Instructions to do with the running of the program are made up of the Start, Stop, and Wait commands. In addition, the BEEP command generates a tone signal of variable period.

REM	CONT	LET	STOP	WAIT
RUN	GOTO	END	HOLD	BEEP

Data The computer is capable of storing or changing program data (e.g. limit values or texts) which may be arranged in data lines or arrays.

DATA	READ	RESTORE	DIM	CLR

Jumps and Loops Particular program blocks in frequent use are easily and clearly brought under a subprogram. The aids to the writing of subprograms are the jump and loop commands.

GOTO	ON GOSUB	FOR... TO... STEP
ON GOTO	RETURN	NEXT
GOSUB	IF THEN	

String manipulation String commands are used to handle texts or text variables (e.g. use in IEC-bus transfer).

LEN	ASC	STR$	MID$
VAL	CHR$	RIGHT$	LEFT$

Input/output commands

OPEN	CLOSE	PRINT	INPUT	GET
CMD				

Editor commands Editor commands are designed to help to write programs rapidly and easily and to carry out changes and testing of programs.

NEW	Delete program
OFF	Delete program with switch-on reset
LIST	List program on VDU
SEQ	Automatic line numbering
DEL	Delete lines
RES	Renumber lines
SEA	Search text or command
REP	Replace text or command

Special cursor keys and keys with delete and insert functions make way for comfortable change of characters or complete program lines. All keys of the standard keyboard are provided with the repeat funciton.

Machine programming

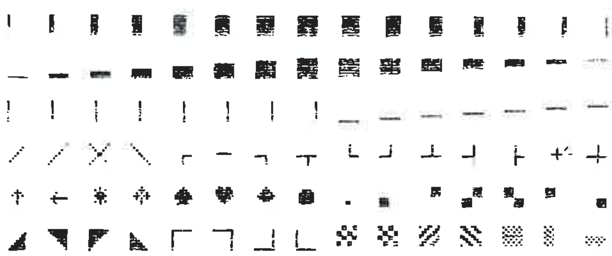
The PUC is directly programmable in machine language. Simple memory and input/output instructions are executed by orders of magnitude faster than those in BASIC. The shortest execution time is 2 µs. Machine programs may be called up in BASIC and subsequently executed. Hung-up machine programs can be interrupted with the RESET key without the BASIC program being deleted. A RAM block is available for the writing of machine programs; this block is not being used by BASIC. An efficient memory monitor facilitates program writing and testing. Machine programs can also be loaded into the memory from a floppy disk.

Machine commands

POKE	Write in memory
PEEK	Read contents of memory
BSE	Set limit of memory
BPS	Set start of BASIC
BPE	Set end of BASIC
SYS	Call machine program
USR	Call up with variable transfer
TIM	Monitor memory

Graphics

Numerous graphic characters (see below) which are part of the basic configuration of the PUC allow clear display. High-resolution graphics display for the presentation of curves of measurements (e.g. Smith charts) is possible using the High-resolution Graphics Option PUC-B6 (see page 17) as a retrofit.



Keyboards

There are three keyboards available. The **standard keyboard** (PUC-Z1) has 75 alphanumeric and special keys for the input, processing and testing of programs. All characters and symbols can be entered for normal (bright) or reverse (dark on bright background) display. All keys have repeat capability.

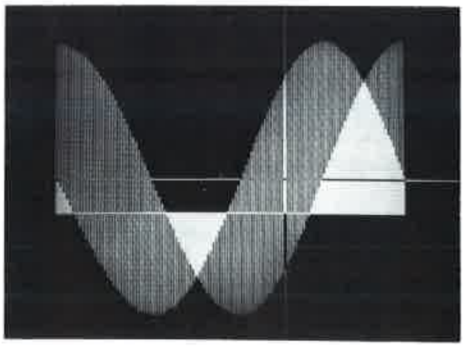
The **user keyboard** (PUC-Z2) has been designed especially for automatic test assemblies used in production and in the test department. The advantage of the keyboard is that computer experience is not a prerequisite to operate the system. The user keyboard consists of function keys and a numeric keypad (0 to 9, decimal point, minus sign plus DELETE and RETURN). The 20 function keys permit the assignment of arbitrary functions to programs. The replaceable overlays can be marked with the function chosen for a particular key.

The **footswitch** (PUC-Z3) serves to answer Yes-No program prompts or to start and stop programs. Hands remain therefore free to be used for adjustments and repairs. The footswitch can be hooked up together with one of the other keyboards.

For applications where manual control is unnecessary as in communications services and fully automatic testing, the PUC can be operated **without a keyboard.** The first program of the floppy disk is in this case loaded and started on switch-on or on pressing the RESET key. Further programs may be fetched under program control, if required.

Basic keyboard commands

INPUT	Enter via keyboard
GET	Read character from keyboard



Sinewave function displayed on PUC using graphics adapter PUC-B6

A graphics display may then be stored on a floppy disk and be fetched when required. For hardcopies of test results, the Universal Printer PUD 2 outputs the graphics displays.

Graphics commands

G. DOT	Draw dot
G. MOVE	Move graphics cursor
G. LINE	Draw line
G. WIDTH	Draw dotted line
G. PAGE	Clear graphics display
G. INVERT	Invert graphics
G. S, OFF	OFF: dark mode
G. S, INVERT	INVERT: reverse drawing mode
G. S, ON	ON: bright mode
G. WINDOW	Specify range of display coordinates
G. VIEWPORT	Specify detail of display
G. TAKE	Transfer from display memory to graphics memory
G. G. COPY	Print hardcopy
G. SAVE	Store graphics display on floppy
G. LOAD	Load graphics display from floppy

Floppy-disk Drive Option PUC-B2 The standard built-in and the retrofit optional floppy drives are identical. The mass storage medium used is the 5¼" floppy disk which provides access to data and programs within seconds. The floppies are of single-density type written on both sides. Each floppy has a storage capacity of 156 kbytes and is divided into 305 areas/side, 256 bytes/area.

Rohde & Schwarz supplies formatted and tested floppy disks, although floppies can be formatted by the user with the supplied motherdisk.

A comprehensive set of instructions enables the control of the floppy drives.

Floppy commands

SEL	Select drive
SET	Set write/read head
INIT	Set write/read head to track 0
LOAD	Load program
CHAIN	Load new program and delete variables
DIR	Call disk directory
APP	Append program
ADD	Add program before another one
SECU	Load and start secured program
SAVE	Store program
VERIFY	Compare new program with that of floppy
IN	Load data
PR	Store data

Options

High-resolution Graphics Option PUC-B6 For the clear presentation of results of automatic measurements, for mathematical functions and diagrams a resolution which is higher than that offered by the graphic characters of the basic model is called for.

The High-resolution Graphics Option has the capability to drive each of the 320×200 points singly. An easy-to-use set of commands enables the drawing of bright or dark lines, or the transfer of graphic characters entered via the keyboard to the display memory of the option. Since this memory is independent of the graphics memory of the PUC, two different displays may at the same time be shown on the screen.

Real-time Clock Option PUC-B10 The option has a battery backed-up clock which outputs information on date and time. The resolution is 100 ms. Accurate time measurements can therefore be carried out, and date and time are entered on test records. Program branching via a command can be made at a given time of day.

RTC commands

RTC TO...	Output date and time
RTC SET...	Set date and time
RTC IRQ... GOTO...	Branching at a given time

PUC – Interfaces, Options

IEC-bus Interface The standardized interface (also conforming to IEEE 488) can simultaneously accommodate up to a maximum of 14 devices (including other controllers). The IEC bus is used to set up automatic runs in testing and control optimally and easily. The majority of Rohde & Schwarz measuring instruments are fitted with the IEC interface. The PUC can drive all commercial instruments compatible with the IEC bus. A set of simple and easy-to-handle instructions does away with the need to dwell on the details of the functioning of the IEC-bus system.

IEC-bus commands

Addressed commands

IECOUT	Send data or instructions
IECIN	Read in data
IECTERM	Define delimiter
IECDEV	Define symbolic addresses
IECSDC	Selected device clear
IECGTL	Go to local
IECGXT	Group execute trigger
IECTCT	Take control
IECSRQ GOTO	Jump for SRQ
IECRET SRQ	Return jump out of SRQ
IECLAD	Send listener address
IECTAD	Send talker address
IECSAD	Send secondary address
IECUNL	Send unlisten
IECSPL	Serial poll

Universal commands

IECDCL	Device clear
IECLLO	Local lockout
IECSPE	Serial poll enable
IECSPD	Serial poll disable
IECPPE	Parallel poll enable
IECPPL	Status word
IECPPU	Parallel poll unconfigure
IECPPD	Parallel poll disable
IECTIME	Set time monitor
IEC←ERR	Error disable
IECERR	Error enable
IECREN	REN active
IEC←REN	REN passive
IECCLEAR	IFC active
IEC←CLEAR	IFC passive
IECATT	ATN active
IEC←ATT	ATN passive
IECEOI	EOI active
IEC←EOI	EOI passive

RS 232 C Interface Option PUC-B5 The serial interface enables the transfer of data to or the reception of data from all devices equipped with a serial interface, such as EPROM programming unit, tape reader, tape punch and printer. In addition, the PUC can be hooked up to a computer.

The interface complies with specifications laid down by the RS 232 C I/O Standards, CCITT Recommendations V.24 as well as the DIN 66020 Standard. The RS 232 C Option can be changed to a current-loop interface (20 mA) with the aid of plug-in links. Data transfer is asynchronous with handshaking. The transfer rate is selectable in steps between 50 and 9600 bauds. Data formats between 5 and 8 bits as well as parity and stop bits can be processed.

RS 232 C commands

V24INIT	Initialize required data format
V24TERM	Define delimiter
OPEN a, 232	Open file to operate serial interface
PRINT #	Output data to external device
IN #	Input data from external device
V24ECHO	Switch echo mode on
V24←ECHO	Switch echo mode off

I/O Interface Option PUC-B7 (User port) A great variety of measurement and control tasks, otherwise requiring extra equipment, can be carried out from the computer with the aid of the I/O Interface. The option is made up of a p.c.b. which is plugged into one of the vacant spaces of the PUC. The interface consists of

32 TTL lines arranged in groups of 8 lines programmable either as output (max. sink current of 24 mA) or as input; controlling test items and devices without standard interface; also applying and reading of bit patterns,

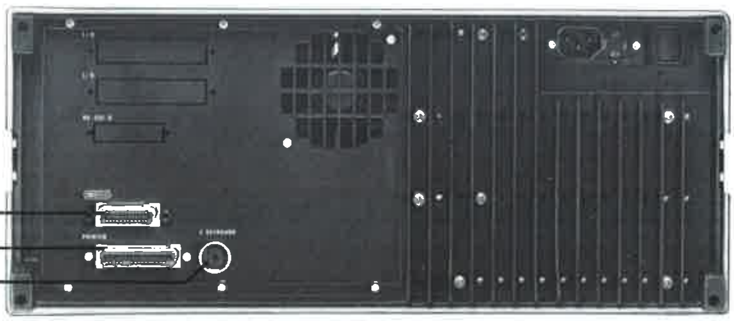
7 relays for supply voltages of up to 50 V and 5 A as well as for any DC and AF signals; they can be selected individually or in groups,

1 A/D converter (0 to +2.55 V), for DC and AF measurements with 8 bit resolution (0.4%), referenced to ground potential; apart from DC measurements, AF signals can be analyzed with the use of machine language,

1 D/A converter (0 to +2.55 V), DC voltages and functions can be generated with 8 bit resolution corresponding to 0.4%.

Service Kit PUC-Z7 Accessory which contains circuit diagrams, test boards and disk with test programs for rapid troubleshooting.

Rear connectors



Printer connection A printer can be connected via a Centronics-compatible interface on the rear of the PUC leaving the IEC-bus connector free for other equipment. Without any extra work involved for the user, the printer (e.g. PUD 2 from R&S) produces printouts of test reports, measurement results and program listings. Commands for the control of the printer are part of the operating system of the PUC. A complete ASCII upper- and lower-case character set for printing texts and figures is available together with the choice of four character styles. With the individual pin-control, the PUD 2 (see page 20) reproduces all graphic symbols including the graphics display of the highresolution graphics option.

Program lines made up of more than 40 characters and therefore displayed in two lines on the screen are automatically listed in one line by the printer.

Printer commands:

SHIFT P	List on printer
CMD	Transfer output display on printer
SHIFT H	Hardcopy (text and graphic symbols)

Specifications

CPU	6502	
Clock	1 MHz	
Available RAM space	31743 bytes	
Number range	$\pm3 \times 10^{-39}$ to $\pm1.7 \times 10^{38}$	
Programming languages	BASIC, with numerous extensions, machine language	
VDU	9″, non-reflecting, non-flicker	
Display	25 lines, 40 characters/line	
Cursor	4 keys plus indirect addressing	
Character set	upper- and lower-case or ASCII and graphic symbols (normal or inverse display)	
Keyboards	shielded; 2.5 m long connecting cable	
Standard keyboard	75 keys, full ASCII character set with double functions, separate numerical pad and special keys for editor as well as RETURN and REVERS	
User keyboard	20 assigned keys and numerical pad with DELETE and RETURN	
Footswitch	two keys (connectable with one of the keyboards or on its own)	
Floppy-disk drives		
Mini-floppy drive	5¼″, standard; 2nd drive as option	
Writing density/type	single density/double-sided	
Storage capacity	156 kbytes	
Disk organization (soft-sectored)	305 areas/side, 256 bytes/area	
IEC-bus interface	IEC 625-1 and IEEE 488	
Functions	SH1, AH1, T1, L1, PP1, DC1, DT1, C1 to C4, C10	
Connector	shielded 24-pole Amphenol female	
Printer connection	Centronics-compatible interface with data strobe and busy signal	
Number of data lines	8	
Permissible output current	I_L <16 mA	I_H >−100 µA
Required input level	V_L <0.4 V	V_H >2.4 V

Specifications of options

Floppy-disk Drive PUC-B2	see above	
RS 232 C Interface (V.24) PUC-B5	bidirectional with additional 20-mA current-loop interface	
Data transfer	asynchronous	
Transfer rate	50 to 9600 bauds	
Connector	25-pole Cannon female	
I/O Interface PUC-B7	four times 8 TTL inputs-outputs, 7 relays	
Permissible output current	I_H >−15 mA	I_L <24 mA
Required input level	V_H >2 V	V_L <0.8 V
Relay rating	$I_{max.}$ <0.5 A	$V_{max.}$ <50 V
Converters	A/D	D/A
Number of bits	8	8
Input/output voltage range	V_{in}/V_{out} 0 to +2.55 V	
Resolution	10 mV/digit	10 mV/digit
Limit values for V_{in}	−0.5 and 3.5 V	—
Offset	1 digit	1 digit
Non-linearity	2 digits	2 digits
Conversion time	max. 15 µs	—
Input/load impedance	100 kΩ	100 Ω min
Connector	50-pole Amphenol female	
High-resolution Graphics PUC-B6		
Resolution	64.000 points	
horizontal	320 points	
vertical	200 points	

Real-time Clock PUC-B10	
Functions	output of time and date; branching at given time
Resolution	100 ms
Accuracy	$<1 \times 10^{-5}$
Battery back-up operation	700 hours

General data

Rated temperature range	0 to +45 °C
Storage temperature range	−40 to +70 °C[1])
Relative humidity	20 to 80%
Power supply	100/120/220/240 V ±10%, 47 to 63 Hz; safety class I
Power rating of basic unit	88 VA
with options	112 VA
RF leakage	
Unwanted voltage	satisfies VDE 0875 (RFI-level K) and requirements of MIL-STD 461B regarding noise on lines
RF interference	satisfies VDE 0871. Meets specifications according to MIL-STD 461B, over the total frequency range with VDU switched off, from 1 MHz with VDU on
Mechanical stress capacity	shock and vibration tested to parts 7 and 8 of DIN 40046, corresponding to IEC Publ. 68-2-27 and 68-2-6)
Dimensions, weight	
Basic unit	470 mm×198 mm×491 mm, 19 kg

Ordering information

Ordering designation		▶ Process Controller PUC
PUC without keyboard		344.8900.10
Standard Keyboard	PUC-Z1	345.2011.04
User Keyboard	PUC-Z2	345.2111.06
Footswitch	PUC-Z3	345.2211.02
Accessories supplied		1 mother disk with programs to format and copy floppies, power cable
Options		
2nd Floppy-disk Drive	PUC-B2	345.2711.02
RS 232 C Interface	PUC-B5	343.6103.02
High-resolution Graphics	PUC-B6	345.3118.02
I/O Interface	PUC-B7	345.2811.02
Real-time Clock	PUC-B10	345.3418.02
19″ Rack Adapter	PUC-Z9	345.2611.02
Service Kit	PUC-Z7	345.2511.02
Recommended extras		
10 formatted floppy disks	PPC-Z2	343.7900.02
IEC-bus cable 0.5 m	PCK	292.2013.05
1 m	PCK	292.2013.10
2 m	PCK	292.2013.20
4 m	PCK	292.2013.40
Universal Printer	PUD 2	359.5018.02
Print paper for PUD 2		079.7107.00

[1]) +5 to +55 °C for Floppy-disk PPC-Z2

PUD 2

new

Universal Printer PUD 2

- Universal matrix printer
- Complete ASCII character set (upper and lower case) plus character set for graphic symbols
- Diagrams using single-dot graphics
- 8-bit parallel interface (Centronics compatible)
- IEC-bus compatible with option

IEC 625 Bus

The **Universal Printer PUD 2** is used to output tables, text, programs, test results and diagrams. It operates on the matrix method and allows bidirectional output at high speed.

PUD 2 is a low-priced, cost-effective unit for small and medium-size computing systems, offering printing capabilities for text and graphics equalling those of much more expensive hardcopy units.

Control The PUD 2 can be controlled from different units or systems; it is optimally adapted to the Process Controller PUC. Via its Centronics-compatible 8-bit parallel interface provided in the standard model it easily accepts complex BASIC-like commands from the PUC.

The **2-kbyte character buffer** permits outputs of text and graphics using a minimum of computer time. While the PUD 2 is printing the computer can continue to process. Printing is bidirectional and route-optimized.

Three character sets (examples on right) permit the printing of normal texts as well as of various types of graphics.

1. ASCII upper- and lower-case character set for printing texts and figures; four character styles including condensed and elongated characters can be selected. A separate line of dots can be activated for underline.

2. Character set for graphic symbols. It enables the printout of graphics identical to the screen display, for example, of Process Controller PUC.

3. Single-dot control permits curve printout with a resolution of 581 dots across the paper width – the printing capacity in the longitudinal direction is not limited.

The **paper feed** can be programmed for line and half line, forward and reverse and for single dot steps.

Types of paper The tractor drive with friction rollers permits the use of perforated fan-fold paper as well as roll paper and single sheets. The drive is continously adjustable over a wide range, facilitating paper installation and use of different paper widths.

Paper quality Paper of any quality may be used.

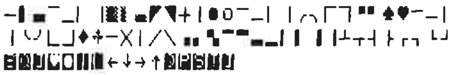
Character styles

Sample program for the R&S Process Controller

```
29Ø OPEN 1, 23Ø
30Ø PRINT #1, CHR$(27); CHR$(19)
31Ø PRINT# 1, „ABCDEFGHIJKLMNOPQRSTUVWXYZ“
32Ø CLOSE 1
```

10 CPI

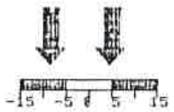
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
1234567890@!#$%'&\()[]^<>,;?:



Text-and-figure printout (scale ≈ 1:2)

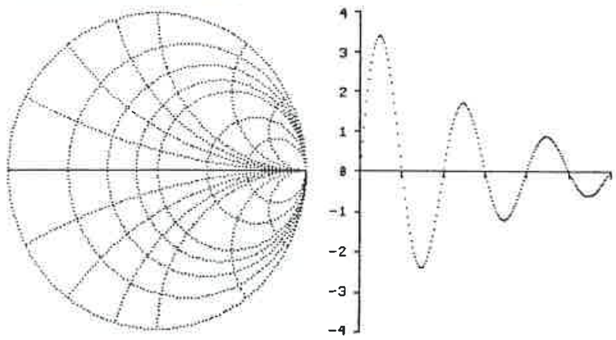
Universal Printer PUD	normal printing
Universal Printer PUD	underline
Universal Printer PUD from R&S	narrow printing
Universal Printer	elongated printing
$P_R = P_V \cdot (S_{11})^2$	half linefeed forward/reverse

Graphics printout (scale ≈ 1:2)



graphics

Diagram printout (scale ≈ 1:2)



Specifications

Principle	matrix print
Printing rate	80 characters/s
Print structure	9×9 for characters n×9 or n×8 for graphics
Character set	200 upper- and lower-case characters and graphic block
Character styles	6 printing widths, 40 to 132 characters/line, 240 to 792 dots/line
Character input buffer	2 kbytes
Paper movement	a) tractor drive for endless form with edge perforation b) friction drive for single sheets and rolls
Paper widths	a) 124 to 250 mm b) 100 to 216 mm
Noise level	<60 dB(A)
RFI	class B of VDE 871 (corresponding to N-12) and FCC 79-555 (U.S.A.)
Safety	VDE 806 = IEC 380 for office machines and BDE 805 = IEC 435 for DP equipment in Europe; UL 114 and UL 478 (U.S.A.)
Interfaces	8-bit parallel (Centronics compatible), 36-way Amphenol female connector

Generell data

Rated temperature range	+5 to +45 °C
Storage temperature range	−25 to +70 °C
AC supply	117/220 V +10/−15%, 50/60 Hz, 20 VA in standby condition, 55 VA during operation
Dimensions, weight	410 mm×310 mm×140 mm, 7.5 kg

Ordering information

Order designation	▶ Universal Impact Printer PUD2 359.5018.02 ▶ Universal Ink-jet Printer PUD3 359.5501.02
Option IEC-bus Interface PUD2-B4 (24-way Amphenol female connector)	359.5418.02

Code Converter PCW

PCW

- Permits IEC-bus programming of parallel-controlled equipment
- Usable for all instruments programmed with TTL levels
- Excellent noise immunity thanks to output buffers
- High transmission speed, bipolar logic

IEC 625 Bus

The **Code Converter PCW** is necessary if instruments designed for parallel remote control are to be programmed via the IEC bus. The PCW receives serial ASCII signals and delivers TTL levels at 44 parallel data outputs.

The PCW is addressable; 26 different addresses can be selected. Instructions are allocated to the data outputs by means of an exchangeable code converter board. This permits the PCW to be adapted to individual instruments. Besides ready-wired, code converter boards for Rohde & Schwarz standard instruments, a universal board is available which can be coded by the user himself for any particular instrument.

Specifications

Input	IEC 625-1/IEEE 488
Connector	24-way, Amphenol
Transfer time per character	approx. 10 µs
Output (50-pole)	8 × 4 bit (TTL level) +12 × 1 bit
Power supply	115/125/220/235 V ±10%, 47 to 440 Hz (10 VA)
Dimensions, weight	484 mm×61 mm×336 mm, 4.5 kg
Order designations	▶ Code Converter PCW
19" cabinet model	244.8015.92
19" rackmount	244.8015.91
Code Converter Boards for DPVP	245.2510.02
SMLU	245.2610.02
Test-item control	245.2762.02
Not wired	245.2910.02

PIF

Pneumatic Interface PIF ♦ 16 control functions

- Electropneumatic control unit for programmed measurement of devices and subassemblies with manually operated switches, keys, potentiometers, etc.
- Drives actuating cylinders for linear motion and stepping mechanisms for rotation
- IEC-bus compatible

IEC 625 Bus

In fully automatic test systems the **Pneumatic Interface PIF** permits automatic control even of those measurements which require mechanical setting, such as range switchover, on the test item.

During final inspection of car radios for instance, programmable adapters press the band and mode buttons for mono/stereo, cassette start and eject. Rationalization can be taken another step forward if the RF, AF and DC connections between the test item and the measuring equipment can also be made fullly automatically.

The Pneumatic Interface PIF can be programmed to perform all these functions via compressed-air cylinders.

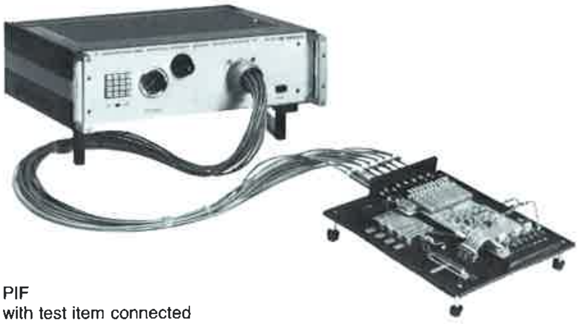
Description

Connection. The PIF is connected via a standard quick-action coupling for one-handed operation to the compressed-air supply generally available in industrial plants. The pressure can be up to 8 bar.

Control. The air is taken to the actuating cylinders via electrically controlled solenoid valves (compressed-air relays). 16 valves of this type are provided; they are controlled with the aid of the keys on the PIF front panel or from a calculator via the built-in IEC-bus interface.

The actuating cylinders – connected to the PIF via flexible compressed-air hoses – are fixed to the test item, see photo below.

For linear movements three standard cylinder types are available featuring different piston diameters (depending on the force and pressure required) and lengths of travel. The working pressure can be set on the internal reducer from 0 to 7 bar.



PIF
with test item connected

For rotary movements a stepping mechanism is available; its hollow shaft with an internal diameter of 8 mm accepts axles up to this size. One step covers 30° (please enquire for other values between 6 and 36°).

Specifications

Mechanical settings on test item	strokes (push and pull) and rotary movements via compressed-air cylinders and stepping mechanism, controlled via compressed-air relays		
Compressed-air relays	16, response time 10 ms, life 30 × 10^6 switching actions		
Working pressure, max.	8 bar, reducer and filter built in		
Pressure range	0 to 7 bar		
Normal rated flow volume	50 l/min per actuated relay, total: 200 l/min max.		
Connector for actuating cylinders	16-way compressed-air socket		
Compressed-air supply	plug insert for quick-action coupling (one-handed operation) NW6 on rear		
Operation			
Manual	via keyboard on front panel (16 keys)		
Remote-controlled	via IEC bus (IEC 625-1/IEEE 488), 24-way Amphenol connector		
Fittings for various motions (to be ordered separately)			
For linear movements	types of compressed-air cylinder:		
	single (push)	single (push)	double (push/pull)
Line diameter	6 mm	16 mm	16 mm
Travel length	25 mm	25 mm	40 mm
Pushing force at 6 bar	12 N	120 N	120 N
Pulling force at 6 bar	—	—	90 N
For rotary movements	stepping mechanism		
Angle	30° (6 to 36°, please enquire) sense: left/right		
Torque	70 N cm		
Diameter of hollow shaft	8 mm		
General data			
Rated temperature range	+5 to +45°C		
Storage temperature range	−20 to +75°C		
AC supply	115/125/220/235 V ±10%, 47 to 420 Hz (80 VA)		
Dimensions, weight	492 mm×161 mm×392 mm, 11 kg		

Ordering information

Order designation	▶ Pneumatic Interface PIF 264.9017.02
Accessories supplied	16-way Compressed-air Connector PIF-Z5; 20 m compressed-air hose, 3 mm dia., plug-in socket for quick-action coupling (one-handed operation) NW6 for ⅜" hose; power cord

Additional fittings required for operation (**optional**):

Compressed-air cylinder	▶ Pneumatic Cylinder PIF-Z1 265.0813.02 PIF-Z2 265.0836.02 PIF-Z3 265.0859.02
Stepping mechanism	▶ Pneumatic Stepping Mechanism PIF-Z4 265.0513.02

AF Relay Matrix PSN for IEC-bus programming ♦ DC and AF

PSN

- Six quick-action reed relays and two power relays
- Af and control applications, high loadability
- Easy to operate, LED indication

IEC 625 Bus

The **AF Relay Matrix PSN** contains eight independent, isolated relays for manual and automatic switchover of control of supply voltages and AF signals for instance in IEC-bus-controlled AF test assemblies, for checkpoint selection and in control engineering. Thus either eight separate switches or max. two 1-out-of-4 switches with the remaining relays as individual switches are available.

Six components are quick-action reed relays featuring high-grade characteristics, while two are power relays which handle currents up to 5 A. All relays are brought out via telephone jacks on the rear panel of the PSN.

Pushbuttons are provided for manual operation with LEDs indicating the switching state. Remote control is performed via the IEC-bus connector. The combined mode permits remote-controlled and manual operation of the relays during program generation and checking.

Specifications

	Relays 1 to 6	Relays 7 and 8
Connectors	telephone jacks on rear panel	
Contact/insulation resistance	150 mΩ/10^9 Ω	20 mΩ/10^9 Ω
Max. power handling capacity	30 VA; 20 W (max. 1 A, 110 V)	1 kVA; 100 W (max. 5 A, 250 V)
Switching	1 ms	5 ms

General data

Life time	>1,000 000 operations;
Rated temperature range	+10 to +45 °C
AC supply	115/125/220/235 V ±10% 47 to 420 Hz (max. 20 VA)
Dimensions, weight	211 mm×112 mm×346 mm, 4.0 kg

Order designation ▶ AF Relay Matrix PSN 290.9210.02

Recommended extras

IEC-bus Cable PCK see Page 19
19″-Adapter ZZA-2 078.8174.00
(for incorporation of max. two PSNs into 19″ racks or cabinets)

RF Relay Matrix PSU for IEC-bus programming ♦ DC to 6 GHz

PSU

- Six independent 50-Ω coaxial relays, low reflection
- RF and pulse applications
- Easy to operate, LED indication

IEC 625 Bus

Six independent, isolated coaxial relays ensure the high flexibility of the **RF Relay Matrix PSU:** six separate coaxial switches or one 1-out-of-4 switch plus three separate switches or two separate 1-out-of-4 switches are possible. The main application is manual and automatic high-precision routing of RF signals in IEC-bus test systems (switching of generators, counters, indicators, attenuators, etc.)

Relays 1 to 3 with 50-Ω N sockets on the front panel of the matrix feature excellent RF characteristics for frequencies up to 6 GHz. Relays 4 to 6 with 50-Ω BNC sockets on the rear panel are suitable for frequencies up to 500 MHz. Pushbuttons are provided for manual operation, with LEDs indicating the switching state Remote control is performed via the IEC-bus connector; the combined mode is the same as for the PSN.

Specifications

	Relays 1 to 3	Relays 4 to 6
Connectors	50-Ω N female on front panel	50-Ω BNC female on real panel
Frequency range	DC to 6 GHz	DC to 500 MHz
VSWR	<1.22 bis 1 GHz	<1.1 up to 100 MHz
Transmission loss	0.3 dB up to 1 GHz	0.2 dB up to 100 MHz
Crosstalk attenuation	>80 dB up to 1 GHz	>40 dB up to 100 MHz
Max. power handling capacity	100 W at 0.1 GHz 50 W at 1 GHz	1 A at 28 V
Switching time	<25 ms	<7.5 ms

General data

Life time	>1,000 000 operations;
Rated temperature range	+10 to +45 °C
Power supply	115/125/220/235 V ±10%, 47 to 420 Hz (max. 25 VA)
Dimensions, weight	211 mm×112 mm×346 mm, 4.8 kg

Order designation ▶ RF Relay Matrix PSU 290.8014.02

Recommended extras

IEC-bus Cable PCK see page 19
19″ Adapter ZZA-2 078.8174.00

PTM

Digital Thermometer PTM ♦ −100 to +300 °C

- Temperature-measuring device of highest precision with platinum-resistance sensors in four-wire circuit
- Measurement of temperature difference between two PTM sensors
- Indication in degrees Celsius (°C) or indication of thermodynamic temperature (K)
- Analog voltage output 0 to 10 V; IEC-bus compatible

IEC 625 Bus

Characteristics, functioning

The **Digital Thermometer PTM** ist suitable for highest-accuracy temperature measurement from −100 to +300 °C or 173.2 to 573.2 K in different media; it has an IEC-bus connector and can thus be used in automatic test systems.

Temperature is measured via exchangeable test sensors (depending on the measurement task), two of which can be connected simultaneously to the two five-pole sockets.

The following three sensor types are available as standard:

1. **contact sensors** suitable for manual measurements,
2. **adhesive sensors** suitable for sticking to critical temperature points (in the form of wafers 6 mm×18 mm×1.5 mm),
3. **Immersion sensors** for gases and liquids or for incorporation into solids (dimensions: 4 mm ∅ ×50 mm).

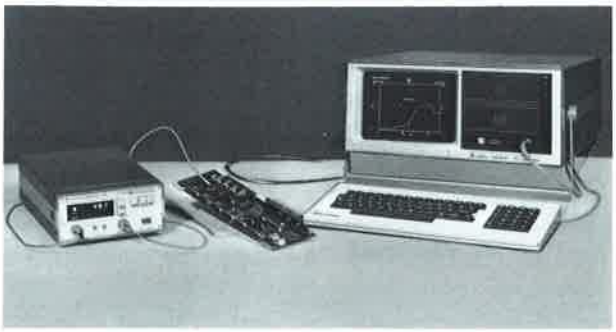
Accuracy. Using these platinum sensors, the maximum error is only 0.2 °C over the entire temperature measurement range. The PTM can be used with one or with two sensing probes (for instance for differential temperature measurement). The resolution is 0.1 °C or 0.1 K over the entire range.

Indication. The PTM displays the temperature (switched when using two sensors) in °C or K. The proportional DC voltage is available at the analog voltage output.

Uses

The PTM finds wide use in the electronic industry and in other fields. Thus the effect of temperature on components or subassemblies when varying the ambient temperature (for instance with the Temperature Controller PTC, see next page) can be checked automatically via the IEC bus. Troubleshooting in case of temperature effects can also be automated.

Automatic measurement of temperature effect on subassembly



Sensors

Specifications

Temperature measurement range	−99.9 to +299.9 °C (173.2 to 573.2 K)	
Indication	°C or K, 4-digit LED (switchable when using two sensors)	
Resolution	0.1 °C or 0.1 K	
Measurement error		
Basic error	0.1 °C over entire range	
Additional sensor error (PT 100)	≦0.1 °C with adjustment ≦0.3 °C without adjustment at 0 °C (tolerance in accordance with DIN 43 760)	
Nonlinearity	<0.1 °C	
Effect of ambient temperature	<0.1 °C at (23 ±5) °C <0.5 °C in rated temperature range	
Test current	3.3 mA ±5%	
Rate	28 to 50 measurements/s	
Sensors	platinum resistance Pt 100 in four-wire circuit	
Input for sensors	two 5-way female connectors	
Input impedance	100 kΩ	
Analog voltage output	0 to 10 V; 2.49 mV/0.1 °C	
Programming	via IEC-bus connector (IEC 625-1/IEEE 488), 24-way Amphenol	
Interface functions	T6, TE6	talker functions with sec. address, serial polling and auto adressing when receiving listener address
	L4	listener function
	RL1	remote/local
	DC1	device clear
General data		
Rated temperature range	+5 to +45 °C	
Storage temperature range	−45 to +70 °C	
AC supply	115/125/220/235 V ±10%, 47 to 440 Hz (30 VA)	
Dimensions, weight	211 mm×112 mm×346 mm, 4 kg	
Order designation	▶ Digital Thermometer PTM 336.8010.02	
Accessories supplied	power cord	
Recommended extras		
Contact Sensor PTC-Z1	336.7914.02	
Adhesive Sensor PTC-Z2	336.7937.02	
Immersion Sensor PTC-Z3	336.7950.02	

Temperature Controller PTC

♦ −100 to +300 °C

- Temperature controller driven via IEC bus; rated temperature entered in °C or K via keyboard
- Precision measurement using platinum-resistance thermometer in four-wire circuit
- Temperature indication in °C or K; status indication
- 10 A/220 V contactor and control relay incorporated

PTC

IEC 625 Bus

Characteristics, functions

The **Temperature Controller PTC** is used as a precision measuring and setting device for temperature-control circuits (also for measurements alone) in the range from −100 to +300 °C or 173.2 to 573.2 K. Thanks to its **IEC-bus connector,** it is system-compatible and suitable for use in automatic test and control systems.

Sensors. Like the PTM, the PTC measures temperature via a platinum-resistance sensor in a four-wire circuit. The types of sensor available are the same as for the Digital Thermometer PTM (see previous page). The connections for temperature measurement and the procedure itself are also the same.

Temperature control. The temperature picked up by the sensor is compared with a set rated value. The control signal derived is used for switching a load relay (e. g. for controlling an oven) and a control relay provided for simultaneous connection of heating and cooling systems. Thus a programmable temperature control system can be set up with only a few system components, such as a calculator, an oven and the PTC.

Accuracy. The platinum sensors used with the PTC ensure high accuracy. For temperature measurement and rated-value setting, the resolution is 0.1 °C over the entire range (measurement error < 0.2 °C or K). Entry is possible in °C or in K with four stepping buttons.

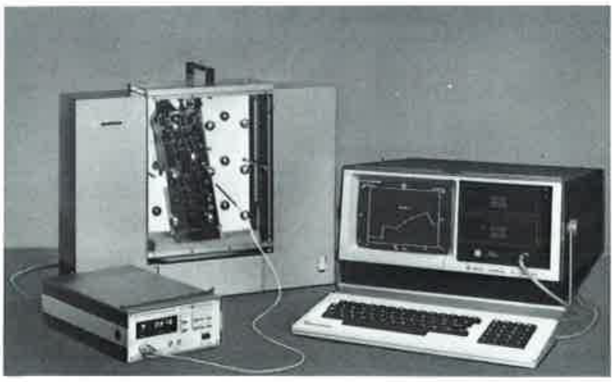
Recording. A voltage porportional to the indication (0 to 10 V) is continuously available at the analog output.

Uses

The programmable Temperature Controller PTC finds a wide range of application, in particular in the development, production and quality control of electronic equipment but also in other fields of industry.

The programmability of the PTC permits not only accurate point-by-point determination of the temperature response but also automatic sweeping of complete temperature cycles along with protocolling via the calculator and printer.

Automatic temperature test on subassemblies using PTC



Specifications

Temperature measurement range	−99.9 to +299.9 °C (173.2 to 573.2 K)
Indication	°C or K, 4-digit, LED (switchable when using two sensors)
Resolution	0.1 °C or 0.1 K
Measurement error	
Basic error	0.1 °C over entire range
Additional sensor error (PT 100)	≦0.1 °C with adjustment ≦0.3 °C without adjustment at 0 °C (tolerance in accordance with DIN 43 760)
Nonlinearity	<0.1 °C
Effect of ambient temperature	<0.1 °C at (23 ±5) °C <0.5 °C in rated temperature range
Test current	3.3 mA ±5%
Rate	30 measurements/s
Sensors	platinum resistance Pt 100 in four-wire circuit
Inputs for sensors	two 5-way female connectors
Input impedance	100 kΩ
Temperature control range	−99.9 to +299.9 °C
Rated temperature setting	with stepping buttons (coarse and fine)
Resolution	0.1 °C
Switching status indication	lamps for load relay on, measured value > or < rated value
Control characteristics	two-level controller, response threshold ±0.15 °C about rated value (hysteresis variable via IEC bus with 0.1 °C resolution)
Outputs	
AC supply voltage (via int. load relay)	max. current 10 A, leakage current <20 mA, 4-way AC-supply female connector
Control relay (switch)	max. switching current 1 A, max. switching voltage 50 V, max. switching power 20 W/30 VA telephone jacks
Supply voltage	±15 V/100 mA via telephone jacks
Analog voltage output	0 to 10 V; 2.49 mV/0.1 °C
Programming	via IEC-bus connector (IEC 625-1/IEEE 488), 24-way Amphenol
Interface functions	same as PTM, see previous page
General data	
Rated temperature range	+5 to +45 °C
Storage temperature range	−45 to +70 °C
AC supply	115/125/220/235 V ±10%, 47 to 440 Hz (30 VA)
Dimensions, weight	211 mm×112 mm×346 mm, 4 kg
Order designation	▶ Temperature Controller PTC 336.7014.02
Accessories supplied	power cable; power connector for heating/cooling
Recommended extras	
Contact Sensor PTC-Z1	336.7914.02
Adhesive Sensor PTC-Z2	336.7937.02
Immersion Sensor PTC-Z3	336.7950.02

More efficient measurements with automatic test systems

R&S offers a choice of automatic test systems for all fields of electronics: for development laboratories, final test, quality control and service departments. The system size ranges from small systems to processor-controlled distributed test systems.

Examples of **computer-controlled test systems** with programming capabilities and software tailored to BASIC are presented on the following pages.

The last two pages of this chapter include also digital and hybrid test systems using the higher programming language ATLAS.

The main fields of application for analog test systems are

- **transceiver testing** for AM, FM, φM and SSB equipment
- **impedance measurements** from 10 Hz to 2 GHz
- **fieldstrength and EMI/EMC measurements** from 9 kHz to 1 GHz
- **radio receiver measurements**

Each **R&S Standard System** for these applications is supplied with a sophisticated, modular **Basic Software Package** in BASIC, which allows the full use of the system after a very short familiarization period.

TRANSCEIVER TEST SYSTEM

Problem

Precise and cost-effective measurement of FM and AM transceivers – even of small batches – during production and for incoming and outgoing inspection in small to medium-size service workshops.

Transmitter tests

RF power and frequency
useful and spurious modulation
modulation distortion
modulation sensitivity
side tone
current drain
options: adjacent channel power, selective calling

Receiver tests

sensitivity acc. to S/N or SINAD
S/N and SINAD ratio
bandwidth
mid-frequency shift
squelch hysteresis
AF level
AF frequency response
AF distortion
image frequency and IF rejection
desensitisation
current drain
options: relay measurement, intermodulation, dyn. adj. channel selectivity, selective calling

Apart from measurements on the transceiver the test system should also be able to check radio subassemblies.

Solution

The heart of the system is the highly intelligent Mobile Tester SMFP 2 which performs all these measurements fully automatically. This is accomplished by using the Process Controller PUC running the sophisticated, modular standard software package SMFP 2-K1.

The results are available as graphics or in alpha-numerical form from the Universal Printer PUD 2. The Programmable Power Supply NGPU 70/10 provides for the required voltages at programmable current limits. As the NGPU 70/10 is equipped with automatically switched shunt resistors, the DC voltmeter of the SMFP 2 can do current drain measurements at optimal accuracy within the 3 current ranges.

Furthermore the SMFP 2 can control programmable transceivers for channel selection (3 digits) and for 9 single functions per program. The test system may be extended by the Signal Generator SMS for relay measurement or for intermodulation and blocking measurements according to the CEPT recommendations. Using a Signal Generator SMPC as second signal source, other parameters such as adjacent-channel selectivity and common-channel rejection can be measured according to CEPT.

If required the test system is available built into a 19″ rack or into a test desk completely cabled and checked out.

Automatic test system
for AM, FM and φM transceivers

TEST SYSTEM TO CEPT T/R 17

new

Problem

All measurements on FM and φM transceivers for land mobile and fixed radio services in the frequency range 30 to 500 MHz as required by CEPT Recommendation T/R 17; also measurements on SSB radio equipment.

More information on page 100

Solution

The heart of the system is the Mobile Tester SMFP 2; it is extended by the Modulation Analyzer FAM (also for SINAD measurements), the Adjacent-channel Power Meter NKS (for measurements of nonharmonic spurious signals and oscillator reradiation), the Programmable Power Supply NGPU and many auxiliary devices such as attenuator set, buffer, relay matrix, etc. The system is controlled from the Process Controller PUC completed with the Universal Printer PUD 2.

Two-signal measurements are performed using the Signal Generator SMPC; this also serves as the local oscillator for the Adjacent-channel Power Meter and the Precision Sideband Mixer ATS-SM. Sideband analyses on SSB equipment up to 30 MHz are performed by the Programmable Test Receiver ESH 3.

Basic software developed by Rohde & Schwarz for this test system relieves the user from the measurements proper even where the task is complex, e.g. with two-signal measurements.

Test system for transceivers, in line with CEPT recommendations, extended for SSB and two-signal measurements

REFERENCE SYSTEM FOR TRANSCEIVER TEST

new

Problem

For transceiver measurements affording greater testing depth and higher accuracy than those offered by the test systems built up around the Mobile Tester SMFP 2, R&S can propose a configuration of instruments of highest precision. The basic equipment of the transceiver test system copes with the following tasks: all measurements in the useful channel on simplex and duplex equipment, relay stations equipment with acknowledgement and data transmission radio equipment.

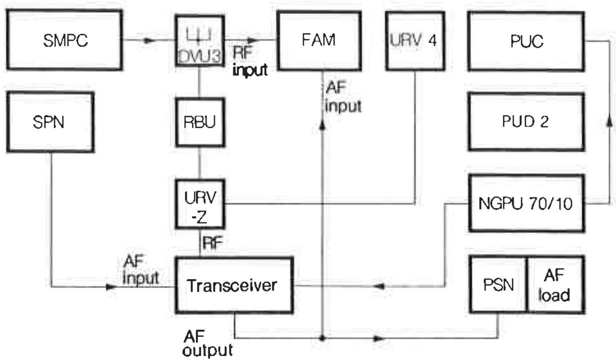
Solution

The following instruments from the comprehensive R&S line are combined into a high-quality measuring system:

Signal Generator SMPC (Synthesizer); Generator SPN for the microphone voltage; Modulation Analyzer FAM for modulation measurement and determination of AF level, distortion factor and SINAD; Millivoltmeter URV 4 with 100-V insertion unit (for 200 W) for RF power measurement ahead of High-power Attenuator RBU; AF Relay Matrix PSN for switchover of AF loads and Power Supply NGPU 70/10.

The system is controlled from the Process Controller PUC equipped with the Selective Call Encoder/Decoder for Data Transmission PUC-B9. The Universal Printer PUD 2 provides a hardcopy record.

The basic software packet dedicated to this system is compatible with Basic Software SMFP 2-K1, so the system can easily be used as a reference for one or more SMFP 2 test systems. By adding further measuring instruments in stages test system complying with CEPT T/R 17 can be configured.



Block diagram of reference system for transceiver test

STEREO-CAR-RADIO TESTER

Problem

Measurements on stereo car radios for final testing and goods-inwards inspection, for example:

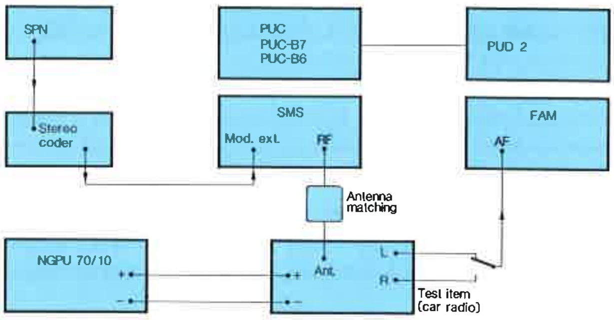
sensitivity tuning error image-frequency rejection weighted and unweighted S/N ratio mono/stereo with FM distortion mono/stereo crosstalk attenuation pilot-tone suppression	weighted and unweighted S/N ratio: tape distortion: tape muting muting treshold AM suppression AF frequency response with tone control left, centre, right

Solution

The test assembly outlined in the block diagram affords a time saving of about 45% in measurements on stereo car radios against the measurement times of conventional semi-automatic systems. The use of a video processor for checking the digital displays, especially the search tuning indicator, further cuts down on measurement time. The test data for the display figures, letters and symbols between the process controller and the video processor is transferred in compressed form.

Video processor for computer-controlled display recognition and evaluation in car-radio test (example)

new



Block diagram of automatic test system for stereo car radios consisting of Generator SPN 1 Hz to 1.3 MHz, Signal Generator SMS 0.1 to 520 MHz, Modulation Analyzer FAM, Power Supply NGPU 70/10, Process Controller PUC and Universal Printer PUD 2

S-PARAMETER TEST SYSTEM

Problem

Semicconductor testing and s-parameter measurement on RF small-signal transistors or other active and passive twoport networks in the range 5 MHz to 2 GHz:

- Measurement of the four s-parameters
- Testing of bipolar RF transistors, junction FETs and MOS-FETs
- Measurement of diode RF characteristics
- Frequency-response measurement in range 5 MHz to 2 GHz
- Determination of s-parameters as functions of transistor DC operating point

Solution

The Process Controller PUC uses the system software (dialog mode) to control the Vector Analyzer ZPV with s-parameter Test Adapter ZPV-Z5 and Sweep Generator SWP. The result is output on Universal Printer PUD 2.

If the test item connected to the ZPV-Z5 requires a power supply, the DC Feed Unit ZPV-Z6 serves the purpose. Two Programmable Power supplies of the NGPV series can be used to set the desired DC operating point (not shown in the illustration).

The system is handed over on a turnkey basis except for test-item adaption, ready-wired in the rack and checked out, documentation inclusive. The instruments are built into a test cabinet or desk as required.

s-parameter test system

new

AUTOMATIC TEST SYSTEM FOR USEFUL AND INTERFERING SIGNALS

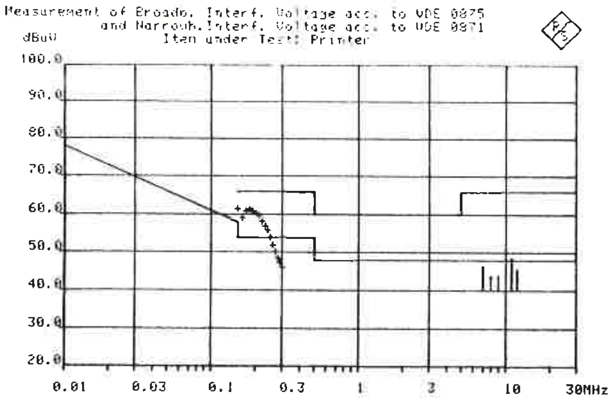
Problem

Detection, (graphic) display and measurement (recording with printer) of useful and interfering signals in the frequency range 9 kHz to 1 GHz:

- Selective voltage measurement in laboratories and test departments for generator, twoport and linearity measurements
- Field-strength measurement using test antennas for the determination of radiation patterns, propagation characteristics and coverage
- Radiomonitoring (field-strength and remote frequency measurements with different types of demodulation for aural monitoring)
- Radio-interference measurements according to CISPR, VDE and FCC and EMI measurements to MIL specifications and VG regulations
- Automatic measurement of directional patterns of ship antennas

Solution

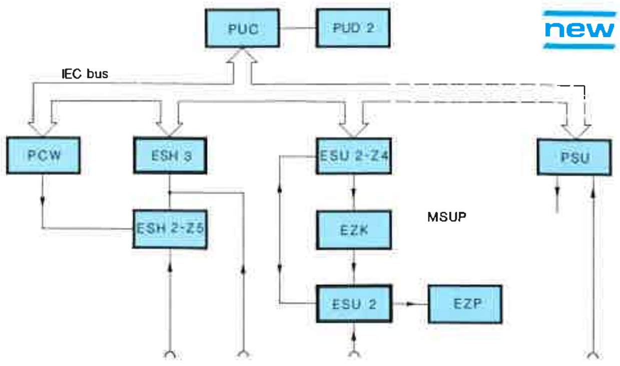
In the presence of pulse spectra adequate measurement accuracy is obtainable only with selective receivers or measuring equipment because of the wide dynamic range involved.



Radio-Interference measurement according to VDE, CISPR and FCC: rapid peak and average measurements permit distinction of wideband and narrowband interference. Only wideband interference near limit value is measured to CISPR to reduce overall measurement time (approx. 8 min for one phase of power lead); limit curves to VDE 0875 (grade N) and VDE 0871 (class B)

The VHF-UHF Test Equipment MSUP combining the Test Receiver ESU 2 with the Frequency Controller EZK, the Panoramic Adapter EZP and the IEC-bus Adapter ESU 2-Z4 is augmented by the automatic Test Receiver ESH 3 for 9 kHz to 30 MHz to form an IEC-bus programmable test system for 9 kHz to 1 GHz. The ESH 3 takes a lot of load off the IEC-bus controller (Process Controller PUC, on right in the photo) thanks to its total automatic calibration, autoranging, and automatic scanning with constant linear or logarithmic step size.

new

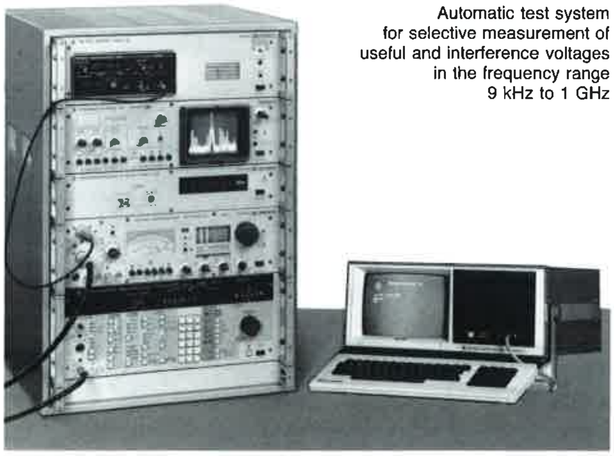


Block diagram of automatic HF-VHF-UHF system consisting of Test Receiver ESH 3, VHF-UHF TEST Equipment MSUP, Code Converter PCW, Artificial Mains Network (LISN) ESH 2-Z5, Process Controller PUC and Universal Printer PUD 2

Software Applications software is available for the controller; it consists of

a) the MSUP basic software
b) a dialog program for preparing a graphics data set that can be stored on tape or floppy disk for use in the individual test programs. One or more graphics data sets are produced before a test run for each program and stored in one or more data files.

new



Automatic test system for selective measurement of useful and interference voltages in the frequency range 9 kHz to 1 GHz

RF COMPONENT TESTER ATS-COM

new

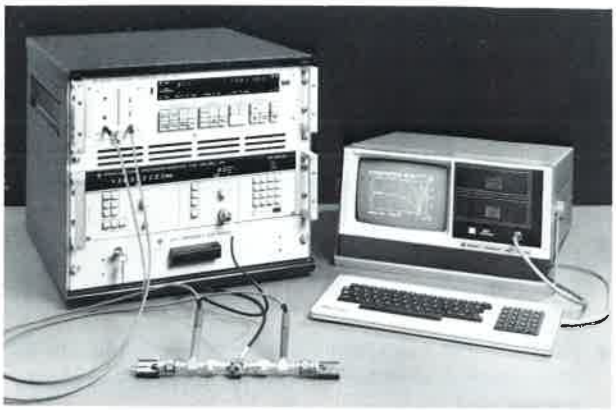
Problems

Measurements

on RF coils and RF chokes to determine inductance, self-resonant frequency, Q at a particular frequency, and internal capacitance

on capacitors of all types and specifically chip capacitors to determine capacitance, Q and tanδ at high frequencies

on materials to determine dielectric constant ε_r and relative permeability μ_r

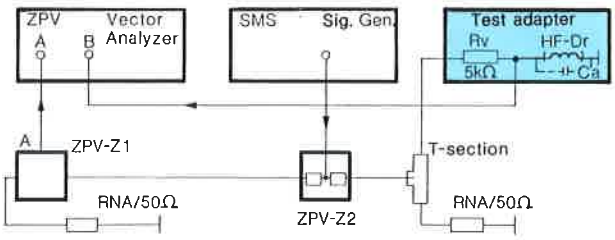


RF-component tester with test adapters for Q and capacitance measurements on chip capacitors

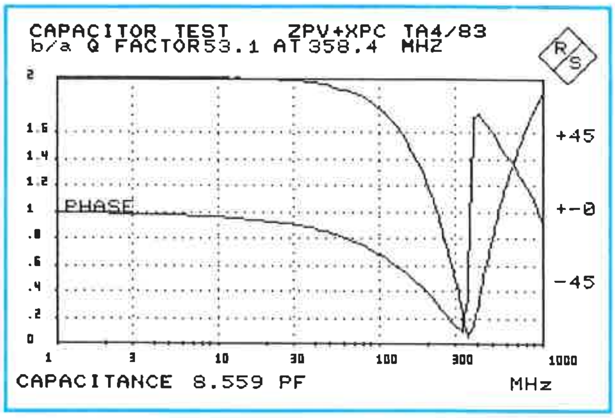
Solution

TO CHOKE MEASUREMENT

The measurement philosphy of the RF-choke test system is based on the analysis of parallel resonant circuits, the inductance and Q of the test item being determined from the measured resonance frequency and resonance peak. The test item is connected in prallel with a known capacitance, which is part of the test adapter. A second test adapter without a parallel capacitance is necessary for measuring the self-resonant frequency of the RF choke. The system software contains test routines as well as calibration routines for determining the specific test-adapter constants, including those of user-made adapter employing the same measurement technique.



Block diagram of RF-choke test system



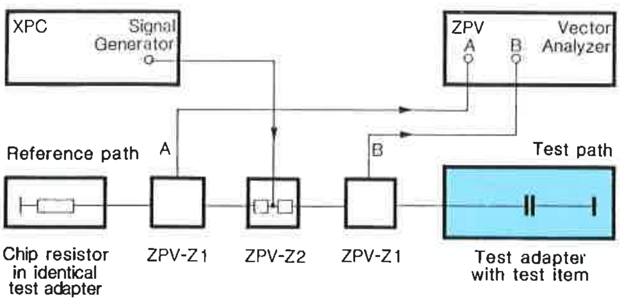
Printout of chip-capacitor measurement

TO MATERIAL-CHARACTERISTICS MEASUREMENT

The methods described above for capacitor and coil measurements are employed to determine dielectric and magnetic material constants respectively. The parameters of interest are calculated from the measured results.

TO CAPACITOR MEASUREMENT

The measurement is based on the analysis of series resonant circuits formed by the test adapter and the test item; see block diagram below. The Q of the unknown capacitor can be calculated from the circuit Q of the resonant circuit.



Block diagram of RF-component tester for capacitors

Specifications

(Shortform; typical values when using test-item optimized test adapter)

Frequency range of test signal	0.1 to 1000 MHz, down to 10 Hz with option
Induductance range	0.1 µH to >1 mH, up to >1 H with option
Measurement range for RF chokes	
Q	10 to 50
Error ΔQ	≦10%
Self-resonant frequency	up to 500 MHz
Capacitance range	0.5 pF to 100 nF, up to 10 µF with option
Measurement range for chip capacitors	
Q (1/tanδ)	up to ≈10,000
Error ΔQ	<15% at 10,000
Capacitance error ΔC	<1%
Test frequency at C = 1 pF	800 MHz typ.
tanδ measurement on tantalum electrolytic capacitors and blocking capacitors (>100 nF)	
Frequenca range	1 to 400 MHz, down to 200 kHz with option
Loss resistance	10 mΩ to >100 Ω
Error ΔR	5%

R&S SYSTEM RESPONSIBILITY

The standard test systems presented on the preceding pages have been designed for the most frequent applications in the respective fields.

The scope of delivery and support provided for R&S test systems is explained below by some important items.

System Planning

Additional measurements can be embodied in a standard system configuration by integration of appropriate instruments or by modification of the software packet. The system project worked out in close consultation with the customer is laid down in a binding system proposal.

Hardware Integration

Depending on their size, the test systems are built into castered 19″ cabinet racks or 19″ desktop cabinets. Each cabinet rack contains besides the measuring instruments at least one blower providing adequate ventilation and an EMI filter suppressing electromagnetic interference from the power line. High-quality, usually double-shielded, cables are used for system-related signal cabling.

Drawers for accessories, connector panels and flange-mounted 19″ working tops are available on request.

The photo below shows a system version for mobile use wherein the inner 19″ frame is connected to the outer shell through shock-absorbing rubber buffers. – Rohde & Schwarz also equips test vehicles and shelters for mobile use in any climatic zone of the earth.

Software

The software for the standard test systems is always designed in the form of a modular basic software packet, which allows fast and reliable preparation of test programs. On request we develop dialog software packets for particular measurement tasks and self-test software for a given system.

Documentation

In addition to the handbooks for the individual system instruments R&S supplies documentation for complete systems including hardware configuration and software.

System Training

On request, R&S provides system training for operating staff. Courses last one to five days and are conducted preferably at the head office in Munich. Courses on the maintenance of the system units are also offered.

System Acceptance

Following the system training, the acceptance test is performed on one or more items proposed by the customer and system performance is documented in a test report. After delivery and installation of the system, an identical acceptance test is made on the same test items and laid down in the acceptance test report.

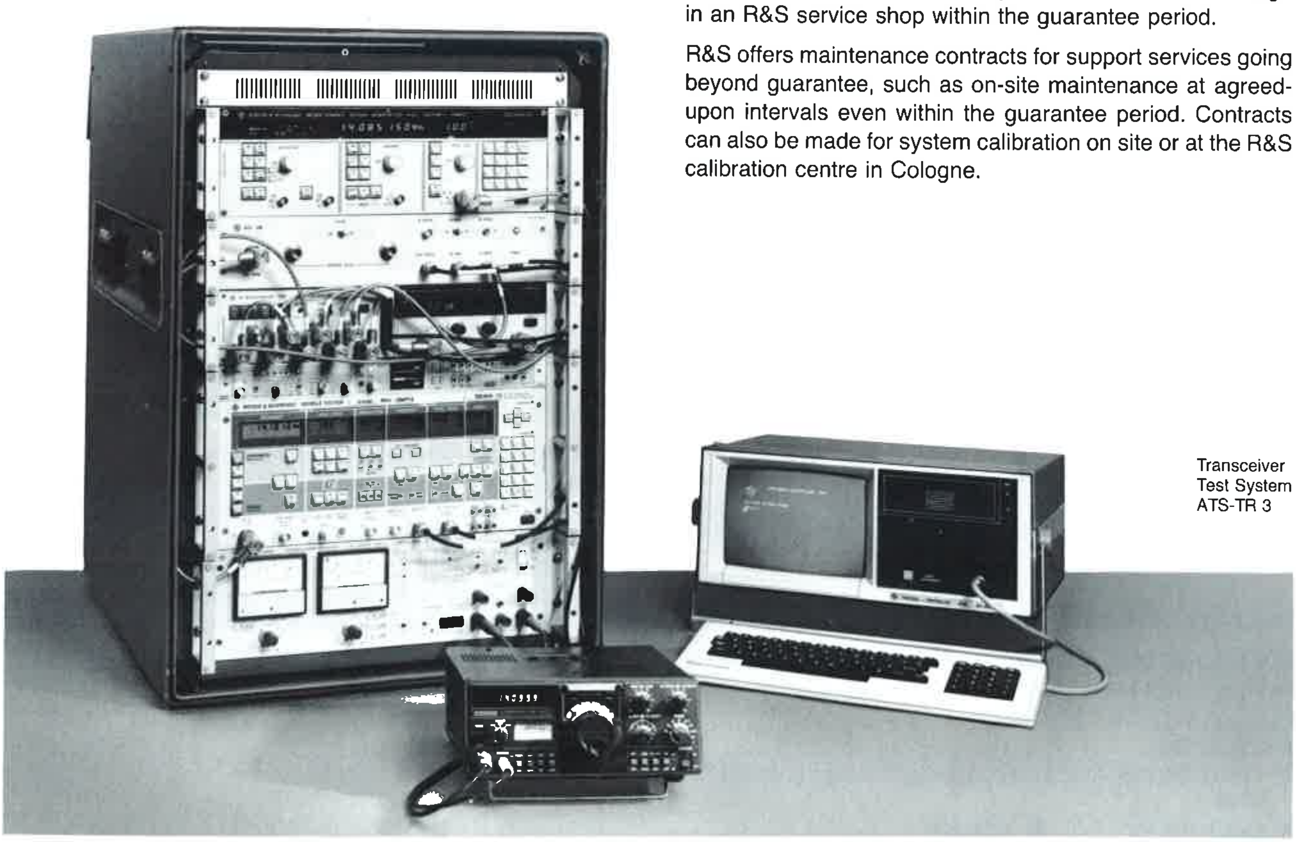
System Installation

The test systems delivered are installed on site by R&S staff. Power line stabilizers can be provided on request.

System Guarantee

The guarantee stipulated in the R&S conditions of sales normally covers the repair of any defective unit free of charge in an R&S service shop within the guarantee period.

R&S offers maintenance contracts for support services going beyond guarantee, such as on-site maintenance at agreed-upon intervals even within the guarantee period. Contracts can also be made for system calibration on site or at the R&S calibration centre in Cologne.



Transceiver Test System ATS-TR 3

AUTOMATIC TEST SYSTEM TSR 6060

- Functional testing capability
- Diagnosis at component level
- 10-MHz logic test unit
- Programmable adapter interface
- Universal switch panel up to 25 MHz
- Programming in ATLAS
- Comprehensive software
- Digital simulator

new

Digital Station TSR 6061

Uses

Today **automatic testing** of electronic subassemblies and modules for quality assurance in batch production, performance checking and fault diagnosis in large repair shops is indispensable.

The **test system TSR 6060** from Rohde & Schwarz forms a flexible system family with modular system components tailored to the specific tasks.

Test system selection and functions

Function-oriented systems. The following function-oriented assemblies can be set up for different fields of application of main interest:

- Digital Station TSR 6061
- Hybrid Station TSR 6062
- RF Station TSR 6063

A wide line of hardware and software system components permits the devices unter test to be given the checks required accurately yet inexpensively.

Test-item connection. The test items are connected to the test-item interface via standardized adapters. The interface is a junction panel with approximately 400 test-item connections.

The programming language (test language) for the test systems is ATLAS (**A**bbreviated **T**est **L**anguage for **A**ll **S**ystems) which has become the international standard for formulating test instructions.

Hardware configuration of a test system

System elements. The test system hardware comprises the following groups:

- computer and peripherals
- interfacing
- measuring instruments and signal generators (instrumentation)
- switch panels
- adapters

Computer and peripherals. The central controller is a powerful 32-bit processor with 16 registers, a 1-Mbyte central memory (extensible to 5 Mbytes) and an address capacity of 4 Gbytes.

The standard set of peripherals comprises a VDU (24 lines, 80 characters each or 14 lines, 132 characters each), control unit (9 user-definable keys), operator console (typewriter keyboard, separate numeric keys, floppy-disk unit (2×0.5 Mbyte), disk drive (fixed disk 121 Mbyte, removeable disk 10 Mbyte) and line printer (132 characters/line; 180 characters/s).

Interfacing. The measuring instruments and signal generators are controlled via the IEC bus (IEC 625-1; IEEE 488); due to its high data processing speed, the digital test unit alone has direct access to the central memory via the DMA version of the IEC bus. The I/O devices are driven via the peripheral bus.

Measuring instruments and signal generators. Basically there are three signal groups which require different processing: digital, hybrid and high-frequency signals. Depending on the measuring instruments selected, the corresponding function-oriented type of test system is obtained.

Digital signals are handled by the digital station which can be extended in steps of 16 bidirectional channels up to a total of 256. The channels can be switched from transmit to receive or to tristate mode at full data rate (3 to 10 MHz). Each channel has five auxiliary stores of 1 kbit each for manifold functional modes. The digital station meets all requirements for digital signals in accordance with IEEE 416-ATLAS. It generates logic signals with freely programmable levels (−20 to +20 V/100 mA) and processes signals with levels between −25 and +25 V.

Low-frequency signals are produced by power supplies, AF signal or waveform generators and measured with the aid of digital multimeters, distortion meters and analyzers.

Pulse-shaped signals are produced by pulse and waveform generators and measured with the aid of waveform analyzers, timers/counters and spectrum analyzers.

High-frequency signals. The whole line of R&S measuring instruments, including special test assemblies for communication and navigation devices, dealt with in the following chapters, is available for signal processing.

Switch panels. Three different types of switch panel are available corresponding to the signals to be handled:

Hybrid switch panel. It is of modular design and switches either certain channels of the digital test unit or generators and instruments to the test-item connectors. Up to 48 instrument connections can be switched as required to 256 test-item connections. The hybrid switch panel is a 50-Ω system handling all AF and pulse signals up to 25 MHz and 1 A.

Power switch panel. It connects the test item to the power supplies. Voltages up to 500 V and currents up to 15 A can be handled. Modular design permits the use of up to 9 power supplies via 9 switching modules.

RF switch panel. This panel consists of four relay matrix boards each comprising six RF switching relays. The connectors are accessible from the front panel; frequency range 0 to 6 GHz; see also the RF Relay Matrix PSU, page 23,

Adapters. The modules can be connected to the central system interface through an RF adapter or an AF adapter. All signals of the test system up to a frequency of 25 MHz are available – freely programmable – at this junction panel. No further mechanical adaption is required for digital, analog and hybrid modules. The shortest way of linking RF signals is through the RF switch panel.

Software configuration of a test system

The programming language and the available software are of great importance for an automatic test system. The R&S test system uses the internationally standardized test language ATLAS as defined in IEEE standard 416.

Reaching beyond other programming languages, ATLAS contains instructions which describe all signals required for the test in an easily unterstood signal-oriented form.

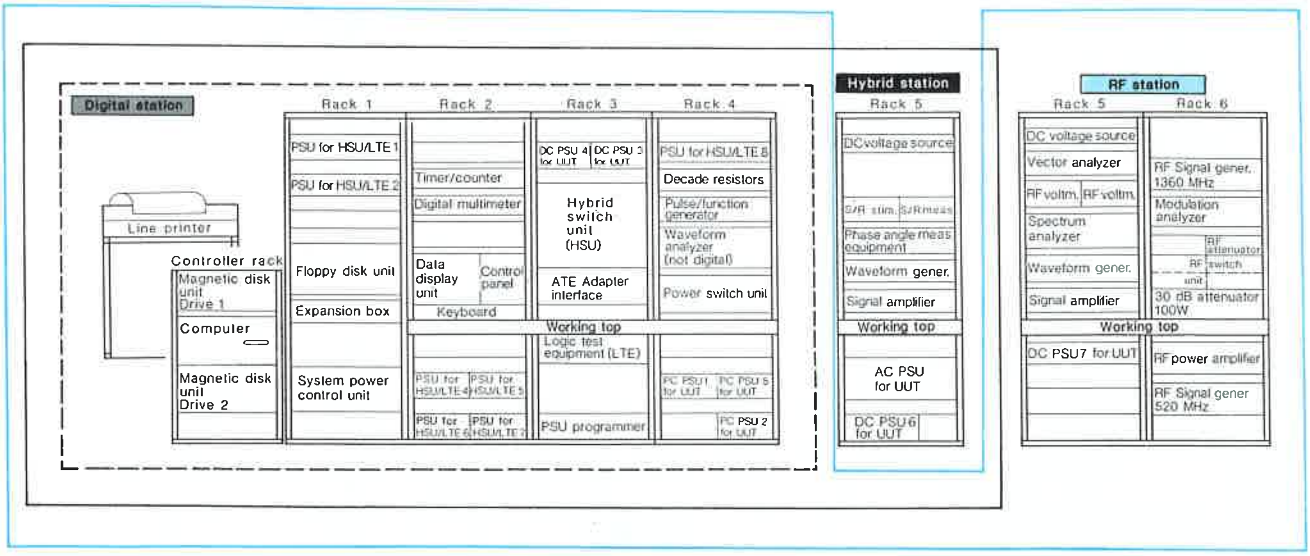
```
$
C        Anlegen der Versorgung
$
 001100 APPLY, DC SIGNAL USING 'dc psu',
            VOLTAGE 5. V ,
            CURRENT MAX 400. MA ,
            CNX
            HI     J1-1
            LO     J1-2 $
C        Pruefen der Ausgangsfrequenz
$
 001200 VERIFY, (FREQ INTO 'ausgangsfreq'),AC SIGNAL USING 'freqmess',
            LL 0.95 KHZ UL 1.05 KHZ ,
            FREQ RANGE 0.5 KHZ
               TO 1.5 KHZ ,
            VOLTAGE RANGE 1. V
               TO 1.4 V ,
            CNX
            HI     J2-1
            LO     J2-2 $
C
```

Programming example in the test language ATLAS

The ATLAS test programs are fully checked, also during entry, through an incremental ATLAS compiler. Alterations can be made at any time to a test program without renewed compilation of the whole program.

The display unit of the system shows the number of the instruction being processed at each moment, the last value measured and the limit values in the case of a comparison. Special modes such as repetition of measurement, stop at fault, stop at each test, printout of all values, manual test, i.e. direct control by means of instructions entered, are possible during the program run. A powerful digital simulator system with automatic test program generation completes the software concept.

Order designation		....	▶ Automatic Test System
Digital Station	TSR 6061	....	360.0116.02
Hybrid Station	TSR 6062	....	360.0216.02
RF Station	TSR 6063	....	360.0316.02



Signal Generator SMPC
for 5 kHz to 1360 MHz,
IEC-bus-compatible;
details on page 54

AF and RF signal generators

Signal generators

Rohde & Schwarz offers a complete line of signal generators for the **AF to SHF ranges covering 1 Hz to 12.5 GHz.** The line comprises solid-state mechanically tuned signal sources with synchronization capability, synthesized generators of finest frequency resolution and highest stability as well as klystron generators for the highest frequencies.

All R&S signal generators feature

- an easy-to-read and fine frequency adjustment,
- an extremely accurate and easy-to-vary output level and
- versatile modulation characteristics.

R&S signal generators have all the characteristics which are required for use in development, production (test department) and servicing over the entire range of low- and high-frequency technology, permitting the performance of the most diversified measurements and simulation of all signals which are necessary for testing components, circuits, receivers and instruments of various types. The possibilities include, for example, receiver tests for sensitivity, selectivity and adjacent-channel characteristics. The comprehensive modulation characteristics include stereo of highest quality. Signal generators with high power output permit special measurements such as intermodulation and crossmodulation at high levels, driving of power stages and frequency multipliers, etc.

Characteristics of RF signal

The application of a signal generator depends on criteria such as

- frequency range and resolution,
- frequency stability,
- level range and resolution,
- harmonic content and
- modulation characteristics.

Another essential criterion is the signal quality with respect to
phase noise and
nonharmonic spuria.

A common way of **phase noise** evaluation is to indicate the ratio of the SSB noise power per 1-Hz bandwidth to the total signal power in dBc. A graphical representation of the noise sideband shows especially well the corresponding characteristic as a function of the spacing from the carrier.

The term **nonharmonic spuria** designates all the discrete signals which occur at the output in addition to the carrier and its harmonics. These spurious levels are indicated as relative levels in dBc, i.e. referred to the carrier level.

The spurious FM yields further information on the spectral purity. The **spurious FM,** i.e. the frequency deviation measured at a demodulator with a fixed bandwidth, is directly related to the phase noise and the nonharmonic spuria. The lower the phase noise and the spuria level, the lower is the residual FM.

The requirements on spectral purity are especially stringent for measuring the **adjacent-channel characteristics** on receivers since the noise frequency spectrum falling within the adjacent channel must not invalidate the measurement. If, for instance, an adjacent-channel selectivity (S/N ratio) of 80 dB is to be measured, the SSB phase noise of the noise source must be below −135 dBc at the channel spacing.

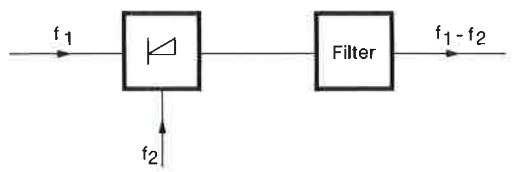
Synthesized generators

These are signal generators whose adjustable output frequency is derived from a single, crystal-referenced control frequency. Generally, they differ from free-running generators in their considerably higher frequency accuracy.

Basically synthesized generators can be digitally controlled. Hence, they are particularly suitable for modems, keyboard-oriented designs with microprocessor control and for use in automated test systems, e.g. with IEC-bus control.

Regarding AM/FM modulation characteristics and output-level adjustment and regulation they do not differ from free-running signal generators. Several basic techniques of frequency synthesis are possible:

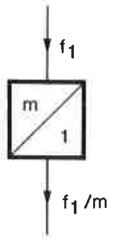
1. Frequency generation by mixing



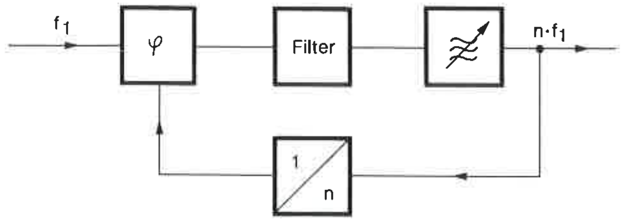
The advantages of this method are the extremely short frequency switching time and the lack of problems when the signal is modulated (FM, AM and SSB).

2. Frequency division

The frequency division method stands out as requiring minimum circuitry in the lower and medium frequency range. With this method the spectral purity of the divided signal is improved by the amount of the division factor so that in this way particularly low-noise signals can be generated mainly in medium frequency ranges.



3. PLL technique



Phase-locked loops have the advantage that they are largely free from spurious responses since these are filtered out by an AF filter in the control voltage path. When using suitable dividers any integral frequencies can be selected, so the PLL technique is ideal for generating the main frequency range of synthesizers. With a control response that is fast enough and a suitable reference frequency particularly low-noise output signals can be produced. Frequency modulation can be transferred.

The disadvantages of the phase-locked loop lie in the limitation of its transient response, in its unusability with amplitude modulation and in the complex circuitry that is required if frequencies are to be selected with high resolution.

4. Computer synthesis

With this method a high-speed computer calculates at crystal-referenced time intervals the amplitude the desired output signal should have at the respective time. The numercial values are converted into an analog curve via a D/A converter.

The advantages of this method are the extremely fast phase-coherent frequency switching, the high frequency resolutions that are possible and the relatively simple circuit design.

For synthesized signal generators a **combination of these methods,** depending on the particular application, is used.

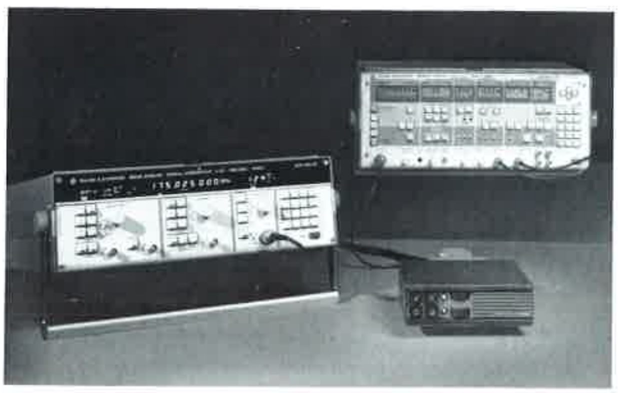
Low-noise synthesized generators 5 kHz to 1360 MHz: SMPC and XPC

The SMPC is a high-grade modern synthesized signal generator featuring high spectral purity, outstanding modulation characteristics and a wide frequency range with a resolution of 0.1 Hz. The low phase noise (−143 dBc at 100 MHz and 20 kHz from the carrier) and the low level of discrete spurious signals (−90 dBc) permit all receiver measurements including exacting adjacent-channel measurements even with narrow channel spacing.

Signal Generator SMPC

For the first time a synthesized generator with this high degree of spectral purity features also AM, FM and φM characteristics of maximum quality. The FM distortion of less than 0.1% and an adjacent-channel crosstalk which is down more than 56 dB permit measurements even on high-grade stereo receivers to be performed.

For frequency response measurements, digital sweeping is possible in the linear or logarithmic mode. The short frequency setting time of 18 ms enables relatively high sweep speeds and high test speeds in automatic test assemblies.



SMPC used as interference source in two-source measurements on RT unit

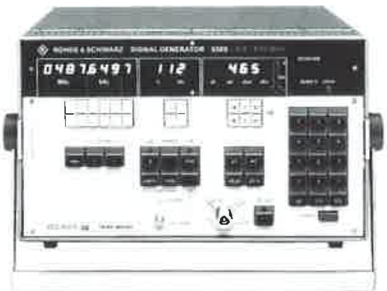
Synthesized generators

The Synthesizer Generator XPC is a high-quality source for unmodulated RF signals. All the characteristics of the CW signal as well as the operation and remote control of the instrument are identical with those of the SMPC. The XPC is an economy-priced alternative to the SMPC for all the applications which require an accurate crystal-controlled frequency, high spectral purity and precise level adjustment of the unmodulated signal. The XPC can be generally used for instance as a low-noise local oscillator (LO) or as a reference source in noise test assemblies.

Synthesizer Generator XPC

Economy-priced synthesized generator 0.1 to 520 MHz (0.1 to 1040 MHz)

The basic model of the Signal Generator SMS uses the synthesizer principle to produce a signal in the range from 0.1 to 520 or 1040 MHz with 100-Hz resolution. The level-controlled output signal can be universally modulated and adjusted between +13 and −137 dBm in 0.1-dB steps.



Signal Generator SMS

The good signal quality (phase noise −120 dBc at 20 kHz from carrier with 1-Hz test bandwidth, wideband noise −145 dBc at 1 MHz from carrier) permits all receiver measurements to be performed in the receive channel such as sensitivity, modulation characteristics, selectivity, overload capacity, etc. Most out-of-channel measurements, e.g. desensitization and intermodulation suppression are also possible with the aid of the SMS. Moreover the SMS is suitable for a multitude of measurements on components and modules and for use as a precise signal source in twoport and impedance measurements. Complex impedance and group delay can be measured in the frequency range from 0.1 to 1040 MHz in conjunction with the Vector Analyzer ZPV. The settings are made rapidly and easily through the key arrays, each setting can be varied quasi-continuously. The

Program-controlled frequency measurement with Signal Generator SMS, Process Controller PUC and Millivoltmeter URV4

short setting time of 40 ms enables comprehensive measurement tasks to be solved quickly by computer control via the IEC bus.

Signal Generator SMK 10 Hz to 140 MHz

The SMK combines the characteristics of a conventional AM-FM signal generator of highest quality with the advantages of a state-of-the-art synthesizer.

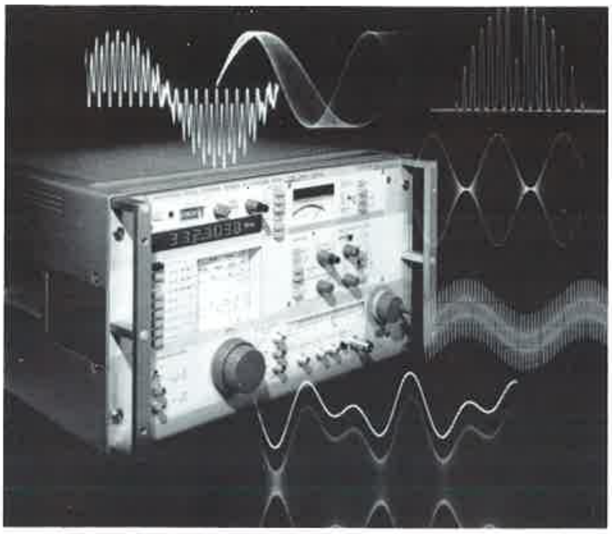
The crystal-controlled frequency stability and accuracy with a resolution of 1 Hz, an extremely small spurious FM (<1 Hz), low SSB phase noise (−135 dBc at 20 kHz from carrier), a high S/N ratio and excellent RF shielding are characteristics which qualify the SMK for all the measurements required on radio direction finders, RTs, shortwave receivers including SSB equipment and sound broadcasting receivers. The SSB test input of the SMK is of special advantage for intermodulation measurements on SSB receivers. When applying fixed-frequency signals, the SMK delivers an SSB spectrum covering the desired frequency range.

Signal Generator SMK

The low FM distortion (0.02%) and stereo crosstalk (down 60 dB) make the SMK ideal for measurements on top-class stereo receivers. DC coupling for external modulation sources enables FSK modulation. FM and AM can be selected independently at the same time. With FM and AM, two-tone modulation is possible for intermodulation measurements. Moreover, the SMK is suitable for swept-frequency measurements with a sweep width of up to 500 kHz (like with FM).

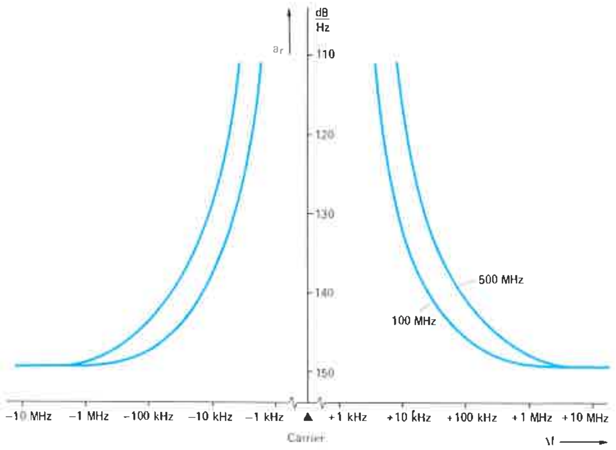
Mechanically tuned generators

A well-proven universal signal generator from R&S in this category is the **Signal Generator SMDU,** covering the frequency range from 15 Hz to 1.05 GHz. Most information transmissions fall into this range: broadcasting from LW to VHF, radiotelephony from SW to UHF, air navigation and communication plus important IF bands for transmissions above 1 GHz.



Signal Generator SMDU (see page 66)

The SMDU carrier frequency is indicated on a seven-digit frequency meter with a resolution of 1 Hz or 10 Hz, which also permits measurement of external signals from 15 Hz to 525 MHz – up to 1 GHz using the frequency range extension. The synchronizer option makes the instrument a synthesized signal generator with a stability of 10^{-8}/month. Thanks to the good control action of the phase-locked loop, the high spectral purity is maintained in addition to the synthesizer stability.



Signal-to-noise ratio of SMDU carriers 100 MHz and 500 MHz at 1-Hz test bandwidth

This option permits checking of high-quality receivers which require instruments of outstanding performance for testing characteristics such as the dynamic adjacent-channel selectivity, desensitization, crossmodulation and intermodulation rejection. Further advantages are electronic fine tuning and synchronized frequency settings corresponding to the standard channel spacings. When synchronized, any frequency can be adjusted and any common channel spacing covered in steps starting with any frequency.

The level range of the Signal Generator SMDU starts at 0.1 μV EMF – the sensitivity limit of modern receivers – and reaches up to 2 V EMF – the maximum test voltage for components or the overdrive limit of receivers. The accuracy of the RF output voltage, which is ±0.5 dB typ. over the full level and frequency ranges, corresponds virtually to that of a standard. Any form of modulation (AM, FM or φM) may be applied to the output signal, the harmonic distortion remaining negligible even at large deviations and modulation depths. The universal model 04 of this signal generator family also permits testing of hifi studio and stereo receivers.

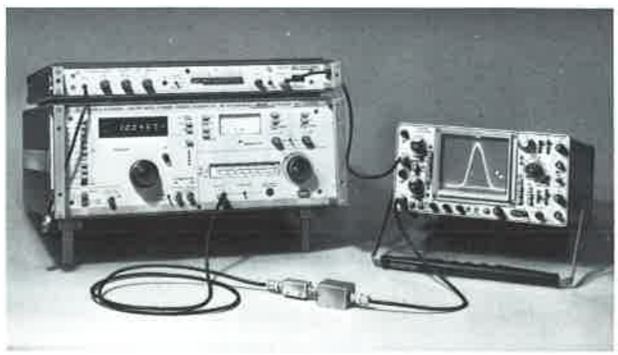
The SMDU is no conventional signal generator; it is also a substitute for a digital frequency meter (15 Hz to 1.05 GHz), an AF generator and an AF voltmeter. Several different models and options permit an optimum solution to be found for each application (see overview on page 64).

The **Adjacent-channel Power Meter NKS** completes the RT Test Assemblies SMDU. It measures the adjacent-channel radiation of RT transmitters in compliance with national and international standard specifications.

For measurements on receivers from LF to VHF – in particular on high-quality sound broadcasting receivers – the **AM/FM Signal Generator SMUV** supplies test signals of the highest precision and spectral purity.

The SMUV covers the frequency range from 10 kHz to 130 MHz and is ideal for measurements on SSB receivers.

Swept-frequency measurement on a bandpass filter using the SMUV with option Sweep Oscillator SMUV-B5 and Sweep Unit SMLU-Z5



The SMUV specifications regarding the frequency stability and accuracy, the spectral purity and the spurious deviation, the modulation characteristics, the level range and the level setting accuracy are better than those of even very expensive comparable units. Moreover, the SMUV is very easy to operate: it offers rapid frequency selection, a single-range attenuator with tuning knob and a counter that can be used for external measurements.

Three models and five options permit matching the SMUV to any specific application. In addition to the excellent characteristics as a signal generator for receiver measurements, it also qualifies for a great number of other tasks.

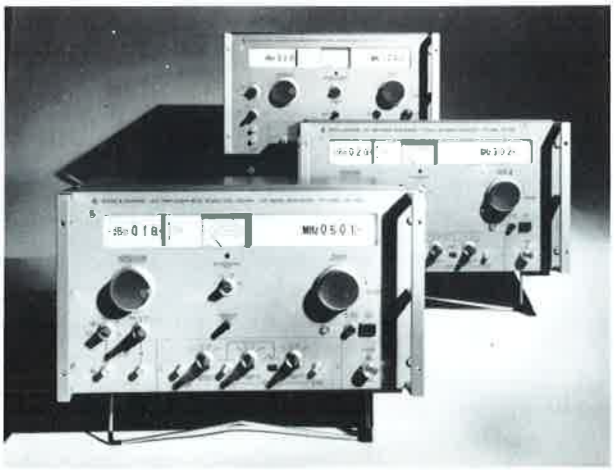
A high-performance sweep tester can be assembled using the option **Sweep Oscillator** SMUV-B5 and the Sweep Unit SMLU-Z, which permits swept-frequency measurements both on narrowband test items (filters, bandpass filters, etc.) and on broadband amplifiers.

The **2-W-Amplifier** extends the SMUV to form a power signal generator which is particularly suitable for interference measurements. The Synchronizer SMUV-B9 and the Crystal Oscillator SMUV-B1 raise the frequency stability and accuracy of the SMUV to synthesizer standard.

Klystron signal generators from UHF to SHF

A family of general-purpose signal generators delivering high-stability signals is available for the microwave region. The three instruments **SMAI, SMBI, SMCI** together span the frequency range from 0.5 to 12.5 GHz. The output level can be accurately adjusted from −130 dBm to +10 dBm; it is also electronically levelled.

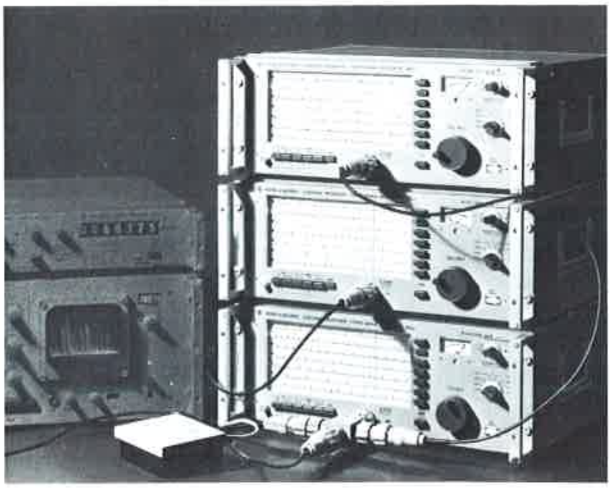
Their outstanding pulse-modulation characteristics make these signal generators well suited for use a radar test generators and for checking out DME, ATC and TACAN equipment. Steep edges and carrier suppression by at least 80 dB ensure accurate simulation of radar pulses. FM and AM are also possible.



Signal Generators SMAI, SMBI, SMCI (see page 68)

Power signal generators

From VLF to SHF, R&S power signal generators provide continuous coverage for the range between 10 kHz and 2.7 GHz.



Power Signal Generator SMLU (see page 70) used in test setup for crossmodulation measurement

Together, the **SMUV and SMLU** cover the range from 10 kHz to 1 GHz, delivering a levelled output power of 2 W (1 W). The **SLRD**, covering 280 MHz to 2.75 GHz, is a power signal generator for applications which require high levels and stable frequencies; its maximum output level is 35 W. Versatile modulation characteristics (AM, FM, pulse modulation) and sweep operation permit universal use for a large variety of measurements.

Signal generators for low frequencies

AF generators are used in many fields of instrumentation. Various designs exist depending on the applications. The most important criteria are frequency accuracy, output level, level accuracy, distortion, switching speed and transient response after frequency changing.

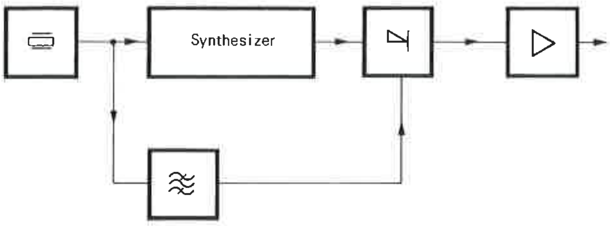
In broadcasting – particularly for hifi – signal generators with low distortion and a relatively high output level are normally required.

The new Generator SPN is an optimum combination of modern synthesizer and time-proven BFO techniques.

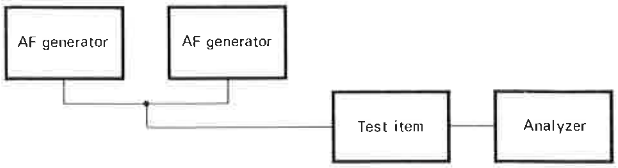
Generator SPN

The SPN design guarantees equally good performance in different respects: high frequency stability, low distortion, high spectral purity and flat frequency response of the output signal.

The SPN can be remote-controlled via the IEC bus; this makes it especially suitable for use in automatic test systems – e.g. for AF distortion measurements using the difference-frequency method.



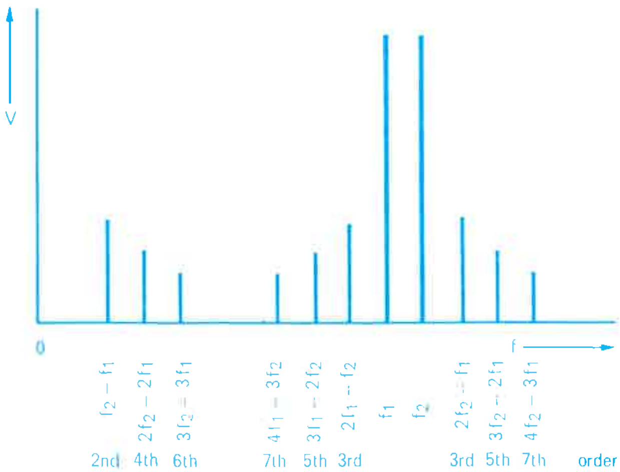
Principle of Generator SPN



AF distortion measurement by the difference-frequency method

Example: Difference-frequency measurement using an LF generator

Due to its linear output impedance, the SPN is ideal for difference-frequency measurements (see above). Distortion occuring in AF modules can be reliably detected. The method has the advantage over conventional distortion measurements that the available dynamic range is much greater when an analyzer is used. The high frequency stability of the SPN ensures good reproducibility and easy evaluation of the measurements. The test item, e.g. an amplifier, is fed with two signal of different frequencies (f1 and f2) and equal amplitude at a frequency spacing $\Delta f = f2 - f1$. The non-linear characteristic of the test item gives rise to additional frequencies at the output. The 2nd- and 3rd-order difference frequencies are generally used for the measurement, the values being $\Delta f = f2 - f1$ for the former, $f2 + \Delta f = 2f2 - f1$ and $f1 - \Delta f = 2f1 - f2$ for the latter.



Intermodulation spectrum

Difference-frequency method

Although distortion measurements can be performed with low-distortion Wien-bridge oscillators, the difference-frequency method is preferable, since the judging of non-linear distortion depends on the response of the human ear. The pitch and masking effects play an important part, besides the sound pressure. Harmonics are less annoying than non-harmonic difference and sum tones whicch are preceived more intensely. Similarly, distortion at the upper end of the audible frequency range irritates the listener although the corresponding harmonics are imperceptible. Difference requency measurements are technically preferable because the inherent distortion of the two signal generators does not affect the result, provided the test frequencies are selected appropriately.

Higher-order difference frequencies appear as further spectral lines at distances of Δf.

Second-order intermodulation distortion is

$d_2 = \frac{V_{\Delta f}}{V_{out}\sqrt{2}}$, where $V_{\Delta f}$ is an rms voltage component and

V_{out} the rms value of the total voltage at the output.

Third-order intermodulation distortion is:

$$d_3 = \frac{V_{(f1-\Delta f)} + V_{(f2+\Delta f)}}{V_{out}\sqrt{2}}$$

AF generators

Frequency range	Designation	Type	Order No. (complete No. see text)	Frequency error	Frequency resolution/ indication	Output level EMF
1 Hz to 1.3 MHz	Generator	SPN	336.3019.02	1×10^{-5}/month 1×10^{-6}/°C	0.1 Hz, 4-digit display	Sine: 1 mV to 10 V Square: TTL level Z_{out}: 600/50/≈5 Ω

RF generators

Frequency range	Designation	Type	Order No. (complete No. see text)	Frequency error	Frequency resolution/ indication	Output level EMF
Synthesized generators						
10 Hz to 140 MHz	Signal Generator	SMK	348.0010.02	(crystal; synthesizer)	1 Hz, 9-digit display	0.025 µV to 2 V into 50 Ω (−138.9 to +19 dBm)
0.1 to 1040 MHz	Signal Generator	SMS	302.4012...	(crystal; synthesizer)	100 Hz, 8-digit display	0.03 µV to 1 V into 50 Ω (−137 to +13 dBm)
5 kHz to 1360 MHz	Signal Generator	SMPC	300.1000.52	(crystal; synthesizer, 1×10^{-8}/day	0.1 Hz, 10-digit display	0.016 µV to 1 V into 50 Ω (−143 to +13 dBm)
5 kHz to 1360 MHz	Synthesizer Generator	XPC	337.8014.52	(crystal; synthesizer, 10 MHz; 1×10^{-8}/day)	0.1 Hz, 10-digit display	0.016 µV to 1 V into 50 Ω (−143 to +13 dBm)
0.1 to 2500 MHz	Sweep Generator	SWP	339.0010...	(crystal)	1 kHz, 6-digit display	0.7 µV to 707 mV (−110 to +10 dBm)
Mechanically tuned and synchronized generators						
0.01 to 130 MHz	AM/FM Signal Generator	SMUV	301.0120...	(10-MHz crystal with option: 1×10^{-8}/month	7-digit display	0.05 µV to 0.5 V (10 V) into 50 Ω
0.14 to 1050 MHz	Signal Generator	SMDU	249.3011...	(10-MHz crystal: 1×10^{-8}/month)	7-digit display	0.05 µV to 2 V EMF (−138 to +13 dBm) 50 Ω
0.5 to 1.8 GHz	UHF Signal Generator	SMAI	100.4594.13	±0.5% ext. freq. sync possible model with ALC	100 kHz/div.	−130 to +10 dBm 50 Ω constant level ±1 (1.75) dB
1.7 to 5.0 GHz	SHF Signal Generator	SMBI	100.4607.13	±0.5% ext. freq. sync possible model with ALC	1 MHz/div.	−130 to +5 dBm 50 Ω constant level ±1 (2) dB
4.8 to 12.5 GHz	SHF Signal Generator	SMCI	100.4613.13	±0.5% ext. freq. sync possible model with ALC	1 MHz/div.	−130 to 0 dBm 50 Ω constant level ±1 (2.5) dB
Power signal generators						
10 kHz to 130 (40) MHz	AM/FM Signal Generator + Option SMLH-B3	SMUV	301.0120... 284.4210.50	(10-MHz crystal; 1×10^{-5}/month)	1/10/100 Hz	0.5 to 10 V (10 kHz to 40 MHz) into 50 Ω
25 to 1000 MHz	Power Signal Generator	SMLU	200.1009.03	±2%	0.2 to 5 MHz/div.	−13 to +33 dBm (2 W) const. level; 50 Ω
0.280 to 2.75 GHz	UHF Power Signal Generator	SLRD	100.4194.02	±2% ext. freq. sync possible	5 to 50 MHz/div.	−50 to +45 dBm (P_{max} = 35 W)

Noise generators

Frequency range	Designation	Type	Order No.	Frequency error	Frequency resolution/ indication	Output level EMF
20 Hz to 50 MHz	Noise Generator	SUF 2	282.8819.03	—	—	≦1 V_{rms} into 75 Ω; 0.775/0.7 V_{rms} link-selected
1 to 1000 MHz	Noise Generator	SKTU	100.4688...	—	—	0 to 6.5/33 kT_O, 50 Ω 0 to 6.4/32 kT_O, 75 Ω

AF generators

Output level error	Harmonic distortion	Switching time	Dimensions in mm (W×H×D)	Remarks	Text on page
±0.2/10 dB	>70 dB (1 Hz to 100 kHz) >54 dB (100 kHz to 1.3 MHz)	15 ms	245×154× 349	synthesizer, IEC-bus-compatible; swept-freq. op. possible	44

RF generators

Output level error	Type of modulation AM = amplitude mod. FM = frequency mod.; φM = phase mod.	Modulation frequency range internal	external	Dimensions in mm (W×H×D)	Remarks	Text on page
					Synthesized generators	
±1.5 dB	AM: 0 to 100% FM: 0 to 500 kHz Sweep: 0 to 500 kHz	5 frequencies 5 frequencies 3 frequencies	20 Hz (DC) to 20 kHz 20 Hz (DC) to 100 kHz DC to 3 kHz	349×206× 462	AM-FM signal generator, 2-tone AM, 2-tone FM, stereo-compatible, SSB test signals	46
±1.5 dB	AM: 0 to 95% FM: 0 to 125 kHz φM: —	400 Hz/1 kHz 400 Hz/1 kHz —	20 Hz to 20 kHz 20 Hz to 20 kHz 20 Hz to 8 kHz	345×206× 370	synthesizer, system-compatible, IEC-bus-compatible, extremely low-priced	50
±1.7 dB	AM: 0 to 99% FM: 0 to 1600 kHz φM: 0 to 200 rad	10 Hz to 50 kHz 10 Hz to 100 kHz 10 Hz to 3 kHz	10 Hz (DC) to 50 kHz 10 Hz (DC) to 125 kHz 10 Hz to 8 kHz	470×162× 469	particularly low-noise synthesizer with excellent modulation characteristics	54
±1.7 dB	—	—	—	470×162× 469	synthesizer, IEC-bus-compatible, digital sweeping, data retention in case of AC supply failure	58
±2 dB	AM: 0 to 80% FM: 0 to 10 MHz Pulse:	1 kHz squarewave	0 to 10 kHz 0 to 100 kHz 10 μs	470×162× 483	sweep generator with excellent narrowband sweep characteristics	126
					Mechanically tuned and synchronized generators	
±1 dB	AM: 0 to 98% FM: 0 to 100 kHz	1 kHz/400 Hz	0 to 100 kHz	492×205× 514	with options: synchron. with 1-kHz steps, sweep oscillator, 2 W output power, suitable for stereo	60
±1 (2) dB	AM: 0 to 98% FM: 0 to 1 MHz φM: preemph. 50/75 μs	0 to 150 kHz	0 to 150 kHz	492×296× 434	six models available: general RF measurements, RT testing, avionics	64
±(0.1 dB ±0.005 dB/1-dB step)	pulse: 100% FM: 0 to >100 kHz AM: 0 to 70%	1 kHz square- wave	up to 200 kHz 1 Hz to 10 MHz 2 Hz to 100 kHz	484×283× 512		68
±(0.1 dB ±0.01 dB/1-dB step)	pulse: 100% FM: 0 to >500 kHz AM: 0 to 70%	1 kHz square- wave	up to 250 kHz 1 Hz to 10 MHz 2 Hz to 100 kHz	484×283× 512	extension of frequency and pulse modulation characteristics using modulation unit	
±(0.1 dB ±0.015 dB/1-dB step)	pulse: 100% FM: 0 to >8 MHz AM: 0 to 70%	1 kHz square- wave	up to 1 MHz 1 Hz to 10 MHz 2 Hz to 100 kHz	484×283× 512		
					Power signal generators	
±1 dB	AM: 0 to 98% FM: 0 to 50 kHz	1 kHz 1 kHz	30 Hz to 20 kHz 30 Hz to 20 kHz	492×205× 514		60
±0.12 dB/5 dB	AM: 0 to 90% FM: 1 subrange	1 kHz (70%) —	10 Hz to 8 kHz 0 to 8 kHz	484×194× 436	remote control via IEC bus using Code Converter PCW; sweeping possible	70
±(1 dB ±0.05 dB/dB)	pulse	1 kHz square- wave	0 to 100 kHz	484×328× 512		74
					Noise generators	
±0.5 dB	—	—	—	210×118× 349	generator for white, pink, triangular noise and program replacement signal	338 (App.)
±0.5 dB	—	—	—	470×195× 260	skale calibration in terms of noise figure F and F_{dB}	75

SPN

Generator SPN ⧫ 1 Hz to 1.3 MHz

- Compact, economy-priced generator with wide frequency range
- High frequency-accuracy (synthesizer)
- Wide output-voltage range, outputs for sinewave and squarewave signals
- Low distortion
- Switch-selected output impedance: 600/50/≈5 Ω
- IEC-bus-compatible, swept-frequency operation (lin/log) possible
- Maximum stability with external reference frequency (1 MHz)

IEC 625 Bus

new

An optimum combination of time-proven BFO and modern synthesizer techniques, the **Generator SPN** offers at once high frequency stability, extremely low distortion, high spectral purity and flat frequency response of the output signal.

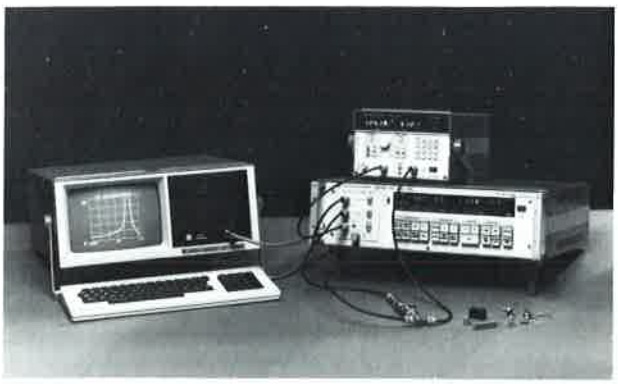
Applications

The Generator SPN can be operated manually as well as via the IEC bus, so it finds wide-spread use in many fields such as

acoustics
hifi technology
development and production
research and training
servicing of AF equipment
automatic test assemblies

There is also a large number of other fields in which accurate frequencies are required, for instance in telemetry and physics or in mechanical control processes. In addition, the outputs of two SPN generators can be connected in parallel for measuring non-linear distortions.

Test assembly using SPN
for computer-controlled measurement of components



Characteristics

Ease of operation. The built-in microprocessor makes the generator an intelligent unit which is easy to operate and to program. Manual settings are made by pressing the keys first for the numerical value and then for the unit. Quasi-continuous settings are possible with the rotary knob.

Keyboard of SPN affording great ease of operation

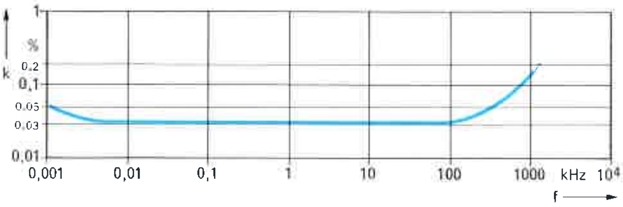
Storage capability. The SPN is able to store five complete setups (memory addresses: 1 to 5). The RCL key permits both complete setups and individual frequency or level settings to be recalled.

Frequency. State-of-the-art synthesizer technology ensures crystal-referenced output frequencies from 1 Hz to 1.3 MHz with a frequency setting time of only 15 ms. The short setting time is important in computer-controlled test systems with a high measuring rate or for the generation of tone sequences such as those required for measurements on selective calling equipment. The frequency entered via the keyboard is read out on the display in five digits (smallest resolution: 0.1 Hz) with a floating decimal point. The frequency can be varied quasi-continuously using a rotary knob. The SPN offers another convenient way of frequency variation by frequency jumps with selectable step size and by calling up the standard octave and third-octave sequences. Logarithmic frequency variation is possible by entering a multiplication or division factor between 1.00 and 2.00.

Output level (sinewave output). Adjustable between 0.1 mV and 10 V with smallest resolution of 0.01 mV (depending on output impedance selected). The output level is read out in three digits with a floating decimal point on the level display (in V, mV, dBV or dBm). The output level entered can also be varied quasi-continuously or in steps and it can be converted from one unit into another simply at the push of a button. The maximum output EMF is 10 V_{rms}.

Distortion is as low as 0.03% in the frequency range from 50 Hz to 100 kHz, so that the SPN fulfils the most demanding requirements of the audio-frequency range.

Output level on/off. The level is switched off by pressing the illuminated R_i key and switched on by pressing one of the dark R_i keys.



Guaranteed distortion limits for maximum output EMF of 10 V_{rms} (k=distortion)

Output impedance. The impedance of the sinewave output can be selected between 600, 50 and approximately 5 Ω at the push of a button and thus be matched to the standard system impedances. The output impedance is linear and real, allowing the sinewave outputs of two SPN generators to be connected in parallel.

Squarewave output. In addition to the sinewave output, an output with a squarewave signal of the same frequency is available for driving digital circuits as well as for other measuring tasks; output level: TTL, positive.

External sweeping. The generator frequency can be swept in linear or logarithmic mode over the entire frequency range or certain subranges – required sweep voltage 0 to 1.3 V. The logarithmic conversion is done internally. The sweep range is from 1 Hz up to the upper range limit which can be selected and is indicated on the display.

Range	1	1 Hz to 1.3000 kHz	3	1 Hz to 130.00 kHz
	2	1 Hz to 13.000 kHz	4	1 Hz to 1300.0 kHz

Remote control. All settings of the Generator SPN can be made remotely. The short programming time makes the SPN suitable for use in automatic measuring assemblies and test systems.

SPN-Z1

Balun (option). Used for feeding balanced line systems or amplifiers and for eliminating hum pickup in test setups. Stepdown transformation, so low internal impedance (≈15 Ω).

Specifications

Frequency range	1 Hz to 1.3 MHz
Frequency setting	keyboard entry
Display	5-digit readout
Resolution	
at 1 Hz to 1.3 kHz	0.1 Hz
1.3 to 13 kHz	1 Hz
13 to 130 kHz	10 Hz
130 to 1300 kHz	100 Hz
Frequency switching time	15 ms
Crystal aging	$<1 \times 10^{-5}$/month
Temperature effect	$\leq 1 \times 10^{-6}$/°C
Outputs	separate outputs for sine and squarewave signals
Sine output	
Level setting	keyboard entry
Display	3 digits with unit V, mV, dBV, dBm
Resolution	0.1 dB
Output EMF, rms	1 mV to 10 V (Z_{out} = 600 and 50 Ω) 0.1 mV to 1 V (Z_{out} ≈5 Ω)
Output impedance, switch-selected	600, 50, ≈5 Ω
Connector	BNC female
Level off	by pressing R_i keys
Distortion	
1 to 50 Hz, 10 V	<0.05%
50 Hz to 100 kHz, 10 V	<0.03%
0.1 to 1.3 MHz, 10 V	<0.2%
Harmonics	
1 Hz to 100 kHz	>70 dB down
0.1 to 1.3 MHz	>54 dB down
Error of output EMF	
at 300 mV to 10 V	<±2%
10 to 300 mV	<±3%
1 to 10 mV	<±5%
Frequency response flatness of output EMF	
at 1 Hz to 9,999 kHz	<±0.5% corresp. to ±0.05 dB
10 kHz to 1.3 MHz	<±0.5% corresp. to ±0.05 dB
1 Hz to 1.3 MHz	<±1% corresp. to ±0.1 dB
Spurious signals	>70 dB down from 1 Hz to 700 kHz >65 dB down from 700 kHz to 1300 kHz
Squarewave output	TTL levels, positive
Fan-out	10
Connector	BNC female
Ref. output/input	1 MHz, TTL signal, 0.2 to 2 V, >500 Ω
Sweep operation	with external signal in linear or logarithmic mode, switch-selected
Linear sweep range	
1 Hz to	1.3 kHz/13 kHz/130 kHz/1.3 MHz
Sweep voltage	0 to 1.3 V/10 kΩ
Sweep frequency	0 to 10 kHz
Programming	
System	IEC 625-1/IEEE 488
Connector	24-way Amphenol
Interface functions	T6 talker
	L4 listener
	RL1 remote/local
	DC1 device clear
	SR1 service request
General data	
Rated temperature range	+5 to +45°C
Storage temperature range	−40 to +70°C
AC supply	100/120/220/240 V ±10%, 47 to 63 Hz (55 VA)
Dimensions, weight	245 mm×154 mm×349 mm, 6.5 kg

Ordering information

Order designation	▶ Generator SPN 336.3019.02
Accessories supplied	power cable

Recommended extras

Options:	
Balun SPN-Z1	265.4319.02
19" Adapter ZZA-23	078.8397.00

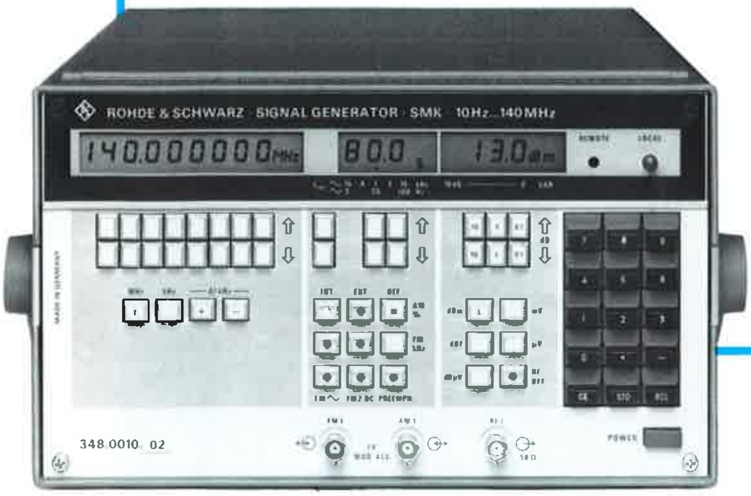
Specifications of Balun SPN-Z1

Input connector	BNC male with coaxial cable
Output connector	4 mm knurled terminal
Frequency range	30 Hz to 100 kHz
Open-circuit turns ratio	3.16:1 = −10 dB (±0.1 dB)
Impedance	15 Ω
Permissible load impedance	150 Ω up to open circuit
Distortion	<0.2% (for source voltage 10 $V_{rms\,max}$ and Z_{out} = 50 Ω)
Dimensions, weight	83 mm×130 mm×105 mm, 1.5 kg

SMK

Signal Generator SMK ♦ 10 Hz to 140 MHz

- High frequency stability and resolution (1 Hz)
- Low spurious FM: <1 Hz in accordance with CCITT
- Output level 0.025 µV to 2 V into 50 Ω
- Large variety of modulation modes: 2-tone AM, 2-tone FM, AM+FM, AC/DC
- Low modulation distortion (0.02% with FM)
- Input for generating SSB test signals
- Nonvolatile storage of 40 instrument settings
- IEC-bus-compatible for all functions



IEC 625 Bus

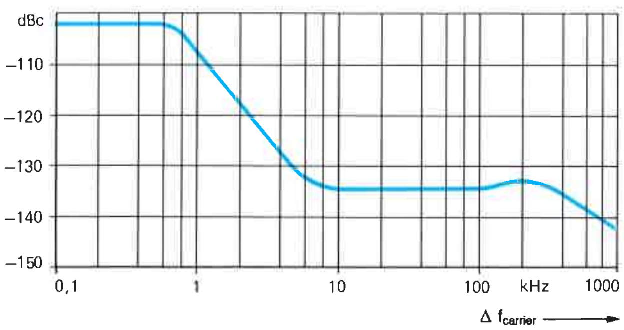
new

Characteristics, uses

The **Signal Generator SMK** is a fully programmable AM-FM synthesized generator covering continuously the frequency range from 10 Hz to 140 MHz. It contains AF sources for internal modulation and frequency sweeping.

These features as well as its frequency resolution, signal quality and modulation capability qualify the Signal Generator SMK for all measurements on **shortwave receivers** – including SSB equipment – and on AM and **hifi FM sound broadcasting receivers.** Stereo crosstalk for instance is down 60 dB.

The SMK is extremely convenient to operate and protected against incorrect settings, see righthand column. Levels can be set in µV, mV, dBµV and dBm as well as in dBf (reference: femto watt = 10^{-15} W). Moreover, a comprehensive **self-test** of the synthesizer functions is possible; any errors are read out on the display.



Typical values of SSB phase noise, f = 120 MHz

Thanks to the **programmability** of all functions via the IEC bus (IEC 625-1 and IEEE 488), the SMK can be used in semi-automatic or fully automatic test assemblies.

Ease of operation

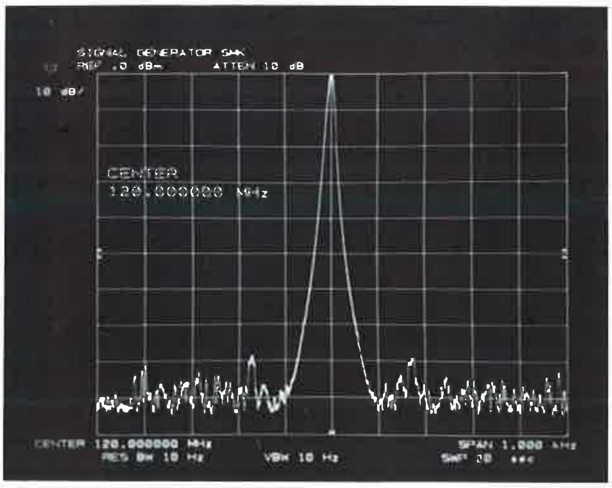
- Clear arrangement of the front panel by splitting up the keyboard and display into sections for frequency, modulation and level.
- Keyboard entries in the normal order – numerical value plus unit.
- Direct digital readout, high resolution and automatic shift of decimal point.
- Easy variation of all settings; frequency, modulation and level can be varied with the ⇧ and ⇩ keys. The settings are changed either in single steps or rapidly by holding the key down.
- Upward or downward change of frequency in steps of any size using the Δf kHz keys.
- The level can be read out in any of five units.
- Stored settings: Whenever the modulation, the level (RF OFF) or the instrument itself is switched off, the settings remain stored and are read out automatically upon power up. Independently 40 instrument settings can be stored in the nonvolatile memory.
- Incorrect entries are not accepted by the instrument; the display section involved blinks to signal an erroneous setting.

Technical data

Frequency. The frequency range covers 10 Hz to 140 MHz. The high resolution of 1 Hz permits measurements on SSB receivers and narrowband test items. Instead of the internal frequency standard, an external control frequency of 1, 5 or 10 MHz can be used.

Level. The output level, which can be set in 0.1-dB steps from −138.9 to +19 dBm, is read out in four digits in µV, mV, dBµV, dBm or dBf. The level can be varied in steps of 10 dB, 1 dB and 0.1 dB. The 0.1-dB level variation is carried out without interruption of the RF level over a range of 20 dB, a characteristic that is indispensable for squelch measurements.

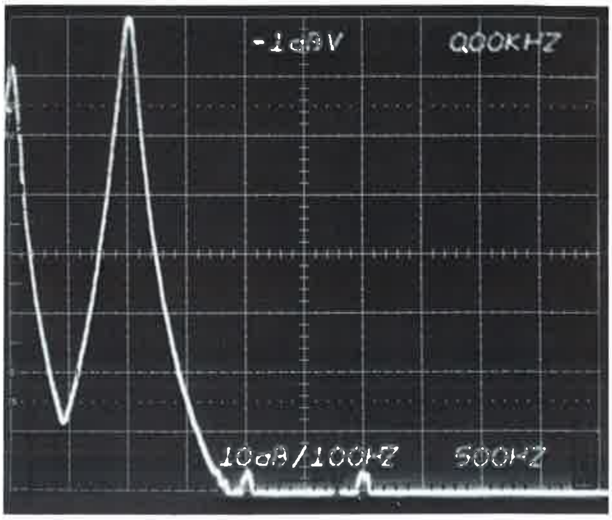
Spectral purity. The output signal is of high spectral purity. The nonharmonic spurious signals (including power-related and microphonic spuria) are typically down more than 75 dB from the carrier level. The SSB phase noise at 20 kHz from the carrier is 135 dBc down for a bandwidth of 1 Hz. Thus the spurious FM remains extremely low, being <3 Hz for a test bandwidth of 30 Hz to 20 kHz. Thanks to this high spectral purity, the SMK can be used for all critical adjacent-channel measurements and measurements on SSB receivers.



Signal quality close to carrier (suppression of hum and microphonic sidebands); resolution: 100 Hz/div., 10 dB/div.

Modulation. The Signal Generator SMK provides low-distortion, broadband AM and FM, both modes being adjustable in fine steps. The versatile modulation capability includes 2-tone AM, 2-tone FM, simultaneous AM and FM, sweeping with internal or external deflection signal as well as AC and DC coupling for all modulation modes.

To connect external modulation sources, the SMK is fitted with two inputs for AM and for FM. For 2-tone modulation and simulteneous AM and FM, either the internal and an external or two external modulation sources can be used. AM and FM can be adjusted independently even with simulteneous AM and FM.



Typical FM harmonic distortion at 100 kHz deviation and f_{mod}=1 kHz; resolution: 500 Hz/div., 10 dB/div.

(Internal) modulation generators. The internal SMK modulation sources are provided by

- a generator producing low-distortion sinewave signals of 150/400 Hz, 1/3/15 kHz and
- a generator producing linear triangular sweep signals of 3/30/100 Hz.

External modulation/coupling. One modulation input each for AM and FM (AM1 and FM1) is equipped with automatic level control. This level control facility ensures that the frequency deviation and modulation depth remain within the specified tolerances over a wide range of the modulation rms voltage (between 0.5 and 2 V).

The AM modulation input AM2 is DC-coupled, the FM modulation input FM2 can be switched to AC or DC coupling.

Pilot tone input FM3. A separate pilot tone input permits variation of the stereo signal deviation while holding the pilot tone constant.

AM DC. The AM DC mode permits voltage-controlled variation of the signal amplitude. It is used when the signal generator is to be operated in an ALC loop with an external probe.

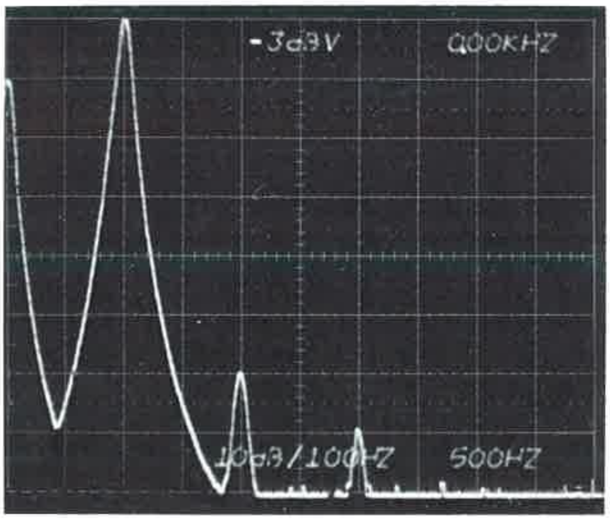
FM DC. DC coupling is required for FSK modulation. A further application in conjunction with the Vector Analyzer ZPV is the determination of crystal resonances in a test assembly which is self-tuning with the aid of a phase-locked loop. DC coupling permits sweep operation with an external triangular or sawtooth voltage. With FM DC an internal frequency counter ensures correct frequency indication; the frequency can be read out via the IEC bus.

SMK – Signal Generator

Sweep. Sweeping can be controlled either by the internal triangular signal source or by an external signal via the FM2 input with DC coupling enabled. In both cases, the sweep width (max. ±500 kHz) can be selected from the keyboard.

Uses. Thanks to the extremely low spurious FM of the SMK and its high frequency stability, sweeping of crystal and ceramic filters with extremely steep skirt selectivity is possible in addition to sweeping of tuned circuits, FM demodulators, IF amplifiers or IF filters.

FM and AM characteristics. The wide FM range up to 100 kHz with small phase rotation permits high-quality stereo modulation plus transmission of the 57-kHz auxiliary carrier for traffic radio identification. With an inherent distortion factor of less than 0.1%, the SMK is ideal for all distortion measurements on VHF receivers. Amplitude modulation is possible without restriction down to the lowest carrier frequency. Thus measurements in the low-frequency and AM-IF ranges can also be performed with full capability. The extremely low AM distortion of typically only 0.2% permits measurements on high-quality AM receivers.



Typical AM distortion with m = 80% and f_{mod} = 1 kHz

SSB test input. A −20-dBm signal of 40 MHz $\pm f_{AF}$ applied to the test input is converted to the set output level and the set carrier frequency $f_{carrier}$ $\pm f_{AF}$. Intermodulation measurements on SSB receivers, which normally require two complete signal generators, can be carried out with a single SMK by applying two signals in the vicinity of 40 MHz to the test input.

Self-test. The most important functions of the frequency synthesis are continuously monitored during operation. Errors are signalled on the display and an error message is output via the IEC bus.

Specifications

Frequency

Range	10 Hz to 140 MHz	
Setting	from keyboard, smallest step 1 Hz, stepwise or continuous variation (see "Ease of operation", page 46)	
Display	9-digit readout (LCD), resolution 1 Hz	
Error	same as reference frequency (±1 digit for FM DC)	
Setting time (after receiving last character via IEC bus)	<40 ms (to within 100 Hz from final frequency)	
Reference frequency	from internal reference oscillator or external source	
Internal reference oscillator	standard	option SMS-B1
Crystal aging	$<2 \times 10^{-8}$/day	$<2 \times 10^{-9}$/day
Temperature effect	$<1 \times 10^{-6}$/°C	$<2 \times 10^{-9}$/°C
Warmup time	30 min	15 min
Output/input for int./ext. reference frequency	common female connector, f_{ref} 1 MHz/5 MHz/10 MHz (internally selected)	
Output voltage with internal reference	TTL level	
Input voltage with external refernce	>100 mV, sinewave or TTL level	

Output level

Level range for CW and FM	−138.9 to +19 dBm (0.025 µV to 2 V into 50 Ω)
for AM	−138.9 to +13 dBm (0.025 µV to 1 V)
Level units displayed	mV, µV, dBµV, dBm, dBf
Resolution	0.1 dB
Range of variation without interruption of RF level	10 dB (20 dB with special function)
Total error of RF level (including frequency response)	<±1.5 dB[1]
Frequency response flatness	<1 dB
Output impedance	50 Ω (BNC female connector)
VSWR	<1.2 (level <3 dBm)
Level switchoff (RF OFF)	switchover to minimum output level: output impedance remains unchanged
Level at RF output 2	50 mV[1] (for CW and FM)

Spectral purity

Harmonics	down >30 dBc, typ. >36 dBc
Nonharmonic spuria	down >65 dBc, typ. >75 dBc
Microphonic and power-related spuria	down >65 dBc, typ. >75 dBc
Noise referred to 1-Hz bandwith (see also diagram on page 46)	
SSB phase noise	
20 kHz from carrier	down >130 dBc, typ. 135 dBc
5 kHz from carrier	down >125 dBc, typ. 130 dBc
Wideband noise	
>2 MHz from carrier	dow >140 dBc[1] (for CW and FM)
Spurious FM (rms)	<1 Hz (CCITT) <3 Hz (30 Hz to 20 kHz)

[1]) When level VAR readout is 0 dB.

Modulation

Modulation modes	internal: AM, FM and sweep with triangular signal external: AM AC/DC, FM AC/DC
2-tone AM	AM INT + AM EXT (AM 2 connector) or 2 × AM EXT (AM 1 and AM 2 connectors)
2-tone FM	FM INT + FM EXT (FM 2 connector) or 2 × FM EXT (FM 1 and FM 2 connectors)
AM + FM	any combination of AM, FM, ext., int.
Internal modulation	sinewave 150 Hz, 400 Hz, 1 kHz, 3 kHz, 15 kHz; sweep 3 Hz, 30 Hz, 100 Hz
Frequency error	<0.1%
Outputs	AM 1, FM 1 on front panel; EMF: 1 V sinewave, ±5 V sweep; Z_{out} = 600 Ω
External modulation	
Inputs	AM 1, FM 1 on front panel, AM 2, FM 2, FM 3 on rear panel; inputs AM 1 and FM 1 provided with ALC
Input impedance	600 Ω (AM 1, FM 1), 10 kΩ (AM 2, FM 2, FM 3)
Input level (V_{rms})[2]	0.5 < V < 2 V for AM 1, FM 1; 1 V for AM 2, FM 2, FM 3

Amplitude modulation

Modulation frequency range for AM EXT	20 Hz (DC) to 20 kHz
Modulation frequency response flatness for 20 Hz to 10 kHz	<1 dB, typ. 0.3 dB
Modulation depth setting	0.5 to 100%
Resolution	0.5%
Error up to m = 80%	<5% of set value[1])
Distortion for m = 80% and f_{mod} = 1 kHz	
up to 2 MHz	<0.5%, typ. 0.2%
above 2 MHz	<1%, typ. 0.4%
Spurious AM (rms)	<0.01% (CCITT) <0.02% (30 Hz to 20 kHz)
Incidental φM for m = 30% and f_{mod} = 1 kHz	<0.1 rad

Frequency modulation

Modulation frequency range	
for FM EXT AC	20 Hz to 100 kHz
for FM EXT DC	DC to 3 kHz
Modulation frequency response flatness	<0.2 dB (20 Hz to 100 kHz)[3])
Frequency deviation setting	0.05 to 500 kHz
Resolution up to 10 kHz dev.	0.05 kHz
up to 100 kHz dev.	0.5 kHz
up to 500 kHz dev.	2 kHz
Deviation error	<3% of set value or 10 Hz
Distortion (deviation = 100 kHz)	
for f_{mod} = 1 kHz	<0.05%, typ. 0.02%[3])
for f_{mod} = 100 Hz to 20 kHz	<0.2%
Distortion for stereo (deviation = 40 kHz)	<0.1% for 1 kHz AF[1])
Stereo crosstalk (deviation = 40 kHz)	down >45 dB at 40 Hz to 15 kHz[3]) down >56 dB at 500 Hz to 10 kHz[3])
Unweighted S/N ratio	
Stereo (40 kHz deviation, 50 µs)	>70 dB (CCIR, unweighted S/N ratio[3]) from 30 Hz to 20 kHz)
Mono (40 kHz deviation, 50 µs)	>76 dB (CCIR, unweighted S/N ratio[3]) from 30 Hz to 20 kHz)
Preemphasis (switch-selected)	50 µs; 75 or 750 µs can be link-selected
Incidental AM on FM (f_{mod} = 1 kHz, dev. = 40 kHz)	<0.2% at carrier frequency >10 MHz[3])

[1]) When level VAR readout is 0 dB.
[2]) Input level required for specified accuracy.
[3]) With FM AC.

Sweeping

Internal frequencies	3/30/100 Hz
Sweep width	0.05 to 500 kHz
Resolution	same as for FM
Swept output signal	±5 V, triangular at female connector FM 1

Input for SSB test signals

Frequency	40 MHz ±Δf (Δf ≦500 kHz)
Level	−20 dBm for set output level; lower level values yield correspondingly lower output level values
Third-order intermodulation products with two input signals	
d_3 in sideband with J3E	down >60 dB
$d_3/\Delta f \geqq 30$ kHz	down >60 dB

Programming and data output

System	IEC 625-1 (IEEE 488)
Connector	24-way, Amphenol
Interface functions	T6 basic talker, serial poll, unaddress if MLA
	L4 basic listener, unaddress if MTA
	SR1 service request function, complete capability
	RL1 remote/local function, complete capability
	DC1 device clear function, complete capability

General data

Rated temperature range	+5 to +45 °C
Storage temperature range	−40 to +70 °C
AC supply	100/120/220/240 V ±10%, 47 to 420 Hz (110 VA, 95 W), safety class I to VDE 0411
RF leakage	in accordance with VDE 0871 (spurious radiation and interference on connecting cables) and VDE 0875 (limit values of radio interference grade K)
Shock and vibration resistance	shock-tested in accordance with DIN 40046, Part 7 (30 g, 11 ms), and vibration-tested in accordance with DIN 40046, Part 8 (11 to 55 Hz, 2 g); corresponding to IEC Publications 68-2-27 and 68-2-6
Dimensions, weight	347 mm×206 mm×462 mm, 20.5 kg

Ordering information

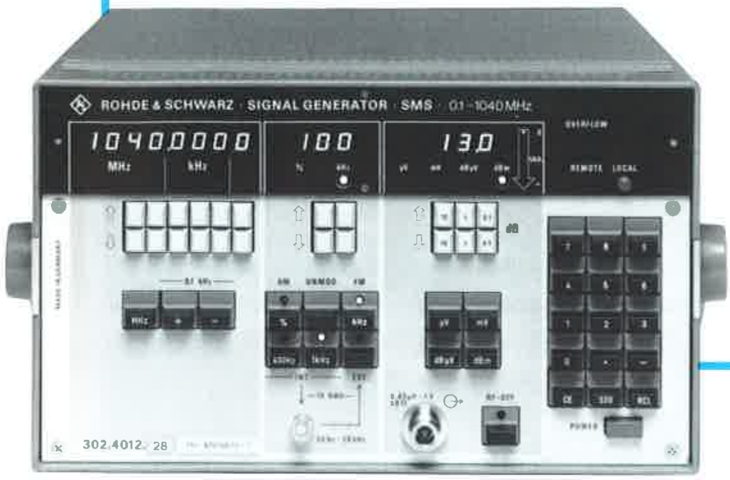
Order designation	▶ Signal Generator SMK 348.0010.02
Accessories supplied	power cord

Options

Reference Oscillator SMS-B1	302.8918.02
Overvoltage Protection SMK-B3	335.0716.02

SMS

Signal Generator SMS ⧫ 0.1 to 1040 MHz



- Universal, programmable signal generator using synthesizer technology; low-noise instrument with excellent modulation characteristics for AM, FM and phase modulation
- Compact, favourably priced instrument for use in development, production and servicing
- Ease of operation: keyboard entry, digital readout – quasi-continuous variation of frequency, modulation and level
- Wide output voltage range, accurate level setting in dBm, dBμV, μV or mV

Improved characteristics

- 40 instrument settings retainable in nonvolatile memory
- Conversion of level units possible

IEC 625 Bus

Characteristics, uses

With its excellent characteristics the **Signal Generator SMS** meets all the exacting demands that can be made on a general-purpose signal generator of the latest state-of-the-art. The **synthesizer technology** ensures crystal-controlled and stable output frequencies with 100-Hz resolution and negligible spurious modulation. At 20 kHz from the carrier the signal-to-noise ratio is about 120 dB (1-Hz bandwidth).

The compact SMS is easy to carry and also suitable for mobile use. Thanks to a number of option, inexpensive adaptation to various applications is possible.

Stable output signal of high accuracy

Frequency. The wide frequency range from 100 kHz to 520 MHz covers all sound broadcasting ranges from MF up to VHF as well as the frequencies of the most important RT bands and radio services up to UHF. The range can be extended up to 1040 MHz with the aid of the Frequency-range Extension Option SMS-B2.

The frequency is read out with a resolution of 100 Hz. The Reference Oscillator Option SMS-B1 (aging $<1\times10^{-6}$/year) further enhances the accuracy. A reference frequency input is provided on the rear panel of the signal generator. The Δf keys permit easy channel stepping with any desired step size. The output signal features low spurious deviation, only 3 Hz (CCITT) or 15 Hz (30 Hz to 20 kHz). The S/N ratio 20 kHz from the carrier is greater than 120 dB at a test bandwidth of 1 Hz, and typically 145 dB at 1 MHz from the carrier.

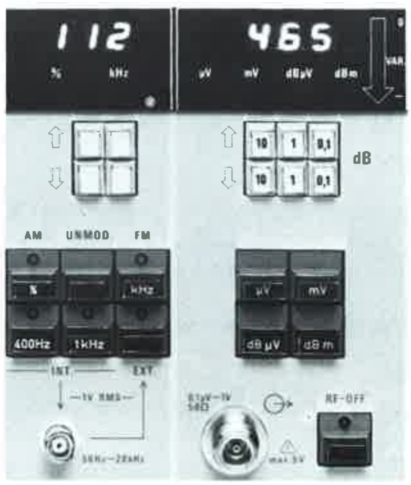
Modulation. The SMS features excellent modulation characteristics. AM up to 95% and FM up to 125 kHz deviation are possible with the aid of the internal modulation generator (400 or 1000 Hz) or with an external signal. The modulation frequency and modulation depth or deviation can be accurately set from the smaller keyboard and are read out with a resolution of 0.05/0.5% or 50 Hz/500 Hz/1kHz.

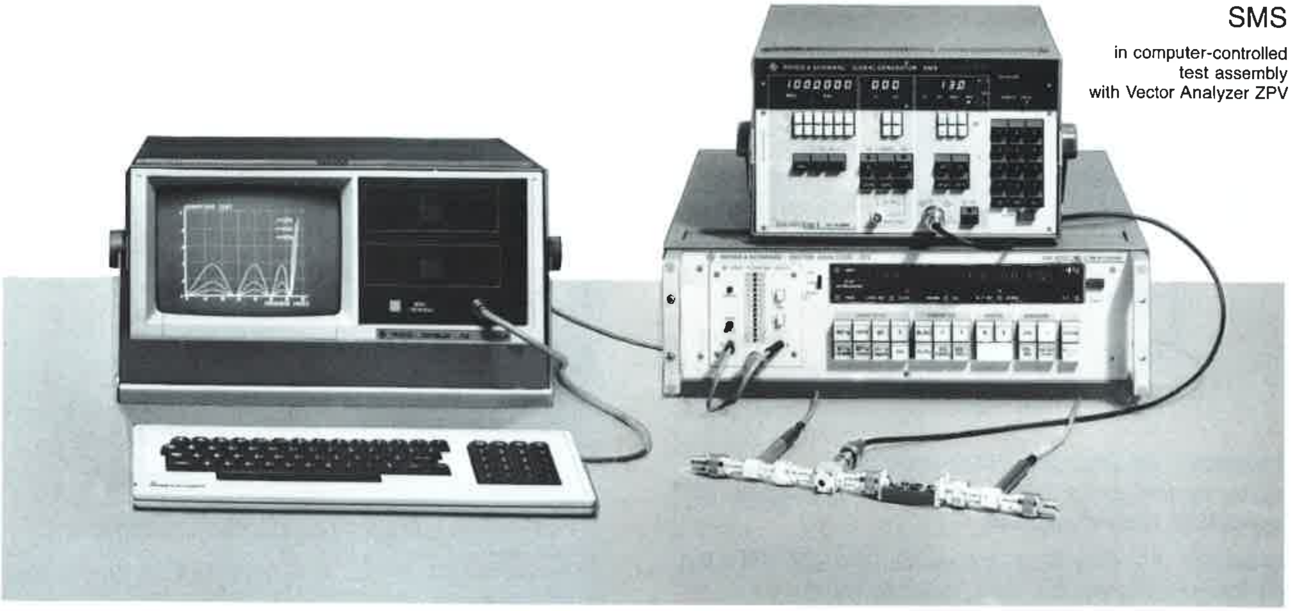
The maximum frequency deviation of 125 kHz is available over the entire frequency range. The high resolution of the frequency deviation of 50 Hz is helpful when testing transceivers. In addition to AM and FM, the SMS offers the following types of modulation:

- AM+FM together
- phase modulation (φM)
- frequency-shift keying for data transmission (FSK)
- external level control (ALC)
- stereo modulation (with model 26)

The output level is adjustable from +13 to −137 dBm with a resolution of 0.1 dB, the error being typically 0.8 dB. Entry is in μV, mV, dBμV and dBm via keyboards. Its minimum output voltage of 0.03 μV makes the SMS also suitable for measurements on future, extremely sensitive receivers. Noninterrupting level variation over 10 dB in 0.1-dB steps is indispensable for squelch measurements. The output level can switched off by means of the RF-OFF button so zero adjustment of measuring instruments is very convenient. RF leakage of the SMS is minimal, i.e. even receivers with a sensitivity of 0.2 μV (e.g. paging receivers) will not respond at a distance of 10 cm from the front panel.

Front panel section with setting controls and displays for modulation and output level





SMS
in computer-controlled test assembly with Vector Analyzer ZPV

IEC-bus programming

The Signal Generator SMS can also be put to use in computer-controlled test assemblies via the IEC-bus interface. Its extremely short setting time of only 40 ms makes it capable of high-speed computer-controlled frequency response measurements – even with high resolution. The control instructions are in accordance with IEC standard 625-1. Each instruction consists of a header, the numerical value and a comma as the delimiter. The numerical value is entered in unformatted form with or without sign and with or without decimal point.

Examples: Device setting	Programming instruction
Frequency: 122.19 MHz	A122.19,
Level: −23 dBm	S-23,
Modulation: AM, 30%	B30,

Options

A number of options permit flexible, low-cost adaptation of the SMS to various or special requirements. All options listed below can be included in the SMS prior to delivery or incorporated later.

Temperature-controlled Reference Oscillator SMS-B1 improves the frequency stability of the signal generator. By means of temperature control the frequency drift of $<\pm1\times10^{-6}/°C$ is reduced to merely $<\pm1\times10^{-7}$ over the operating temperature range, the aging of the crystal is less than 5×10^{-8}/month.

1.04-GHz Frequency Range Extension SMS-B2 doubles the SMS frequency range (i.e. to 1.04 GHz), the full setting range of the output level being maintained. The harmonics and subharmonics (½f, ³⁄₂f...) are typically 20 dB down. For applications up to 1000 MHz another version of the option SMS-B2 with the same characteristics but a different order number is available: see options and recommended extras on page 53.

Ease of operation

Simple keyboard entry. The function keys and the associated displays for frequency, modulation and level are arranged in three sections on the front panel for user-oriented operation. The parameters are entered in ordinary notation, first the numerical value and next the unit.

Example: For entry of a frequency of 360 MHz, a level of −17.9 dBm, and frequency modulation with 125 kHz frequency deviation and 400 Hz internal modulation frequency simply press the following keys:

[3] [6] [0] [MHz]

[−] [1] [7] [•] [9] [dBm]

[1] [2] [5] FM [kHz] INT [400 Hz]

Storage of device settings. Up to 40 device settings can be stored in a nonvolatile memory using the STO key and recalled with the RCL key.

Example: Storage of complete device setting at memory location 3:

Keys pressed [STO] [3]

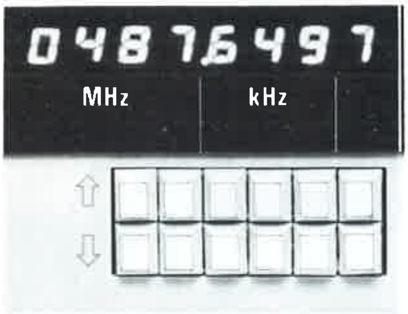
Recalling [RCL] [3]

When switching off the modulation and the level (RF OFF) and upon powering down, the setup remains stored.

Example: The frequency modulation setting is switched off by means of the key [UNMOD] and switched back on again by means of the key FM [kHz]

Easy variation of all settings. Frequency, level and modulation can be varied by means of the keys ⇧ and ⇩ which are associated with the various digits of the displays. The selected digit is varied in unit steps with automatic carry to the next digit either by one step per keystroke or (if the key is held down) continuously. Rapid coarse tuning in 10-MHz steps as well as fine tuning in 100-Hz steps is possible.

SMS – Operation



Keys associated with the various digits permit stepwise or continuous variation of numerical values entered (e.g. frequency as here displayed)

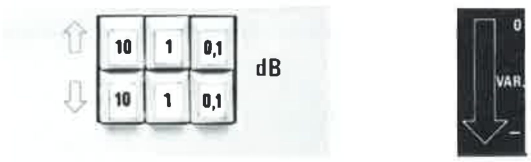
Frequency variation with channel stepping. The Δf kHz keys (see photograph below) permit channel stepping with any desired channel step size.

Example: For entry of a frequency step of +12.5 kHz press the following keys on the large, main keyboard:

For each additional step in the positive or negative direction all there is to do is to press the [+] or [−] Δf kHz key. The selected step size is preserved until it is overwritten by a new entry.

Keys for freely selectable frequency steps in positive or negative direction

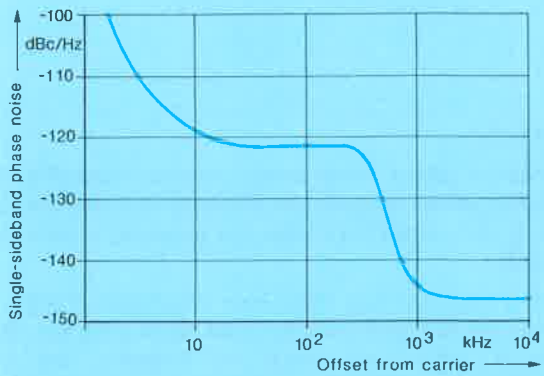
Noninterrupting fine level adjustment. The keys ⇧ and ⇩ (0.1 dB) permit noninterrupting electronic adjustment of the level in 0.1-dB steps over a range of 10 dB (indispensable for squelch measurements), the corrected value being read out on the level display. The state of the electronic level variation can be seen from an LED array (see photograph below).



The 0.1-dB keys are used for noninterrupting electronic fine level adjustment. The state of the electronic level variation can be seen at a glance from the LED array

Specification of SMS

Frequency range	0.1 to 520 MHz, with Option SMS-B2 up to 1040 MHz	
Frequency setting	from keyboard	
Readout	8-digit display	
Resolution	100 Hz	
Error, drift	depending on reference frequency	
Reference oscillator	standard	option SMS-B1
Crystal aging	$<\pm1\times10^{-6}$/month	$<\pm5\times10^{-8}$/month
Temperature effect	$<\pm1\times10^{-6}$/°C	$<\pm1\times10^{-7}$ within operating temperature range
Warm up time	—	15 min
Output/input for internal/external referenz frequency, (single connector)	10 MHz	
Output	TTL levels	
Input	>0.5 V (sinewave) or TTL levels	
Output level with CW/FM	−137 to +13 dBm (0.03 µV to 1 V into 50 Ω)	
with AM	−137 to +7 dBm (0.03 µV to 0.5 V into 50 Ω)	
Setting	from keyboard	
Readout	3½-digit display in µV, mV, dBµV or dBm	
Resolution	0.1 dB	
Fine adjustment	0 to −10 dB with 0.1 dB resolution, without interruption of RF level	
Error of output level	≦±1 dB + frequency-response error¹)	
Frequency response flatness	≦±0.5 dB from 8 to 520 MHz ≦±1 dB at <8 MHz	
Level reduction with RF OFF	>80 dB	
Output		
Output impedance	50 Ω, N female connector	
VSWR	≦1.2 (for level ≦−3 dBm)¹)	
Overvoltage protection	protects the RF output from externally applied RF (1 to 1000 MHz) or DC voltage	
Max. input power	30 W	
Max. input DC voltage	35 V	
Spectral purity		
Harmonics	down ≧30 dBc²)	
Nonharmonic spurious signals	down ≧60 dBc²) (≧5 kHz from carrier)	
Spurious deviation, rms		
0.3 to 3 kHz	≦4 Hz (weighted in accordance with CCITT)	
0.03 to 20 kHz	≦16 Hz	
Spurious AM, rms		
0.03 to 20 kHz	down ≦70 dBc²)	
Single-sideband phase noise (see also diagram below)	typ. down 120 dBc²) (test bandwidth 1 Hz, 20 kHz from carrier)	
Single-sideband broadband noise	typ. down 145 dBc²) (test bandwidth 1 Hz, 2 MHz from carrier)	



Typical single-sideband phase noise of Signal Generator SMS ($f_{carrier}$ = 360 MHz)

¹) With fine level adjustment = 0 dB.
²) dBc = relative level referred to carrier amplitude.

Modulation

AM internal .... f_{mod}: 400 Hz or 1 kHz
external from 8 to 520 MHz .... f_{mod}: 20 Hz to 20 kHz
from 0.1 to 8 MHz .... f_{mod}: 20 Hz to 2 kHz
Modulation depth .... 0 to 95%
Setting .... from keyboard
Readout .... 3-digit display
Resolution .... 0.05% from 0 to 9.95%, 0.5% from 10 to 95%
Error of AM .... ≦4% of modulation-depth setting[1]) from 8 to 520 MHz, ≦7% at <8 MHz
Modulation distortion
at m = 80% .... ≦1.5%
at m = 90% .... ≦3%
Input requirement .... 1 V_{rms} ±1% into 600 Ω
Spurious φM
(peak value at 30% AM) ...... <0.1 rad

FM internal .... f_{mod}: 400 Hz or 1 kHz
external .... f_{mod}: 20 Hz to 20 kHz
Frequency deviation .... 0 to 125 kHz; ≦($f_{carrier}$ −100 kHz)
Setting .... from keyboard
Readout .... 3-digit display
Resolution .... 50 Hz from 0 to 9.95 kHz, 500 Hz from 10 to 99.5 kHz, 1 kHz from 100 to 125 kHz
Error of frequency deviation .... ≦5%
Modulation distortion (f_{mod} 0.4/1 kHz, deviation 75 kHz) .... ≦1%

model 26:
Distortion with stereo mod. (10.7 and 87 to 108 MHz; f_{mod} 50 Hz to 10 kHz; deviation 40 kHz) .... <0.4%, typ. 0.2%
Stereo crosstalk (10.7 and 87 to 108 MHz; f_{mod} 50 Hz/1/10 kHz) .... down typ. 40/45/45 dB
S/N ratio, referred to 40 kHz deviation (filter 31.5 to 16 kHz) .... typ. 65 dB

Input voltage requirement .... 1 V into 600 Ω (V_{rms})
Spurious AM (20 kHz deviation, FM INT.) .... <0.1%
Output voltage with internal AM and FM .... 1 V into 600 Ω (V_{rms})

Additional modulation input at rear of SMS for phase modulation (φM), 20 Hz to 8 kHz; FM, 20 Hz to 20 kHz (internally selectable) or ALC (AM), DC to 20 kHz.
Required input voltage into 600 Ω:
ALC (AM), DC-coupled .... 0 to +2.83 V for 0 to −40 dB
φM (V_{rms}) .... 1 V for 5 rad
FM (V_{rms}) .... 1 V for 100 kHz deviation

Data of options

Option: Reference Oscillator SMS-B1 see page 52

Option: 1.04-GHz-Frequency Range Extension SMS-B2
Frequency range .... 0.1 to 1040 MHz
Data of SMS with option SMS-B2, from 520 to 1040 MHz:
Resolution of the frequency indication .... 200 Hz
Harmonics and subharmonics .... typ. 20 dBc[2]) down (subharmonics ½f, ³⁄₂f...)
Non harmonic signals
>200 kHz from carrier .... down >60 dBc[2])
>5 kHz from carrier .... down >55 dBc[2])
Spurious deviation, rms
0.3 to 3 kHz .... ≦8 Hz (weighted in accordance with CCITT)
0.03 to 20 kHz .... ≦32 Hz
Single-sideband phase noise
20 kHz from carrier .... down typ. 115 dBc[2]) (test bandwidth 1 Hz)
1 MHz from carrier .... down typ. 140 dBc[2]) (test bandwidth 1 Hz)
Error of output level .... ≦±1 dB + frequency response error[1])
Frequency response of level .... flat ±1 dB
Error of mudulation-depth indication with AM (m <90%) ...... ≦7% +1%[1]) of reading
AM distortion (f_{mod} = 0.4/1 kHz, m = 80%) ...... ≦5%
Other specifications same as for basic unit.

[1]) With fine level adjustment = 0 dB.
[2]) dBc = relative level referred to carrier amplitude.

Option: 1-GHz Frequency Range Extension SMS-B2
Frequency range .... 0.1 to 1000 MHz
All other specifications same as for 1.04-GHz Frequency Range Extension Option SMS-B2.

IEC-bus-control

Interface in accordance with IEC 625-1 (IEEE 488) for control of all operating modes and for data transfer in listener operation

Interface functions	AH 1	acceptor handshake
	L 2	listener
	RL 1	remote/local
	DC 1	device clear

Setting time .... 40 ms for all functions (typ. frequency error after 40 ms: <100 Hz)

Models

Model 24 .... 0.1 to 520 MHz
Model 26 .... 0.1 to 520 MHz
Stereo capability .... see under "Modulation" (FM), lefthand column
Model 28 .... 0.1 to 1040 MHz
All models fitted as standard with overvoltage protection

General Data

RF-leakage .... conforms to VDE 0871 and MIL STD 461 A in accordance with method CE 03 and RE 02 concerning spurious radiation and interference on the connecting cables. The SMS also complies with the requirements of VDE 0875 (limit values of radio interference grade K)
Stock and vibration resistance .... shock-proofed in accordance with DIN 40046, Part 7 (30 g, 11 ms); vibration-tested in accordance with DIN 40046, Part 8 (11 to 55 Hz, 2 g); corresponds to IEC Publications 8-2-27 and 68-2-6
Rated temperature range .... +5 to +45 °C
Storage temperature range .... −40 to +70 °C
AC supply .... 115/125/220/235 V ±10%, 47 to 420 Hz; safety class I to VDE 0411
Power consumption .... 60 W (80 W when fitted with all options)
Dimensions, weight .... 347 mm×206 mm×370 mm, 14.6 kg

Ordering information

Order designation .... ▶ Signal Generator SMS
Model 24 (0.1 to 520 MHz) 302.4012.24
Model 26 (0.1 to 520 MHz, stereo-compatible) 302.4012.26
Model 28 (0.1 to 1040 MHz) 302.4012.28

Options

Reference Oscillator	SMS-B1	302.8918.02
1.04-GHz Frequency Extension	SMS-B2	335.0016.02
1.0-GHz Frequency Extension	SMS-B2	335.0016.04

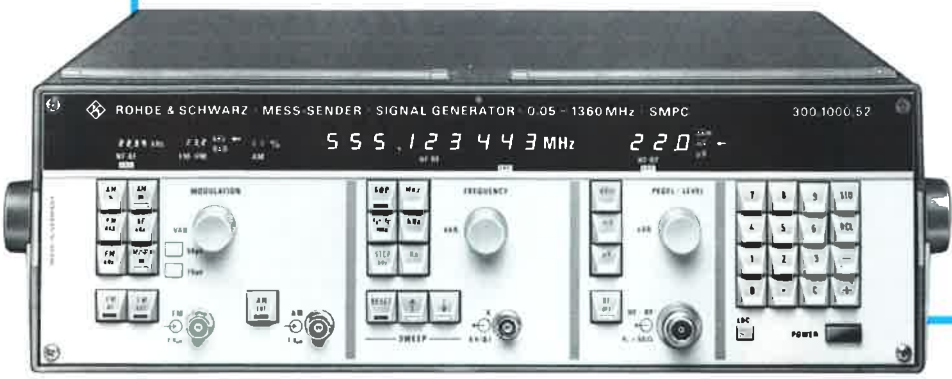
Recommended extras

19" Adapter (for rackmounting)	SMS-Z1	302.8860.00

SMPC

Signal Generator SMPC ♦ 5 kHz to 1360 MHz

- High spectral purity
- Frequency resolution 0.1 Hz
- Digital sweep
- Output level −143 to +13 dBm
- AM, FM, φM, stereo-compatible
- Modulation generator
  10 Hz to 100 kHz
- Frequency switching time 18 ms
- Nonvolatile data memory



IEC 625 Bus

new

Characteristics, uses

The **Signal Generator SMPC** is outstanding for its characteristics, such as high spectral purity, low spurious FM, excellent modulation quality and wide frequency range combined with high resolution. For the first time a general-purpose synthesizer featuring such a wide frequency range and the specified signal purity offers modulation capabilities of maximum quality.

The SMPC meets all the requirements specified for **receiver measurements** – from critical adjacent-channel measurements through to distortion measurements on high-quality AM and FM sound broadcasting receivers. The SMPC can be used both as a low-noise local oscillator and a reference source in noise test assemblies.

Thanks to its excellent frequency stability, high resolution and the digital **sweep capability,** the Signal Generator SMPC can also be used for **measurements on narrowband filters and crystals.**

Front panel section
with setting controls and display for frequency

Ease of operation

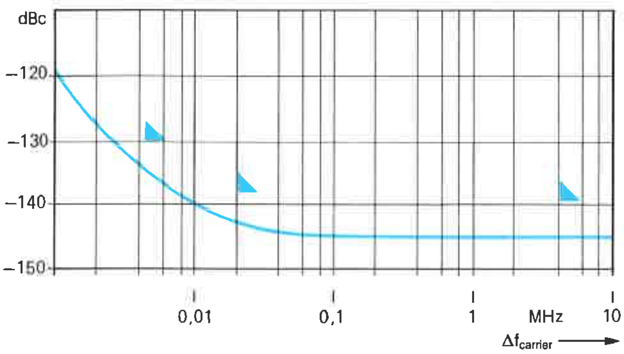
- The minimum of front panel controls plus optimum layout ensures an excellent overview and the great ease of operation of the SMPC.
- Keyboard entries in the normal order – numerical value and unit with direct display of the numerical value entered (above the numerics keyboard).
- Direct readout on separate digital displays with high resolution and floating decimal point.
- Quasi-continuous variation of the values selected for frequency, modulation and level using three rotary knobs leaving no room for operating errors.
- Frequency and level variations possible either in linear or logarithmic mode.
- All settings can be increased or reduced by any amount.
- Level readout can be selected either in V or dBm.

Technical data

Frequency. With a slightly extended level tolerance, frequencies down to 5 kHz can be selected beyond the specified range from 50 kHz to 1360 MHz. The resolution is 0.1 Hz between 5 kHz and 1000 MHz, and 1 Hz above 1000 MHz. Up to 1360 MHz, the output signal is produced directly and not by doubling. Thus subharmonics do not exist.

Typical values of SSB phase noise in dBc (1 Hz)
f=20 MHz

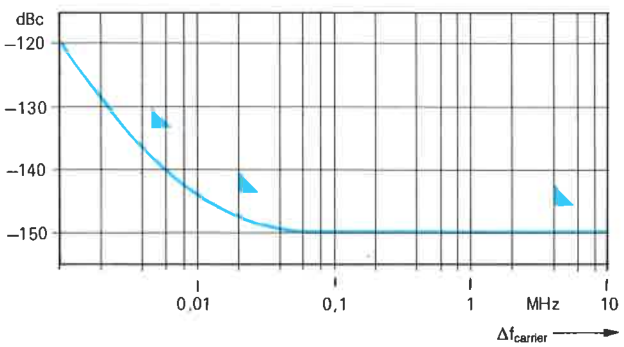
Blue triangles: guaranteed values



Level. The wide output level range from −143 to +13 dBm plus a resolution of 0.1 dB, the high level accuracy and the excellent frequency response flatness are especially important for measurements on receivers and wideband subassemblies. A level variation in 0.1 dB steps over the range of 10 dB without interrupting the RF signal permits also squelch measurements on radio equipment.

Typical values of SSB phase noise in dBc (1 Hz)
f=100 MHz

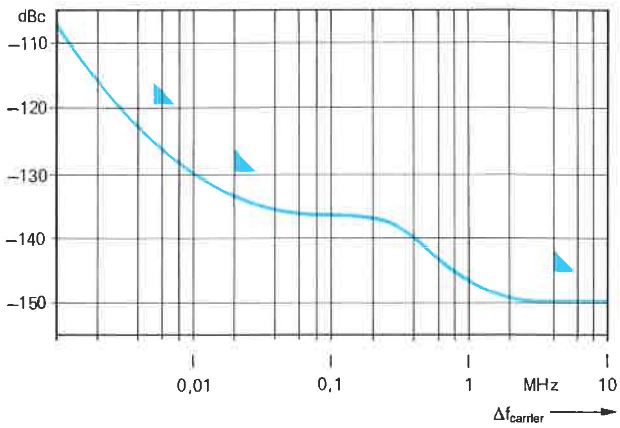
Blue triangles: guaranteed values



Spectral purity. Nonharmonic spurious signals are down more than 80 dB from 0.05 to 21.25 MHz, more than 90 dB between 21.25 and 680 MHz and more than 84 dB above 680 MHz. The SSB phase noise 20 kHz from a 500-MHz carrier at a bandwidth of 1 Hz is typically down 134 dBc, see the diagrams. At the lower frequencies these values even improve until the minimum wideband noise level typically −150 dBc is reached. The typical value for residual FM to CCITT is below 1 Hz at 500 MHz and below 0.2 Hz at 100 MHz. Thanks to its high spectral purity, the SMPC is an ideal noise source for all two-source measurements on RT equipment to FTZ or CEPT specifications.

Typical values of SSB phase noise in dBc (1 Hz)
f=500 MHz

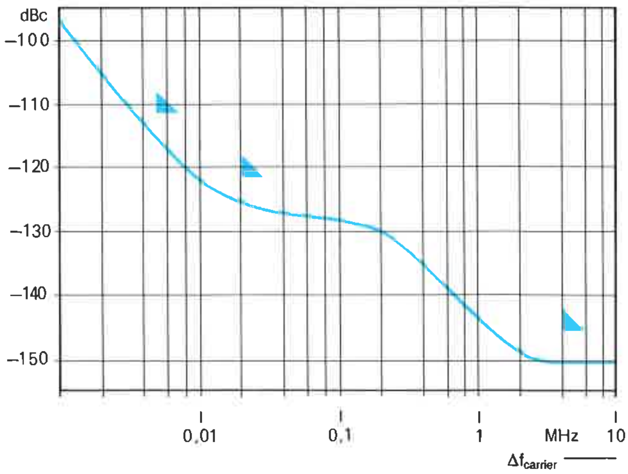
Blue triangles: guaranteed values



Modulation (wideband and low-noise). The Signal Generator SMPC provides AM, FM and φM modulation capabilities. The modulation modes can be selected separately at the same time. The outstanding modulation characteristics (FM distortion 0.1%, AM distortion 0.5%, stereo FM crosstalk down 56 dB) permit all measurements required on AM and stereo sound broadcasting receivers. For the frequency range of wideband-modulated radio services, deviations up to 800 kHz can be set on the SMPC. The modulation generator is an AF synthesizer for 10 Hz to 100 kHz.

Typical values of SSB phase noise in dBc (1 Hz)
f=1360 MHz

Blue triangles: guaranteed values



Digital sweep. The digital sweep capability facilitates frequency response measurements, Q-factor determination and similar tasks. The sweep limits, step widths and dwell time per step can be freely selected.

Storage. Up to 40 device settings can be stored. Even with the device switched off, the memory contents are retained for about three weeks.

Remote control. All device functions can be remote-controlled via the IEC-bus interface.

SMPC – Signal Generator

IEC-bus commands

Setting commands consist of data (optional) and of a two-character combination designating the unit and/or function and serving also as a delimiter. Storage commands and special functions are terminated with numerics.

All characters can be used as separators except numerics, the decimal point, polarity signs and the letters used in the commands. Places in the data block which exceed the resolution of the SMPC are ignored.

List of most important commands

Function	Data	Command Delimiter
Set carrier frequency in MHz in kHz in Hz	up to 10 places, decimal point	MH KH HZ
Set level in dBm in mV in µV	up to 4 places, decimal point	DB MV UV
Switch RF output off on		F0 F1
Program sweep: upper limit frequency MHz lower limit frequency MHz step width kHz single sweep upwards downwards periodic sweep	up to 10 places, decimal point	FU FL SK SU SD SP
Set AF generator in kHz	up to 4 places, decimal point	NK
Frequency/phase modulation: set deviation in kHz in rad switch on FM/φM switch off FM/φM select internal FM/φM select external FM/φM FM AC FM DC	up to 4 places, decimal point	FK PR P1 P0 PI PE FA FD
Amplitude modulation: set modulation index in % AM on AM off internal AM external AM external level control	up to 2 places, decimal point	AP A1 A0 AI AE LC
Storage functions Complete device setup: store recall Frequency setting: store recall Level setting: store recall	n: memory location 1 to 5	ST n RC n ST MH n RC MH n ST DB n RC DB n

Specifications

Frequency	
Range	5 kHz to 1360 MHz, (specifications for level and harmonics valid from 50 kHz on)
Setting/resolution	a) keyboard entry with least increments of 0.1 Hz for $f_{carrier}$ up to 1000 MHz 1 Hz for $f_{carrier}$ >1000 MHz
(Frequency variation)	b) quasi-continuous with rotary knob in steps of 0.1 Hz, 0.1 kHz, 0.1 MHz at $f_{carrier}$ ≦1000 MHz 1 Hz, 1 kHz, 1 MHz at $f_{carrier}$ >1000 MHz
Frequency readout	10-digit display
Error referred to reference frequency	<5 × 10^{-12} at $f_{carrier}$ >21.25 MHz <0.8 mHz at $f_{carrier}$ ≦21.25 MHz
Setting time (after receiving last character via IEC bus)	<18 ms to within 2 × 10^{-6} at $f_{carrier}$ >21.25 MHz to within 300 Hz at $f_{carrier}$ ≦21.25 MHz <43 ms to within 2 × 10^{-8} at $f_{carrier}$ >21.25 MHz to within 3 Hz at $f_{carrier}$ ≦21.25 MHz
Reference frequency	from internal temperature-controlled crystal oscillator or external
Internal crystal oscillator	10 MHz, output: >0.2 V into 50 Ω
Crystal aging	<1 × 10^{-8}/day (after 100 days of operation)
Temperature effect	<1 × 10^{-9}/°C
Warmup time	15 min
External control	10 MHz ±100 Hz, 0.2 to 2 V V_{rms} into 500 Ω, sine or squarewave signal or TTL level
Output level	
Range	−143 to +13 dBm (0.016 µV to 1 V into 50 Ω)
Resolution	0.1 dB
Error (including frequency response)¹)	<±1.7 dB ($f_{carrier}$ ≦600 MHz) <±2.2 dB ($f_{carrier}$ >600 MHz)
Frequency response flatness	
up to 600 MHz	<1 dB
up to 1360 MHz	<2 dB
Source impedance	50 Ω
VSWR¹)	0.05 to 680 MHz / 680 to 1360 MHz
Output level ≦−2 dBm	<1.2 / <1.35
>−2 dBm	<1.4 / <1.6
Level switchoff (RF OFF)	switchover to minimum output level: source impedance remains unchanged
Switching time for level variations	<20 ms
Spectral purity	
Harmonics for output ≦10 dBm	>30 dBc (typ. 35 dBc) down
12 dBm	>25 dBc (typ. 30 dBc) down
Subharmonics	none
Nonharmonic spurious signals (at ≧1 kHz from carrier)	
at $f_{carrier}$ ≦21.25 MHz	>80 dBc down
>21.25 MHz	>90 dBc (typ. 100 dBc) down
>680 MHz	>84 dBc down

Signal-to-noise ratio, referred to 1-Hz bandwidth

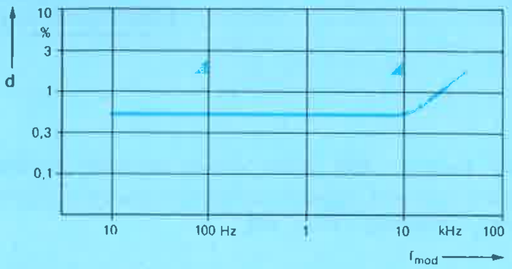
	Carrier spacing	Carrier frequency 20	100	500	1360	MHz
SSB phase noise	5 kHz	>130	>134	>120	>111	dBc down
	20 kHz	>138	>143	>130	>121	dBc down
Wideband noise	4 kHz	>140	>145	>145	>145	dBc down

Modulation generator	
Frequency range	10 Hz to 100 kHz
Resolution up to 10 kHz	1 Hz
above 10 kHz	10 Hz
Frequency error	<1 Hz + reference error
Frequency response flatness	<0.1 dB
Level at rear output	1 V_{rms} into 600 Ω, Z_{out} = 10 Ω
Distortion	<0.1%
Harmonics	typ. >65 dBc down
Nonharmonics	typ. >65 dBc down
Phase-coherent frequency switching:	
Switching time (after receiving last character via IEC bus)	<10 ms

¹) Applies only if special function RCL 94, noninterrupting level variation, is disabled.

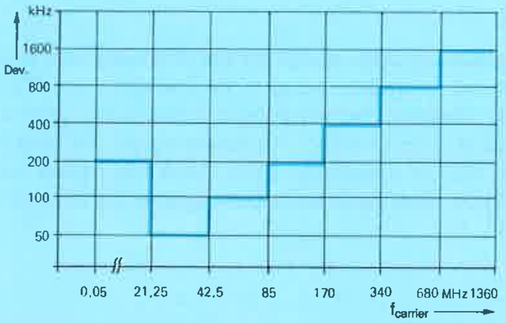
Amplitude modulation

Modes .... internal, external, external DC-coupled for level control with external probe
Modulation frequency, internal ..... 10 Hz to 50 kHz
external .... DC oder 10 Hz to 50 kHz
Modulation frequency response flatness
up to 10 kHz .... <0.4 dB
up to 50 kHz .... <1.0 dB
Modulation depth .... 0.1 to 99%
Resolution .... 0.1 to 10%/1 to 99%
Setting error at 1 kHz/≦80%
up to 500 MHz .... <3% } of set value
above 500/1000 MHz .... <6%/<10% } of set value
Incidental φM, peak value .... <0.1 rad (at 1 kHz and m = 50%)
Modulation distortion .... see diagram for m = 80%, output ≦6 dBm (typical values, triangles: guaranteed values)



Frequency modulation

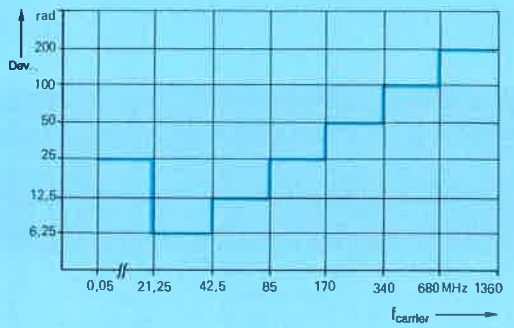
Modes .... internal, external, AC, DC; preemphasis 50 µs, 75 µs
Modulation frequency, internal ..... 10 Hz to 100 kHz
external .... DC or 10 Hz to 125 kHz
Modulation frequency response flatness
internal, 10 Hz to 100 kHz .... <0.2 dB
40 Hz to 15 kHz .... <0.1 dB
external, 10 Hz to 125 kHz ...... <0.1 dB
40 Hz to 53 kHz ...... <0.2 dB
Maximum adjustable deviation ..... see diagram



Resolution of deviation setting ..... <1% of set value or 10 Hz
Deviation error (at f_{mod} = 1 kHz) .... <3% of set value or 20 Hz
Modulation distortion
at 50% maximum deviation ..... <0.1% bei 1 kHz
<0.3% at 20 kHz
with stereo (40 kHz deviation, $f_{carrier}$ <21.25 MHz or 85 to 170 MHz) .... <0.1% at 1 kHz
Stereo crosstalk .... >45 dB down at 40 Hz to 15 kHz
56 dB at 500 Hz to 10 kHz
Unweighted signal-to-noise ratio
Stereo (40 kHz deviation, 50 µs) $f_{carrier}$ <21.25 MHz or 85 to 170 MHz .... >76 dB
Mono (conditions same as above) >76 dB
Preemphasis (switch-selected) ..... 50 µs, 75 µs
Additional deviation error .... <2%
Incidental AM at f_{mod} = 1 kHz and 40 kHz deviation .... <0.1%
Carrier frequency error when switching to FM DC .... $<1 \times 10^{-6}$ for $f_{carrier}$ >21.25 MHz
<155 Hz for $f_{carrier}$ ≦21.25 MHz
Recalibration occurs each time FM AC or FM OFF is selected.

Phase modulation

Modes .... internal and external
Modulation range .... 10 Hz to 8 kHz
Maximum adjustable deviation ..... see diagram



Resolution of deviation setting ..... <1% of set value or 0.1 rad
Error of deviation setting .... <5% of set value or 0.02 rad (at f_{mod} = 1 kHz)
Frequency response flatness ...... <0.05 dB up to 3 kHz,
<0.1 dB up to 8 kHz
Modulation distortion at 50 % of maximum deviation, internal ..... <0.2%
external .... <0.1%

Digital sweep

Modes .... single sweep up or down, periodic triangular sweep
Sweep width .... freely selectable over entire frequency range
Step width .... freely selectable, least increment 1 Hz, log 0.01 to 50% per step
Dwell time .... normally 18 ms per step, programmable up to 5 s per step
Voltage swing at X-output .... 5 V (BNC female)

Programming and data output

System .... IEC 625-1 (IEEE 488)
Connector .... 24-way, Amphenol
Interface functions T6, L4, SR1, RL1, DC1

Option Overload Protection SMPC-B2

Protects the RF output against externally applied RF or DC voltages
Max. permissible RF power .... 30 W
Max. permissible DC voltage ...... 35 V
Response indication .... LED in RF OFF key, service request possible via IEC Bus

General Data

Rated temperature range .... +5 to +45 °C
Storage temperature range .... −40 to +70 °C
AC supply .... 115/125/220/235 V ±10%, 47 to 420 Hz, 220 VA, 150 W, safety class I to VDE 0411
RF leakage .... conforming to VDE 0871 (spurious radiation and interference on connecting cables) and VDE 0875 (limit values of radio interference grade K)
Mechanical stress capacity .... shock test to DIN 40060, Part 7 (30 g, 11 ms) and vibration test to DIN 40046, Part 8 (11 to 55 Hz, 2 g) corresponding to IEC Publications 68-2-27 and 68-2-6
Dimensions, weight .... 470 mm×162 mm×485 mm, 23 kg

Ordering information

Order designation .... ▶ Signal Generator SMPC 300.1000.52
Accessories supplied .... power cable

Recommended extras

Option Overload Protection .... SMPC-B2 ... 346.1019.02
19" Rack Adapter .... SMPC-Z9 ... 346.1219.02
Service Kit .... XPC-Z1 ... 337.9810.02

XPC

Synthesizer Generator XPC ♦ 5 kHz to 1360 MHz

- High spectral purity
- Frequency resolution 0.1 Hz
- Digital sweep
- Output level +13 to −143 dBm
- Nonvolatile data storage
- Self-test with error signalling
- IEC-bus-compatible, frequency setting time 18 ms

IEC 625 Bus

Characteristics, uses

The **Synthesizer Generator XPC** largely corresponds to the SMPC described in the preceding pages – this relationship is not limited to the outer appearance and is evident at the first glance but it also applies to the characteristics of the XPC, such as high stability and spectral purity of the signal, wide frequency and level range together with short setting times, are identical with those of the SMPC except for the fact that the XPC cannot be modulated.

The range of applications for a generator which cannot be modulated is so varied that, due to its considerable price advantage, the XPC holds an important position as against generators with modulation capability, in particular when setting up automatic test assemblies:

- Especially stable and low-noise oscillator (LO)
- Reference source in noise test assemblies
- Signal source in RF test assemblies for determining two-port parameters (e.g. with the ZPV)
- Use in calibration laboratories
- Generator for measurements on steep-edged filters and on crystals

Digital sweep. The digital sweep capability enables measurement and display of frequency response characteristics, selectivity curves, etc.

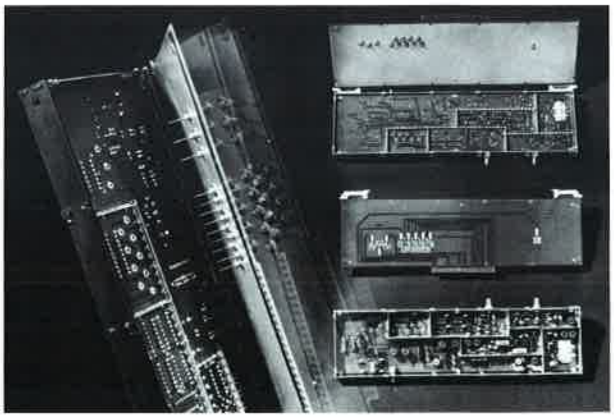
Remote control. All settings can be remote-controlled via the IEC-bus interface (IEC 625-1) which is fitted as standard. Thanks to the short setting times (18 ms for frequency) the XPC is ideally suited for use in automatic test assemblies.

Design

All RF subassemblies, except for the attenuator and output amplifier, are designed as plug-in, RF-leakage-proof boards. The new screening technique used affords easy access of the PC boards for servicing. The power supply and data bus lines as well as noncritical signal lines are routed via a motherboard, thus cable harnesses becoming a thing of the past.

XPC used as precision signal source in test assembly for s parameters

Example of plug-in RF boards in new technique as used in XPC



Specifications

Frequency

Frequency range .... 5 kHz to 1360 MHz, (Specifications for level and harmonics valid from 50 kHz on)

Frequency setting .... a) keyboard entry with least increments of 0.1 Hz for $f_{carrier}$ <1000 MHz; 1 Hz for $f_{carrier}$ ≧1000 MHz

(Frequency variation) b) quasi-continuously with rotary knob in steps of 0.1 Hz, 0.1 kHz, 0.1 MHz at $f_{carrier}$ <1000 MHz; 1 Hz, 1 kHz, 1 MHz at $f_{carrier}$ ≧1000 MHz and logarithmic with variable step size of 0.01 to 50%

Frequency steps .... step width programmable, same as for SWEEP

Frequency readout .... 10-digit display

Resolution .... 1 Hz/0.1 Hz

Error referred to reference frequency .... <0.8 mHz for $f_{carrier}$ ≦21.25 MHz; $<5\times10^{-12}$ for $f_{carrier}$ >21.25 MHz

Setting time (incl. 15 ms for computer)

$f_{carrier}$ ≦21.25 MHz .... <18 ms to 300 Hz; <43 ms to 3 Hz

$f_{carrier}$ >21.25 MHz .... <18 ms to 2×10^{-6}; <43 ms to 2×10^{-8}

Reference frequency .... from built-in crystal oscillator or external

Built-in crystal oscillator .... 10 MHz, output >0.2 V_{rms} into 50 Ω

Crystal aging .... $<1\times10^{-8}$/day (after 100 days of operation)

Temperature effect .... $<1\times10^{-9}$/°C

Warmup period .... 15 min

External control .... 10 MHz ±100 Hz, 0.2 to 2 V_{rms} into 500 Ω, sine or squarewave signal, TTL levels possible

Output level

Range .... –143 to +13 dBm (0.016 µV to 1 V into 50 Ω)

Setting .... from keyboard in dBm, mV and µV

Resolution .... 0.1 dB (four digits)

Readout .... in dBm, mV and µV, four digits with floating decimal point

Error (incl. frequency response)[1] .... <±1.7 dB ($f_{carrier}$ ≦600 MHz); <±2.2 dB ($f_{carrier}$ >600 MHz)

Frequency response flatness

up to 600 MHz .... <1 dB

up to 1360 MHz .... <2 dB

Source impedance .... 50 Ω

VSWR)[1]	0.05 to 680 MHz	680 to 1360 MHz
Output level <–2 dBm	<1.2	<1.35
>–2 dBm	<1.4	<1.6

Level switchoff (RF OFF) .... switchover to minimum output level: source impedance remains unchanged

Switching time for level variations .... <20 ms

Spectral purity of output signal
(dBc: relative level referred to carrier amplitude)

Interfering signals:

Harmonics for output ≦10 dBm .... >30 dBc (typ. 35 dBc) down

Subharmonics .... none

Nonharmonic spurious signals (at ≧1 kHz from carrier)

at $f_{carrier}$ ≦21.25 MHz .... >80 dBc down

>21.25 MHz .... >90 dBc down (typ. 100 dBc down)

>680 MHz .... >84 dBc down

Signal-to-noise ratio (referred to 1-Hz bandwidth):

	Carrier spacing	Carrier frequency 20	100	500	1360	MHz
SSB phase noise	5 kHz	>130	>134	>120	>111	dBc
	20 kHz	>138	>143	>130	>121	dBc
Wideband noise	>4 MHz	>140	>145	>145	>145	dBc

Typical values of SSB phase noise are given in the diagrams under SMPC on page 55.

[1]) Applies only if special function RCL 94, noninterrupting level variation, is disabled.

Digital sweep

Modes .... single sweep upwards and downwards, periodic sweep (triangular)

Sweep width .... freely selectable over entire frequency range

Step size .... freely selectable, resolution 1 Hz, logarithmic 0.01 to 50% per step

Voltage swing at X output .... 5 V (BNC female)

Programming and data output

System .... IEC 625-1 (IEEE 488)

Connector .... 24-way Amphenol

Interface functions .... T6 basic talker, serial poll, unaddress if MLA; L4 basic listener, unaddress if MTA; SR1 service request function, complete capability; RL1 remote/local function, complete capability; DC1 device clear function, complete capability

Option Overload Protection

SMPC-B2 .... protects the RF output against externally applied RF and DC voltages

Max. permissible RF power .... 30 W

Max. permissible DC voltage .... 35 V

Response indication .... LED in RF OFF key

General data

Rated temperature range .... +5 to +45°C

Storage temperature range .... –40 to +70°C

AC supply .... 115/125/220/235 V ±10% 47 to 420 Hz (120 VA), safety class I to VDE 0411

RF leakage .... conforming to VDE 0871 (spurious radiation and interference on connecting cables) and VDE 0875 (limit values of radio interference grade K)

Mechanical stress capacity .... shock test to DIN 40046, Part 7 (30 g, 11 ms) and vibration test to DIN 40046, Part 8 (11 to 55 Hz, 2 g); corresponding IEC Publications 68-2-27 and 68-2-6

Dimensions weight .... 470 mm×162 mm×485 mm, 21.5 kg

Ordering information

Order designation .... ▶ Synthesizer Generator XPC 337.8014.52

Accessories supplied .... power cable

Recommended extras

Options: Overload Protection SMPC-B2 .... 346.1019.02

RF output at rear XPC-B5 .... 338.2010.02

Service Kit XPC-Z1 .... 337.9810.02

19" Rack Adapter SMPC-Z9 .... 346.1219.02

SMUV

AM/FM Signal Generator SMUV ♦ 10 kHz to 130 MHz

- High frequency stability and spectral purity of the output signal
- Frequency counter with 1-Hz resolution
- Wide level range with negligible attenuator error, single range output-level setting
- Low AM and FM distortion, stereo-compatible
- Frequency synchronization in 1-kHz steps (with option)

Characteristics, uses

The **AM/FM Signal Generator SMUV** is an attractively priced and extremely versatile signal source for use in the laboratory, production and servicing.

Three models and five options – see page after next – make it possible to match the SMUV exactly to the application on hand.

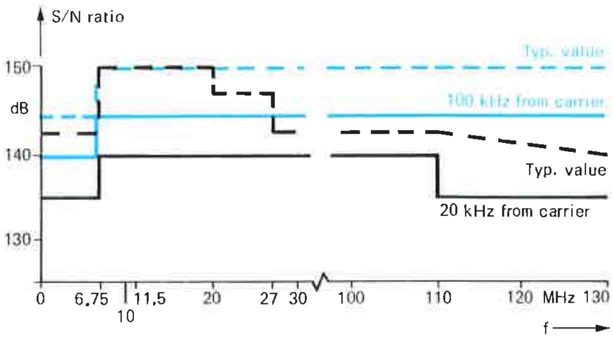
The possibilities of **sweep operation** up to 130 MHz, of **frequency synchronization** with 1-kHz steps and of expansion into a **power signal generator,** together with stereo compatibility, make the SMUV into a general-purpose signal generator which meets all requirements up to the VHF range.

Special features such as

high frequency stability and accuracy,
high spectral purity,
extremely low spurious FM,
very low narrowband and broadband noise,
high spurious suppression and
excellent RF shielding

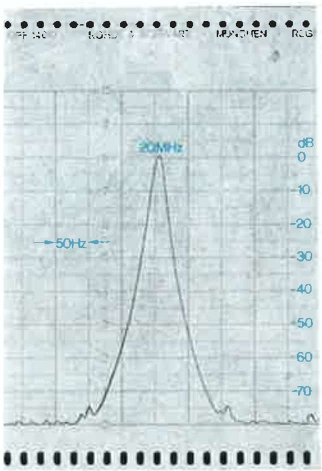
make the SMUV ideal for precise measurements on active and passive components, subassemblies and equipment of all types such as direction finders, radiotelephones, short-wave receivers, including SSB sets, and sound broadcasting receivers. Its excellent performance data allow its use where extreme requirements for stability, spurious FM, signal-to-noise ratio and spuria rejection are to be met. Receiver measurements, in particular, require – in addition to high-quality modulation characteristics – a high spectral purity of the output signal such as that of the SMUV.

Thus it is possible to carry out all measurements such as dynamic adjacent-channel selectivity, intermodulation and crossmodulation ratios and blocking without difficulty. Thanks to the excellent signal-to-noise ratio (narrow and broadband) both close to and far off from the carrier, and to the high frequency stability – reaching synthesizer stability when the synchronizer option is used – the SMUV can be used as the interfering source for measurements on receivers of even the highest selectivity.



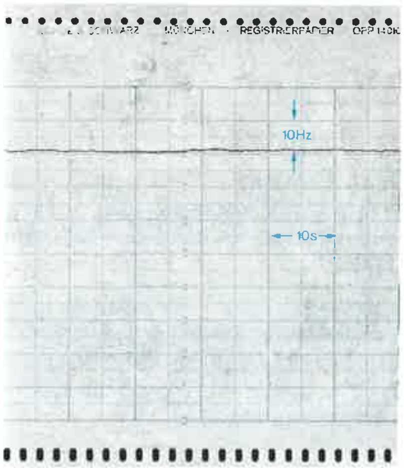
Signal-to-noise ratio referred to 1 Hz as a function of carrier frequency and offset from carrier

With its high rejection of spurious signals and extremely low spurious FM the SMUV is an ideal local oscillator or reference oscillator and permits signal-to-noise ratio measurements to be performed without introducing an error.



Quality of SMUV signal: sideband suppression close to carrier (hum suppression)

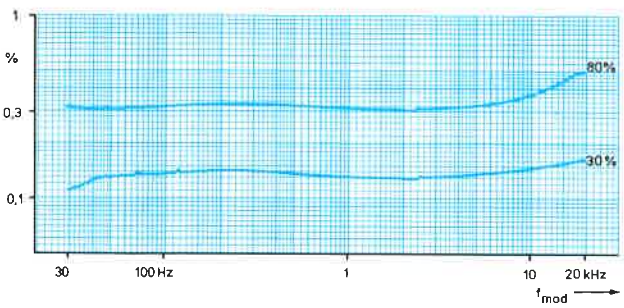
Frequency setting, frequency counter. Pushbuttons for the range selection and a tuning knob with coarse/fine drive without stop provide for rapid and reliable frequency setting, the electronic fine tuning permitting an accuracy of 1 Hz. The frequency counter reads out the output frequency of the SMUV in seven digits with a selectable resolution of 1, 10 or 100 Hz. External frequencies of 10 Hz to 130 MHz can be measured with the same resolution, the sensitivity being typically 10 mV.



Quality of SMUV signal at 20 MHz:
short-term carrier stability (unsynchronized)

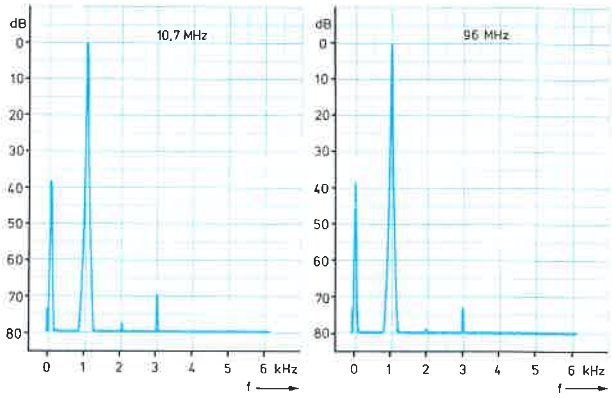
Even shortly after switch-on or selection of a new frequency range the frequency of the SMUV is so stable that measurements can be made on steep-edged filters or receivers with a narrow channel spacing. The sturdy construction of the oscillators, particularly the solid, cast frame, makes the SMUV exceptionally insensitive to mechanical vibration or acoustic interference. The long thermal time constant of the cast frame ensures that changes in the environmental temperature have virtually no effect on the short-term stability of the frequency.

Modulation, sweeping; amplitude modulation. The very low distortion that is almost independent of carrier and modulation frequency permits measurements even on high-grade AM receivers. The low intermodulation products with multitone AM are very important when testing SSB receivers.



Typical AM distortion of the SMUV at modulation depths of 30% and 80%

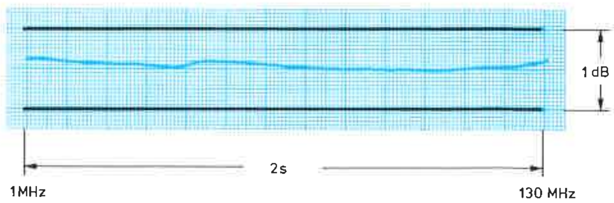
Frequency modulation is possible down to 10 kHz carrier frequency with large deviation and very little distortion. Thanks to the very low modulation distortion in the VHF and VHF-IF (see diagram) the SMUV in conjunction with a stereocoder can be used for all measurements, even on first-class stereo receivers.



Typical FM distortion at 75 kHz deviation,
left: $f_{carrier}$ = 10.7 MHz, right: $f_{carrier}$ = 96 MHz

Narrowband sweeping – e.g. of tuned circuits, IF amplifiers, FM demodulators and filters with high skirt selectivity – is enabled by DC coupling with external FM.

Wideband sweeping. The sweep oscillator option covers the total frequency range from 0.1 to 130 MHz in three subranges which can be electronically switched over with TTL levels so that the entire range can be swept. The Sweep Unit SMLU-Z is tailored to this specific application (see next page).



Typical frequency response of Sweep Oscillator SMUV-B5

Output level. The output voltage of the SMUV of 0.05 µV to 0.5 V into 50 Ω is continuously adjustable with a single-range attenuator, thus permitting sensitivity measurements on receivers as will as measurements on components. In conjunction with the 2-W amplifier option the SMUV delivers up to 10 V into 50 Ω in the frequency range 10 kHz to 40 MHz. The high output voltage makes good decoupling possible between the signal sources in multi-signal measurements, e.g. of intermodulation and crossmodulation. It is also indispensable when the immunity to overdriving is to be checked of amplifiers, receivers or active antennas, as well as in determining the radiation efficiency and directivity of antennas.

SMUV models

SMUV **basic unit.** Options may be retrofitted or incorporated in the factory prior to delivery

SMUV **model 55** with standard options Synchronizer (SMUV-B9) and Crystal Oscillator (temperature-compensated, SMUV-B1)

SMUV **model 57** with standard option 2-W Amplifier (SMLH-B3)

Models 55 and 57 can be equipped with additional options at the factory prior to delivery or retrofitted after delivery.

Overload Protection SMLH-B7. The overload protection option protects the RF attenuator and the output stage, should the external RF or DC voltage applied to the RF output be too high.

Synchronizer SMUV-B9. The synchronizer option brings the frequency stability of the SMUV up to the level of a synthesizer. The SMUV combines the capabilities of a high-stability precision signal generator with that of a free-running signal generator of extremely low noise and with universal modulation characteristics.

Options

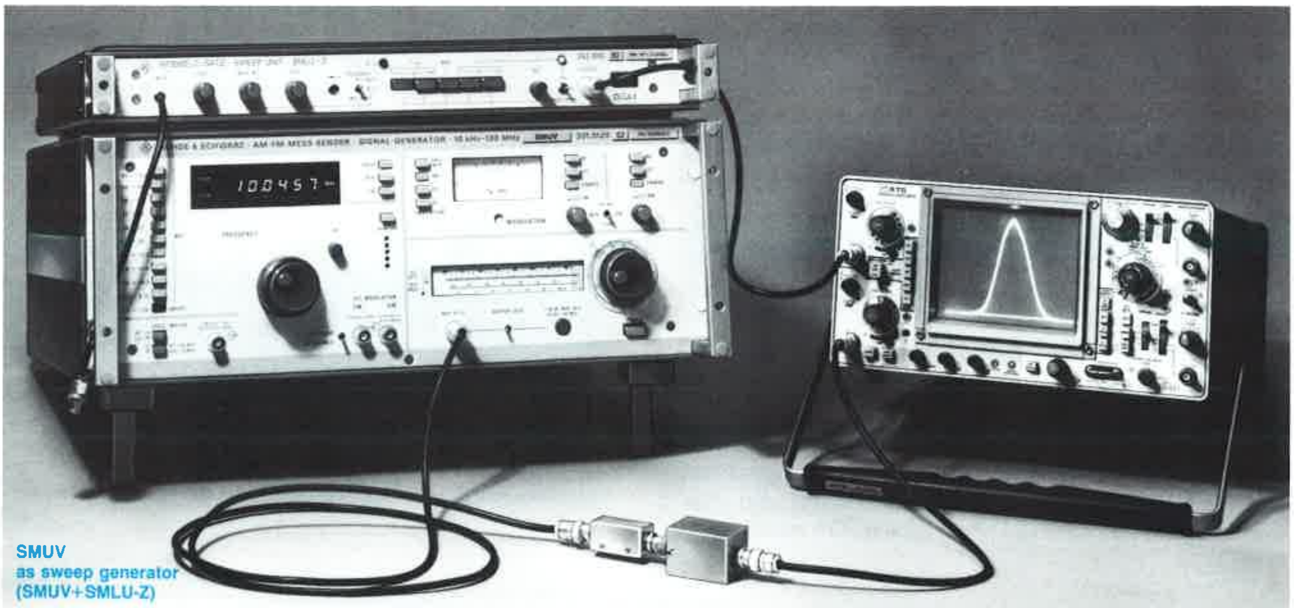
The options are independent of one another and can be incorporated at the factory or added later to all models, following the mounting instructions supplied with them and without requiring any trimming.

Crystal Oscillator SMUV-B1. The temperature-compensated Crystal Oscillator SMUV-B1 improves the accuracy of the built-in frequency counter and moreover – in conjunction with the Synchronizer – the stability of the signal generator to 5×10^{-8}/month.

SMUV as sweep signal generator

In conjunction with Sweep Oscillator SMUV-B5 and Sweep Unit SMLU-Z, the AM /FM Signal Generator SMUV constitutes a wideband sweep generator for the frequency range from 400 kHz to 130 MHz.

Free selection of sweep subranges. Through electronic switching of the three SMUV sweep frequency subranges of 0.4 to 43.5 MHz, 43.5 to 87 MHz and 87 to 130 MHz by the Sweep Unit SMLU-Z, it is possible to sweep the entire frequency range from 400 kHz to 130 MHz.



SMUV
as sweep generator
(SMUV+SMLU-Z)

2-W Amplifier SMLH-B3. This amplifier raises the output power to 2 W (10 V into 50 Ω) in the frequency range **0.01 to 40 MHz.** The maximum permissible modulation depth is 98% up to an output signal of 4 V. For higher output signals it decreases linearly to 0% at 10 V.

Sweep Oscillator SMUV-B5. The sweep Oscillator SMUV-B5 covers the entire frequency range from 0.4 to 130 MHz in three subranges. These subranges are electronically switched so that the overall range can be continuously swept with an appropriate sawtooth generator; for instance, the Sweep Unit SMLU-Z.

Any desired subrange can be swept by setting the corresponding start and stop frequencies with two potentiometers. Another potentiometer is used to set a marker within the sweep range, its frequency being read out on the SMUV frequency counter. The marker can be displayed simultaneously as a bright spot on an external VDU. If the start or stop button is pressed, the corresponding frequency is displayed on the SMUV.

Sweep times. The sweep time is adjustable from 10 to 1000 ms; single sweeps of 2 to 200 s or manual scan from start to stop frequency are also possible.

The curve display. Any standard oscilloscope with X-Y input as well as ordinary VDUs are suitable for showing the measured curves. Operation in conjunction with XY or YT recorders is also possible; the SMLU-Z is provided with outputs for the X-deflection voltage and the marker pulse.

Display driving. The SMLU-Z has an X output and a pulse output for blanking during flyback of the sawtooth.

Specifications

SMUV basic unit

Frequency range	10 kHz to 130 MHz in 10 subranges
Readout	in 7 digits
Control crystal	10 MHz, aging 1×10^{-5}/month option SMUV-B1: 5×10^{-8}/month
Frequency meter for ext. test frequencies	10 Hz to 130 MHz, V_{in} = 30 mV (typ. 10 mV) to 3 V
Input impedance f <10 MHz	5 kΩ
f >10 MHz	50 Ω
Frequency tuning	
mechanical	coarse/fine drive
electronic	ca. 100 to 500 Hz, depending on range
Frequency drift	after 10 min / after 2 h
unsynchronized at f ≦40 MHz	<1 kHz/5 min / <300 Hz/5 min
at f >40 MHz	<2 kHz/5 min / <1 kHz/5 min
synchronized	see option Synchronizer SMUV-B9
RF output	Z_{out} = 50 Ω, BNC female
Output voltage	0.05 µV to 0.5 V into 50 Ω
Setting	continuous
Error limits	<±1 dB with V_{out} ≦0.2 V <±2 dB with V_{out} >0.2 V
Frequency response flatness	<±0.5 dB

Spectral purity

S/N ratio, referred to 1-Hz bandwidth	140 (135) dB at 20 kHz from carrier 145 (140) dB at 100 kHz from carrier
Harmonics	>30 dB, typ. 36 dB down
Spurious signals	>90 dB down at <15 MHz from carrier
Spurious FM acc. to CCITT	<2 Hz, typ. 0.5 Hz
Spurious FM acc. to CCIR	<7 Hz, typ. 3 Hz
Suppression of hum sidebands (f <40 MHz)	
50 Hz	>50 dB } typical for f >40 MHz
≧100 Hz	>60 dB } typical for f >40 MHz

Modulation

AM internal	f_{mod}: 400 Hz/1 kHz modulation depth up to 98%, adjustable
external	30 Hz to 20 kHz voltage requirement 10 mV/%
Input impedance	600 Ω, BNC female connector
Indicating range	10/30/100%
Error at m = 80%	± (5% of rdg +1.5% of fsd)
Envelope distortion	100 Hz to 10 kHz / 30 Hz to 20 kHz
at m = 80%	<1%, typ. 0.3% / <2%, typ. 1%
Suppression of inter-modulation, m = 80%	>40 (46) dB from 100 Hz to 10 kHz
Spurious AM (CCITT/CCIR)	<0.01%/<0.03% in subrange (10 to 11.5 MHz) typical values
FM internal	f_{mod}: 400 Hz/1 kHz (distortion same as with external FM)

	f_{mod}	distortion %	(typ.)	Δf kHz
external AC 0.01 to 40 MHz	30 Hz to 20 kHz	<1	0.5	≦10
40 to 130 MHz	30 Hz to 100 kHz	<1	0.5	≦100
10 to 11.5 MHz	30 Hz to 100 kHz	<0.1	0.05	≦75
87 to 108 MHz	30 Hz to 100 kHz	<0.15	0.08	≦75
external DC 0.01 to 40 MHz	0 to 20 kHz			
40 to 130 MHz	0 to 100 kHz			
10 to 11.5 MHz	0 to 100 kHz			

Input impedance AC/DC	600 Ω/10 kΩ, BNC female connector
Voltage requirement	10 mV_p/kHz
Frequency deviation	
0.01 to 40 MHz	adjustable up to 50 kHz
40 to 130/10 to 11.5 MHz	adjustable up to 100 kHz
Modulation indicating ranges	f_{mod} >30 Hz
Indicating error (f_{mod} >30 Hz)	±(5% of rdg +1.5% of fsd)
Incidental AM (f = 10 kHz, f_{mod} = 1 kHz)	<1%, typ. 0.2%
Stereo crosstalk (10 to 11.5; 87 to 108 MHz) 50 Hz/1 kHz/15 kHz	>40/46/46 dB, typ. 50 dB down

SMUV options

Crystal Oscillator SMUV-B1 ...... 10 MHz, temperature-compensated (fitted as standard in SMUV model 55)

Crystal aging	5×10^{-8}/month
Frequency drift	5×10^{-8}/10 min after 15 min warmup and at constant ambient temperature

2-W Amplifier SMLH-B3
(fitted as standard in SMUV model 57)

Frequency range	10 kHz to 40 MHz	
Output voltage	0.5 to 10 V into 50 Ω	
Setting, resolution	same as for basic model	
Error limits	±2 dB, typ. ±1 dB + error of basic unit	
Harmonics		
with V_{out} between 0.5 and 5 V	>30 dB, typ. 40 dB down	
between 5 and 10 V	>25 dB, typ. 30 dB down	
S/N ratio referred to 1 Hz test bandwidth	20 kHz from carrier	200 kHz from carrier
with V_{out} between 0.5 and 2 V	typ. 135 dB	typ. 140 dB
between 2 and 10 V	typ. 140 dB	typ. 150 dB
Amplitude modulation depth		
with V_{out} between 0.5 and 4 V	adjustable up to 98%	
between 4 and 10 V	linear reduction from 98% at 4 V to 0% at 10 V	
Envelope distortion at m = 80%		
$f_{carrier}$ = 30 MHz, V_{out} <4 V	<2%, typ. 1%	} + error of basic unit
$f_{carrier}$ = 40 MHz, V_{out} <3 V	<4%, typ. 2%	} + error of basic unit
Indicating error at m = 80%		
$f_{carrier}$ = 30 MHz, V_{out} <4 V	<±10%	
$f_{carrier}$ = 40 MHz, V_{out} <3 V	<±10%	

No guaranteed values for intermodulation distortion with AM

Sweep Oscillator SMUV-B5

Frequency ranges	400 kHz to 43.5 MHz 43.5 to 87 MHz 87 to 130 MHz
Range switching	via 36-pole female connector on rear panel with TTL levels
Sweep frequency	0 to 100 Hz, control voltage 0 to +10 V
Harmonics (1 to 130 MHz)	>30 dB, typ. 40 dB down
Spurious FM (1 to 130 MHz)	<1 kHz
Frequency response flatness (1 to 130 MHz)	<±1 dB, typ. 0.5 dB

Overload Protection SMLH-B7

Max. permissible RF power	50 W (max. DC voltage 50 V)

Synchronization SMUV-B9 synchronizes the output frequency with that of the built-in crystal oscillator, disconnectible
(fitted as standard in SMUV model 55)

Frequency error	error of control crystal +5 Hz
Frequency steps	1 kHz
Max. FM modulation index	approx. 10 (f_{mod} >100 Hz, Δf <10 kHz)

General data

Rated temperature range	+10 to +45°C
Storage temperature range	−40 to +70°C
Power supply	115/125/220/235 V ±10%, 47 to 420 Hz (40 to 60 VA depending on model)
Dimensions, weight	492 mm×205 mm×514 mm, 20 kg

Ordering information

Order designation .... ▶ AM/FM Signal Generator SMUV
(description of various models see preceding page)

SMUV, basic unit	301.0120.52
SMUV, model 55	301.0120.55
SMUV, model 57	301.0120.57
Accessories supplied	power cable

Recommended extras and accessories

Options:	
Crystal Oscillator SMUV-B1 (5×10^{-8})	301.5809.02
2-W Amplifier SMLH-B3	284.4210.50
Sweep Oscillator SMUV-B5, voltage-controlled	301.4802.02
Overload Protection SMLH-B7	284.6007.50
Synchronization SMUV-B9	301.5609.02
Accessory units:	
Sweep Unit SMLU-Z	243.3010.92
Power Splitter/Combiner DVS	342.1014.50

Signal generator family SMDU – models and options

general RF measurements

airnav . . .

Models*

04

(34)

08

(38)

Low-cost signal generator as basic equipment for laboratories or as second source in intermodulation and similar measurements.

The ideal test assembly for the laboratory covering wideband measurements and **all receiver tests.** Frequency measurements from 15 Hz to 525 MHz (1 GHz); all AF measurements from 15 Hz to 150 kHz. Specially suited for AF and RF signal generation in hifi and stereo broadcast applications.

All SMDU models (04 to 09) are particularly suited for use as the interfering generator in 2- or 3-source test methods.

In combination with the VOR-ILS unit: Air-navigation measurements of highest precision on VOR-ILS receivers and communications receivers.

AF generator with two fixed frequencies: 400 and 1000 Hz

Broadcast FM quality (stereo-compatible; crosstalk 46 dB down). AF generator and AF voltmeter for 15 Hz to 150 kHz. Autoranging of modulation and voltage indication. FM deviation ±500 kHz.

Complete test assembly featuring continuous monitoring of the output values of the VOR-ILS signals and built-in self-check of the most important parameters.

page 66

110

Options ▶

All models of the SMDU can be fitted with the mutually independent options. The options can be ordered together with the signal generator or – with the exception of options B8 and B9 – added later as required.

Synchronizer
SMDU-B1

Overload Protection
SMDU-B2

1.05-GHz Frequency Range Extension
SMDU-B3

1-GHz Frequency Meter
SMDU-B4

1.05-GHz Frequency Doubler
SMDU-B5

Amplitude Modulation 525 to 1050 MHz
SMDU-B8

S/N Ratio Improvement
SMDU-B9

Common features

- Extremely wide frequency range and high frequency stability (drift $<5\times10^{-8}$/month)
- High spectral purity in respect of harmonics, spuria and noise
- Accurate output level (0.05 µV to 2 V EMF) with single-knob setting
- Precise AM, FM and φM modulation characteristics

*) The numerical designation of the different models (04, etc.) refers to the last two digits of the order number.

and aircoms | radiotelephones

and aircoms	radiotelephones	
 07	 06 (52) (53) (56)	 09

When used with the AM Unit SMDU-Z1 or the Power Test Adapter SMDU-Z2, these models form complete **AM/FM radiotelephone test sets,** ideally suited for the full range of transmitter and receiver measurements. At the receiver: S/N or SINAD sensitivity, squelch performance, bandwidth, AF distortion and (using a second signal generator to feed the main channel) adjacent-channel selectivity and desensitization. At the transmitter: frequency, power, modulation (FM and, with SMDU-Z1, AM), modulation frequency (e.g. call tone) and modulation distortion. High accuracy in both simple and complex test routines. Time savings when testing multichannel units thanks to semi-automatic deviation meter and channel-to-channel tuning.

07	06 (52) (53) (56)	09
In combination with VOR-ILS unit: as for SMDU 08 plus measurements on AM/FM transmitters.		Testing of mobile hifi and stereo broadcast receivers with built-in Citizens' Band radio.

External semi-automatic deviation meter for wanted and unwanted modulation (5 Hz to 50 kHz), SINAD meter (6 to 46 dB), CCITT filter, 1-kHz distortion meter (0.5 to 50%), AF generator (30 Hz to 30 kHz and six standard test frequencies), AF rms voltmeter, autoranging. Automatic switching from receiver to transmitter measurements when used with AM Units SMDU-Z1.

07	06 (52) (53) (56)	09
Complete test assembly featuring continuous monitoring of the output values of the VOR-ILS signals and built-in self-check of the most important parameters.	Compact test assemblies with SMDU 06 and option B1+Z1/30 W: (52) or +Z1/60 W: (53) or +Z2/30 W: (56)	Special FM performance: very low distortion (0.15% at 100 kHz deviation) and good stereo channel separation (46 dB).
110	104	104

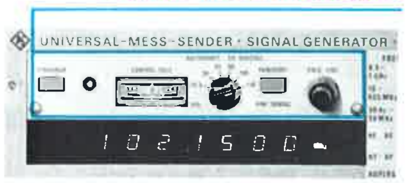
Frequency stability is improved to that of a synthesizer while the high spectral purity of a free-running oscillator is maintained. Operation is greatly simplified by the possibility of synchronized fine tuning and the channel facility.

The RF output of the SMDU is protected against externally applied power of up to 50 W. This option is fitted as standard in models 06, 07 and 09.

Extends the frequency of the RF generator to 1.05 GHz without affecting the other characteristics. Digital display of internal frequency up to 1.05 GHz; option SMDU-B4 is not required.

Extends the range of the counter to 1 GHz for external signals (high sensitivity).

SMDU with option SMDU-B1

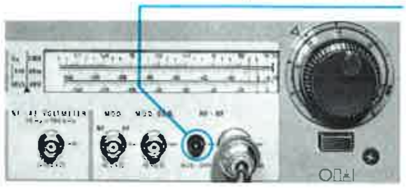


Low-cost option for doubling the RF generator range to 1.05 GHz. Subharmonics and harmonics at least 20 dB below carrier level. Frequency displayed digitally.

Option B8 permits AM up to 1050 MHz when the frequency range of the SMDU is extended beyond 525 MHz (when ordering a new SMDU, B8 is already incorporated).

Option B9 improves the signals-to-noise ratio. e.g. for measuring the adjacent-channel selectivity far beyond 80 dB.

SMDU with option SMDU-B2



SMDU

Signal Generator SMDU ♦ 15 Hz to 525 (1050) MHz

- Extendable signal generator coming in different models, general RF measurements: **universal model** with modulation unit meeting highest requirements and including AF voltmeter
- Extremely high frequency stability and spectral purity, crystal control with option
- Easy to operate, rapid frequency selection, single-range output attenuator of highest precision
- Output EMF 0.05 μV to 2 V

Overview models and options on pages 64/65.

The **SMDU** family of signal generators can be used for all kinds of measurements on active and passive components, modules and units. These generators are

of precise electrical performance,
economical thanks to available options and
versatile in application.

They comply with all national and international standard specifications for measurements on receivers and RT equipment (including aeronautical communication). Other user-oriented features are:

- suitable for stereo operation at carrier and intermediate frequencies (very low modulation distortion even with multiplex signals),
- frequency locking with selectable channel spacing (radiotelephony channels) using synchronizer option,
- DC coupled FM input for narrowband sweeping.

The **SMDU family** comprises models for

general RF measurements,
air navigation and communication,
RT measurements

Overview on pages 64/65

In addition to these different models several options can easily be added, permitting an optimum, user-oriented system configuration.

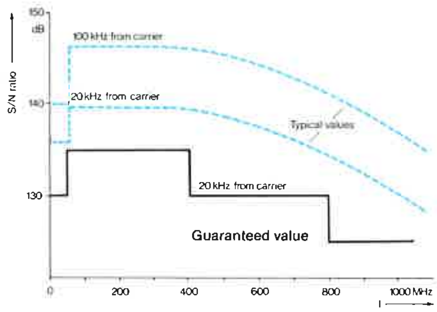
Details on the application of the SMDU for air-navigation and RT measurements are included in the discription of the corresponding test assembly.

SMDU model for general RF measurements

Universal model with AM/FM capability meeting highest requirements, internal modulation frequencies 15 Hz to 150 kHz, AF voltmeter with autoranging facility.

The SMDU includes an RF generator 0.14 to 525 MHz and a frequency meter up to 525 MHz. Any of the options available (see pages 64/65) can be incorporated. For power measurements, the power test adapter or the AM unit (which also measures modulation depth) can be used.

Frequency adjustment by pushbuttons (ranges) and continuous in-between ranges. Frequency indication: coarse on analog scale, fine by seven-digit readout. High frequency stability reached shortly after switching on permits measurements on steep-edged filters and receivers with narrow channel spacing. The SMDU reaches synthesizer stability using the synchronizer option. By means of synchronization, frequency locking is possible at the standard channel spacings. Electronic fine tuning permits the adjustment of intermediate values to an accuracy of a few hertz. Using option SMDU-B3 extends the range up to 1.05 GHz without sacrificing performance. Option SMDU-B5 also permits range extension up to 1.05 GHz, however, with reduced harmonics suppression. When adding any of the two frequency extension options, it is recommendable to order also the option SMDU-B8 (for AM up to 1050 MHz); this option is already incorporated when ordering a new SMDU with frequency extension.



Signal-to-noise ratio as a function of carrier frequency and offset from carrier at 1-Hz test bandwidth; for frequency deviations >100 kHz 6 dB less

(even better values are obtained with option SMDU-B9)

Modulation (internal and external). For the universal model, AM up to 98% and FM with maximum deviation 1000 kHz (also AM+FM) with very low distortion (<0.15% at 100 kHz deviation). Switch-selected preemphasis of 50 or 75 μs for FM. The typical distortion factor of the modulation generator (15 Hz to 150 kHz) in the AF range is 0.1%. Automatic range selection (can be switched off) and automatic selection of units (kHz, mV, %) for modulation indication. The output voltage of the modulation generator is adjustable between 5 mV and 1 V. Narrowband sweeping via the DC coupled FM input is possible.

RF output signal. Flat frequency response (output levelling) over entire level range and high-accuracy level adjustment. The high output voltage (2 V EMF) can be reduced accurately to as low as 0.05 μV EMF by means of a single-range attenuator with large attenuation range. The carrier can be suppressed without affecting the impedance (pushbutton). The high spectral purity of the output signal permits the SMDU to be used as interfering-signal source in multi-signal measurements.

Frequency measurement. The seven-digit frequency meter of the SMDU measures all internally produced and externally applied signals from 15 Hz to 525 MHz with a maximum resolution of 1 Hz or 10 Hz. The option SMDU-B4 extends the range to 1000 MHz for external signals, the resolution then being 10 Hz. The measured frequency is available at a data output in BCD code.

AF voltage measurement. The AF voltmeter of the universal model also measures external AF voltages (average-responsive rectification) in addition to modulation generator voltages and forms together with the modulation generator an AF level measuring assembly.

Overload protection. The option SMDU-B2 automatically prevents excessive external RF and DC voltages from affecting the output of the SMDU.

Specifications (options included)

Frequency range .... 0.14 to 525 MHz (8 subranges)
with 1.05 GHz frequency range extension .... 0.14 to 1050 MHz (11 subranges)
Indication .... 7-digit readout and analog scale
Control crystal .... 10 MHz (external: TTL)
Aging .... <5×10⁻⁸/month
Error limits and resolution of indication:

Frequency	0.14 to 50 MHz	50 to 800 MHz	800 to 1050 MHz
Digital	1 or 10 Hz	10 or 100 Hz	0.1 oder 1 kHz
Analog	±5% +300 kHz	±1%	±1%

Frequency variation (within 10 min measuring time):

	free-running	with synchronizer option locked	with synchronizer option +fine running
Warmup time	3 h	15 min	15 min
0.14 to 200 MHz	<1.5 kHz	<5×10⁻⁸ +10 Hz	<100 Hz
200 to 525 MHz	<3 kHz		<5×10⁻⁷
525 to 1050 MHz	<6 kHz		

Spacing of locking points (with synchronizer) .... 12.5/20/25/50/100/150 kHz
Frequency settability

	free-running	with electronic fine tuning	
0.14 to 64 MHz	approx.100 Hz	<5/ to/<20 Hz	depending on spacing of locking points
64 to 525 MHz	approx.100 Hz	<10/ to /<25 Hz	
525 to 1050 MHz	approx. 150 Hz	<20/ to /<50 Hz	

Harmonics (dB) .... 0.14 to 50 MHz: >26, typ. 30 down
50 to 525 MHz: >35, typ. 40 down
525 to 1050 MHz: >26, typ. 30 down
Spurious responses, if any .... >90 dB, typ. 100 dB down
Incidental AM with f_{mod} = 1 kHz .... <1%, typ. 0.5% at 100 kHz deviation (for f >1 MHz)
with option SMDU-B9 .... <3%, typ. 1% at 100 kHz deviation (for f >20 MHz)

RF output .... N female connector (adaptable); Z_{out} = 50 Ω
Output EMF or level .... 0.05 μV to 2 V EMF/ −139 to +13 dBm
Scale calibration (linear) .... V EMF/dBm/dBV/V into 50 Ω
Resolution .... 0.7 mm/dB or 16 mm/dB
Min. output-voltage increment .... 0.25 dB
Attenuator error 0.4 to 525 MHz down to 140 kHz .... ±1 dB
and up to 1050 MHz .... <±2 dB
Carrier suppression .... pushbutton on front panel
(VSWR) <0.2 V EMF .... <525 MHz: <1.2; >525 MHz: <1.4
RF output (on rear panel) .... N female (adaptable) ≧20 mV into 50 Ω

Frequency meter (7 digits)

	Resol. (Hz)	Input (ext. max. 10 V)
Int. 15 Hz to 50 MHz	1/10	matched
50 to 800 MHz	10/100	
800 to 1050 MHz	100/1000	
Ext. 15 Hz to 30 MHz	1/10	>10 mV into 10 kΩ ‖ 20 pF
20 to 1000 MHz	10/100	>10 (>525 MHz: >30) mV into 50 Ω

Recorder output .... BCD (TTL-level)
Modulation .... AM, FM, AM + FM

Mod. Generator .... 15 Hz to 150 kHz
Indication .... analog and digital, resolution 1 Hz
Distortion factor .... 50 Hz to 53 kHz: <0.2%, other ranges: <0,5%
V_{out} (Z_{out} = 200 Ω) .... 5 mV to 1 V into 600 Ω
Indication ranges .... 10/30/ ... /3000 mV
Error limits .... ±(3% of rdg +1.5% of fsd)
Frequency resp. .... <2%, typ. 1%

AM .... internal and external
Modulation depth .... for V_{out} ≦1 V EMF: up to 98%
for V_{out} up to 2 V EMF: decreasing linearly to 30%
Ranges: $f_{carrier}$ (MHz) .... 0.14 to 0.45 | 0.45 to 8 | 8 to 525
f_{mod} (kHz) .... 0.03 to 4 | 0.03 to 10 | 0.03 to 100
Distortion factor .... 0.45 to 525 MHz: <1(2)%; 140 to 450 kHz: <3% — f_{mod} <4 kHz, m = 80%
Idicating ranges 3/10/30/100%
Error (≦1 V EMF) .... 0.45 to 525 MHz: <±3%; 140 to 450 kHz: <±5% — f_{mod} <4 kHz, m = 80%
V_{in} for ext. AM .... 15 mV/%

FM .... internal and external
Frequency deviation
$f_{carrier}$ (MHz) .... <525 | >525
Deviation (kHz) .... 0 to 500 | 0 to 1000 (ranges.: 10/100/1000)
f_{mod} .... 15 Hz to 150 kHz if AC-coupled
0 to 150 kHz if DC-coupled
100 Hz to 150 kHz with synchronizer option
Distortion factor .... <1%
broadcast range: <0.15%
Crosstalk with stereo .... f_{mod} 50 Hz: >40 dB down
1 kHz: >46 dB down
15 kHz: >46 dB down
Preemphasis .... 50/75 μs
Ind. ranges (kHz) 3/10/30/100/300/1000
Error .... ±(5% of rdg +1.5% of fsd)
V_{in} for ext. FM .... Δf 100 kHz: <50 mV/kHz (Δf >100 kHz: <10 mV)

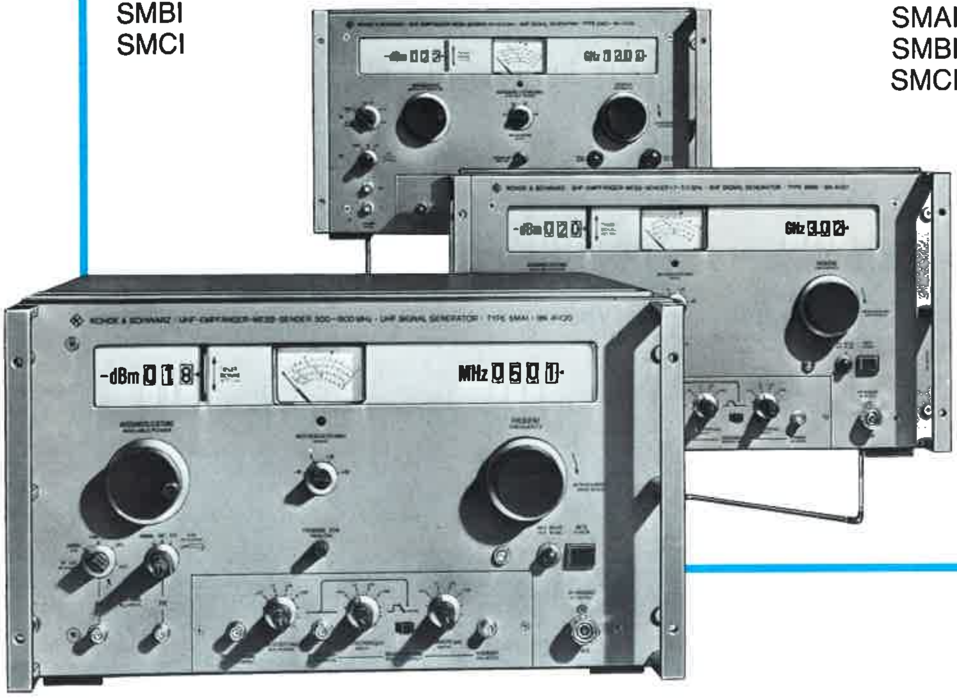
AF-Voltmeter .... 15 Hz to 150 kHz
1 mV to 3 V
Input .... >100 kΩ ‖ 10 pF; BNC
Indicating ranges .... 10/30/ ... /3000 mV
Error limits
15 Hz to 53 kHz .... ±(2% of rdg +1.5% of fsd)
53 to 150 kHz .... ±(5% of rdg +1.5% of fsd)

Overload protection (option) .... responds automatically if excessive RF power or DC voltage is applied to the RF output
Max. perm. level .... 50 W, 50 V
Indication .... LED

General Data
AC supply .... 115/125/220/235 V ±10%, 90 to 120 VA (depending on model)
Dimensions and weight .... 492 mm×294 mm×436 mm, 26 kg
Order designation .... ▶ Signal Generator SMDU
Universal model 249.3011.04
Universal model with option B1 .... 249.3011.34
Air-navigation model 249.3011.08
Air-navigation with option B1 .... 249.3011.38
Accessories supplied .... power cable

Options
SMDU-B1: Synchronizer 249.6340.02
SMDU-B2: Overload Protection 249.7346.02
SMDU-B3: 1.05-GHz Frequency Range Extension 249.9484.02
SMDU-B4: 1-GHz Frequency Meter 250.0012.02
SMDU-B5: 1.50-GHz Frequency Doubler 275.1312.02
SMDU-B8: Amplitude Modulation 525 to 1050 MHz 295.2150.02
SMDU-B9: S/N Ratio Improvement 295.2189.02

SMAI
SMBI
SMCI



UHF-SHF Signal Generators

SMAI ♦ 500 to 1800 MHz
SMBI ♦ 1.7 to 5 GHz
SMCI ♦ 4.8 to 12.5 GHz

- Constant output power with all signal generators
- Suitable for wide range of FM and pulse modulation applications, AM up to 70%
- Frequency-linear shaft for connection of recorder

Signal generators for UHF and SHF

Types **SMAI, SMBI and SMCI** form a family of modern signal generators which span the entire frequency range from 500 MHz to 12.5 GHz.

The signal generators are suitable for applications such as:

Measurements on receivers:

Noise figure
Dynamic range
Control characteristics
Selectivity
Conversion loss
Image rejection

Measurements on two-port networks:

Reflection coefficient
(using directional coupler
or impedance-match bridge)
Attenuation constant
(passband characteristic,
point-by-point or swept)

Uses in radar systems. Sensitivity measurement, simulation of echo pulses for checking the indication. Due to its high modulation quality, the SMAI is particularly well suited for measurements on DME and ATC equipment.

The **synchronization facility** makes possible measurements requiring extreme frequency stability: on narrowband AM and FM transmission systems, filters with sharp cutoffs, Doppler radar systems.

Advantages of ALC. The ALC also permits amplitude modulation up to 70%. To obtain the full output power, the ALC can be switched off.

The ALC facility leads to new applications.

Attenuation measurement and recording is possible using the signal generators with ALC since the power input to the two-port network remains constant and the attenuation characteristic can immediately be seen from the output power.

Operation

Frequency setting with digital indication on roller counters. A friction drive with high gear reduction ensures both rapid tuning and high resolution. A frequency-linear shaft, accessible through the side wall, permits the connection of a recorder or control unit. Attenuation or selectivity curves can thus be plotted automatically.

The **frequency stability** is sufficient even for narrowband test items. Most stringent requirements – e.g. in the field of microwave spectroscopy – are met when the signal generator is synchronized with the harmonic of a crystal oscillator (second RF output) by means of suitable equipment.

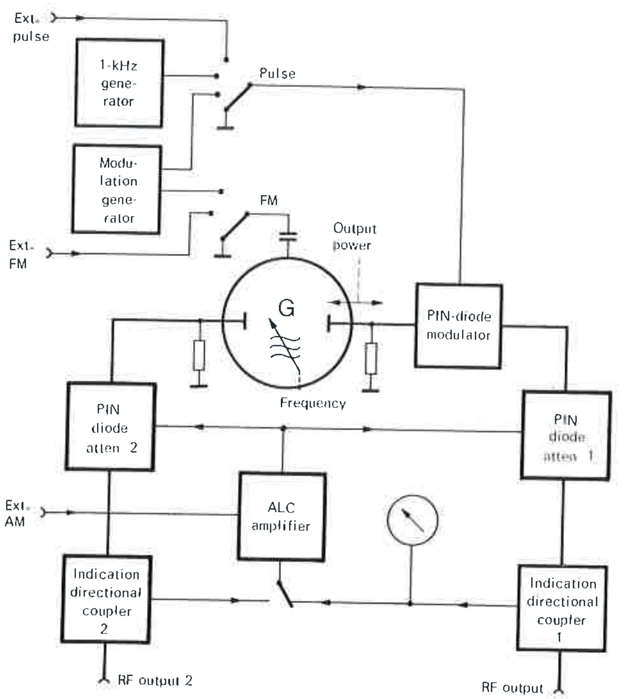
Versatile modulation characteristics are obtained when the plug-in modulation unit (to be ordered separately) or a pulse generator is employed. Simultaneous FM and pulse modulation are possible.

A PIN-diode modulator in the output circuit generates the pulse modulation with a carrier suppression of greater than 80 dB. The signal generator is designed for internal and external pulse modulation. Owing to the built-in modulation amplifier, an input voltage of 2 V is sufficient for full modulation. The signal for internal pulse modulation is delivered either by the built-in 1-kHz generator or by the plugged-in modulation unit. The latter permits adjustment of the repetition frequency, pulse width and delay and can therefore produce all commonly used radar pulses.

External frequency modulation is possible with all versions. If the modulation unit is being used, it delivers a sawtooth voltage with adjustable repetition frequency for internal FM.

The RF energy is coupled out by a piston attenuator. The available output power is indicated by the meter (large values) or can be read from the attenuator (smaller values down to −130 dBm). Constant output level is achieved by two PIN diodes. At the same time, the diodes are used for the amplitude modulation of the output signal.

During pulse modulation, an unmodulated signal is available at the second RF output; it can be applied to a frequency meter or used for frequency synchronization in the pulse mode.



Block diagram of the SMAI with modulation unit

Specifications

	SMAI	SMBI	SMCI
Frequency range	0.5 to 1.8 GHz	1.7 to 5.0 GHz	4.8 to 12.5 GHz
Frequency setting	frequency-linear single-knob tuning in one range		
Frequency indication	on roller counters		
Error limits	±0.5%	±0.5%	±0.5%
Scale resolution	100 kHz/div.	1 MHz/div.	1 MHz/div.
Frequency drift due to change of temperat.	$\leqq 7\times10^{-5}$/°C	$\leqq 7\times10^{-5}$/°C	$\leqq 4\times10^{-5}$/°C
Residual FM	≦1.5 kHz	≦1.5 kHz	$\leqq 1.5\times10^{-6}$
Output level	≧+10 dBm (≧+8 dBm)	≧+5 dBm (≧0 dBm)	≧0 dBm
Adjustment range	+10 to −130 dBm	+5 to −130 dBm	0 to −130 dBm
Smallest readable attenuator increment	0.1 dB	0.1 dB	0.1 dB
Residual AM	down ≧60 dB	down ≧60 dB	down ≧60 dB
Amplitude variation due to ±10% AC supply change	≦0.02 dB	≦0.02 dB	≦0.02 dB
Output impedance	50 Ω	50 Ω	50 Ω
Connector (adaptable)	N female	N female	N female
VSWR	≦2.5	≦2.5	≦2.5
Residual amplitude variation	≦ ±1 dB (≦ ±1.75 dB +att. error)	≦ ±1 dB (≦ ±2 dB +att. error)	≦ ±1 dB (≦ ±2.5 dB +att. error)
Residual AM with ALC	≦1%	≦1%	≦1%
Second RF output	on rear panel for frequency meter or synchronizer		
Output power	≧−15 dBm	≧−20 dBm	≧−15 dBm
Output impedance	50 Ω	50 Ω	50 Ω
Modulation			
Pulse – internal			
Repetition frequency	1000 Hz	1000 Hz	1000 Hz
Pulse width	0.5 ms	0.5 ms	0.5 ms
Rise/fall time	≦100 ns	≦100 ns	≦50 ns
Pulse – external			
Repetition frequency	0 to 200 kHz	0 to 200 kHz	0 to 1 MHz
Pulse width	min. 0.3 µs	min. 0.3 µs	100 ns to 5 ms
Rise/fall time	≦100 ns	≦100 ns	≦50 ns
FM – external	10 Hz to 500 kHz	10 Hz to 500 kHz	1 Hz to 10 MHz
Sensitivity	30 (50) kHz/V Z_{in} = 180 Ω	50 kHz/V Z_{in} = 180 Ω	for max. dev.: 2 V_{pp}
AM – external	10 Hz to 100 kHz, 0 to >70%	10 Hz to 100 kHz, 0 to >70%	10 Hz to 100 kHz, 0 to >70%
With modulation unit			
Pulse – internal			
Repetition time	0.02 to 200 ms	0.02 to 200 ms	0.02 to 200 ms
Pulse width	0.3 to 1000 µs	0.3 to 1000 µs	0.1 to 1000 µs
FM – internal (sawtooth)			
Modulation frequency	50 Hz to 50 kHz	50 Hz to 50 kHz	5 Hz to 50 kHz
Trigger output	pos., delayed 0.1 to 1000 µs	pos., delayed 0.1 to 1000 µs	pos., delayed 0.1 to 1000 µs
Trigger input	negative	negative	negative
Synchronization			
Tuning range	0.25×10^{-3}	0.25×10^{-3}	0.5×10^{-3}
Voltage requirement	max. 20 V	max. 20 V	max. 20 V
General data			
Rated temperature range	+10 to +35 °C (storage temperature range: −20 to +75 °C)		
Power supply	115/125/220/235 V ±10%, 47 to 63 Hz		
Dimensions, weight	484 mm×283 mm×512 mm, 31 kg		

Ordering information

Order designations ▶ Signal Generator

	SMAI	SMBI	SMCI
	100.4594.13	100.4607.13	100.4613.03
Modulation Unit	SMAI-E 100.4636.02	SMBI-E 100.4636.02	SMCI-E 100.4636.02

Accessories supplied 1 power cord, 1 shortcircuit N plug

SMLU

Power Signal Generator SMLU

♦ 25 to 1000 MHz

- Wide frequency range with seven linear subranges
- Maximum output level 33 dBm (2 W) with ALC
- External frequency sweep possible; frequency, range and power programmable

For use as a power sweep generator see page 72

IEC-bus compatible using Code Converter PCW

The **Power Signal Generator SMLU** offers the perfect solution to all measurement problems where the output level of conventional signal generators is insufficient. Thanks to its wide frequency range, ALC and sweep facility as well as its capability to be extended to form a system (see page 72), the SMLU is particularly suitable for measurements

on power stages and transistors, frequency multipliers,
of antenna directional patterns and impedances,
of intermodulation and crossmodulation at high levels,
of attenuation, reflection coefficient and transfer impedance of cables.

The Sweep Unit SMLU-Z extends the SMLU to a wideband power sweep generator for 25 to 1000 MHz while the Frequency Controller SMLU-Z3 permits measurement of the SMLU output frequency, synchronization, measurement of the marker frequency during swept-frequency operation and frequency programming.

Characteristics and function

For each frequency subrange, the SMLU has a separate voltage-controlled oscillator, operating at the output frequency. A diode network ensures extremely good linearization of the tuning characteristic.

The provision of ALC and a well-defined 50-Ω output open up a number of new possibilities.

Frequency selection. Pushbutton selection of frequency range, fine adjustment accurate to $\leqq 1 \times 10^{-4}$ on linear scale with 0.2 to 5 MHz resolution. Manual tuning, programming and sweeping possible.

Sweeping. Either single internal sweep of one frequency subrange lasting 20 s – e.g. when using a chart recorder – or external sweep with f_{sw} = 0 to 50 Hz and max. sweep width = 1 subrange. The deflection voltage (sawtooth) of any oscilloscope is suitable as the sweep voltage. Frequency modulation is possible with manual or programmed adjustment of the centre frequency.

For wideband sweeping over any subrange or the total range using the sweep unit see page 72.

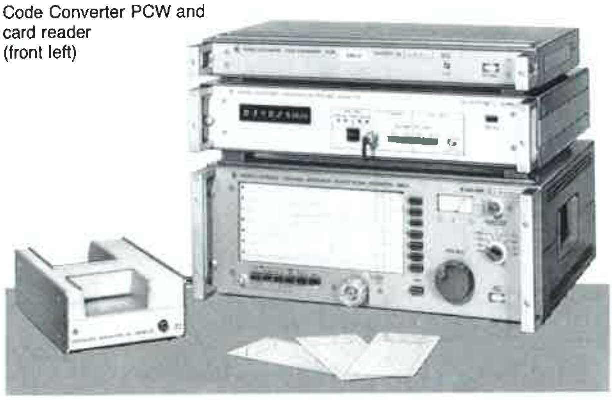
Modulation characteristics. In addition to FM (see under „Sweeping"), internal and external amplitude modulation of the SMLU output signal is possible. Amplitude modulation is performed via the ALC amplifier, ensuring a very linear modulation characteristic even at large depths of modulation. Internal AM: 1 kHz, m = 70%. External AM: 10 Hz to 8 kHz, m = 90% (6.5 V_{pp} for 80%).

The output power is extracted via a broadband directional coupler and kept constant by means of an ALC amplifier. The output power can be reduced continuously by 10 dB through variation of the reference level and also attenuated in 5-dB steps up to a maximum of 35 dB with a variable attenuator. Panel meter indication of level. An internal protection circuit prevents overloading of the power stages when the signal generator is mismatched.

Frequency and output-level programming

Frequency, range and output level can be programmed in parallel in BCD code, the level in steps of 0.5 dB. Via the Code Converter PCW, the SMLU can be combined with any IEC-bus-compatible measuring instruments and computers, thus forming any desired computer-controlled test assemblies.

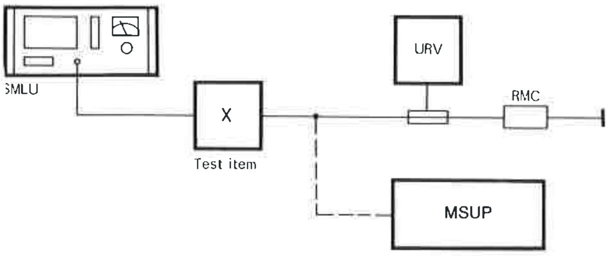
Programmable test assembly with Frequency Controller SMLU-Z3, Code Converter PCW and card reader (front left)



Applications of SMLU

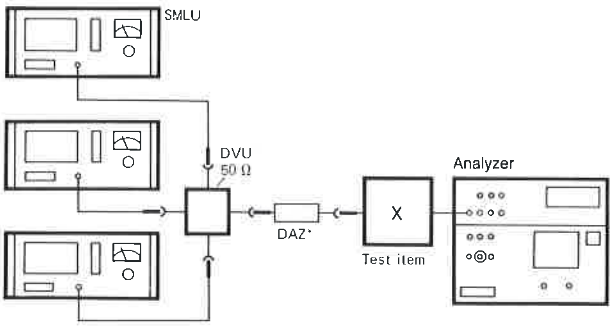
Test setup for transmission measurements

In conjunction with a broadband voltmeter (e.g. the URV 4) a dynamic range of up to 80 dB is obtained. Measurements up to 130 dB are possible using selective test equipment such as the MSUP.



Test setup for intermodulation and crossmodulation measurements

The Power Signal Generator SMLU is ideal for this purpose. Its hight output power of 2 W (1 W) enables good isolation of the three signal generators, minimizing intermodulation and crossmodulation products. The wide frequency range from 25 to 1000 MHz covers all TV bands, permitting easy measurements. Programmability makes for further simplification of the measurement; see photo on page 70.



*Matching pad if required

The three SMLUs are connected via the Four-port Junction Box DVU 4 (201.4018.03). The output impedance ist 50 Ω. For measurements on 6-Ω or 75-Ω test items a matching pad (DAZ) can be used.

Matching pad 50 → 60 Ω: 242.1013.02
(attenuation 0.79 dB)

Matching pad 50 → 75 Ω: 242.1513.02
(attenuation 1.76 dB)

Interaction of the three signal generators is precluded by setting the output attenuator of each signal generator to an adequate value. A fine control is provided on the SMLU for fine level adjustment. If the input level at the test item is to be varied, it is best to insert an adjustable attenuator (RF Step Attenuator DPSP 334.6010.02) between the fourport junction box and the matching pad or test item.

Automatic rest setups for

- intermodulation and crossmodulation measurement
- RF cable measurements

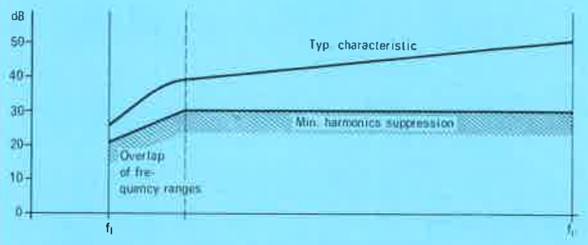
see under RF test asemblies, section 3.

Specifications

Frequency range	25 to 1000 MHz
Subranges	25 to 44/42.5 to 74/70.5 to 125/119 to 210/200 to 352/337 to 595/570 to 1000 MHz
Error of frequency indication	≦ ±2%
Residual FM (10 Hz to 100 kHz test bandwidth)	0.7 to 15 kHz, depending on range
Drift (after 70 minutes of operation)	100×10^{-6}/10 min
Effect of load	230×10^{-6} (between short- and open-circuit)
Frequency synchronization	via 2nd RF output and frequency control output

Output power with ALC

Frequency subranges	
1 to 6 (25 to 595 MHz)	≧ +33 dBm (2 W, 10 V into 50 Ω)
7 (565 to 1000 MHz)	≧ +30 dBm (1 W, 7 V into 50 Ω)
With AM: 1 to 6	≧ +33 dBm PEP
7	≧ +30 dBm PEP
Attenuation	
fine	−10 dB (progr. in 0.5-dB steps)
coarse	−35 dB in 5-dB steps
Attenuator error	≦ ±0.12 dB per 5-dB step
Meter	+22 to +33 dBm (3 to 10 V)
Reflection coefficient	≦15% (VSWR ≦1.35)
Connector	N female, adaptable
Harmonics	range 1: ≧30 dB down, for all other ranges see diagram



RF output II (rear)

Output power	30 dB below meter indication
Source impedance; connector	50 Ω; BNC female

Modulation

AM internal	modulation frequency 1 kHz, modulation depth 70%
AM external	10 Hz to 8 kHz, max. 80%; V_{in}: 2 to 12 V for 80% modulation

Sweeping

Internal	single sweep of one frequency subrange within 20 s
External	0 to 50 Hz (sawtooth), max. 1 subrange, input requirement 0 to +10 V
External sweep Δf	FM with centre frequency set by manual or programmed adjustment; 0 to 8 kHz
Output for frequency-proportional voltage	0 to +40 V, on rear, Z_{out} = 10 kΩ

Remote control (programming)

Logic function of control inputs	negative logic, TTL-compatible
Programming input	BCD code in parallel for frequency, range and level

General data

Rated temperature range	+10 to +40°C
Storage temperature range	−20 to +70°C
AC supply	115/125/220/235 V ±10%, 47 to 440 Hz (100 VA)
Dimensions, weight	484 mm×194 mm×436 mm, 18.6 kg

Ordering information

Order designation	▶ Power Signal Generator SMLU 200.1009.03

Recommended extras

For remote control via IEC bus:	
Code Converter PCW (section 1)	244.8015.92
Code Converter Board for SMLU	245.2610.02
Sweep Unit SMLU-Z (page 73)	243.3010.92
Frequency Controller SMLU-Z3	242.5019.92

SMLU alone and with accessory units (blue): Sweep Unit SMLU-Z (centre) and Frequency Controller SMLU-Z3 (top)

SMLU System

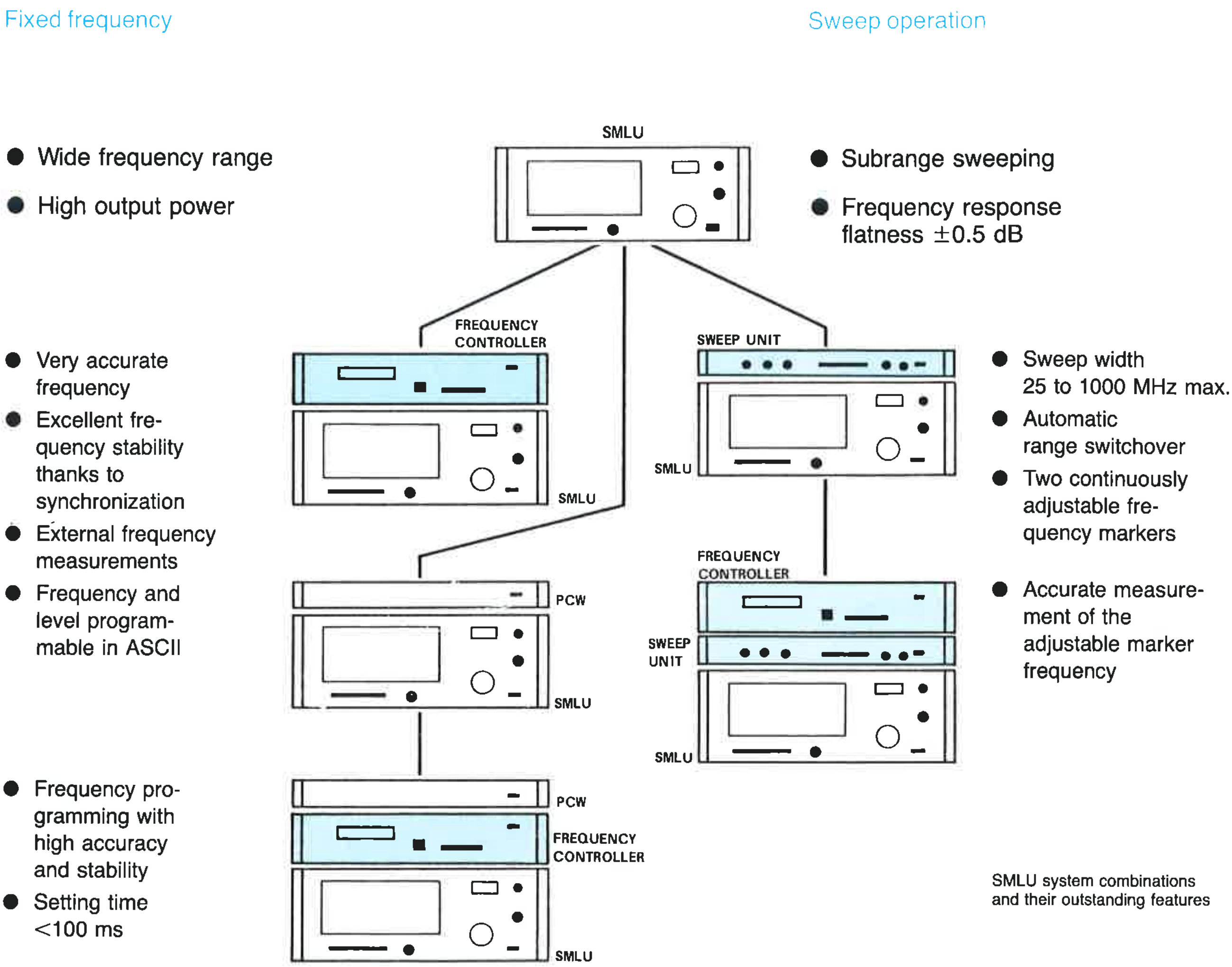
The **Power Signal Generator SMLU** – a standard instrument for a variety of measurement tasks in the range 25 to 1000 MHz (see page 70) – is system-compatible and can be adapted with great flexibility to the particular task at hand by simply connecting the accessory units

Sweep Unit SMLU-Z,
Frequency Controller SMLU-Z3

and/or Code Converter PCW (for serial programming, see section 1).

This combination constitutes an extremely wideband sweep generator of high output level which permits very rational and time-saving execution of all broadband measurements.

The following diagram gives an overall picture of the different combinations possible and their outstanding features.



SMLU system combinations and their outstanding features

Power Sweep Generator (SMLU+SMLU-Z)

The **Power Signal Generator SMLU** and the **Sweep Unit SMLU-Z** constitute a wideband power sweep generator for the range 25 to 1000 MHz.

The whole frequency range or any part thereof can be swept through. Switchover between the seven subranges is made automatically by the sweep unit during the sweep process. The start and stop frequencies can be set independently over the whole frequency range. The sweep is logarithmic so that the frequencies at the beginning of the range can be adjusted with the same relative accuracy as those at the end.

The sweep time can be varied over a wide range, enabling optimum conditions for each test item. A lamp signals unsuitable settings.

Single sweep for recorder operation and manual scan are also possible. The necessary contacts for driving the recorder are provided.

Two electronic frequency markers can be shifted independently over the whole frequency range; they appear as bright spots on the display, for instance an oscilloscope. The marker frequency is indicated on the SMLU scale with the reading accuracy of the SMLU or can be measured with an external digital frequency counter. A counter output is provided. The start or stop frequency can also be indicated by pressing a pushbutton.

The measured curve can be represented on a simple oscilloscope or an inexpensive VDU.

SMLU + sweep unit = power sweep generator

Specifications of SMLU + SMLU-Z

Sweepable frequency range	25 to 1000 MHz or any part thereof
Sweep width	max.: total range min.: 0.75 × 10^{-3} of centre frequency
Sweep time, adjustable	10 to 1000 ms, single sweep 2 to 200 s
Output power, stability, harmonics content	same as for SMLU, page 71
Frequency markers	bright spots or marker pulses
Marker output	+5 V_p; BNC female connector
X output voltage	0 to +10 V; BNC female connector
Blanking output, switch-selected	+15 V_p; BNC female connector
Switching contact for recorder control	max. 20 V/1 A
AC supply	115/125/220/235 V ±10%; 47 to 440 Hz (100 + 12 VA)
Rated temperature range	+10 to +40°C
Dimensions, weight (SMLU + SMLU-Z)	484 mm×260 mm×436 mm, 24 kg
Order designations	▶ Power Sweep Generator SMLU + SMLU-Z
(order units separately)	
SMLU with programming unit	200.1009.03 and
Sweep Unit SMLU-Z	243.3010.92

Frequency Controller SMLU-Z3
♦ 10 to 1000 MHz

In addition to the Sweep Unit SMLU-Z another add-on unit to the Power Signal Generator SMLU for 25 to 1000 MHz is available in the **Frequency Controller SMLU-Z3.**

This unit gives a 6-digit frequency readout in the range of 100 Hz to 1000 MHz and is ideal for the following four tasks:

1. Measuring the SMLU output frequency with a resolution of 1 kHz or 10 kHz.
2. Synchronization, meaning that any frequency adjusted on the SMLU can be maintained with crystal stability by pressing a button.
3. Accurate measurement of the marker frequency in operation with the sweep unit; sweep width is adjustable from 25 to 1000 MHz.
4. Programming the SMLU frequency rapidly (<100 ms) and accurately (10 kHz).

External signal frequencies from 100 Hz to 1000 MHz can also be measured; sensitivity 10 mV, resolution 10 Hz.
The Frequency Controller SMLU-Z3 is driven via the second RF output of the SMLU; the frequency is indicated on a 6-digit readout.

SMLU-Z3

Specifications of SMLU-Z3

Frequency range	10 to 1000 MHz
Indication	6 digits (7-segment LEDs)
Measurement error	±1 digit + error of timebase
Input 1	Z_{in} = 100 kΩ || 30 pF (BNC)
Frequency range	100 Hz to 30 MHz
Resolution	10 Hz or 100 Hz, pushbutton-selected
Input voltage	10 mV to 2 V
Input 2	Z_{in} = 50 Ω (BNC)
Frequency range	10 to 1000 MHz
Resolution	1 kHz or 10 kHz, pushbutton-selected
Input voltage	10 mV to 2 V (AGC)
Internal timebase	10 MHz, aging 1 × 10^{-6}/month
Synchronization with SMLU	
Deviation of centre frequency	±10 kHz
Capture and hold range	≧2%; setting time ≦100 (400) ms
Programming	TTL level, negative, BCD
Rated temperature range	+10 to +40°C
AC supply	115/125/220/235 V ±10%, 47 to 440 Hz (37 VA)
Dimensions, weight	492 mm×116 mm×392 mm, 7 kg
Order designation	▶ Frequency Controller SMLU-Z3 242.5019.92

SLRD

UHF Power Signal Generator SLRD ⧫ 0.28 to 2.75 GHz

- Output power up to 35 W, adjustable down to 1×10^{-8} W
- Model suitable for synchronization can be supplied
- External pulse modulation, internal squarewave modulation 1000 Hz

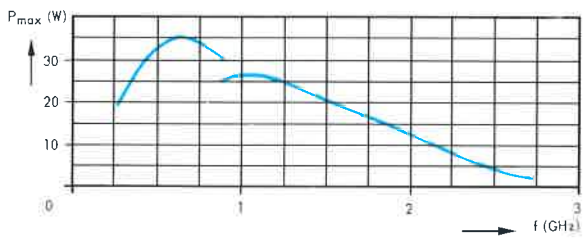
Single-stage **UHF Power Signal Generator SLRD** using a disc-seal triode oscillator and tunable coaxial resonantline circuits for anode and cathode. Both circuits have separate scales calibrated in MHz. The scale drives can be ganged (single-knob tuning). The whole frequency range is covered in two bands.

Single-knob manual tuning permit accurate adjustment of small frequency increments and rapid tuning through the whole range.

The SLRD model that is suitable for synchronization incorporates two diode tuning units providing signals of crystal accuracy and spectral purity. The tuning units may also be added later.

Modulation characteristics. Internal 1-kHz squarewave modulation of high stability; external pulse modulation possible with rise and fall times of 0.08 to 2 µs and repetition frequencies up to 100 kHz.

The output power can be adjusted from maximum down to −50 dBm in accurate intervals, direct reading being provided by a directional coupler and a meter for levels from +47 to +9 dBm. A piston attenuator calibrated in dB permits the adjustment of low levels.



Typical values of maximum output power

Uses. Measurement of stopband and passband characteristics of filters and other two- and four-terminal networks of high attenuation, feeding of impedance meters (slotted lines, reflectometers), determination of propagation conditions and of transmission loss.

Specifications

Frequency range	280 to 2750 MHz
Error limits of indication	±2%
Frequency change due to temperature variation	$\leqq 7\times10^{-5}$/°C
Harmonics	typ. 20 dB down
Residual FM	1 to 10 kHz, depending on frequency
Residual AM	≧40 dB down
Synchronization	
Maximum tuning range	1×10^{-4} for 280 to 950 MHz 2×10^{-5} for 850 to 2750 MHz
Control voltage requirement	±20 V for max. tuning range
Modulation	
Pulse modulation (squarewave), internal	
Modulation depth	100%
Repetition frequency	1 kHz
Rise/fall time	0.08 to 2 µs
Pulse modulation, external	
Repetition frequency	0 to 10/0 to 100 kHz
Pulse width	4 µs to 1 ms
Rise/fall time	0.08 to 2 µs
Voltage requirement	3 V_{pp} into 150 Ω
Output power	
1st RF output (front panel)	Dezifix B, 50 Ω; adaptable
Max. output power	35 W, depending on frequency, see diagram on left
Min. adjustable power	−50 dBm (1×10^{-8} W)
Indication for powers	
> +9 dBm	on panel meter
< +9 dBm	on meter and dB scale of piston attenuator
Adjustment range of attenuator	0 to 70 dB
Attenuator error	± (1 dB + 0.05 dB/1 dB)
2nd RF output (rear panel)	Dezifix A, 50 Ω; adaptable
Output power	10 µW to 100 mW, depending on frequency; not adjustable
General data	
Rated temperature range	+10 to +35 °C
AC supply	115/125/220/235 V ±10%, 47 to 63 Hz (175 VA)
Dimensions, weight	484 mm×328 mm×512 mm, 38 kg

Ordering information

Order designations	▶ UHF Power Signal Generator SLRD 100.4194.02 (no synchronization)

Tuning units required for synchronization (on request, the SLRD is supplied with one or two tuning units which can also be added at a later date):

Range 280 to 950 MHz	▶ Tuning Unit SLRD-Z 100.4207.02
Range 850 to 2750 MHz	▶ Tuning Unit SLRD-Z 100.4213.02

Noise Generator SKTU

SKTU

⧫ 1 to 1000 MHz

- Easy determination of noise figure over a wide frequency range
- Scale calibration in F (noise factor) and noise figure (F_{dB})

Noise Generator SUF 2 on page 338 (20 Hz to 50 kHz – for white, pink, triangular noise and program replacement signal

The **Noise Generator SKTU** supplies a measurable and adjustable continuous white noise spectrum for the rapid and easy determination of the noise figure of amplifiers or receivers. The noise power is generated using a temperature-limited diode.

The receiver input voltage that gives the signal-to-noise ratio 1 with the measured noise figure and the given receiver bandwidth can be read in microvolts on the nomogram engraved on the left side of the front panel.

Specifications

Frequency range	1 to 1000 MHz		
Source impedance	50 or 75 Ω, depending on order number		
Noise power	continuously adjustable		
Indicating ranges	50 Ω	60 Ω	75 Ω
Noise factor, 1 to	6.5/33	8/40	6.4/32
Noise figure in dB, 0 to	8/15	9/16	9/15
Error of indication	0.5 (1) dB		
AC supply	115/125/220/235 V		
Dimensions, weight	470 mm×195 mm×260 mm, 9 kg		

Order designation	▶ Noise Generator SKTU
50-Ω model	100.4688.50
75-Ω model	100.4688.70

Theory of noise measurements

The **noise figure** of four-terminal networks is readily determined with the help of a generator producing white noise in the frequency range concerned. Such generators permit rapid measurements to be made without calculation. The results allow the comparison in sensitivity of different types of receivers or amplifiers.

Definition of noise factor

The **noise factor** F is the ratio of the signal-to-noise power ratio at the input to that at the output of a four-terminal network.

$$F = \frac{S_1/P_1}{S_2/P_2} = \frac{P_2}{G_0 P_1}$$

where
S_1 signal power at the input
$S_2 = S_1 G_0$ at the output
P_1 noise power at the input
P_2 at the output

The noise factor is by definition a dimensionless quantity.

$P_1 = kT_0\Delta f$ is the noise power due to the source impedance under the assumption that the temperature of the generator source impedance equals the standard noise temperature T_0. Then

$$F = \frac{P_2}{kT_0\,\Delta f\, G_0}$$

P_2 output noise power in W
k Boltzmann's constant in Ws/K
T_0 absolute ambient temperature in Kelvin
Δf effective noise bandwidth in Hz
G_0 power gain
kT_0 4×10^{-21} Ws

The total noise power at the output is referred to the amplified reference power of 1 $kT_0\Delta f$. P_2 is composed of this amplified reference power and the component produced by the noisy four-terminal network. Thus the noise factor can be split up

$$F = \frac{G_0 P_1 + P_2}{G_0 P_1} = 1 + \frac{P_2}{G_0 P_1} = 1 + F_Z$$

where F_Z represents the contribution of the noisy four-terminal network.

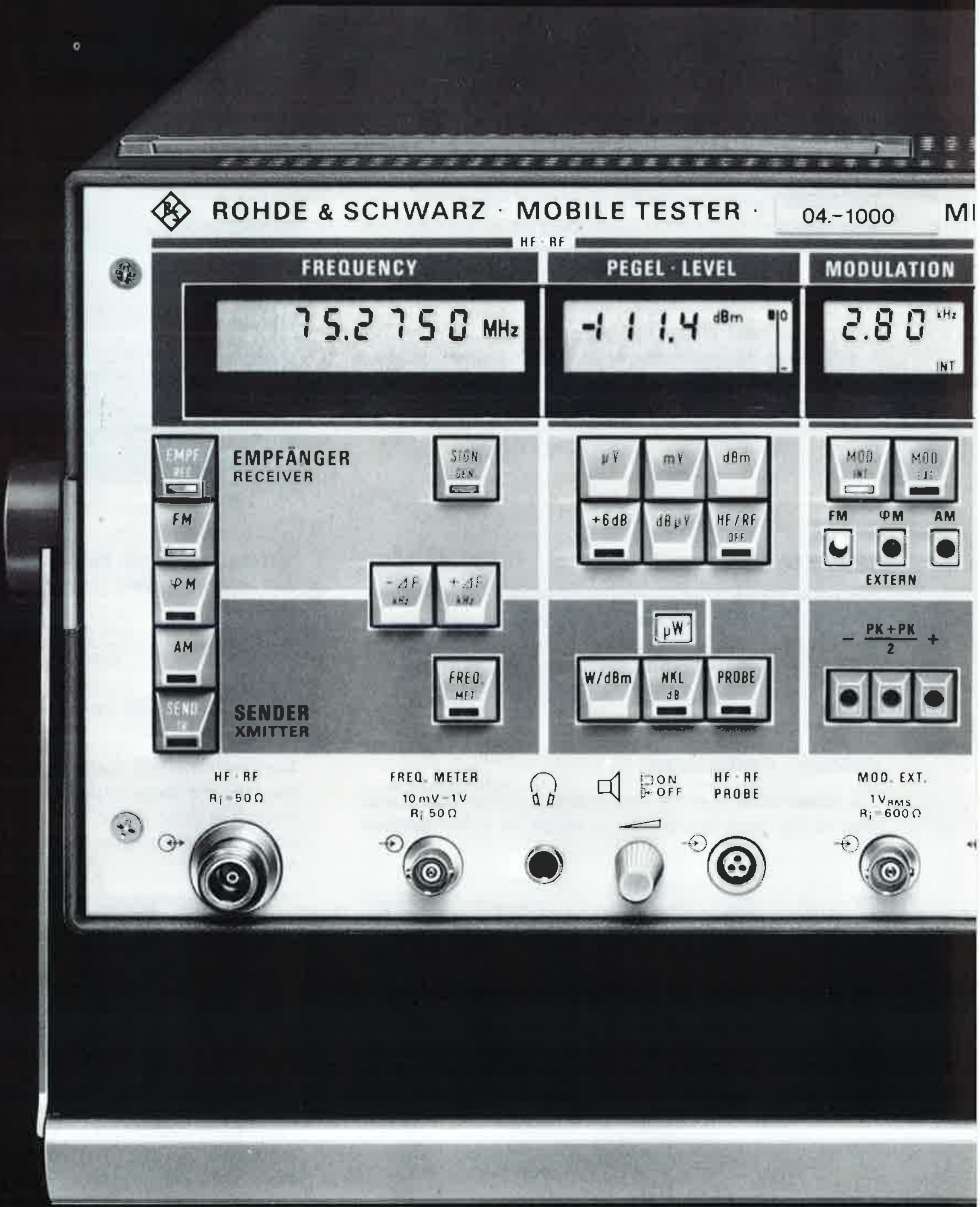
The definition of the noise factor is based on the assumption that only the linear transmission range of the four-terminal network is used in the measurement. Non-linearity would seriously alter the noise spectrum and thus lead to measurement errors.

The **noise figure in dB** is obtained as $F_{dB} = 10 \log F$.

Measurement of noise factor

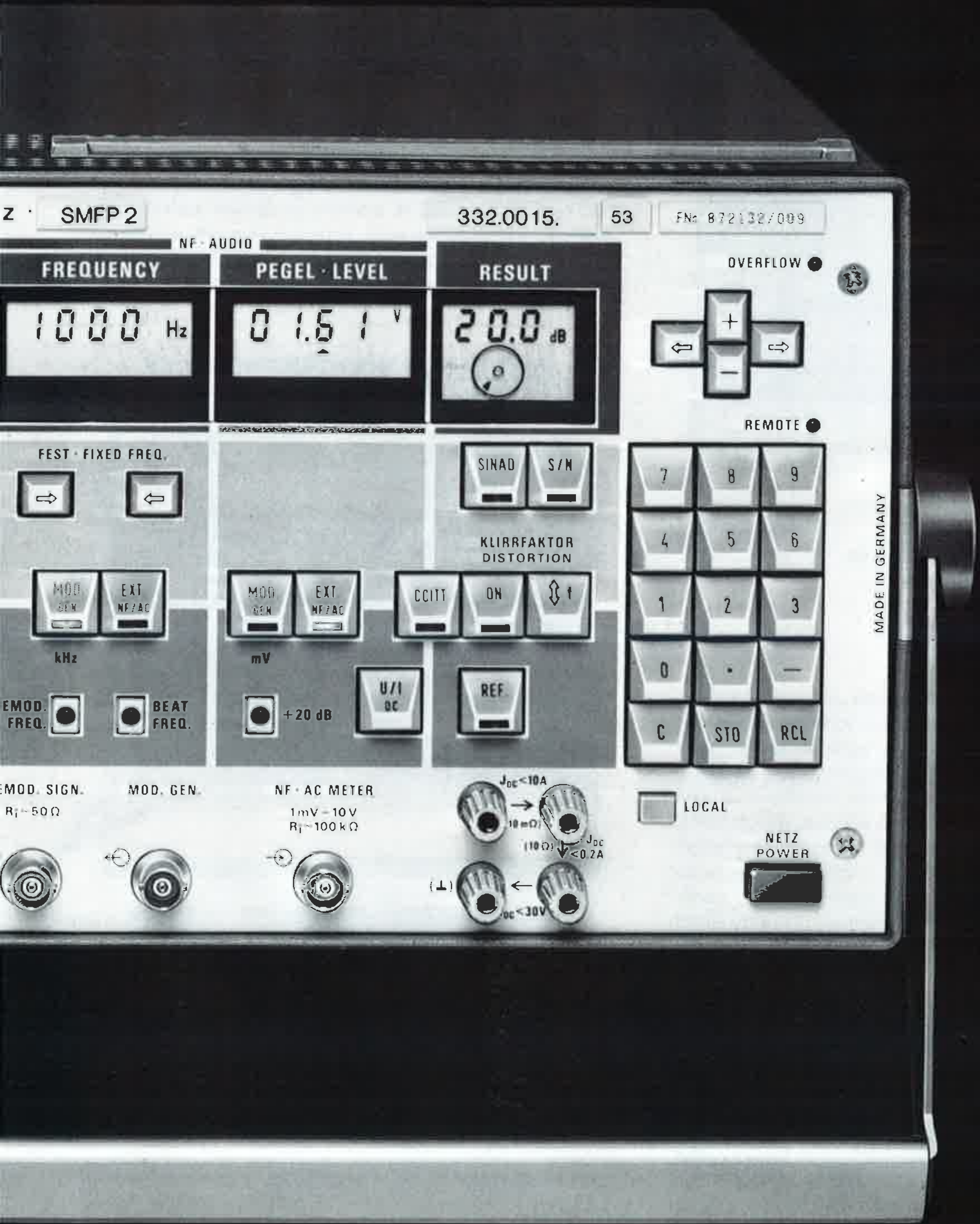
The definition of the noise factor does not specify the way in which the signal power is generated. It is possible to compare the signal power from a signal generator operating on a discrete frequency with the power of the noise spectrum which, dependent on the passband, appears at the output. To calculate this noise power it is necessary to determine the effective bandwidth. An easier way is to derive the signal power from a noise source. The signal of this noise source is subjected to the same bandwidths which act upon the noise spectrum applied to the input. The effect of bandwidth is thus eliminated. Generators delivering white noise (continuous spectrum with frequency-independent rms value) are therefore used for measurement.

Automatic
radiotelephone testing:
Mobile Tester SMFP2
0.4 to 1000 MHz; details on page 80



3

radiotelephone test assemblies



Radiotelephone test assemblies

Signal generators play an important role in checking out receivers during development, production and servicing. By complementing the signal generator with power, frequency and modulation meters as well as AF test equipment, a test assembly for checking transceivers is obtained.

For ten years Rohde & Schwarz has been combining measuring instruments to form transceiver test assemblies.

The latest generation of test assemblies, consisting of models SMFS2 and SMFP2, embodies a novel instrument concept for testing transceivers; automatic routines afford particularly great ease of operation.

Mobile Tester SMFS2 with Analog Display SMFS-B9

The Mobile Tester SMFS2 is a portable, manually operated unit with semi-automatic measurement routines for AM, FM and φM transceivers. It is primarily a maintenance test set for workshops and field service but thanks to its ease of operation and semi-automatic measurement routines it is also suitable for use in laboratories and production departments. When a transmitter signal is applied, its frequency, power and modulation are measured and indicated on separate displays. The test set adjusts the AF signal level at a standard audio frequency until the transceiver operates at its nominal modulation. Then the operator switches off the transmitter and the tests are performed on the receiver section. Again the SMFS2 automatically selects the standard parameters and indicates the RF level required to obtain the desired S/N ratio. The front panel of the tester is divided into areas for receiver or transmitter tests. Keys are provided for the selection of special functions such as RF level +6 dB or RF level off, external modulation and SINAD or S/N ratio.

The frequency of the built-in synthesizer can be varied via the keyboard in steps of any size, for example to match the channel spacing or to change between the upper and lower sidebands. Sensitive counters and deviation meters enable remote measurements to be performed on radio signals. A DC voltmeter/ammeter measures the DC voltages and currents of the transceiver. The SMF2 can be operated from a car battery.

An adjacent-channel power meter can be incorporated in the SMFS2 as an option. Also available are a reference oscillator of high stability, an AF synthesizer, a selective-call encoder, a selective-call decoder, a 60-W power meter, an RF millivoltmeter and a control interface.

The Mobile Tester SMFP2 is a programmable model, identical in operation and measuring capability with the SMFS2 and likewise suitable for all service applications. **Programmability via the IEC bus** makes this tester ideal for use in automatic test systems. A fully automatic transceiver test assembly for small-batch and large-scale production testing can be obtained by adding the Process Controller PUC. The extremely low price – you pay no more for the SMFP2 than for a conventional manually operated test assembly – makes it possible to set up value-for-money automatic and semi-automatic configurations for all repetitive measurements occurring in laboratories, production and servicing departments. In addition to the IEC-bus interface, the SMFP2 has 12 control lines (TTL levels and relays) for the control of the test item (transceiver) or auxiliary equipment such as relay matrices and switching units. In conjunction with an IEC-bus compatible printer, the SMFP2/PUC combination permits records of all measurements to be obtained.

Mobile Tester SMFP2 with Process Controller PUC

In the Automatic RX/TX Tester SMAT a go/nogo tester for transceivers is available for the first time with which, by means of an extremely fast performance test, the major parameters governing the performance of transceivers can be checked within seconds, the measured data compared to stored ratings and adherence to tolerance simply shown by green and red indicators.

The SMAT can store a variety of test programs for as many as 75 different transceivers and, in addition to controlling the entire test sequence, automatically matches the connected transceiver for the next measurement that is to be carried out on it.

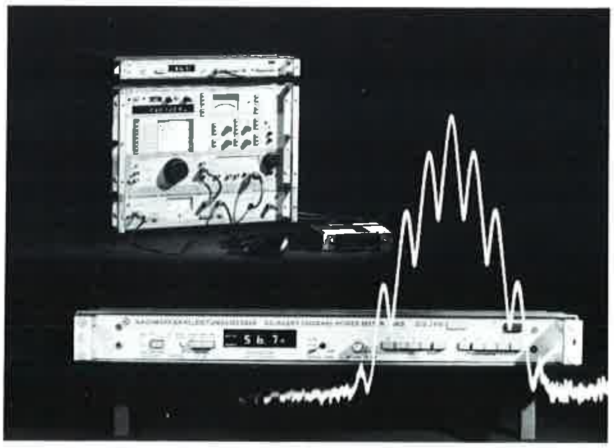
Automatic RX/TX Tester SMAT

As for manually operated test assemblies, the SMDU models 06, 07 and 09 in conjunction with the AM Unit SMDU-Z1 or the Power Test Adapter SMDU-Z2, feature obsolescence-proof design combined with optimum operating convenience. Compact test assemblies with integrated accessories are available under the designations SMDU 52, 53 and 56; see page 109. The SMDU concept meets the requirements of national and international standards, such as CEPT, FTZ, GPO or EIA, with the same ease with which it permits semi-automatic operation of the individual measuring instruments and simultaneous display of the most important test parameters.

The SMDU options permit custom-tailored optimization of the test assembly. Measurements in the 900-MHz band are also possible and the requirements existing for measurements on radio sets equipped for reply call are met.

The Adjacent-channel Power Meter NKS rounds off the line of radio test equipment. In conjunction with the SMDU it measures the adjacent-channel power of radio transmitters in line with national and international standards (CEPT). The NKS tunes automatically to the selected adjacent channel (details on page 115).

RT Test Assembly SMDU with Adjacent-channel Power Meter NKS



Air-navigation test assemblies

In civil aviation, **VOR/ILS** navigation receivers determine the position and direction of planes. Amplitude-modulated signals in the VHF and UHF ranges are required for testing these receivers. These signals should exhibit a constant group delay between 9 and 11 kHz, very low distortion at 30 and 9960 Hz and a flat frequency reesponse at the modulation frequencies of 90 and 150 Hz.

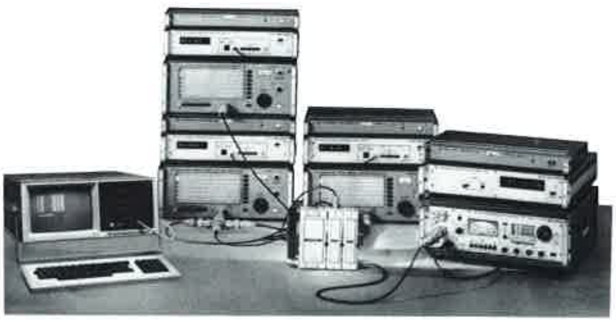
Models 07 and 08 of the Signal Generator SMDU meet these requirements. In conjunction with the Rohde & Schwarz VOR/ILS Unit, these versions constitute a complete test assembly for VOR/ILS receivers of one make. The special advantages of this combination are the continuous monitoring of the modulated RF signals and the built-in self-check of the most important operating parameters.

Automatic RF test assemblies

Test assemblies whose routine is controlled from a desktop computer via the standard IEC bus permit rationalization of RF measurements up to 1000 MHz. Rohde & Schwarz offers two complete test assemblies for different measuring tasks, together with software for the Rohde & Schwarz Process Controller PUC.

The automatic test assembly for intermodulation and crossmodulation measurements determines nonlinear distortion of antenna and cable-TV amplifiers as well as of semiconductors. Depending on the method used, two or three Power Signal Generators SMLU are included in the test setup.

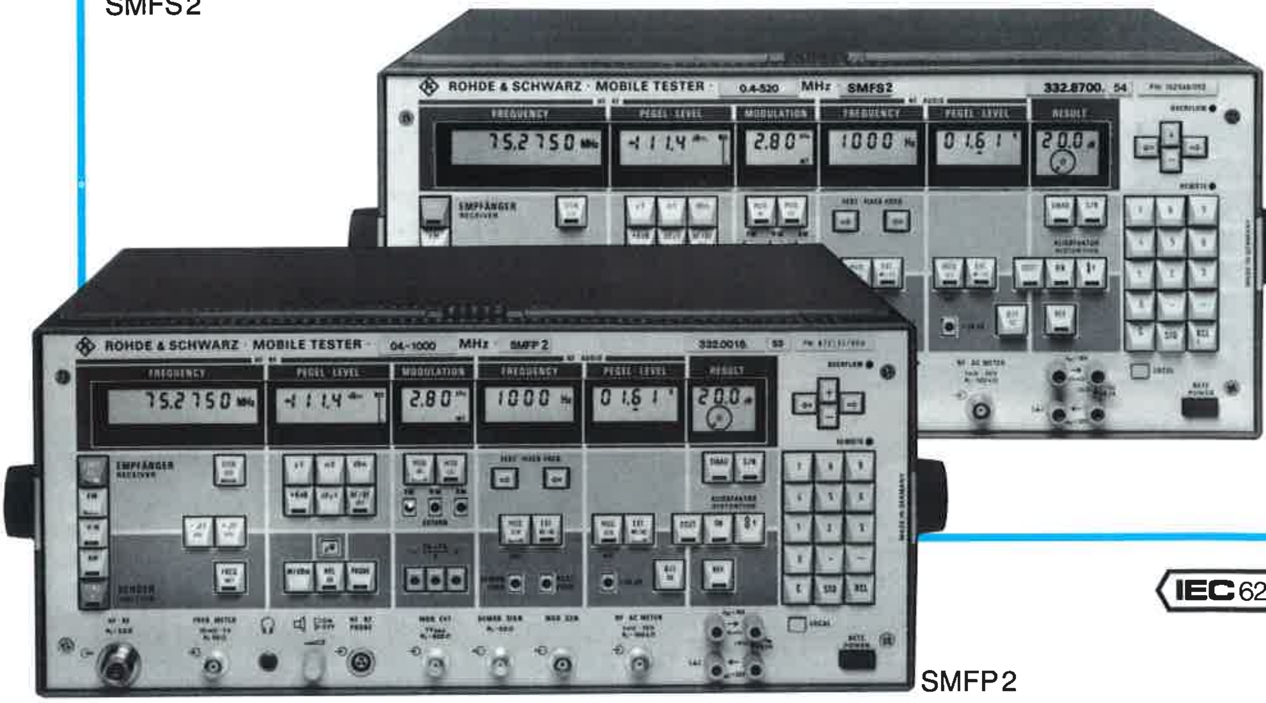
The programmable VHF-UHF Test Receiver ESU 2 permits selective measurement of interference products. Operator errors are excluded since the whole test sequence is controlled from the computer. The intermodulation or crossmodulation suppression is printed out directly in dB.



Automatic test assembly for intermodulation and crossmodulation measurements (see page 116)

The test assembly for RF cables automatically measures the average characteristic impedance and attenuation of RF cables in accordance with the specifications of IEC 96-1 or DIN 47 250. It consists of the programmable Power Signal Generator SMLU, an RF voltmeter and an analog/digital converter and can be extended by the Vector Analyzer ZPV. The resonance method is used for measuring. In addition to controlling the test routine, the desktop computer furnishes the test results, the characteristic impedance being printed out in Ω or the attenuation in dB.

SMFP 2 SMFS 2 Mobile Testers



SMFS 2

SMFP 2

IEC 625 Bus

new

Mobile Testers SMFP 2 and SMFS 2
♦ 0.4 to 1000 MHz

Successors to the successful Mobile Testers SMFS and SMFP with extended measurement and setting capabilities and new options

SMFP 2/SMFS 2 features

- Compact testers for AM, FM and φM transceivers
- Manual operation and semi-automatic or fully automatic measurements, depending on type and configuration

Both test sets contain all measurement capabilities required for transceiver testing; see next page.

Other common features:

- High measurement accuracy and high test rate
- Use in servicing, production and development
- Easy-to-grasp front-panel configuration and microprocessor-controlled key interlocking
together with
- Semi-automatic measurement routines for easy operation
- Many automatic settings and test routines – e.g. 6-dB bandwidth, reply call
- Compact, handy unit requiring little bench space and suitable for battery operation
- Options available to extend the range of applications

Additional SMFP 2 features

Basic unit for the following test systems:

- Self-contained semi-automatic transceiver test set for servicing in the field as well as in the lab
- Extended test assembly for servicing and batch testing – fully automatic, flexible and easy to operate thanks to the Process Controller PUC
- Test system for large-scale production testing, backed by controller and minicomputer (and data bank)

Differences between SMFP 2 and SMFS 2

The two test sets embody the same basic design and offer the same measurement capabilities; they differ only in

a) measuring convenience
SMFP 2: IEC-bus compatible, can be built into fully automatic computer-controlled test assemblies
SMFS 2: manual operation with semi-automatic measurement routines

b) modulation generator
SMFP 2: continuous tuning from 10 Hz to 25 kHz, crystal reference, synthesizer; 7 fixed frequencies; built-in selective-call encoder
SMFS 2: 12 fixed frequencies from 0.1 to 10 kHz, with options same as SMFP 2

Characteristics, uses, configurations

With the Mobile Testers SMFP2 and SMFS2, single test systems for all transceiver measurements are available for the first time. Manual and automatic operation, mobile and stationary use, universal measuring capabilities and high measuring speed together with high technical performance are just some of the advantages of these versatile systems for use in development, test departments, final test and servicing.

Both testers contain all the facilities required for precision measurements on transceivers (see listing below). While the SMFS 2 is exclusively designed for manual operation, all test parameters and measurements can be programmed for the SMFP2 with the aid of a controller, simple IEC-bus instructions and basic software ensuring fast programming.

Measuring and control devices	in SMFP 2 and SMFS 2	Receiver test	Transmitter test
RF GENERATOR	0.4 to 520 MHz (to 1000 MHz with option)	●	
MODULATION GENERATOR		●	●
– SMFP2: continuous tuning plus 7 fixed frequencies			
– SMFS2: 12 fixed frequencies (continuous tuning with option)			
RF FREQUENCY METER	1 to 520 MHz (to 1000 MHz with option)		●
POWER METER	up 30 W (to 60 W with option)		●
SINAD-METER	switch-selected CCITT weighting filter	●	
S/N METER	switch-selected CCITT weighting filter	●	●
MODULATION METER	for AM, FM and φM		●
– Switch selection of positive, negative or average peak value	switch-selected CCITT weighting filter		
SPURIOUS-MODULATION METER			●
– true rms meter	switch-selected CCITT weighting filter		
AF VOLTMETER	switch-selected CCITT weighting filter	●	
DISTORTION METER	switch-selected CCITT weighting (additional)	●	●
AF FREQUENCY METER	20 Hz to 1 MHz	●	●
BEAT-FREQUENCY METER			●
– with loudspeaker and connector for headphones			
DC VOLTMETER and AMMETER		●	●
ADJACENT-CHANNEL POWER METER (option)			●
SELECTIVE-CALL ENCODER	(option with SMFS 2)	●	
SELECTIVE-CALL DECODER	(option)		●
RF MILLIVOLTMETER	(option)	●	●
CONTROL DEVICE	for transceiver (optional with SMFS 2)	●	●
– 12 TTL control lines and relay matrix			
AURAL MONITORING	with loudspeaker and headphones	●	●
ANALOG DISPLAY	(option)	●	●
– with oscilloscope and analog indicators			

Operation, measurement routines, indication

The controls of the SMFP2 and SMFS2 are arranged in different sections of different colours according to the measurement mode (transmitter or receiver) and the setting or the parameter to be measured. This logical organization of the front panel ensures error-free operation without any training and fast access to the automatic routines. Moreover, illuminated keys for data setting and the readout of measurements in progress prevent erroneous interpretation of the measured values. By switching to receiver test or transmitter test the SMFP2 or SMFS2 is completely preset for the particular measurement.

Measurement routines. The possibility of choosing manual operation or calling up automatic measurement routines makes for versatile use of the test set on the one hand and speedy and error-free measurement of repetitive standard values on the other.

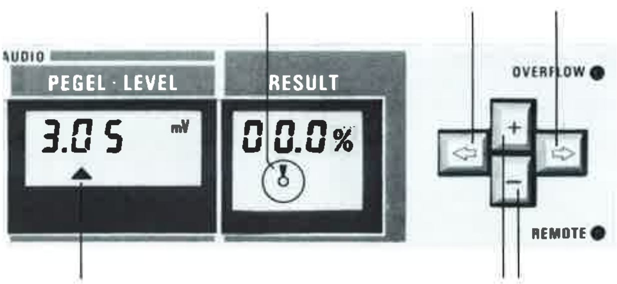
Indication. Six LCD's **simultaneously** read out virtually **all the test results,** eliminating reading errors and enabling the interdependence of individual parameters to be determined. A **quasi-analog readout,** which can be assigned to any desired digit, simplifies adjustments and indicates tendencies.

SMFP2/SMFS2 – Function

Parameter setting

Automatic settings and automatic routines in both the SMFP2 and the SMFS2, assigned to particualr modes for receiver and transmitter testing, spare the user the repetitive settings which are otherwise needed over and over again in day-to-day measurements. Special buttons and the keyboard further permit all the additional measurements required for a complete check of a transceiver.

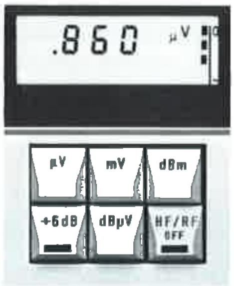
Parameters that differ from the automatic test routines can be altered **with the keyboard.** With the four buttons arranged to the right of the displays any frequency or level value of the AF and RF generators as well as the modulation can also be varied continuously (illustration below). Two buttons designated with arrows shift a marker beneath the display until it indicates the digit columen to be varied. The other two buttons ("+" and "−") then permit this digit to be varied in steps or, if kept depressed, in a fast sequence. Since the carry of the digit varied is also considered automatically, the test set offers the user, besides the digital entry via the keyboard, quasi-analog tuning with selectable resolution. It is also possible to vary the frequency of the RF generator in steps of any desired size (e.g. from channel to channel) with the two keys "+ Δf" and "−Δf".



Buttons on mobile tester for varying any desired digit of level and frequency of RF and AF generators as well as modulation section

RF generator

The output voltage of the RF generator is entered in µV, mV, dBµV or dBm. Conversion from one physical unit to another is initiated at the push of a button without cutting off or changing the RF level. The output voltage can also be reduced by up to 10 dB with an electronic attenuator without cutting off the level, as is necessary, for example, for an exact determination of squelch hysteresis. The setting of the attenuator is read out on the RF-level display and is a reliable indication of whether the range of variation is likely to be exceeded (see illustration). The keys RF OFF and +6 dB permit fast variation of the RF level.

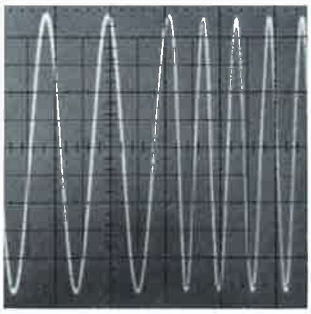


SMFP2/SMFS2 output-level display combined with readout of electronic-attenuator setting plus keys for entry and conversion of physical units

AF generator

Seven (SMFP2) to twelve (SMFS2) standard frequencies of the modulation generator can be called up at the push of a button and varied proceeding in either direction. These cover all of the important modulation frequencies for transceiver testing. It is possible to increase the outputlevel setting by 20 dB with the aid of a special key, thus simplifying overmodulation measurements, which are an absolute necessity when testing modulation limiters for instance.

Using the SMFP2 – or the SMFS2 with AF synthesizer/selective-call encoder option – all other frequencies in the AF range can be set with crystal accuracy and high resolution via the keyboard or the variation buttons. With extremely short frequency and amplitude switching times and phase continuity when changing the frequency all the requirements of tone sequence generation (selective calling) are met.



Frequency change

The AF Synthesizer/Selective Call Encoder produces tone sequences with one to eight single tones according to ZVEI and CCIR standards. The setting of the test set to the particular standard and the entry of the desired call is keyboard-controlled from the front panel. If the same code number is entered successively the repeat tone is sent automatically. The entered tone sequence can be sent singly or repeatedly.

With the SMFP2 it is also possible to use simple IEC-bus instructions to call up tone sequences or to vary the parameters of the tone sequences. For example, the first tone may be lengthened, pauses may be introduced and the frequency of the single tones may be varied for tolerance investigations. Moreover, completely different tone sequences, such as European radio-paging signals, can be produced.

Transmitter test/receiver test selection

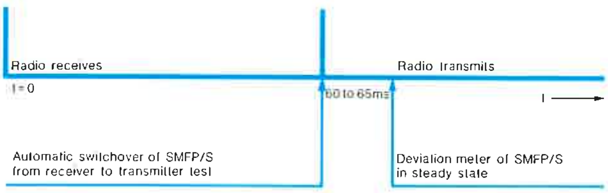
The two main modes of operation – **transmitter test** and **receiver test** – are engaged automatically according to the power arriving from the transceiver. The switchover can moreover be performed or inhibited by pressing a button so that parts of each test may be combined. For example, the SINAD ratio of a receiver can be checked during a transmitter test to determine the useful-signal transfer in duplex operation.

On switching from transmitter to receiver test, the **frequency of the RF generator** is set automatically **either**

to a frequency entered over the keypad **or**
to the transmit frequency of the transceiver measured
or
to the duplex pair frequency in the upper or lower band.

When the main mode is switched over, **all test parameters** are **stored** and – provided the operator does not alter them in the meantime – automatically reset upon recalling. So no new entries are required even with repeated switchover.

When the transmit frequency of the transceiver is entered via the keypad and the deviation meter is on, the mobile tester switches within 70 ms from receiver to transmitter test. This makes it possible to measure transceivers that send an acknowledgement signal.



Timing sequence for testing transceivers that send an acknowledgement signal

Transmitter test

In transmitter testing the SMFP2/SMFS2 measures automatically

the **transmit frequency** of the transceiver with 10 Hz resolution,
the **transmitter power** in W or dBm and
the **modulation** with high resolution (using the self-tuning demodulators).

At the push of a key the test set increases or decreases the level of the modulation generator until the modulation entered over the keypad is reached. If no modulation has been entered, the test set adjusts to the modulaton value last entered for the receiver test. The level of the modulation generator then represents

the **modulation sensitivity**

for the given modulation, which is read out as a true measured value on the MODULATION display.

By simply selecting the modulation-generator frequencies one after the other,

the **modulation frequency response** of the transceiver

can be determined rapidly. A relative value in dB – referred to any measured or keyed-in value – can be displayed in addition to the absolute value.

Also at the push of a key the test set determines

the **modulation distortion**

at all frequencies prescribed by CEPT – 300 Hz, 500 Hz and 1 kHz – or, by switching the modulation voltage cyclically on and off,

the **signal-to-noise ratio**

of the transceiver; the result is read out in % or dB on the RESULT display.

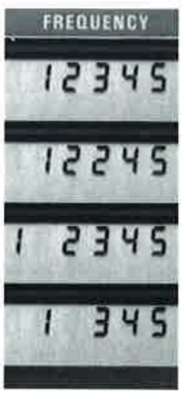
The additional AF generator with 1-kHz fixed frequency in conjunction with the modulation generator permits **doubletone modulation of a transceiver.** Resulting intermodulation products that lie in the adjacent channel can be measured directly with the adjacent-channel power meter.

If the modulation is switched off during transmitter measurement, the tester indicates the spurious modulation of the transceiver, broadband or CCITT weighting being selectable. After attenuation by 30 dB the decoupled transmitter signal is available on the rear panel of the test set for checking by means of an oscilloscope or a spectrum analyzer.

For measurements on **selective calling equipment** the test sets can be preset to ensure quick response of the demodulators. The tone sequence can be applied from a front-panel output to a selective-call evaluation unit, or, when the selective call decoder option is fitted, decoded and displayed directly by the SMFS2/P2.

Selective Call Decoder SMFS2B6. The SMFS2B6 Option permits decoding of tone sequences to ZVEI or CCIR standard (1 to 7 single tones) demodulated in the basic unit or applied to the AF voltmeter input. The decoded code numbers are read out on the display. Repeat tones are automatically decoded. Excessive pauses or tones that deviate from the chosen standard can be readily recognized as can be seen from the examples of displayed decoded tone sequences.

Examples of displayed decoded tone sequences



Tone sequence to standard

Decoded repeat tone

Excessive pause after first tone

Wrong or missing tone

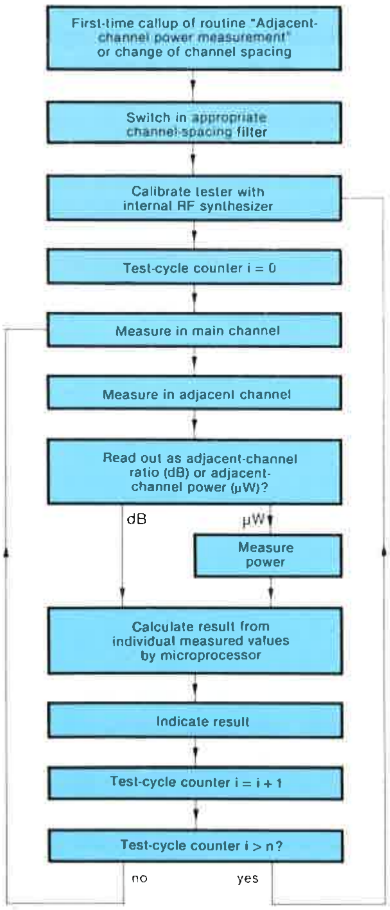
SMFP2/SMFS2 – Measurement capabilities

Transmitter test

Fitted with the optional

Adjacent-channel Power Meter (SMFP B6)

the SMFP2 or SMFS2 measures the power radiated in the adjacent channels. For this the nominal transmit frequency of the transceiver must simply be entered over the keyboard and the channel in which the adjacent-channel power is to be measured selected. Readout of the adjacent-channel power ratio in dB relative to the carrier power or direct readout of the absolute value of the adjacent-channel power in µW can be selected.



Comprehensive automactic internal test routines offer extreme operating ease combined with high accuracy: simplified flow chart for automatic test routine for adjacent-channel power measurement

External attenuators are automatically taken into account in all settings and readouts of measured values by entering their attenuation values. This permits the SMFP/S 2 to be used for error-free testing of transceivers of any transmitting power without sacrificing ease of operation.

Receiver test

In receiver testing, the test parameters such as

frequency, RF level, modulation and modulation frequency

are preset and the SMFP2/SMFS2 measures, in addition to the level of the transceiver AF output signal, either

the **SINAD ratio**

or, with the modulation cyclically switched on and off,

the **signal-to-noise ratio**

with or without CCITT weighting. If a certain SINAD or S/N ratio is entered over the keypad, the test set will automatically increase or decrease the RF level until the entered value is obtained. The RF level obtained represents

the **sensitivity** of the transceiver

and is indicated on the LEVEL display; the corresponding SINAD or S/N ratio appears on the RESULT display as a true measured value.

In addition to the two automatic routines for determining sensitivity according to the S/N and SINAD method in receiver testing, the SMFP2/S 2 now offers a third capability – **quieting measurement.** Furthermore, the averaging time of the two test assemblies can be extended in automatic S/N and SINAD measurement, thus narrowing down measurement tolerances in the case of impulse noise and further enhancing accuracy.

The RF OFF key facilitates rapid testing of the squelch function and electronic level fine adjustment without interruption of the level permits an accurate determination of

squelch hysteresis.

The SMFP2/SMFS2 measures

the **6-dB bandwidth**

with a single keystroke and indicates either bandwidth or bandwidth plus frequency offset. By varying the modulation frequency or selecting several one after the other,

the **AF frequency response** of the receiver

can readily be determined. As in transmitter measurement, it is possible to read out the absolute level or the relative value in dB referred to any measured or keyed-in value.

The built-in distortion meter permits checking

the **AF distortion**

of the transceiver, as in transmitter measurement, at all frequencies prescribed by CEPT.

The 1-kHz fixed-frequency oscillator allows simultaneous frequency and amplitude modulation of the carrier for

checking AM suppression.

If the 1-kHz singal is used for the FM, the built-in distortion meter can be used for this test.

Main automatic settings

Transmitter test	Measurement of frequency, power and modulation
Receiver test	Measurement of AF level
Transmitter test/receiver test selection	Switchover controlled by arriving/missing radio transmitter power with automatic setup of the tester
Receiver test frequency	Use of the transmitter frequency as receiver test frequency (in the case of duplex operation with + or − offset)
Fast deviation measurement	With preset $f_{transmit}$ −200 kHz output of the demodulated signal immediately upon transmitter switch-on
Acknowledgement signal test	Switchover from receiver to transmitter test within 70 ms (transient time of deviation meter) after transmitter switch-on
SINAD ratio measurement	Setting of 1-kHz modulation frequency
Distortion measurement	Setting of appropriate AF frequency
Tone sequence	Automatic setting and evaluation of repeat tone, tone sequence generation followed or not by useful modulation
External attenuators	Setting of parameters and display of results taking into account external attenuators

Main automatic test routines

Routine	Function	Display
Sensitivity, SINAD or S/N ratio	Variation of RF level until entered value is reached	SINAD or S/N ratio and corresponding RF level
Frequency response	Measurement with instantaneous measured value or programmable value as reference value	+dB or −dB
6-dB bandwidth	Determination by variation of RF level and RF frequency	Bandwidth and centre-frequency error
Modulation sensitivity	Variation of modulation level until entered modulation is reached	Modulation and AF level
Adjacent-channel power ratio	Determination or power in upper or lower adjacent channel	Relative in dB or absolute value in µW

Two-signal measurements

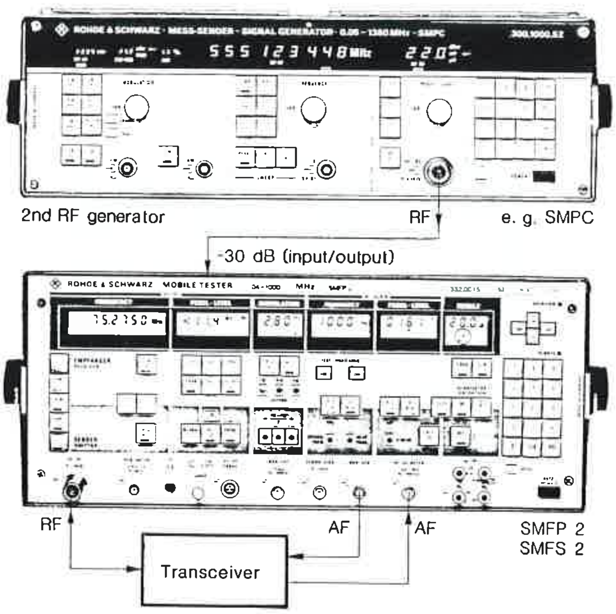
For receiver measurements requiring two signal generators, the SMFP2/SMFS2 has a rear RF input/output isolated by 30 dB from the main RF input/output on the front panel. All two-signal measurements, e.g. of

- adjacent-channel selectivity,
- intermodulation and cross-modulation,
- desensitization,

can thus be performed without further accessories (attenuators, prescalers, etc.).

For very exacting two-signal measurements – e.g. for determining adjacent-channel selectivity – the second signal source should be an extremely low-noise type. The R&S model SMPC is very well suited.

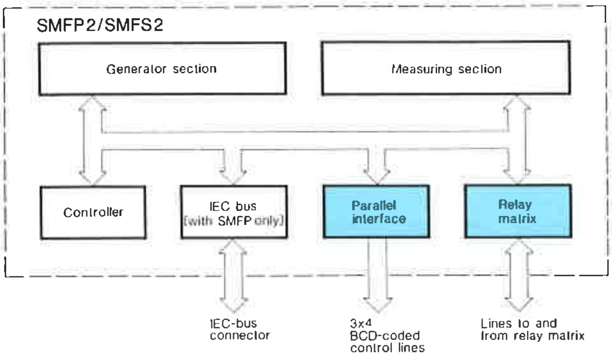
To perform **measurements on repeaters,** a second signal can again be fed into the RF path via the RF input/output on the rear to drive the repeater while the test set measures the transmit signal from the repeater.



Test setup for two-signal measurements and measurements on repeaters

SMFP2/S 2 – Configuration/control

Interface for Remote Control SMFS-B5 (option with SMFS2)

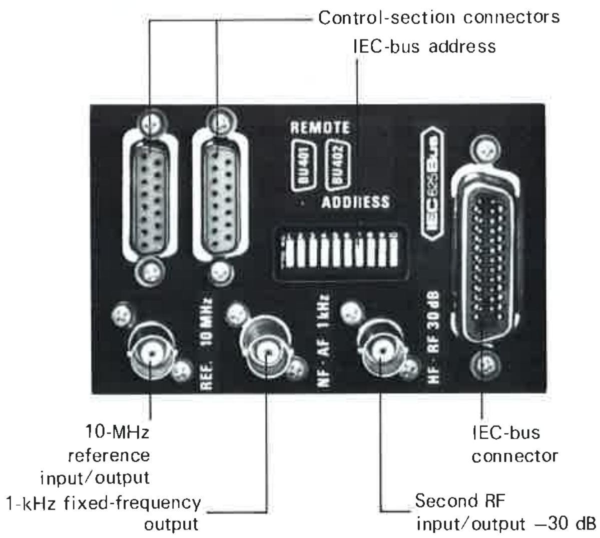


Basic diagram of SMFP2 and SMFS2 subdivided into generator, measuring and control sections;
blue: standard with SMFP2, optional with SMFS2

3×4 programmable BCD-coded control lines and an AF relay matrix (standard with SMFP2, optional with SMFS2) permit automatic setting of the transceiver from the computer (SMFP2 only) or over the keypad both prior to and during the measurement. For example,

channel selection,
transmitter/receiver switchover,
loudspeaker on/off,
squelch on/off

and the control of non-IEC-bus-compatible accessory equipment can be programmed. The relay matrix can also be used as a singal scanner. An additional relay is coupled with the transmitter/receiver switchover, so the transceiver mode can be switched simultaneously when the mode is switched on the front panel of the test set.



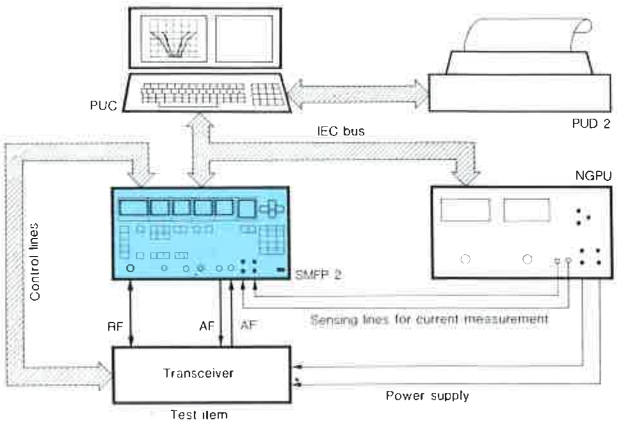
Rear panel of SMFP2/SMFS2

Fully automatic operation with SMFP2

Extension possibilities

In conjunction with a controller the SMFP2 forms a fully automatic transceiver test assembly. The control section contained in the SMFP2 (see diagram left) takes charge of setting the transceiver during the test, so no additional interfaces are required.

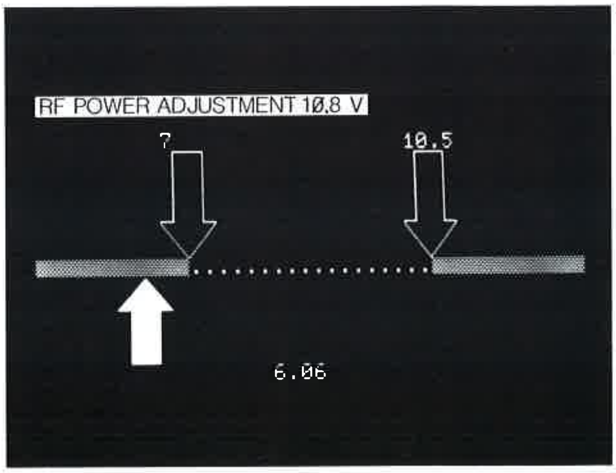
Simple **IEC-bus instructions** combinable with internal **test routines** and an elaborate **basic software** (SMFP2-K1) facilitate rapid program writing.



Fully automatic transceiver test assembly with Mobile Tester SMFP2, Process Controller PUC, Universal Printer PUD2 and Programmable Power Supply NGPU

Controller. For extending the SMFP2 to form a fully automatic transceiver test assembly (illustration above), use of the **Process Controller PUC** with built-in floppy-disk drive is recommended, permitting program and data output in seconds and providing a large screen for good readability and neat display of program and measured data.

Printer. The new, low-priced **Universal Printer PUD2** available for the PUC, which can be connected to a separate socket on the PUC without loading the IEC bus, provides hardcopy program records and test printouts.



Example of display of transceiver adjustment on screen of Process Controller PUC (power adjustment with tolerance limits and actual value) using basic-software routine 86

SMFP2 – Software

Basic Software for SMFP2. The computer-controlled, automatic transceiver test system SMFP2 facilitates the rapid and accurate execution of measurement sequences without any setting errors.

Before operating such a system, however, it is necessary to prepare a test program, or **software,** which will cause the system to execute all the necessary settings and measurements. The preparation of such a program generally calls for pertinent knowledge and experience on the part of the programmer and requires a long time. In contrast, the use of the

Basic software SMFP2-K1,

made available by Rohde & Schwarz in the form of a floppy disk for the SMFP2, brings many advantages: programming using the basic software involves nothing more than preparation of a user program in which the required test routines are called up, no programming knowledge being required. In this way even complex measurement procedures can be programmed in a very short time.

Test routines. More than 80 routines contain all the steps necessary for the execution of the measurement: setting the measuring instrument, input and output of data, changing of settings on the test item, computation of final results from several measured values. Output routines display the result on the screen of the computer or generate a printout on a printer connected to the computer. The results are also compared with preset nominal values and an indication is given if the tolerance limits are exceeded.

The user can, of course, extend the basic software by the addition of special routines. This permits non-standard problems to be solved.

Example of a complete transceiver test program using the Basic Software SMFP2-K1

Black: program

Blue: explanation of settings or measurements executed

```
10 R=1:GOSUB9000                              START ROUTINE
12 R=40:GOSUB9000                                 XMTR TEST
14 Y=2                                 TYPE OF MODULATION FM
16 R=6:GOSUB9000                                    SETTING
18 R=42:GOSUB9000                 MEASUREMENT RF FREQUENCY
20 PRINT"HF-FREQUENZ: ";Y;"[HZ]
22 R=41:GOSUB9000                     MEASUREMENT RF POWER
24 PRINT"HF-LEISTUNG: ";Y;"[W]"
26 Y=120                             MOD. GEN. LEVEL 120 mV
28 R=17:GOSUB9000                                   SETTING
30 R=43:GOSUB9000                MODULATION MEASUREMENT
32 PRINT"POS.MODULATION: ";Y,"[KHZ]"
34 INPUT"EMPFANGSFREQUENZ [MHZ]";X(1)
36 R=62:GOSUB9000                             RECEIVER TEST
38 Y=2                                       2 µV RF LEVEL
40 R=9:GOSUB9000                         SETTING RF LEVEL
42 Y=1                                 1 kHz AF FREQUENCY
44 R=16:GOSUB9000                     AF FREQUENCY SETTING
46 Y=2.8                             2.8 kHz FM INTERNAL
48 R=12:GOSUB9000                     MODULATION SETTING
50 R=28:GOSUB9000                   AF LEVEL MEASUREMENT
52 PRINT"NF-PEGEL: ";Y;" [MV]"
```

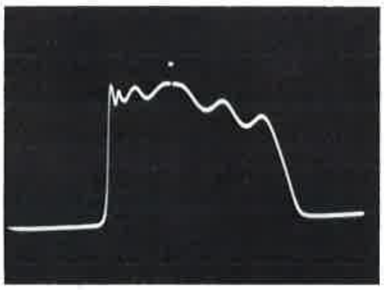
Routine No.		Routine
1		Start
2		RF = receive freq.
3	Input data	Channel spacing
4		Upper band/lower band spacing
5		IF ±
6		Modulation: AM, FM, φM
7		Max. modulation
8		RF frequency
9		RF level
10		RF off/on
11		RF level contin. variation ±0.1 dB
12		Mod. int. %, kHz or rad
13		Mod. ext.
14	Instrument settings	Mod. int. off/on
16		AF frequency setting
17		AF level setting
18		CCITT filter off/on
19		Tone sequence to ZVEI or CCIR
20		Control lines off/on
21		BCD output setting
22		Radio channel setting
23		NGPU current-limit level setting
24		NGPU voltage setting
27		AF frequency measurement ext.
28		AF level measurement ext.
30		Distortion 300 Hz, 500 Hz, 1 kHz in %
31	Receiver and transmitter measurements	RF voltage
32		AF frequency response
33		Tone-sequence generation
34		Tone-sequence evaluation
35		DC voltage measurement
36		DC current measurement
37		NGPU current measurement using SMFP2 voltmeter
39		Universal adjustment
40		Transmitter test
41		RF power
42		RF frequency error
43		Pos. modulation
44		Neg. modulation
47		Spurious modulation
48	Transmitter measurements	Mod. sensitivity at 1 kHz
49		Mod. frequency response referred to 1 kHz with test-frequency input
51		Mod. distortion 300 Hz, 500 Hz, 1 kHz
53		S/N transmitter
54		Freq. meter/RF input selection
55		Frequency of demod. signal
56		Beat frequency
58		Adj.-channel power ratio in dB
59		Adj.-channel power in µW
62		Receiver test + sig. gen. frequency setting
64		S/N measurement at 1 kHz
65		SINAD measurement at 1 kHz
66		Sensitivity for given S/N
67		Sensitivity for given SINAD
68	Receiver measurements	Quieting sensitivity
69		6-dB bandwidth + centre-frequency offset
71		Modulation acceptance bandwidth
72		Squelch upper and lower thresholds and hysteresis
76		AF frequency responce ref. to 1 kHz with test-frequency input
77		Signal transfer at diplexer
78		Image-frequency rejection
86		Adjustment with analog display + call of routine
87		Text (instruction on screen)
88		Print out text on printer
89	Output	Print out result on printer
90		Printer output with nominal/actual comparison
91		Screen output with nominal/actual comparison
92		Frequency chart
93		Hardcopy
100		Internal: error

SMFP2/SMFS2 – Options

Analog Display SMFS-B9. The Analog Display option for the Mobile Testers SMFP2 and SMFS2 consists of an **AF oscilloscope** and two **bar displays** that can be assigned to any of the variety of measurements, thus offering additional checking capabilities and detectors with analog screen display, designed to match the specific requirements of **production testing and servicing.** With its automatic setting feature for the oscilloscope and the bar displays and the AUTO LEVEL button which does away with the need for readjustment during the tests, this option integrates easily with **automatic test systems.** When operating in the internal mode, the **oscilloscope** displays the signal demodulated by the SMFP2 or SMFS2 in a transmitter test or the AF singal delivered by the transceiver in a receiver test, with switch-selected time and amplitude resolution. The vertical deflection calibrated in V for AF, in kHz for FM, in % for AM and in rad for φM ensures precise signal evaluation. By pressing a button, all signals can be displayed with constant amplitude, i.e. no adjustment on the oscilloscope is then required when test parameters such as modulation, modulation voltage and modulation freqency vary. When operating in the external mode, the oscilloscope displays the signal that is applied through the BNC cable or measured by means of a probe, with switch-selected time and amplitude resolution. At the push of a button, AC or DC coupling can be selected.

The X-axis signal is available at a rear socket and can be applied to the MOD. EXT. input of the basic unit for **sweeping.** Its level matches the input sensitivity so that the sweep width can be entered directly in kHz via the keypad.

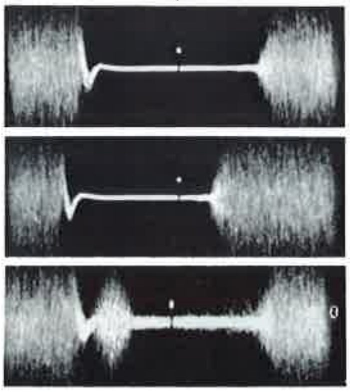
The frequency response curve is displayed directly on the screen of the SMFS-B9 with the aid of a demodulator probe.



Swept-frequency measurement on a filter with frequency-response display and centre-frequency marker on screen of Analog Display

A marker can be added at the centre frequency at the push of a button. This cuts off automatic triggering. Using the parameter variation keys on the basic unit the centre sweep frequency can be shifted to find resonance frequencies, attenuation peaks or cutoff frequencies; the corresponding frequency can then be read directly on the RF frequency display on the basic unit. Input and output stages, IF amplifiers, filters, duplexers and resonant circuits can thus be measured with the aid of a demodulator probe (available as an accessory; can be completed with an adapter to form an insertion unit with or without 50-Ω termination).

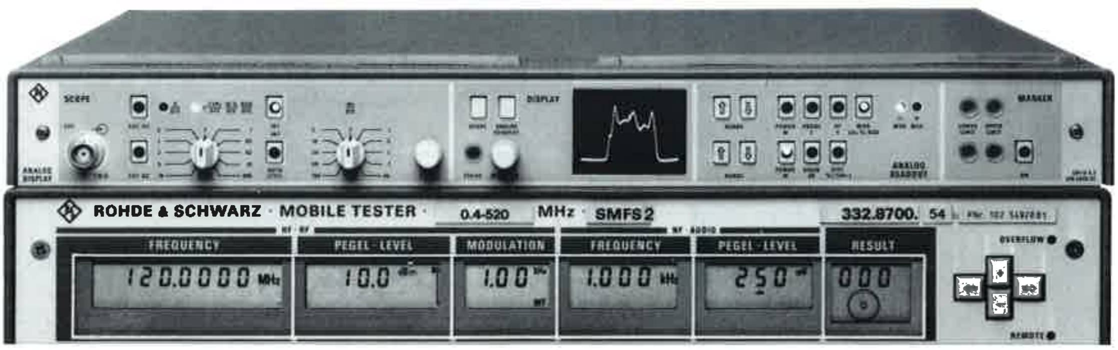
Overall sweeping – from the RF input of the receiver to the AF output – offers a quick overview of bandwidth, centre frequency tuning and sensitivity within the receiver range. The switch-selected CCITT filter built into the basic unit ensures suppression of build-up or dying out transients in the transceiver.



Swept-frequency measurement on a transceiver from the RF input to the AF output

The superimposed centre-frequency marker also permits points of interest, such as the lower or upper band limit as well as dips to be checked; the corresponding frequency can then be read directly on the RF frequency display on the basic unit.

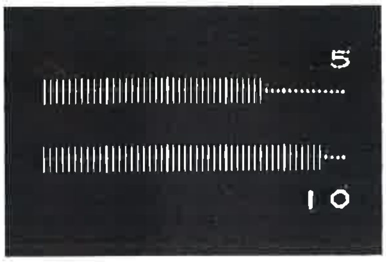
The simultaneous display of both band limits simplifies centre-frequency tuning of the receiver. All there is to do is to see to it that the upper and the lower band limit are at the same distance from the centre-frequency marker.



SMFS-B9 on SMFP2

Two **analog screen displays** are provided in the form of bars with bright-up scales. The scales, measurement ranges and time constants of the test points have been designed to suit the specific requirements of transceiver measurements.

The exact assignment of each scale division to a measured value, the different scales displayed depending on the measurement to be made, and the full-scale values displayed on the screen ensure unambiguous determination of the measured values and make for maximum clarity of presentation.



Analog screen displays with bright-up scales and indication of full-scale value

Interdependence of the test parameters is easily discernible since both displays can be observed at the same time.

The bars automatically display

SINAD ratio and AF level	in receiver testing.
Power and positive or negative modulation, whichever is greater, with additional LED display as an aid for symmetry adjustment	in transmitter testing.

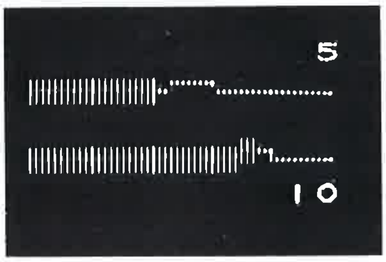
In addition, the following measured values can be displayed at the push of a button

Distortion of AF output signal	in receiver testing.
Modulation distortion	in transmitter testing.

Measurement capabilities with analog display	Measurement ranges
AF	12.5/5/2.5/0.5 V
FM	25/10/5/1 kHz
AM	125/50/25/5%
φM	12.5/5/2.5/0.5 rad
SINAD ratio	50/25 dB
Distortion	50/5%
Power	50/10/2.5/0.5 W

The measurement capabilities can be combined with one another, for example simultaneous display of measured power and SINAD ratio when adjusting duplexers.

For adjustment to given nominal values it is also possible to display tolerances separately for each bar. Maximum and minimum values can be set by means of potentiometers.



Bars with displayed tolerances

Reference Oscillator SMS-B1 (SMFP2 only, incorporated in SMFS2) improves the frequency accuracy of the RF and AF generators and of the counter (aging $\leqq 5 \times 10^{-8}$/month, temperature effect $\leqq \pm 1 \times 10^{-7}$).

1-GHz Frequency Extension SMFP-B2 extends the frequency range of the RF generator, the RF counter, the deviation meter and the adjacent-channel power meter to 1 GHz.

60-W Power Meter SMFP2 B3. The SMFP2 B3 Option extends the measurement range of the power meter built into SMFP2 and SMFS2 from 30 W to 60 W. The measurement range extension has been achieved by the inclusion of an internal 3-dB power attenuator.

Adjacent-channel Power Meter SMFP-B6[1]) measures the power components of the transmitter in the adjacent channel. The channel spacing and nominal transmitter frequency are entered via the keypad. The indication can be either in dB relative to the power in the main channel or absolute in µW.

Selective Call Decoder SMFS2 B6[2]) The SMFS2 B6 Option permits decoding of tone sequences to ZVEI or CCIR standard (1 to 7 single tones) demodulated in the basic unit or applied to the AF voltmeter input. The decoded code numbers are read out on the display. Repeat tones are automatically decoded. Excessive pauses or tones that deviate from the chosen standard can be readily recognized as can be seen from the examples of displayed decoded tone sequences (see also page 83).

RF Millivoltmeter SMFS2 B. In conjunction with suitable probes the SMFS2 B8 Option permit RF voltage measurements from 1 mV to 100 V over the range 10 kHz to 1 GHz. Suitable probes are any of the probes and insertion units available for the RF Millivoltmeter URV. Operating controls and display of the measured result are fully integrated into the RF level section of the Mobile Testers, the original operational convenience being preserved. In addition to digital display in mV, V or dBm the RF signal can also be displayed on the Analog Display Option SMFS-B9, if fitted, in four selectable ranges. In the SMFP2, the RF Millivoltmeter can of course also be used via the IEC/IEEE bus.

[1]) Because of the necessary frequency accuracy it is recommended to fit SMS-B1 together with SMFP-B6.
[2]) For SMFS2 only with SMFS2 B7.

SMFP2/SMFS2 – Options

Options for SMFS2

(integrated in SMFP2)

AF Synthesizer/Selective Call Encoder SMFS2 B7 extends the frequency range of the modulation generator and permits crystal-referenced frequency setting throughout the AF range from 10 Hz to 25 kHz with high resolution. It produces tone sequences (selective calling) with 1 to 8 single tones in accordance with ZVEI and CCIR standards.

Interface for Remote Control SMFS-B5 consists of 3×4 BCD-coded programmable control lines and a 9-relay matrix which permits the transceiver to be set from the front-panel keypad during the test.

Options for SMFS and SMFP

AF Synthesizer SMFS-B7 extends the frequency range of the modulation generator of the SMFS and permits crystal-referenced frequency setting throughout the AF range from 10 Hz to 25 kHz with high resolution.

Reference Oscillator SMS-B1, 1-GHz Frequency Extension SMFP-B2, Adjacent-channel Power Meter SMFP-B6, Interface for Remote Control SMFS-B5 and Analog Display SMFS-B9 can also be retrofitted in the SMFS and SMFP (see tabel below).

Recommended extras for SMFP2 and SMFS2

Protective Covers SMFP-Z8 for front and rear panels of the SMFP2 or SMFS2 without Analog Display SMFS-B9.

19″ Adapter SMFS Z10 permits incorporation of the SMFP2 or SMFS2 together with Analog Display SMFS-B9 into 19″ systems.

19″ Adapter SMFP-Z9 permits incorporation of the SMFP2 or SMFS2 without Analog Display SMFS-B9 into 19″ systems.

Oscilloscope Probe SMFS-Z1. This probe features switched attenuation (1:1/10:1/Ground) and may be used for displaying external AC and DC signals on the Analog Display SMFS-B9.

Demodulator Probe SMFS-Z2. This probe may be used for displaying frequency response curves in the frequency range 100 kHz to 500 MHz during sweep measurements on duplexers, IF filters, tuned circuits and demodulators. It may be used with the Analog Display SMFS-B or with any other oscilloscope.

RF Probe URV-Z7 and **RF Insertion Units URV-Z2** and **URV-Z4** in conjunction with the RF Millivoltmeter SMFS 2-B8 permit the measurement of RF voltages and RF levels in the wide frequency range 10 kHz to 1 GHz and with the wide dynamic range 1 mV to 100 V (depending on model).

Table of options and extras

× Option can be fitted – Option cannot be fitted ● Standard equipment [1]) Only with SMFS2B7

Options		SMFP2	SMFS2	SMFP	SMFS
Reference Oscillator	SMS-B1	×	●	×	×
1-GHz Frequency Extension	SMFP-B2	×	×	×	×
60-Watt Power Meter	SMFP2B3	×	×	–	–
Adjacent-channel Power Meter	SMFP-B6	×	×	×	×
Control Interface	SMFS-B5	●	×	●	×
AF Synthesizer	SMFS-B7	–	–	●	×
AF Synthesizer/Selective Call Encoder	SMFS2 B7	●	×	–	–
Selective Call Decoder	SMFS2 B6	×	×[1])	–	–
RF Millivoltmeter	SMFS2 B8	×	×	–	–
Analog Display	SMFS-B9	×	×	×	×
Extras					
Protective Cover	SMFP-Z8	×	×	×	×
19″ Adapter	SMFP-Z9	×	×	×	×
19″ Adapter	SMFS Z10	×	×	×	×
For Analog Display SMFS-B9:					
Oscilloscope Probe	SMFS-Z1	×	×	×	×
Demodulator Probe	SMFS-Z2	×	×	×	×
For RF Millivoltmeter SMFS2 B8:					
RF Probe	URV-Z7	×	×	–	–
RF Insertion Unit	URV-Z2	×	×	–	–
RF Insertion Unit	URV-Z4	×	×	–	–

Specifications of SMFP 2 and SMFS 2

Receiver measurement

– Test signals –

Signal-generator frequency range	0.4 to 520 MHz (to 1000 MHz with option)
Frequency setting	via keyboard
Frequency indication	8-digit display
Resolution	100 Hz
Accuracy and drift	dependent on reference frequency (crystal)

Reference oscillator	**Standard**	**Option SMS-B1**
Aging	$<\pm 1 \times 10^{-8}$/month	$<\pm 5 \times 10^{-9}$/month
Effect of temperature	$<\pm 1 \times 10^{-6}$/°C	$<\pm 1 \times 10^{-7}$ over specified temperature range after 15 min warmup

Output level CW and FM	−137 to +13 dBm (0.032 µV to 1 V into 50 Ω)
AM	−137 to +7 dBm (0.032 µV to 0.5 V into 50 Ω)
Setting	via keyboard
Fine level setting	0 to −10 dB with 0.1 dB resolution without interruption of output signal
Indication	in µV, mV, dBµV or dBm 3½-digit display
Resolution	0.1 dB
Error of output level	≦±1 dB + frequency-response error[1]
Frequency response	flat ±0.5 dB (8 to 520 MHz) flat ±1 dB (0.4 to 8 MHz)
Output impedance	50 Ω, VSWR ≦1.2 (level ≦−3 dBm)[1] connector: N female

Spectral purity

Harmonics	≧30 dBc down[2]
Non-harmonics spurious signals	≧60 dBc down[2] (≧5 kHz from carrier)
Spurious FM, rms 0.3 to 3 kHz	≦4 Hz (weighted in accordance with CCITT)
Spurious AM, rms 0.03 to 20 kHz	≧70 dBc down[2]
Single-sideband phase noise	typ. 120 dBc down[2] (test bandwidth 1 Hz, 20 kHz from carrier)
Single-sideband broadband noise	typ. 145 dBc down[2] (test bandwidth 1 Hz, 2 MHz from carrier)

Modulation generator	**SMFP 2**	**SMFS 2**
	AF synthesizer (continuous adj. Selective Call Encoder)	with option as for SMFP 2, otherwise fixed frequencies only
Frequency range	10 Hz to 25 kHz	—
Resolution f < 1 kHz	0.1 Hz	—
<10 kHz	1 Hz	—
>10 kHz	10 Hz	—
Selectable fixed frequencies	0.3/0.4/1/1.25/2.7/3/6 kHz	0.1/0.3/0.4/0.6/1/1.25/2.7/3/4/6/8/10 kHz
Indication	4 digits	4 digits
Frequency error	as for reference frequency	±1%
Distortion	≦1%	≦1%
Output EMF	0.1 mV to 4.995 V	0.1 mV to 4,995 V
Resolution V <100 mV	0.1 mV	0.1 mV
V <1 V	1 mV	1 mV
V <5 V	5 mV	5 mV
Error of output voltage V >1 mV	±(2%+0.1 mV)	±(2%+0.1 mV)
V <1 mV	typ. 2%	typ. 2%
Source impedance	approx. 1 Ω	50 Ω
Minimum load impedance V <100 mV	R_L ≧1 Ω	any
V >100 mV	R_L ≧50 Ω	any
Selective Call Encoder Standard tone sequences	tones 0 to 9 + repeat tone in accordance with ZVEI and CCIR	
Number of single tones	1 to 8	

Amplitude modulation

Frequency range; internal, external	50 Hz to 20 kHz (f >8 MHz) 50 Hz to 5 kHz (f <8 MHz)
Modulation depth	0 to 95%
Indication	3 digits
Resolution (0 to 9.95%)	0.05%
(10 to 95%)	0.5%
AM error (<8 MHz)	≦7% of rdg[1] ±1%
(8 to 520 MHz)	<4% of rdg[1] ±1%
Modulation distortion at 80% modulation	≦1.5% for f_{mod} ≦3 kHz[1] ≦5% for f_{mod} >3 kHz[1]
Input voltage requirement (rms) at AM ext.	1 V ±1% (into 600 Ω)

Frequency modulation

Frequency range; internal, external	20 Hz to 20 kHz (3 dB points <5 Hz, >30 kHz typ.)
Frequency deviation	0 to 125 kHz
Indication	3 digits
Resolution 0 to 9.95 kHz	50 Hz
10 to 99.5 kHz	500 Hz
100 to 125 kHz	1 kHz
Error	≦5%
Modulation distortion (5 kHz deviation)	≦1% for f_{mod} = 50 Hz to 3 kHz ≦5% for f_{mod} = 3 to 20 kHz
Input voltage requirement (rms) at FM ext.	1 V ±1% (into 600 Ω)

Phase modulation

Frequency range; internal, external	100 Hz to 6 kHz
Phase deviation	0 to 10 rad
Indication	3 digits
Resolution	0.1 rad
Error	≦±5%
Input voltage requirement (rms) at φM ext.	1 V ±1% (into 600 Ω)
Double modulation	possible combinations AM int.+ FM or φM ext., FM or φM int.+ AM ext.

Receiver measurement

– Signal evaluation –

Audio frequency meter

Frequency range	20 Hz to 999.9 kHz
Input level	10 mV to 10 V
Indication	4 digits
Resolution f <10 kHz	1 Hz
<100 kHz	10 Hz
<1 MHz	100 Hz
Error	as for reference oscillator

AF level meter

Frequency range	50 Hz to 20 kHz
Measurement range	0.1 mV to 10 V
Indication	3½ digits
Resolution at V_{in} <100 mV	0.1 mV
at V_{in} <1 V	1 mV
at V_{in} >1 V	10 mV
Error limits (f >100 Hz)	±(3% +1 digit)
(f <100 Hz)	±(4% +1 digit)
Input impedance	≧100 kΩ

Distortion meter

Measurement frequencies	0.3 kHz/1 kHz
Minimum input level	100 mV
Indication range	0.1 to 50%, 3 digits, resolution 0.1%
Intrinsic distortion, V_{in} >200 mV	<0.3%, 0.1% typ.
V_{in} <200 mV	<0.5%
Error limits d <10%	± (5% +1 digit) + intrinsic distortion
d >10%	±10% + intrinsic distortion

SINAD-ratio meter

Indication range	6 to 46 dB 3 digits, resolution 0.1 dB
Error limits	±1 dB
Minimum input level	100 mV
S/N meter	determines the S/N ratio by switching the modulation on/off
Error limits	±1 dB + residual FM

Transmitter measurement

RF frequency meter

Frequency range	1 to 520 MHz (to 999.99 MHz with option SMFP-B2)
Input level range at transceiver connector	50 mW to 30 W
at FREQ. METER input	10 mV to 1 V
Indication, resolution	8 digits, 10 Hz
Error	as for reference oscillator
Input impedance	50 Ω

[1]) With fine level adjustment = 0 dB.
[2]) dBc = relative level referred to carrier amplitude.

SMFP 2/SMFS 2 – Specifications, continued

Power meter
Frequency range .... 1 MHz to 1 GHz
Measurement range .... 10 mW to 30 W (10 to 45 dBm)
Error limits for P >100 mW
20 to 500 MHz .... ± (5% +1 digit) + frequency-response error
500 to 1000 MHz .... ± (10% +1 digit) + frequency-response error
1 to 1000 MHz .... ±10% (typ.) + frequency-response error
Error limits for P <100 mW .... as above, but typ.
Frequency-response flatness ...... ±4%

Frequency deviation meter ...... positive, negative or mean deviation
Frequency range .... 10 to 520 MHz (to 999.99 MHz with option SMFP-B2)
Deviation measurement range
peak weighting .... 100 Hz to 20 kHz
rms weighting .... 1 Hz to 100 Hz
Modulation-frequency range
for display .... 100 Hz to 8 kHz or with CCITT weighting
output for demod. signal .... <5 Hz to 10 kHz (3 dB)
Input level range
at transceiver connector .... 100 mW to 30 W
at FREQ. Meter input .... 10 mV to 1 V
Indication, resolution .... 3 digits, 1/10/100 Hz
Error limits .... ± (3% of rdg +1 digit) + residual FM
Spurious FM up to 500 MHz .... <5 Hz (CCITT weighting), typ. 2 Hz
above 500 MHz .... <10 Hz (CCITT weighting), typ. 4 Hz

Phase deviation meter
Frequency and input level .... as for frequency deviation meter
Phase deviation measurement range
peak weighting .... 0.1 to 5 rad
rms weighting .... 0.001 to 0.1 rad
Indication, resolution .... 3 digits, 0.001/0.01 rad
Modulation-frequency range .... 300 Hz to 3 kHz
Additional variation with frequency ±2%

Modulation generator .... see receiver measurement

Amplitude modulation meter
Frequency range .... 10 to 1000 MHz
Input level .... 100 mW to 30 W
AF frequency range .... 100 Hz to 10 kHz
Indication, resolution .... 3 digits, 0.1%
Error limits
(modulation depth <80%)
300 Hz $<f_{mod}<$ 3 kHz .... ± (5% +1 digit)
100 Hz $<f_{mod}<$ 10 kHz .... ± (10% +1 digit)

DC voltmeter
Input resistance .... ≧100 kΩ
Voltage range .... 1 mV to 30 V
Resolution V <0.3 V .... 1 mV
V <1 V .... 3 mV
V <3 V .... 10 mV
V <10 V .... 30 mV
V <30 V .... 100 mV
Indication .... 3½ digits
Error limits .... ± (2% + 2 digits)

DC ammeter
Current range, resolution I .... 0.2 to 10 A, 10 mA
II .... 1 to 200 mA, 0.1 mA/1 mA
Indication .... 3½ digits
Error limits .... ± (3% + 3 digits)

Overvoltage protection
Response thresholds .... <1 W at RF, <5 V at DC
Maximum permissible power ...... 30 W

Remote control (SMFP 2 only)
Interface .... IEC 625-1 (IEEE 488) (Amphenol 24-way connector)
Functions AH1, SH1, L2, T2, SR1, RL1, DC1
Parallel outputs .... e.g. for test-item control (via IEC-bus commands) 12 outputs, TTL open-collector 9 relays 100 V or 0.5 A (one relay coupled with transmitter/receiver switchover)

Options

1-GHz Frequency Extension SMFP-B2
Frequency range .... 0.4 to 1000 MHz
Changes in specifications relative to basic unit for frequency range 520 to 1000 MHz:
Resolution of frequency .... 200 Hz
Spurious FM .... ≦8 Hz (0.3 to 3 kHz, CCITT weighting)

Suppression of subharmonics and harmonics .... typ. 20 dB
Suppression of non-harmonic spurious signals .... ≧60 dB at >200 kHz from carrier[1]) ≧55 dB at >5 kHz from carrier[1])
Error of output level .... ≦±1 dB + frequency-response error[1])
Frequency response of output level .... flat ±1 dB
Amplitude modulation .... 0 to 90%
Modulation distortion at 60% AM . ≦5% for f_{mod} 100 Hz to 10 kHz[1]) ≦10% for f_{mod} 10 to 20 kHz[1])
AM indication error .... ≦7% of AM setting +1% AM[1])
Frequency range of
frequency meter .... 1 to 999.9 MHz
deviation meter .... 10 to 999.9 MHz
adjacent-channel power meter (SMFP-B6) .... 10 to 999.0 MHz

Reference Oscillator SMS-B1 .... see page 91 (fitted as standard in SMFS 2)

60-W Power Meter SMFP 2 B3
Increases all RF power limits specified above by 3 dB.
Power measurement range .... 20 mW to 60 W
Additional error
for f <500 MHz .... ±3%
f <800 MHz .... ±5%
f ≧800 MHz .... typ. 5%
VSWR
for f <500 MHz .... ≦1.2
f ≧500 MHz .... ≦1.3
Output level of RF signal generator
for CW and FM .... −137 to +10 dBm
AM .... −137 to +4 dBm
Overload protection
Maximum safe input .... 60 W

Interface for Remote Control SMFS-B5
(SMFS 2 only; incorporated in SMFP 2)
Parallel outputs .... controllable via keypad, 3 decades BCD TTL (open collector) 9 relays 100 V or 0.5 A (one relay coupled with T/R switchover)

Adjacent-channel Power Meter SMFP-B6[2])
Frequency range .... 10 to 519 MHz (to 999.0 MHz with option SMFP-B2)
Channel spacings .... 10/12.5/20/25 kHz
Input power range .... 0.1 to 30 W
Measurement range f <520 MHz ... down to 72 dB below carrier
f ≧520 MHz ... down to 66 dB below carrier
Indication .... dB or µW, mW, W, 3 digits
Resolution, error limits
Indication in dB .... 0.1 dB, ±3 dB
in µW, mW, W .... 0.001 µW ± (3 dB + relative error of power meter)

AF Synthesizer SMFS 2 B7
(SMFS 2 only; incorporated in SMFP 2) .... see page 91 (modulation generator)

AF Synthesizer SMFS-B7 .... SMFS only; not for SMFS 2
Specifications .... same as SMFS 2 B7, but without selective call encoder and with Z = 50 Ω

Selective Call Decoder SMFS 2 B6
(can be fitted to SMFS 2 only in conjunction with SMFS 2 B7)
Standard tone sequences .... tones 0 to 9 + repeat tone in accordance with ZVEI and CCIR
Number of single tones .... 1 to 7
Decoding range
AF voltmeter .... 100 mV to 10 V
FM meter .... 200 Hz to 20 kHz
φM meter .... 0.1 to 10 rad
AM meter .... 1 to 100%
Decoding probability P for relative offset from nominal frequency
P ≧0.995 .... ±1% (CCIR) ±2% (ZVEI)
P ≦0,03 .... ±3% (CCIR) ±4.5% (ZVEI)
Response time
Tone recognition .... typ. 25 ms
Pause recognition .... typ. 20 ms
Wrong-tone recognition .... typ. 20 ms

[1]) With fine level adjustment at 0 dB.
[2]) Fitting SMS-B1 together with SMFP-B6 is recommended because of the required frequency accuracy.

RF Millivoltmeter SMFS 2 B8[4])

Frequency range	10 kHz to 1 GHz (depends on probe)
Measurement range	1 mV to 10 V/10 mV to 100 V (depends on probe)
Display	3½ digits in mV, V or dBm
Resolution V <100 mV	0.3 mV
V <300 mV	1 mV
V <1 V	3 mV
V <3 V	10 mV
V <10 V	30 mV
Error	inherent error + frequency response error

Inherent error (V >10 mV, V <10 mV typical values):

	Voltage measurement	Level measurement
+20 to 25 °C	3% + 6 digits	0.2 dB +1 digit
+15 to 30 °C	4% + 6 digits	0.3 dB +1 digit
+5 to 40 °C	5% + 8 digits	typ. 0.5 dB

Frequency response error:
depends on probe; see URV 3

Probes	RF Probe URV-Z7 10-V Insertion Unit URV-Z2 100-V Insertion Unit URV-Z4

Analog Display SMFS-B9

Oscilloscope	
Screen size	3×4 cm
Frequency range	
DC coupling	DC to 50 kHz
AC coupling	5 Hz to 50 kHz
Input impedance	1 MΩ
Timebase	0.05 to 100 ms/div with 1-2-5 stepping
Triggering	automatic
Y deflection	
EXT. mode	0.005 to 10 V/div with 1-2-5 stepping
INT. mode	FM: 10 Hz/div to 20 kHz/div AM: 0.05 to 100%/div φM: 0.005 to 10 rad/div AF: 5 mV/div to 10 V/div with 1-2-5 stepping
INT. AUTO LEVEL mode	signal display with constant amplitude over virtually entire level range
X output (sawtooth)	
Output voltage	1.41 V_p into 600 Ω (matched to MOD. EXT. input on SMFP 2/SMFS 2)
Analog displays	two bars with 50-division bright-up scales and superimposed full-scale values; 6-dB, 12-dB and 20-dB points of 25-dB SINAD ratio range are brightened
Test parameters in receiver testing	SINAD ratio and AF level
pushbutton-selected	distortion of AF output level, power
Test parameters in transmitter testing	power and positive or negative modulation, whichever is greater, with additional +/− LED display
pushbutton-selected	modulation distortion, SINAD ratio of demodulated signal
Measurement ranges	
AF	0.5/2.5/5/12.5 V
FM	1/5/10/25 kHz
AM	5/25/50/125%
φM	0.5/2.5/5/12.5 rad
SINAD ratio	25/50 dB
Distortion	5/50%
Power (P_{max} = 30 W)	0.5/2.5/10/50 W
Resolution	2% of FS
Accuracy	same as basic unit ± resolution (only tendency indication for power <0.5 W)

General data

Rated temperature range	+5 to +45 °C
Storage temperature range	−40 to +70 °C
Mechanical resistance	shockproof in accordance with DIN 40046, Part 7 (30 g, 11 ms); vibration test in accordance with DIN 40046, Part 8 (11 to 55 Hz, 2 g); corresponds to IEC Publications 68-2-27 and 68-2-6
Power supply, AC voltage	115 to 125 V/220 to 235 V, ±10% (125 VA), 47 to 420 Hz, safety class I
battery	11 to 33 V (95 W)
Dimensions; weight	
SMFP 2/SMFS 2	470 mm×206 mm×485 mm, 24 kg
with SMFS-B9	470 mm×254 mm×485 mm, 28 kg

Accessories/extras

. . . for Analog Display SMFS-B9

Oscilloscope Probe SMFS-Z1

Attenuation/bandwidth	10:1/approx. 100 MHz 1:1/approx. 10 MHz Ground
Maximum permissible voltage	400 V_p
C compensation range	up to 60 pF
Connector	BNC

Demodulator Probe SMFS-Z2

Frequency range	100 kHz to 500 MHz
Input capacitance	approx. 4 pF
Maximum permissible voltage	30 V_{rms} AC, 50 V DC
Polarity	positive
Connector	BNC

. . . for RF Millivoltmeter SMFS 2 B8

RF Probe URV-Z7 10-V Insertion Unit URV-Z2 100-V Insertion Unit URV-Z4	For specifications see page 207

Ordering information

Order designation		▶ Mobile Tester
SMFP 2		332.0015.53
SMFS 2		332.8700.53

Accessories supplied

50-Ω termination, adapter board, power cable

Options

Reference Oscillator	SMS-B1	302.8918.02
1-GHz Frequency Extension	SMFP-B2	332.9706.50
60-W Power Meter	SMFP 2 B3	357.8610.02
Adjacent-channel Power Meter	SMFP-B6[1])	332.8000.02
Control Interface	SMFS-B5[2])	332.9106.02
AF Synthesizer	SMFS-B7[6])	332.9506.02
AF Synthesizer/ Selective Call Encoder	SMFS 2 B7[2])	346.6810.02
Selective Call Decoder	SMFS 2 B6[3])	346.7000.02
RF Millivoltmeter	SMFS 2 B8[4])	332.9306.02
Analog Display	SMFS-B9	346.5008.02

Recommended extras

Basic Software	SMFP 2 K1	358.2015.02
Process Controller	PUC	344.8900.10
Standard Keyboard	PUC-Z1	345.2011.04
IEC-bus Cable (1 m)	PCK	292.2013.10
Protective Covers	SMFP-Z8[5])	332.7890.02
19" Adapter for SMFP 2/SMFS 2 without SMFS-B9	SMFP-Z9	332.7978.02
for SMFP 2/SMFS 2 with SMFS-B9	SMFS Z10	346.6710.02

Power attenuators; see page 286

Recommended extras for Analog Display SMFS-B9

Oscilloscope Probe	SMFS-Z1	358.0312.02
Demodulator Probe	SMFS-Z2	358.0412.02
Demodulator Probe	SWOB 3-Z	241.2116.00
BNC Adapter	URV-Z	241.1110.02
Termination	RMF (BNC)	100.2927.50 (50 Ω)

Recommended extras for RF Millivoltmeter SMFS 2 B8

RF Probe	URV-Z7	292.5312.02
10-V Insertion Unit	URV-Z2	
50 Ω/N connector		288.8010.55
50 Ω/Dezifix B connector		288.8010.54
100-V Insertion Unit	URV-Z4	
50 Ω/N connector		283.7716.55

For further accessories see URV 3 data sheet (302 901).
For terminations and attenuators see section 10.

1) Fitting SMS-B1 together with SMFP-B6 is recommended because of the required frequency accuracy.
2) Only for SMFS and SMFS 2; fitted as standard in SMFP and SMFP 2.
3) For SMFS 2 only together with AF Synthesizer/Selective Call Encoder SMFS 2 B7.
4) Without probe; for probes see recommended extras.
5) Not together with Analog Display SMFS-B9.
6) For SMFS only, not for SMFS 2.
7) Fitted as standard in SMFS 2.
8) Without SMFS 2 B6 P_{max} = 30 W.

SMAT

Automatic RX/TX Tester SMAT ♦ 0.4 to 520 MHz (1 GHz)

- Automatic, fast go/noge tester for AM, FM, φM and SSB transceivers
- Program-controlled performance tester for military and civilian applications
- Program memory for as many as 75 different types of transceivers
- High level of operating ease through fully automatic test routines
- Alphanumeric display
- AC supply and battery operation

new

With the **Automatic RX/TX Tester SMAT** a go/nogo tester for transceivers is now available which permits extremely fast performance testing. Within seconds it

- checks the major transceiver performance parameters
- compares the measured values with the stored limit values
- indicates the in-tolerance and out-of-tolerance states by green and red LEDs.

The SMAT can **store** a variety of test programs for as many as **75 different transceiver types;** it controls the test sequence and automatically sets the connected transceiver for the measurement to be carried out.

The SMAT is based on the concept of the worldwide successful Mobile Testers SMFP and SMFS (SMFP2 and SMFS2).

Measuring facilities in the SMAT

Generator section	Measuring section (* = option)
RF synthesizer	RF frequency meter
AF synthesizer	AF frequency meter
Pilot-tone generator	Demodulators for AM, FM, φM
Selective call encoder (option)	RF power meter
	AF voltmeter
	S/N ratio meter
Control section	SINAD ratio meter *
	Distortion meter *
4 relays	150-Hz notch filter *
3 control lines	300-Hz high-pass filter *
	Selective call decoder

Applications

The SMAT is used to advantage not only by transceiver manufacturers (e.g. for final checkout before the transceivers are packed or for checking subcontracted units) but wherever the proper functioning of a transceiver is of great significance and/or where **large numbers have to be checked within a very short time,** for example when transceivers are supplied from stock to users such as the police, disaster missions, various other kinds of authorities and the armed forces, either for routine daily operations or, and especially, for exercises, in crises, etc.

The different operating levels of the SMAT – fully automatic test sequence with overall evaluation, calling up of group measurements with evaluation or individual measurements – enable, in conjunction with alphanumeric display of the value measured, systematic searching and location of defective modules and make the SMAT an ideal testing and measuring instrument for the various equipement maintenance levels.

Extreme operational convenience, exclusion of operator's errors and the simplicity of the SMAT permit its use by non-technical personnel.

Measurement capabilities and parameters

	Measurement	Stored limit values
TX	RF power	Minimum
TEST	Modulation Maximum modulation Pilot-tone modulation Modulation distortion	Minimum/maximum Maximum Minimum/maximum Maximum
	RF frequency	Offset in Hz
RX	AF voltage AF distortion	Minimum/maximum Maximum
TEST	S/N ratio SINAD ratio Receiver function at min. RF level (tight squelch)	Minimum Minimum

The Automatic RX/TX Tester SMAT measures and weights the major performance parameters (see table above) of AM, FM, φM and SSB transceivers (no distortion and pilot-tone modulation measurements on SSB equipment). The test parameters for the individual measurements and the limit values to be adhered to can be entered separately for each transceiver type; programming is necessary only once prior to first-time operation. Later modification or extension is readily possible.

Transmitter test

The SMAT measures the **RF power** – up to 30 W or, with option, up to 60 W – of AM, FM and φM transceivers with an unmodulated carrier and of SSB transceivers with a 1-kHz-modulated carrier. Higher powers can be measured using attenuators, whose attenuation settings are entered together with the transceiver-type specific test program and automatically taken into account in all measured parameters.

The SMAT measures the **modulation** of AM, FM and φM transceivers at the modulation voltage determined by the program and at 1 kHz modulation frequency; double modulation with 1 kHz and 1.66 kHz is used to measure SSB transceivers. The filter option is used for transceivers working with pilot tones, to suppress the pilot tones and to determine the useful modulation; either a 300-Hz high-pass filter or a 150-Hz notch filter is then automatically connected in the measurement paths. The pilot-tone modulation is measured by switching off the useful-modulation voltage; frequency is determined to within ±0.1 Hz. Modulation distortion can also be determined with the aid of the filter option.

The **RF frequency** of AM, FM and φM transceivers is measured on an unmodulated carrier with 10 Hz resolution, that of SSB transceivers by modulation with a crystal-referenced 1-kHz signal with 1 Hz resolution, the frequency shift due to modulation and the selected sideband being taken into account automatically.

Receiver test

Frequency. The RF test frequency required for the receiver test can either be stored or be entered through the keypad or results from the preceding transmitter frequency measurement. The frequency is determined by different methods depending on the measurement program:

a) calculation from the measured transmitter frequency by addition or subtraction of a programmable frequency offset

b) determination of the nearest integral multiple of the programmable channel spacing.

The receiver measurements are performed at the exact rated receiver frequency even if the transmitter frequency is offset.

When measuring **AF voltage** for receiver testing the operator is prompted by + and – symbols on the display to set the volume of the AF output singal to the programmed voltage range. A choice of four **programmable load resistances** is here possible. If the filter option (SMAT-B6) is incorporated, the distortion of the AF singal is checked at the voltage set.

Display of measured value: example power measurement

Sensitivity. For checking sensitivity the SMAT measures **signal/noise ratio** or, with the filter option incorporated, the **SINAD ratio** of the programmed RF level. With AM, FM and φM transceivers the S/N ratio is determined switching the modulation on and off and with SSB transceivers by offsetting the RF by 1 MHz. SINAD ratio is measured using an appropriate notch filter.

To check the **receiver performance at minimum RF level,** the transceiver output voltage is measured; if it is not more than 20 dB below the output voltage of the AF measurement, the receiver function is considered satisfactory.

Setting the transceiver

For setting the transceiver to the particular measurement

4 relays (N/C contact), 1 switching relay and
3 programmable control lines

are provided in the SMAT. Their positions or logic states during the test are partly given by and partly linked to the transceiver-specific test program. The following functions, for example, can be performed: selection fo operating mode, on/off switching of squelch and loudspeaker, changing of signal source.

Further applications

For **industrial applications** that do not involve SSB transceivers, use of the AF Synthesizer/Selective Call Encoder option and the Selective Call Decoder option is recommended instead of the incorporated two-tone generator. This makes it possible to measure and evaluate the following additional parameters:

Transmitter test:	modulation frequency response (3 frequencies), selective call decoding to ZVEI and CCIR
Receiver test:	AF frequency response (3 frequencies), selective call encoding to CCIR and ZVEI, generation of any pilot tones.

In **transceivers using a tone sequence,** the tone sequence is started in the transmitter test either automatically via a relay contact or a programmable control line or through the user following a prompt given on the display, and is then decoded by the SMAT. In the receiver test, the transceiver is activated either by the call derived from the transmitter test or by the user entering the call code following the corresponding prompt.

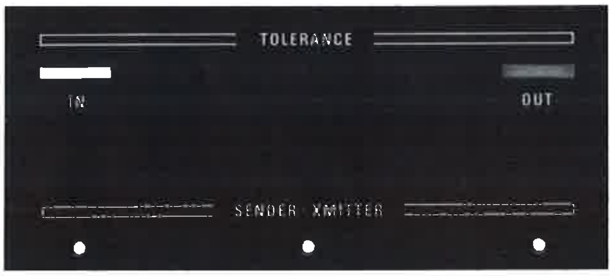
For checking **frequency response** in transmitter and receiver tests, two frequencies with the associated maxima and minima of modulation or AF voltage can be programmed for each operating mode, in addition to the values programmed at 1 kHz.

SMAT – Operation

Operation and test sequence

The built-in intelligence makes operation of the RX/TX Tester very simple. After the transceiver has been connected using only two cables – an RF cable for the transmit and receive signal and a cable for the modulation voltage, the AF output signal of the transceiver and the control section of the SMAT – the measurement can be called up. All other operations are called up by the SMAT.

During fully automatic testing – started at the push of a button – all entered individual measurements are automatically performed one after the other. The measured values are compared with the stored limit values and the result of this comparison is indicated by coloured LEDs – green for in tolerance and red for out of tolerance. The transmitter frequency and the receiver test frequency are briefly indicated after the transmitter and receiver tests have been completed so that they can be checked if desired. Upon completion of all measurements, overall evaluation is provided by large-scale flashing light bars.



Light bars for performance assessment of the transceiver upon completion of the automatic test

In addition, all group measurements of the **transmitter test** – power, modulation and transmit frequency – and the receiver test – AF voltage and S/N ratio – can be called up individually at the push of a button. In this case all of the individual measurements programmed for the particular group measurement are performed and evaluated.

Furthermore, all individual measurements can be called up by entering their number and pressing the appropriate group measurement button, e.g. modulation. The measurement and evaluation are performed continuously and the measured value is read out on the alphanumeric display, thus enabling adjustments to be carried out. During individual measurements the stored limit values can be extended at the push of a button. this means that transceivers can be checked for reduced performance.

Transmitter measurements | Receiver measurements

Automatic test sequence

Group meas. Power	Group meas. Modulation	Group meas. Frequency	Group meas. AF	Group meas. S/N
	1 to n		1 to n	1 to n
1 indiv. meas.	n indiv. meas.	1 indiv. meas.	n indiv. meas.	n indiv. meas.

Test sequence and operating levels of the SMAT (table on left)

- Call-up of automatic test sequence with all stored group and individual measurements and overall evaluation.
- Call-up of any group measurement with all its individual measurements and evaluation.
- Call-up of any individual measurement with alphanumeric display of the measured value.

These different operating levels enable the wide-ranging use of the SMAT, from a simple-to-operate, fully automatic tester through to a precise measuring instrument with digital display of the measured values, in all areas of transceiver testing. Besides transceiver performance checking within seconds, the SMAT also permits location of defective modules. The test sequence being determined by transceiver-specific test programs the SMAT can be set up for any applications.

In conjunction with the interface option, a printer with a Centronics interface (8-bit parallel) connected directly to the SMAT permits hardcopy output of the measured values including the stored limit values and furnishes useful information as a guide to any repairs that may be called for.

Programming

Programming the SMAT is necessary only once prior to first-time operation. The stored data may, however, be readily modified or extended to include new transceiver types.

In the basic version, the required measurements, test parameters and limit values are entered separately for each type of transceiver directly via the keyboard and are stored in battery-backed memories. for this purpose, a program sheet (see next page) is supplied, showing for every entry the appropriate storage location, the required number of digits to be entered and the input units. The memory addresses are automatically advanced and indicated during entry, meaning that the entry is restricted to the numerical values previously entered in the program sheet. For corrections, modifications and additions any storage location can of course be directly accessed from the keyboard and the memory contents – test function, test parameter or limit value – altered.

In conjunction with the interface option, entry is possible in a similar manner from a computer with a V.24/RS232 interface, e.g. the Process Controller PUC.

As a third means of **programming,** EPROMs (2716) previously loaded by means of a programmer can be fitted instead of built-in memories which are programmable from the SMAT.

Program backup. A switchable programming guard prevents both inadvertent erasure or alteration and manipulation of loaded test programs. The backup battery incorporated in the SMAT for the memories has a service life of approx. 5 years. It can be exchanged while the SMAT is operating on the power line; new programming is not required.

Example of program writing

(see filled-in program sheet below)

Under program No. 1 an FM transceiver (lines 1 and 2) is to be tested; band interval between transmit and receive frequencies 8.6 MHz (lines 3, 4), channel spacing 25 kHz (line 5) The frequency of the fictitious zero channel is taken as 0 MHz (line 6), that is the minimum, indivisible frequency calculated by repeatedly subtracting the channel spacing from a random channel frequency: random channel frequency/(n × channel spacing) = zero-channel frequency + remainder. The receiver measurement is to be performed at the rated frequency (channel frequency) (line 7).

External **attenuators** are not needed with the transmitter power here assumed (line 8). The control of the transceiver is fixed under control menu 3 (line 9), contains the position of the relay and the state of the control lines at any time of the test sequence). Neither pilot-tone nor selective-calling techniques are used (line 10).

Transmitter power must be more than 18 W and less than 25 W (lines 11, 12, 13). Modulation voltage should be 12.5 mV (line 14) and the deviation at this level be between 2.8 and 3.5 kHz (lines 15, 16). Maximum modulation must not exceed 4 kHz deviation (line 17) and maximum modulation distortion 3% (line 18). No modulation frequency response measurement need be performed (line 19). The departure of the transmit frequency from rating must be less than 500 Hz (line 20).

Receiver test. Modulation from internal generator (line 21), deviation setting 2.8 kHz (line 22), loading of transceiver AF output 100 kΩ (line 23). For AF measurement the **RF level** should be 500 µV (line 24) and the output voltage be between 2.5 and 3.5 V (lines 25, 26). Distortion must be below 5% (line 27) No AF frequency response measurement need be performed (line 28)

Sensitivity or signal/noise ratio is to be measured by the S/N method (line 29) at an RF level of 1.5 µV (line 30). The value measured must be greater than 20 dB (line 31). The squelch must respond at 0.5 µV (line 32)

Program modification. The following slight modification of a program example shows that programming is simple and yet extremely flexible.

If the unit being tested is a **receiver only,** "1" is to be entered in line 2. A fixed **RF** for the receiver measurement is entered in line 3; if the operator is to be prompted to **enter** the frequency **via the keypad,** zeros are to be entered.

Easy programming of SMAT based on a completed program sheet as example

DEVICE: PROGR. 1, GERÄT XYZ

Line	Storage location (first two figures program No.)	Setups, test functions, test parameters, tolerance limits	Numerical values to be entered	Input unit	
1	0 1 00	MODULATION: FM=1,AM=2,PM=3,SSBL=4,SSBU=5	1		Transceiver description
2	0 1 01	TYPE: T/R=0,R=1	0		
3	0 1 02	TX/RX-FREQUENCY OFFSET	0 0 8 6 0 0 0	100HZ	
4	0 1 09	FREQUENCY OFFSET SIGN: +=1,-=0	1		
5	0 1 10	CHANNEL SPACING	0 2 5 0	100HZ	
6	0 1 14	ZERO-CHANNEL FREQUENCY	0 0 0 0	100HZ	
7	0 1 18	RX-FREQUENCY ROUNDING: ON=1,OFF=0	1		
8	0 1 19	EXTERNAL ATTENUATION	0 0	DB	TX and RX test parameters
9	0 1 21	CONTROL FUNCTION: 1,2,3,4	3		
10	0 1 22	CODE MENUE: NONE=0 OR 1,2,3,4	0		
11	0 1 23	DIMENSION OF LIMITS: 10MW=1,100MW=2,1W=3	3		TX TEST – Power
12	0 1 24	TX-OUTPUT POWER UPPER LIMIT	0 2 5	10MW,100MW,1W	
13	0 1 27	TX-OUTPUT POWER LOWER LIMIT	0 1 8	10MW,100MW,1W	
14	0 1 30	MODULATION AF-LEVEL	0 1 2 5	100UV	Modulation
15	0 1 34	MODULATION UPPER LIMIT	0 3 5	0.1%,0.1KHZ,0.1RAD	
16	0 1 37	MODULATION LOWER LIMIT	0 2 8	0.1%,0.1KHZ,0.1RAD	
17	0 1 40	MAXIMUM MODULATION	0 4 0	0.1%,0.1KHZ,0.1RAD	
18	0 1 43	MAXIMUM DISTORTION	0 3	%	
19	0 1 45	MOD. FREQ. RESPONSE MENUE: NONE=0 OR 1,2,3,4	0		
20	0 1 46	TX-FREQUENCY PRECISION	0 5 0 0	HZ	Frequency
21	0 1 50	MODULATION SOURCE: INTERN=1, EXTERN=2	1		RX test parameters
22	0 1 51	MODULATION AM,FM OR PM	0 2 8	0.1%,0.1KHZ,0.1RAD	
23	0 1 54	AF-VOLT IMPEDANCE: R1=1,R2=2,R3=3,100KOHM=4	4		
24	0 1 55	RF-LEVEL FOR AF-MEASUREMENTS	0 5	100UV	RX TEST – AF
25	0 1 57	AF-VOLTAGE UPPER LIMIT	0 3 5 0	10MV	
26	0 1 61	AF-VOLTAGE LOWER LIMIT	0 2 5 0	10MV	
27	0 1 65	MAXIMUM DISTORTION	0 5	%	
28	0 1 67	AF-FREQUENCY RESPONSE MENUE: NONE=0 OR 1,2,3,4	0		
29	0 1 68	SIGNAL TO NOISE RATIO: S/N=1,SINAD=2	1		S/N ratio
30	0 1 69	RF-LEVEL FOR S/N AND SINAD-MEASUREMENT	0 1 5	0.1UV	
31	0 1 72	MINIMUM S/N OR SINAD-VALUE	2 0	DB	
32	0 1 74	MINIMUM RF-LEVEL FOR RX-OPERATION	0 0 5	0.1UV	

SMAT – Programming

The **menu programs** – control function for the transceiver during testing, code menu for setting and evaluating pilot tones and selechive calls, modulation frequency response menu and AF frequency response menu with statement of test parameters and tolerances – are in the form of subroutines. They are programmed separately and can be simply called up for integration into the running routine (lines 9, 10, 19, 28). Identical subroutines for different transceiver types need be programmed only once and any modification desired is easy to perform: only one number must be entered to call another subroutine in the running routine.

Specifications

The Automatic RX/TX Tester is designed for transmitter and receiver measurements up to 520 MHz; a model with a frequency range up to 1 GHz can be supplied (on request).

Receiver measurements

RF generator

Frequency range	0.4 to 520 MHz
Resolution	100 Hz
Error	same as reference oscillator

Reference oscillator

Crystal aging	$<\pm5\times10^{-8}$/month
Temperature effect	$<1\times10^{-7}$ over operating temperature range after 15 min warmup

RF level

For AF and distortion measurement	0.1 mV to 9.9 mV
Resolution	100 µV
For S/N and SINAD measurement	0.1 µV to 99.9 µV
Resolution	0.1 µV
Error	<±1 dB + frequency response error
Frequency response error	<±0.5 dB (8 to 520 MHz) <±1 dB (0.4 to 8 MHz)
Output	N female connector
Output impedance	50 Ω
VSWR	<1.2

Spectral purity

Spurious FM	<4 Hz (0.3 to 3 kHz, CCITT weighting)
Spurious AM	<−70 dBc (0.3 to 3 kHz, CCITT weighting)
SSB phase noise	typ. −120 dBc (test bandwidth 1 Hz, 20 kHz from carrier)
Broadband noise	typ. −145 dBc (test bandwidth 1 Hz, 2 MHz from carrier)

Modulation generator (standard)

Frequency	1 kHz
Frequency accuracy	same as reference oscillator
Distortion	<1%

Pilot-tone generator

Frequency	150 Hz (can be changed)
Frequency error	<1%
Distortion	<1%

AF Synthesizer/Selective Call Encoder	see options

Amplitude modulation

Modulation depth	0 to 95%
Resolution at 0 to 9.9%	0.1%
10 to 95%	0.5%
AM error at f ≧8 MHz	<4% of setting +1%
f <8 MHz	<7% of setting +1%
Modulation distortion at 80% mod., f_{mod} = 1 kHz	<1.5%

Frequency modulation

Frequency deviation	0 to 99.5 kHz
Resolution at 0 to 9.9 kHz	100 Hz
10 to 99.5 kHz	500 Hz
FM error	<5%
Modulation distortion at Δf = 5 kHz, f_{mod} = 1 kHz	<1%

Phase modulation

Phase deviation	0 to 10 rad
Resolution	0.1 rad
φM error at 1 kHz	<5%

External modulation

Input requirement	1 V ±1% across 600 Ω
Modulation frequency range	
AM, $f_{carrier}$ ≧8 MHz	50 Hz to 20 kHz
<8 MHz	50 Hz to 5 kHz
FM	20 Hz to 20 kHz
φM	100 Hz to 6 kHz

AF voltmeter	true rms
Input impedance	4 Ω, 16 Ω, 600 Ω, 100 kΩ; programmable, can be changed
Frequency range	50 Hz to 20 kHz
Voltage range	
Z_{in} = 4 Ω, 16 Ω, 100 kΩ (±5%)	1 mV to 10 V
Z_{in} = 600 Ω (±10%)	5 mV to 50 V
Resolution	
at 4 Ω, 16 Ω, 100 kΩ	1 mV (V_{in} <1 V), 10 mV (V_{in} >1 V)
at 600 Ω	5 mV (V_{in} <5 V), 50 mV (V_{in} >5 V)
Error	<± (5% + resolution)
Max. input power	5 W
Limit programming	4 digits, resolution 10 mV

S/N meter

Measurement range	6 to 46 dB
Resolution	0.1 dB
Error	<±1 dB
Minimum input level	100 mV
Limit programming	2 digits, resolution 1 dB

SINAD meter	see options

AF frequency meter	for transmitted pilot tones
Frequency range	20.0 to 999.9 Hz
Resolution	0.1 Hz
Error	same as reference frequency
Limit programming	rated frequency and offset in 1 Hz or 0.1 Hz (3 digits)

Selective Call Decoder	see options

Transmitter measurements

RF frequency meter

Frequency range	1 to 520 MHz
Input power range	50 mW to 30 W (60 W with option)
Accuracy	same as reference oscillator
Display	8 digits
Resolution	10 Hz
Internal resolution	
AM, FM, φM	10 Hz
SSB	1 Hz

RF power meter

Frequency range	2 to 520 MHz
Input power range	100 mW to 30 W (60 W with option)
Resolution at P ≦10 W	10 mW
P >10 W	100 mW
Error at P <100 mW, f ≧20 MHz	<± (6% + resolution) + frequency response error
f <20 MHz	<± (10% + resolution) + frequency response error
P >100 mW	values as above, but typical
Frequency response flatness	<±4%

Frequency deviation meter

Frequency range	10 to 520 MHz
Input power range	100 mW to 30 W (60 W with option)
Measurement range	
Peak weighting	200 Hz to 40 kHz deviation
Rms weighting	0 to 200 Hz deviation
Resolution Δf <2 kHz	2 Hz
Δf ≦20 kHz	20 Hz
Δf >20 kHz	200 Hz
Modulation frequency range	50 Hz to 8 kHz
Error (f_{mod} = 1 kHz)	<± (5% + resolution) + residual FM
Limit programming	3 digits, resolution 100 Hz

Amplitude modulation meter

Frequency range	2 to 520 MHz
Input power range	100 mW to 30 W (60 W with option)
Measurement range	0.1 to 95%
Resolution	0.1%
Modulation frequency range	100 Hz to 10 MHz
Error (mod. <0.8, f_{mod} = 1 kHz)	<± (5% + resolution)
Limit programming	3 digits, resolution 0.1% rad

Phase deviation meter

Frequency range	10 to 520 MHz
Input power range	100 mW to 30 W (60 W with option)
Measurement range	0.002 to 10 rad
Resolution	0.002 rad/0.02 rad
Modulation frequency range	300 Hz to 3 kHz
Error (at 1 kHz)	<± (5% + resolution)
Frequency response error	<2%
Limit programming	3 digits, resolution 0.1 rad

Modulation generator (standard)

Frequency AM, FM, φM	1 kHz
SSB	1 kHz + 1.66.. kHz
Frequency error	same as reference oscillator
Output voltage	0.1 mV to 1 V
Resolution at ≦100 mV	0.1 mV
>100 mV	1 mV
Error	<± (2% + 0.1 mV)
Output impedance	50 Ω, balanced, floating

AF Synthesizer ..... see options

Options

Interface SMAT-B4	V.24-/RS 232 C interface*) for programming the SMAT via external control computer Centronics interface*) for direct printer connection for transferring and logging of measured data
Filter SMAT-B6	contains filter for distortion and SINAD meters and 150-Hz notch filter (can be changed) switchable into all AF test paths or 300-Hz high-pass filter (link programmable)
Distortion meter	
Test frequency	1 kHz
Minimum input level	100 mV (Z_{out} = 4 Ω, 16 Ω, 100 kΩ)
for receiver test	500 mV (Z_{out} = 600 Ω)
Measurement range	1 to 50%
Resolution	0.1%
Error at distortion ≦10%	<±5%
distortion >10%	<±10%
Limit programming	2 digits, resolution 1%
SINAD meter	
Test frequency	1 kHz
Measurement range	6 to 46 dB
Resolution	0.1 dB
Error	<±1 dB
Limit programming	2 digits, resolution 1 dB
150-kHz filter	
Frequency response flatness	150 Hz
Attenuation	40 dB for 150 Hz ±2%
300-kHz high-pass filter	
Frequency response flatness at f >300 Hz	<±2%
Attenuation at f <190 Hz	typ. 40 dB
at f <170 Hz	typ. 50 dB
at f <150 Hz	typ. 60 dB

*) Connector: 15-way Cannon female.

60-W Power Meter SMFP2B6

Power range	20 mW to 60 W
Power-handling capacity	60 W
Additional error	<±3%

3-dB rise of the power range limits of frequency deviation meter, amplitude modulation meter, phase deviation meter and RF frequency meter

AF Synthesizer/Selective Call Encoder SMFP2B7	modulation source for transmitter and receiver test and selective call encoder (not for SSB applications)
Frequency range	10 Hz to 25 kHz
Resolution at f <1 kHz	0.1 Hz
f <10 kHz	1 Hz
f <25 kHz	10 Hz
Frequency error	$<\pm1\times10^{-5}$
Output voltage	0.1 mV to 1 V
Resolution at ≦100 mV	0.1 mV
>100 mV	1 mV
Error	<± (2% + 0.1 mV)
Minimum load impedance	
at ≦100 mV	Z_L >1 Ω
>100 mV	Z_L >50 Ω
Output impedance	approx. 1 Ω
Selective call encoder	
Standard tone sequences	tones 0 to 9 + repeat tone to CCIR and ZVEI
Number of single tones	1 to 7

Selective Call Decoder SMFS2B6

Standard tone sequences	tones 0 to 9 + repeat tone to ZVEI and CCIR
Number of single tones	1 to 7
Decoding range	
Deviation meter	400 Hz to 40 kHz deviation
Phase deviation meter	0.2 to 10 rad
AM meter	1 to 99%
Decoding probability with relative offset from rated frequency	
±1% (CCIR), ±2% (ZVEI)	≧0.995
±3% (CCIR), ±4.5% (ZVEI)	<0.03

General data

Rated temperature range	+5 to +45°C
Storage temperature range	−40 to +70°C
Mechanical resistance	shockproof to DIN 40046, Part 7 (30 g, 11 ms); vibration proof to DIN 40046, Part 8 (11 to 55 Hz, 2 g); corresponds to IEC Publ. 68-2-27 and 68-2-6
Power supply: AC	115 to 125/220 to 235 V ±10%, 47 to 420 Hz (125 VA)
battery	11 to 33 V (95 W)
Dimensions, weight	470 mm×206 mm×485 mm, 24 kg

Ordering information

Order designation	▶ Automatic RX/TX Tester SMAT 355.2014.52
Accessories supplied	50-Ω termination, adapter board, power cable, 1 connector for transceiver (SMAT-Z1)

Options

Interface	SMAT-B4	355.3810.02
Filter	SMAT-B6	355.3679.02
60-W Power Meter	SMFP2B3	357.8610.02
AF Synthesizer/Selective Call Encoder	SMFS2B7[1])	346.6810.02
Selective Call Decoder	SMFS2B6[2])	346.7000.02

Recommended extras

Connector	SMAT-Z1	355.3710.00
Protective Covers	SMFP-Z8	332.7890.02
Process Controller	PUC	344.8900.10
Standard Keyboard	PUC-Z1	345.2011.04
Universal Printer	PUD 2	359.5018.02
High-power Attenuators		see page 286

[1]) Not for SSB applications.
[2]) Only in conjunction with AF Synthesizer/Selective Call Encoder SMFS2B7.

ATS-TR4

Automatic Radio Test System ATS-TR4 for measurements to CEPT TR17

⧫ 30 to 500 MHz/0.4 to 520 (1000) MHz

- Turnkey automatic test system for AM, FM, φM and SSB radio sets
- Made up of standard instruments controlled from process controller
- Simple operation through system software
- Acceptance-test program supplied as programming example

IEC 625 Bus

Increasing crowding of the radio bands requires ever higher quality of radio equipment, especially in regard of selectivity, sensitivity and large-signal behaviour.

Manual measurements in this field consume much time and tie up qualified personnel. Automatic test systems (ATS) solve simple as well as complex measurement tasks faster, more accurately, reliably and – in the long run – economically.

Automatic measurements to CEPT TR 17

Regulations. The CEPT RECOMMENDATION TR 17 for stationary and land mobile radio transceivers used privately or in public services has been established, for example, in Europe with a view to unification of quality requirements and pertiment specifications. At the same time it aims at optimum utilization of the frequency band available.

Measurement ranges. The nominal area of application of CEPT TR17 covers FM und φM transceivers for radio services operating in the frequency range 30 to 500 MHz with channel spacings of 12.5 kHz, 20 kHz or 25 kHz. CEPT TR17 may, however, also be used as a basis for testing other radiotelephone systems, such as car radios and walkie-talkies.

Automatic Radio Test System ATS-TR4

The **ATS-TR4** System here presented has been designed to perform the measurements specified in CEPT TR17 through optimum instrument configuration, easy-to-handle modular system software and cost-effective hardware integration.

Beyond the transceiver tests proposed in CEPT TR17 the ATS-TR 4 permits testing transceivers with other types of modulation (AM or SSB). Thanks to the modular structure the user can extend the system in hardware and software either on his own or with the assistance of R&S.

System hardware

The Automatic Test System ATS-TR4 comprises the following units:

1. Mobile Tester — **SMFP 2**
   transceiver test set; central measuring instrument of system — 0.4 to 520 MHz
2. Adjacent-channel Power Meter — **NKS**
   for spurious-response and oscillator-reradiation measurements — 25 to 950 MHz
3. Signal Generator — **SMPC**
   for use as LO and second signal generator of high spectral purity for all two-signal measurements — 50 kHz to 1.36 GHz
4. Programmable Power Supply — **NGPU 70/10**
   for powering DUT — 70 V/10 A
5. Mixer Plug-in — **ATS-SM**
   for selective measurements (BW 105 Hz) of S/N ratios and for sideband analysis — 100 kHz to 1 GHz

Mixer Plug-in ATS-SM

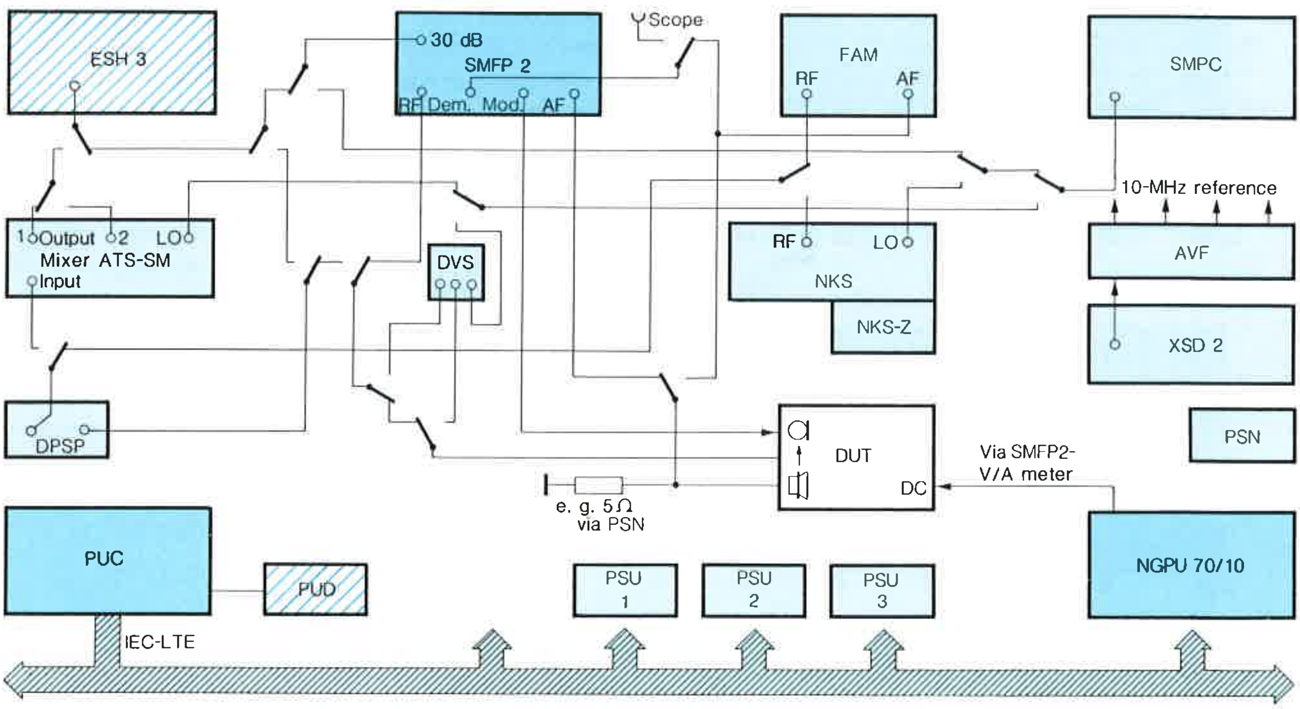
6. RF Attenuator — **DPSP**
   for level matching to mixer input ATS-SM and NKS — 0 to 139 dB, 1-dB steps
7. Power Splitter/Combiner — **DVS**
   for combining RF signals in two-signal measurements
8. Video Distribution Amplifier — **AVF**
   for distribution of 10-MHz reference to all external reference inputs of the system
9. RF Relay Matrix — **PSU** (3×)
   for computer-controlled switching of signal lines
10. Relay Matrix — **PSN**
    for selection of load resistance for the receiver AF outputs
11. Process Controller — **PUC**
    with IEC-bus Extender IEC-LTE for decoupling the IEC bus; RFI-proof — 32 kbytes
12. Printer — **PUD 2**
13. 10-MHz reference — **XSD2+XSRM-Z**
    $\leq 2\times10^{-10}$/month
14. Test Receiver — **ESH 3**
    for selective level measurement with and without input mixer (ATS-SM) and for sideband analysis with great operational ease — 9 kHz to 30 MHz

System description

The configuration shown in the system block diagram represents the optimum CEPT test system in regard of operational convenience, measurement capability, accuracy and test rate.

The CEPT TR17 specifications can be fulfilled without the Test Receiver ESH 3. More complex software and longer measuring times may then compensate for the reduction in operational convenience and certain measurement limits are lowered.

System block diagram of Automatic Radio Test System ATS-TR4

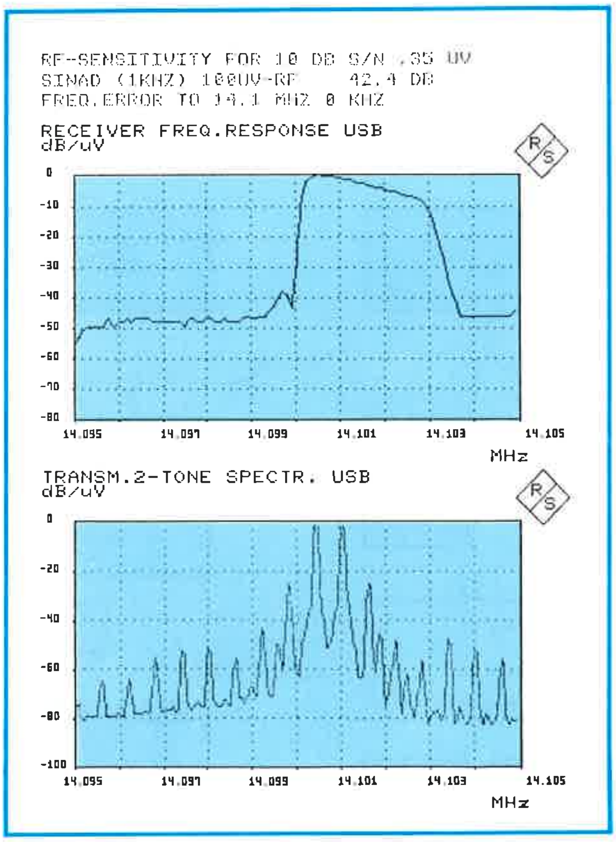


CEPT-TR17 System ATS-TR4

System software

The test routines specified by CEPT are listed below together with the reference numbers of the pertinent chapters of CEPT TR 17 recommendation.

CEPT test routines for FM and φM transceivers	Ref. No.
General measurements	
Power supply	
Current	(3)
Voltage	
Transmitter measurements	
Frequency error of the transmitter	(4.1)
Carrier power	(4.2)
Frequency deviation per modulation frequency	(4.3)
Maximum deviation	
Modulation sensitivity per modulation frequency	
AF frequency response of the transmitter per modulation frequency	
Modulation distortion per modulation frequency	
Adjacent-channel power per channel	(4.4)
Spurious emissions per test frequency	(4.5/4.6)
Residual modulation	
Receiver measurements	
Output power of the receiver	
Distortion of AF signal per test frequency	
AF frequency response per test frequency	(5.2)
SINAD sensitivity	(5.1)
Co-channel rejection per test frequency	(5.3)
Adjacent-channel selectivity per channel	(5.4)
Spurious response per test frequency	(5.5)
Intermodulation rejection	(5.6)
Blocking per test frequency	(5.7)
Oscillator reradiation per test frequency	(5.8)
Limiting characteristic	
Receiver S/N ratio	
Squelch threshold	
Duplex measurements	
Receiver sensitivity in duplex mode	(6.1)
Spurious response in duplex mode per test frequency	(6.2)



Test results: sensitivity measurement (top) and SSB two-tone measurement using Sideband Mixer Plug-in ATS-SM (bottom)

The **system software** for the Process Controller PUC is written as basic software which does the actual work for the user even when carrying out complex measurements, such as two-signal measurements or searching for spurious emissions. Customer-tailored test routines that are not expressly required by CEPT can be readily added to the available test routines within the scope of the system configuration. This is a decisive advantage with respect to later augmentation of the system to include SSB transceiver measurements in the HF and VHF/UHF ranges.

The software is handed over with complete source listing and documentation; the test routine for the acceptance test is included as an example. A selftest package for the system, consisting of software and cable set is available as an option.

System configuration

The standard model of Test System ATS-TR4 is accommodated in a castered 19″ light-metal rack.

An EMI filter built into the rack keeps off interference coming from the AC supply line. Power distribution strips, earthing lines for the chassis and IEC-bus address labels for the integrated instruments are provided.

The signal cable set for the test system is made up of high-quality double-shielded coaxial cable (RG 400) and low-reflection connectors, because simple shielding would be inadequate in two-signal measurements.

Other rack configurations are possible on request, for example use of two desktop racks or of a system front panel carrying all inputs and outputs.

Process Controller PUC and universal printer are placed on a castered table beside the test system. The DUTs may be positioned on a separate table beside the test system.

System handover

Each test system is completely installed and tested in our works and is then available to the customer for 3 to 5 days for acceptance testing and system training.

R&S personnel installs the system on site and repeats the acceptance test performed at the factory. Our system specialists are available for consultation in the initial phase following the installation. Contracts for on-site maintenance are offered on request.

Other transceiver test systems

In addition to the Test System ATS-TR4 for measurements in accordance with CEPT TR 17 Rohde & Schwarz offers **three more automatic systems** for transceiver measurements; their measurement capabilities are designed to suit the requirements of authorities as well as of industry.

Test System ATS-TR1 consists of

SMFP2 – Mobile Tester with option as required
NGPU – Programmable Power Supply for DUT
PUC – Process Controller
PUD 2 – Universal Printer

Software package SMFP2-K1 for all single-signal measurements including selective-call and adjacent-channel-power measurements

Hardware integration in rack

Test System ATS-TR2

Measuring instruments as for ATS-TR1 plus
SMPC – Synthesizer Signal Generator as low-noise interference source for two-signal and duplex measurements, 50 kHz to 1360 MHz

Software package SMFP2-K1 with additional routines for all two-signal and duplex measurements

Hardware integration in castered rack or in two desktop racks

Test System ATS-TR3

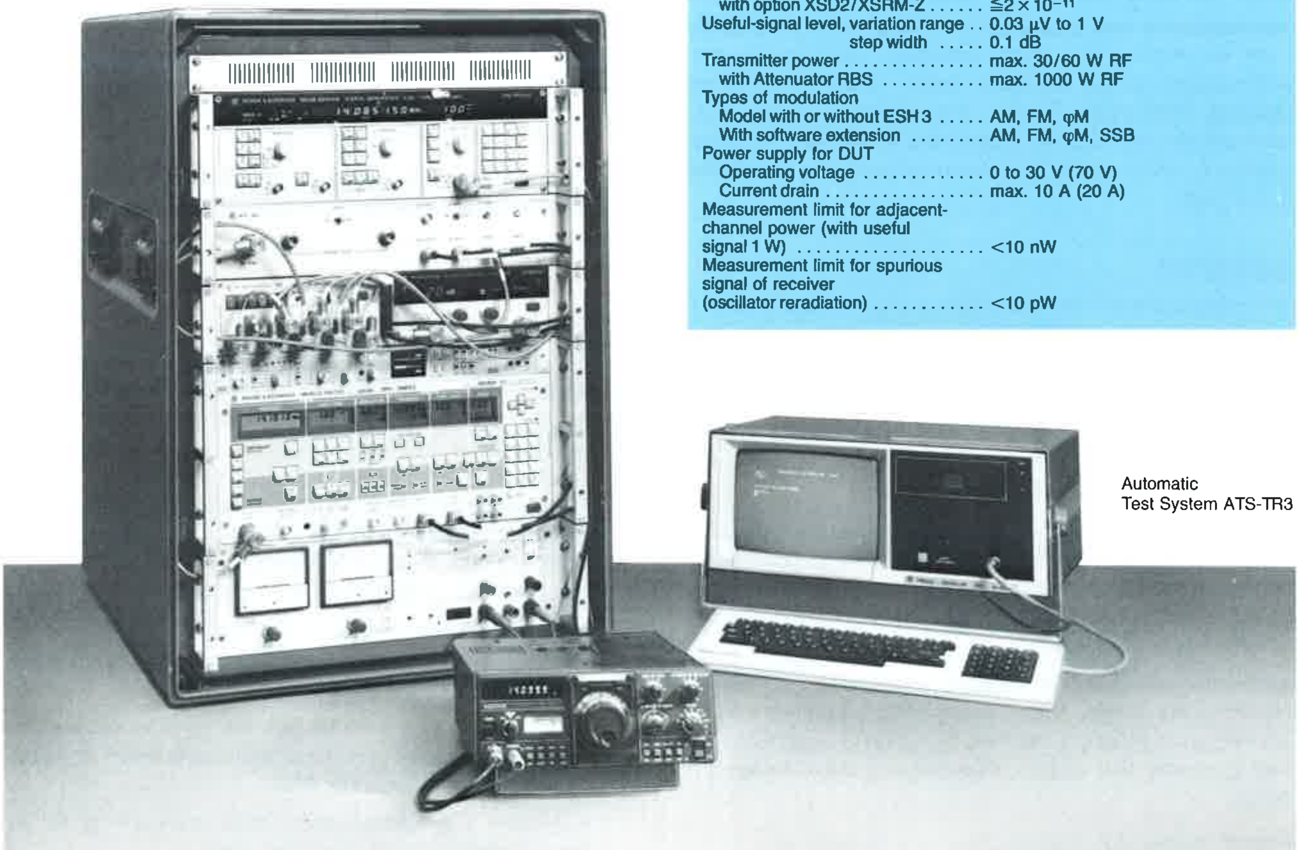
Measuring instruments as for ATS-TR2 plus
ATS-SM – Sideband Mixer 1 MHz to 1 GHz
DPSP – Programmable Attenuator for signal attenuation ahead of ATS-SM
PSU (2 off)– RF Relay Matrix for switching signal path

Software package SMFP2-K3 (as SMFP2-K2) with additional routines for spectrum analysis on transmitters and of oscillator reradiation in receivers – can be extended with special routines for sideband analysis of SSB transmitters.

Hardware integration. Castered rack or two desktop racks

Condensed data of Test System ATS-TR4

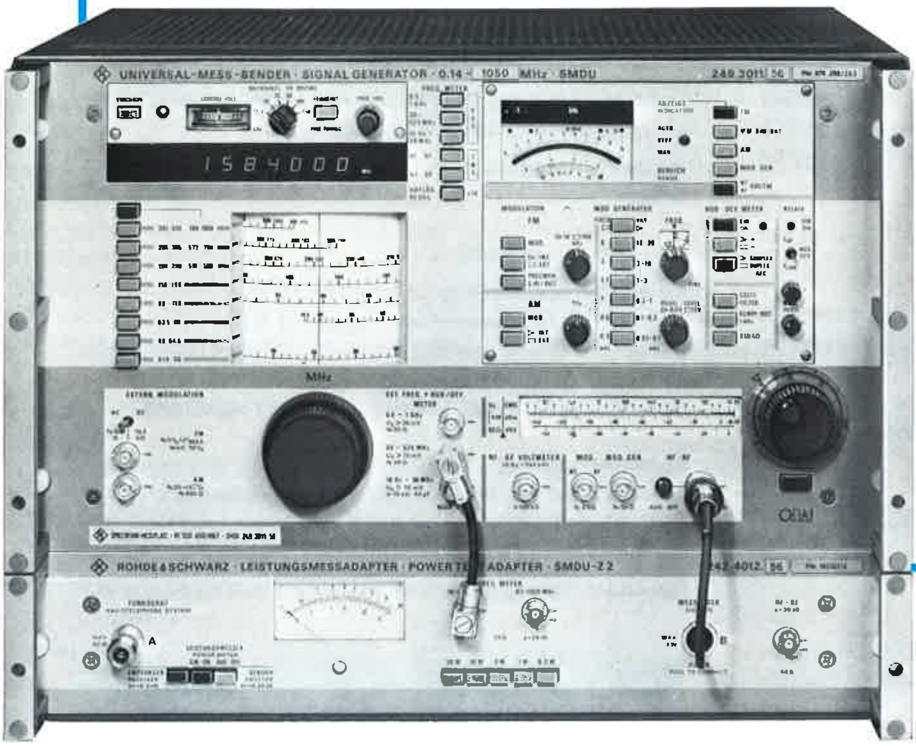
Frequency range for useful signal	0.4 to 520 MHz, up to 1000 MHz with option
Frequency range for spurious signal measurement	
with ESH3	9 kHz to 1000 MHz
without ESH3	100 kHz to 1000 MHz
Frequency range of interference source for two-signal measurements	50 kHz to 1360 MHz
Frequency resolution AF generator	10 Hz/1 Hz
RF generators	100 Hz/1 Hz
Counter	10 Hz/1 Hz
Frequency stability	$\pm 5 \times 10^{-9}$
with option XSD2/XSRM-Z	$\leqq 2 \times 10^{-11}$
Useful-signal level, variation range	0.03 µV to 1 V
step width	0.1 dB
Transmitter power	max. 30/60 W RF
with Attenuator RBS	max. 1000 W RF
Types of modulation	
Model with or without ESH3	AM, FM, φM
With software extension	AM, FM, φM, SSB
Power supply for DUT	
Operating voltage	0 to 30 V (70 V)
Current drain	max. 10 A (20 A)
Measurement limit for adjacent-channel power (with useful signal 1 W)	<10 nW
Measurement limit for spurious signal of receiver (oscillator reradiation)	<10 pW



Automatic Test System ATS-TR3

SMDU

Radiotelephone Test Assembly SMDU ♦ 0.14 to 525 MHz (1.05 GHz)



- System configuration plus options permitting optimum solution of the most diversified measurement tasks
- Synthesizer stability using the synchronizer option, frequency setting accurate to within a few hertz
- Measurement of desensitization beyond 95 dB and adjacent-channel selectivity >80 dB due to high spectral purity of RF signal
- Testing of hifi and stereo broadcast receivers with built-in CB radio

The **Radiotelephone Test Assembly SMDU** is a test system of highest precision which contains all measuring instruments necessary for standard checkout of radiotelephone equipment and meets or even exceeds the requirements of national and international specifications.

This advanced test assembly combines precise measurement techniques with great operating convenience (e.g. automatically tuned deviation meter, channel-to-channel stepping, autoranging facility). The SMDU test setup complies with the most severe stipulations for transceiver measurements, which so far have been met only by specialized instruments.

Applications

The comprehensive instrumentation permits a standard solution to be found for all transceiver measurement tasks. The SMDU test assembly can be used to advantage in laboratories, servicing shops and production plants.

In servicing the great operating convenience of the Radiotelephone Test Assembly considerably reduces the time required for routine measurements.

For **public services** and in **development laboratories,** the high accuracy of the SMDU test assembly permits reliable conclusions in type-approval testing.

In **test and production departments,** the SMDU can be used to advantage for batch measurements thanks to its semi-automatic operation and the possibility of connecting recording equipment. When determining parameters which are difficult to measure, the Test Assembly is superior to any fully automatic test system, especially in regard to spectral purity.

*) SINAD: signal + noise + distortion to noise + distortion.

Configuration

The heart of the Test Assembly is the radiotelephone version of the SMDU (06, 07 or 09); this basic setup is suitable for all measurements up to 1 GHz.

To obtain a complete test assembly, the following equipment is required:

a) Power Test Adapter SMDU-Z2 or
b) AM Unit SMDU-Z1 (power meter and modulation depth meter); see under specifications.

Thus the following **configurations** are possible (also available as compact asemblies in common cabinets):

Signal Generator SMDU with
  RF generator, 140 kHz to 525 MHz (expandable up to 1.05 GHz), FM and AM, automatic overvoltage protection in the case of accidental transmitter keying
  AF generator, 30 Hz to 30 kHz
  frequency meter, 15 Hz to 525 MHz (1 GHz)
  AF voltmeter, 1 mV to 10 V (rms weighting)
  distortion meter, 1 to 100% fsd
  SINAD*) ratio meter, 6 to 46 dB
  psophometric weighting filter (in accordance with CCITT)

Power Test Adapter SMDU-Z2 (30 W) with
  RF relay switching panel; possibility of connecting analyzer and recording equipment – **or**

AM Unit SMDU-Z1 (30/60 W) with the same facilities as the power test adapter plus modulation depth meter and automatic mode selection (TX/RX)

For options, e.g. for frequency range extension or for frequency synchronization, see page 106.

Functions (for receiver and transmitter measurements see page after next)

Signal Generator SMDU

The free-running SMDU oscillator covers the range from 140 kHz to 525 MHz. The oscillator stability is such that any measurement can be started only five minutes after switching on the Test Assembly.

The **1.05-GHz Frequency Range Extension and the 1.05-GHz Frequency Doubler options** double the range of the SMDU, its excellent characteristics being maintained. With the doubler, subharmonics are down 20 dB.

The **Synchronizer option** provides for synthesizer stability without affecting the spectral purity of the signal. In addition, this unit permits frequency settings corresponding to the standard channel spacings of the different radio services between 12.5 and 150 kHz as well as continuous fine tuning to any frequency.

The **frequency meter** for 30 Hz to 525 MHz has a resolution of 1 Hz below 50 MHz and 10 Hz above 50 MHz. An input amplifier provides a sensitivity of 10 mV, thereby making possible measurements of frequency and frequency deviation even with cables of up to about 50 m. The **option SMDU-B 4** extends the measurement range up to 1 GHz.

The **modulation unit** included in the SMDU meets the most stringent requirements so that, for instance in receiver measurements with AM and FM, the inherent distortion is negligible (e.g. model 09: 0.2% for 75 kHz deviation; stereo crosstalk down 46 dB).

With the **Amplitude Modulation 525 to 1050 MHz** option, AM is possible in this frequency range with a modulation depth of about 95% and with constant characteristics even if the SMDU is operated with the Frequency Range Extension or the Frequency Doubler option.

The **modulation generator** delivers six fixed frequencies between 0.3 and 6 kHz or any other modulation frequency which can be set at will between 30 Hz and 30 kHz (the set frequency is indicated on the seven-digit frequency meter, accurate to within 1 Hz). The AF output voltage, which can be continuously adjusted between 1 mV and 5 V, is read from the multimeter which is incorporated in the modulation unit and can be set for mV, kHz or % indication.

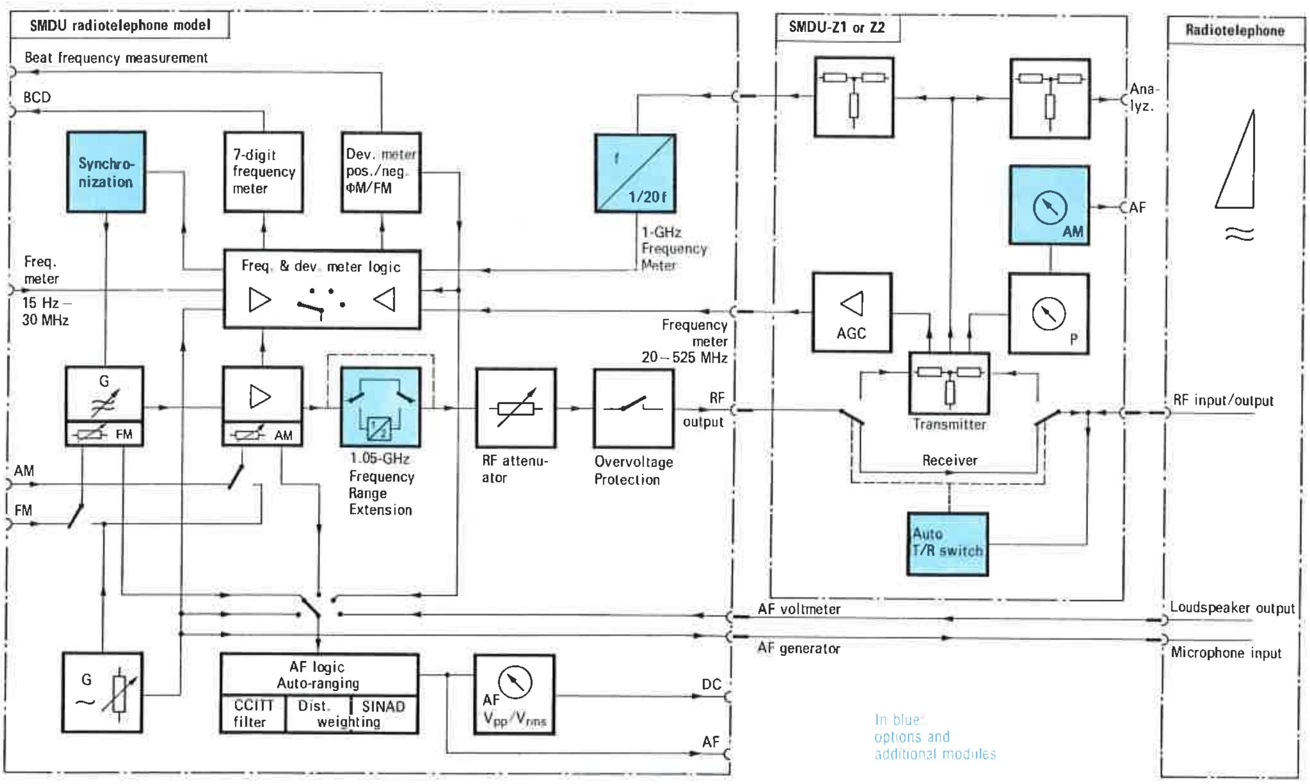
The **AF voltmeter** (30 Hz to 150 kHz, 1 mV to 10 V), which uses a true rms-responding detector, automatically switches to the correct subrange (out of a total of seven). The bandwidth of the voltmeter can be limited by connecting the psophometric CCITT filter.

The **1-kHz distortion meter** (0.5 to 50%) with its autoranging facility can be used in conjunction with the AF voltmeter or the deviation meter. An LED lights up if the test level falls short of the required value.

The **SINAD ratio meter** (6 to 46 dB) measures the ratio of the total signal to the noise and distortion components. The standard SINAD value (6, 12 or 20 dB) of the corresponding measurement range is marked by LEDs on the scale of the meter.

Continued (deviation meter, power meter) ▶

Block diagram of Radiotelephone Test Assembly SMDU



SMDU Functions (continued)

Signal Generator SMDU

The **deviation meter** measures spurious FM between 10 and 300 Hz (rms weighting) and wanted deviations between 300 Hz and 100 kHz (peak weighting). Separate indication of positive or negative deviation is possible; an LED indicates that the deviation meter is ready for operation (counter-display resolution 1 Hz; the CCITT weighting filter or 1-kHz distortion meter can be connected.)

In the simplex mode the deviation meter operates on the receive frequency set on the signal generator whereas it tunes **automatically** to a spacing of between 4.2 and 10 MHz from the latter in the duplex mode.

Thus the deviation meter need not be retuned after channel changeover on multichannel equipment. It is also suitable for measurements on transceivers in relay operation. This saves another deviation meter and a separate tuning operation which would otherwise be required.

SMDU options and conversion kits

SMDU-B1 **Synchronizer**
Standard equipment in the Radiotelephone Test Assembly, improves the long-term stability to that of a synthesizer. Simplifies operation by channel-stepping facility; electronic fine tuning.

SMDU-B2 **Overload Protection**
Standard equipment in the Radiotelephone Test Assembly, protects the RF output against externally applied power of up to 50 W.

SMDU-B3 **1.05-GHz Frequency Range Extension**
Extends the RF-generator range to 1.05 GHz without sacrificing performance characteristics.

SMDU-B4 **1-GHz Frequency Meter**
Extends the range of the counter to 1 GHz for external signals.

SMDU-B5 **1.05-GHz Frequency Doubler**
Low-cost option for doubling the frequency range. Subharmonics and harmonics are at least 20 dB below the carrier level.

SMDU-B8 **Amplitude Modulation 525 to 1050 MHz**
Incorporated in new deliveries of SMDU + Frequency Range Extension; allows amplitude modulation of the carrier up to 1050 MHz.

SMDU-B9 **S/N-ratio Improvement**
Improves the S/N ratio, permitting, for example, adjacent-channel selectivity of more than 80 dB to be measured.

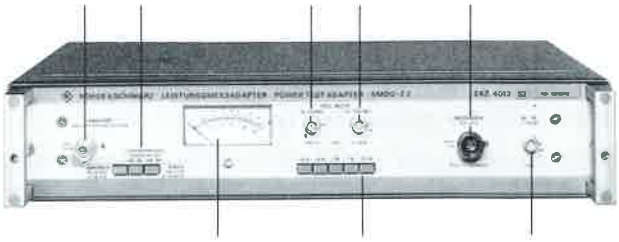
SMDU-U3 **Call Acknowledgement Conversion Kit**
Enables measurements on transceivers that send an acknowledgement signal.

Power Test Adapter and AM Unit

These two instruments, which are both optional, permit connection and adaptation of the transceiver to the test assembly and to additional signal generators (if, for instance, the multisignal method is used) or an analyzer. They can also be used for switchover between receiver and transmitter measurements.

Power Test Adapter SMDU-Z2 (1 to 1050 MHz)

The **SMDU-Z2** contains a relay switching panel and power attenuators. It distributes the RF signal to the frequency and deviation meters, the power meter and to different test outputs (e.g. for analyzer measurements).



Power Test Adapter SMDU-Z2

AM Unit SMDU-Z1 (1 to 1050 MHz)

Compared with the Power Test Adapter, the more convenient **SMDU-Z1** includes an additional modulation depth meter with ranges of 40 and 100%. If powers of ≧100 mW are applied, the SMDU-Z1 automatically switches over to transmitter measurement and selects the correct power measurement range.

The AM Unit comes as **30-W** and **60-W models.**

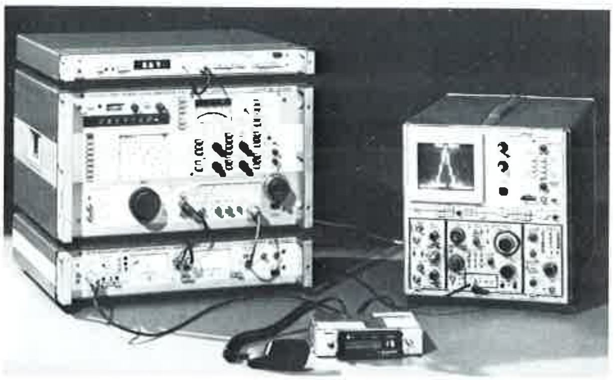
AM Unit SMDU-Z1

Operating convenience and versatility

Setting the Radio Telephone Test Assembly for receiver and transmitter measurements requires only very little time:

1. RF: The RF end of the radio is connected to the Power Test Adaper or AM Unit.
2. AF: a) The mike input is taken to the SMDU modulation generator output and b) the loudspeaker output is connected to the AF voltmeter input.

The measuring instruments are connected via the internal switching panels; thus all measurements can be performed without changing any connections.



Test setup comprising Adjacent-channel Power Meter NKS, Signal Generator SMDU 06 and AM Unit SMDU-Z1

Receiver measurements

After setting the test frequency, modulation type and frequency on the SMDU, the AF voltmeter indicates the voltage at the receiver output or the distortion for a modulation frequency of 1 kHz.

Receiver sensitivity. Convenient measurement is possible using one of the two conventional methods:
S/N ratio of 20 dB
SINAD ratio using the SINAD ratio meter for 6, 12 or 20 dB

Bandwidth. A marker for a 6-dB level difference (EMF and V_{out} cursor lines) on the attenuator simplifies the measurement. Digital display of the cutoff frequencies is provided.

The **squelch threshold** and the limiter action at the AF output of the receiver are determined using the attenuator and the AF voltmeter; the single-range attenuator permits rapid continuous level adjustment without reversal of direction (problemfree determination of hysteresis).

Effects of interfering transmitters, such as intermodulation, adjacent-channel modulation, desensitization or reradiation from closeby receivers, can be measured with great accuracy due to the excellent spectral purity of the generator signal (S/N ratio at 20 kHz from carrier >135 dB, 1 Hz).

Extension of test assembly

The Radiotelephone Test Assembly SMDU incorporates all the instruments required for normal servicing; see also block diagram on page 105.

In practical situations, the investigation of poor radio communications involves further measurements for checking the interference-determining items of the equipment specifications. Consideration must also be given to the possibility that working conditions alone are responsible for disturbed communication. For example, an important parameter such as **adjacent-channel selectivity** can only be measured using a two-source technique. It is therefore advantageous that test assemblies, even when used only for servicing, may be easily extended.

Thanks to the direct connections for a second signal generator and an analyzer, extension of the SMDU Radiotelephone Test Assembly is very straightforward.

Transmitter measurements (brief overview)

Parameter:	Special features:
Frequency tolerance	Immediate indication on frequency meter
Power	Simultaneous indication of power, freqeuncy and deviation
Frequency deviation	Semi-automatic tuning
Deviation limiting	Use of maximum permissible deviation thanks to narrow tolerances
Harmonic distortion	Direct indication at 1 kHz
Calling frequency	Resolution 1 Hz
Modulation depht (using SMDU-Z1)	Power and frequency at the same time
Harmonic distortion	Indication of frequency and distortion
Limiting	With and without weighting
Out-of-band radiation	Direct connection of analyzer
Relay operation	In-service measurement possible without auxiliary oscillators

Adjacent-channel power

For assessment of the modulation sidebands or excessive noise components emitted by the transmitter section of a transceiver, the postal authorities have now introduced the definition of adjacent-channel power. Two methods have been specified: a) Analyzer method, b) method with power test receiver.

The Adjacent-channel Power Meter NKS from Rohde & Schwarz works on method b); see pages 108 and 115.

Measurement of adjacent-channel power involves nothing more than selection of the desired channel spacing (10, 12.5, 20 or 25 kHz) and the upper or lower adjacent channel. An automatic test program determines the power of the transmitter signal and of the interference and provides digital indication of the ratio of unwanted to carrier signal in dB in compliance with the specifications. The absolute power content of the interfering signal is calculated from the carrier-power indication on the SMDU-Z1 or -Z2 and the ratio shown on the NKS.

Extension of SMDU Test Assembly with Adjacent-channel Power Meter NKS

- Power test receiver for 25 to 950 MHz in line with standard specifications
- Measurement of all transceiver characteristics including adjacent-channel power
- Selective measurement of spurious signals

Adjacent-channel Power Meter NKS

Full description on page 115

Due to overcrowding of the radiotelephone bands, the postal authorities have introduced the definition of adjacent-channel power to ensure better-quality communications.

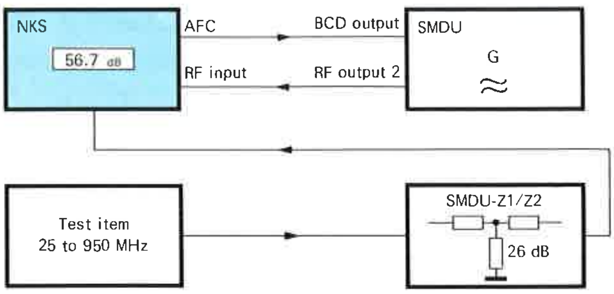
Adjacent-channel power refers to the spectral components present in the adjacent channels of a transmitter; it may be due to ineffective deviation limiting or to modulation distortion in FM transmitters or, with AM, to overmodulation, limiting or harmonic distortion in the event of overdriving.

To extend the SMDU Radiotelephone Test Assembly for the rational and accurate measurement of adjacent-channel power, Rohde & Schwarz offers the

Adjacent-channel Power Meter NKS

The power-test-receiver technique used in the NKS allows the determination of the carrier and adjacent-channel powers by means of an rms-responding rectifier. Thus all signals can be evaluated, the total power in the adjacent channel being measured continuously. The NKS fully complies with the relevant specifications for power test receivers.

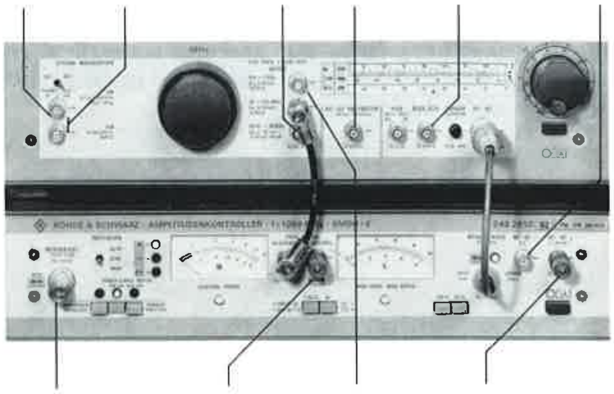
Configuration of test assembly. In conjunction with the SMDU Radiotelephone Test Assembly the Adjacent-channel Power Meter measures the interference in the adjacent channel and indicates the ratio of carrier power to unwanted power in three digits; see block diagram below. Only the desired channel spacing (10/12.5/20/25 kHz) and the upper or lower channel need be selected prior to measurement. Measurement range 0 to 89.9 dB; accuracy ± 0.5 dB.



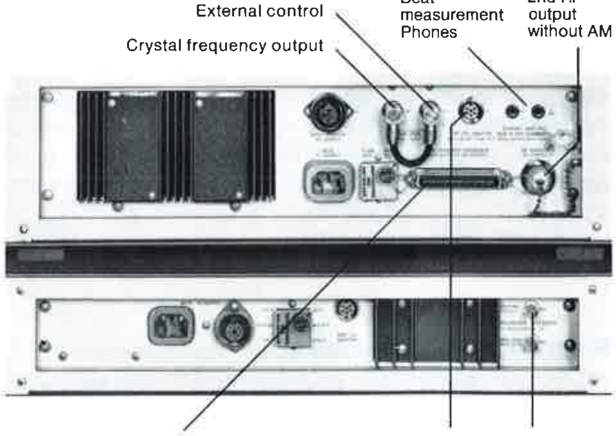
NKS in conjunction with Radiotelephone Test Assembly SMDU

Connectors

SMDU front panel



SMDU rear panel



Specifications

Frequency range	0.14 to 525 MHz; 0.14 to 1050 MHz using SMDU-B3 or B5
Setting, indication	on drum scale, 7-digit readout (crystal 10 MHz, aging 5×10^{-8}/month)
Scale resolution	up to 50 MHz: 1 or 10 Hz up to 800 MHz: 10 or 100 Hz above 800 MHz: 0.1 or 1 kHz
Fine tuning using synchronizer option	
Steps corresponding to channel spacing	12.5/20/25/50/100/150 kHz
Tuning range	20 to 160 kHz
Frequency instability after warmup	
Free-running oscillator	<1.5 to <6 kHz for 0.14 to 1050 MHz
Using synchronizer	$<5 \times 10^{-8}$ +10 Hz (for f ≧525 MHz)
Spectral purity	
Spurious frequencies	down >110 dB (>90 dB for 0.14 to 50 MHz and 392 to 525 MHz)
S/N ratio at 20 kHz from carrier, test band 1 Hz	>135 dB (>130 dB below 50 and >125 dB above 525 MHz)
Spurious AM with FM at f_{mod} = 1 kHz	<1%, typ. 0.5% with 100 kHz deviation (for f >1 MHz)
with SMDU-B9	<3%, typ. 1% (for f >20 MHz) with 100 kHz deviation

RF output I	Z_{out} = 50 Ω; N female connector, adaptable
Output EMF and power	0.05 µV to 2 V, −139 to +13 dBm
Frequency response, attenuator error	up to 500 MHz <±1 dB up to 1.05 GHz <±2 dB
VSWR	<1.2 (above 525 MHz: <1.4)

RF overvoltage protection	automatically disconnects RF outputs
Max. permissible condition	50 W or 50 V DC

AF generator and modulation unit plus measuring instruments

Modulation frequencies	
Fixed	0.3/0.4/1/2.7/3/6 kHz
Continuous	0.03 to 30 kHz
Output voltage	1 mV to 5 V into 200 Ω
Distortion	<0.5% for 100 Hz to 10 kHz

Type of modulation (internal and external)	AM	FM	φM
Modulation range	0 to 98%	0 to 100 kHz	0 to 100 rad
Modulation distortion	<1.5% 80% mod.	<1% f_{max} 20 kHz	<1% f_{max} 6 kHz
Measurement ranges	10/30/ 100%	1/3/10/ 30/100 kHz	1/3/10/ 30/100 rad

Characteristics of model 09	
Modulation distortion	<0.2% at 75 kHz deviation in the FM broadcast ranges
Stereo crosstalk	>40 dB down at 50 Hz >46 dB down at 1 kHz and 15 kHz

Frequency meter/with option	15 Hz to 30 MHz	20 to 525 MHz	0.5 to 1 GHz
Sensitivity	10 mV	10 mV	30 mV
Resolution	1/10 Hz	10/100 Hz	10/100 Hz

Deviation meter	for positive and negative frequency and phase deviation
Measurement ranges	10 to 300 Hz (rms weighting) 300 Hz to 100 kHz (peak weighting)
Symmetry error	<±1.5%

AF voltmeter	1 mV to 10 V, 15 Hz to 30 kHz
Error limits	±(3% of rdg +1.5% of fsd)
Detector/weighting filter	rms-responding/CCITT

Distortion meter	0.5 to 30% (50%), 1 kHz
Voltage/deviation range	80 mV to 3 V/1 to 40 kHz
Error limits	±(10% of rdg +1.5% of fsd) +0.3%

SINAD ratio meter	6 to 46 dB, 80 mV to 3 V
Error limits	±(10% of rdg +1.5% of fsd) plus inherent noise 0.3% (= 50 dB)
CCITT filter	complying with CEPT specifications, usable with deviation meter and AF voltmeter

Power Test Adapter	**SMDU-Z2**	
AM Unit		**SMDU-Z1**
TX/RX switchover	manual	automatic above 0.1 W
Frequency range	1 to 1050 MHz	1 to 1050 MHz
Power measurement range	50 mW to 30 W	50 mW to 30 W or 100 mW to 60 W
Modulation depth meter	—	0 to 40/0 to 100%
RF output	for analyzer connection and multisignal measurements; attenuation input/output 30 dB (VSWR 1.2)	

High-power attenuator	
Attenuation RX/TX measurement with SMDU-Z1/30 W and SMDU-Z2	0+0.6 dB/20±1.3 dB
with SMDU-Z1/60 W	0+0.6 dB/26±1.3 dB

RF connector (analyzer, multisignal measurement)	
Input/output attenuator/VSWR	30±0.8 dB/1.3

Adjacent-channel Power Meter (details on page 115)

Frequency range	20 to 950 MHz
Input voltage range	
RF input	0.1 to 2 V
LO input	50 to 200 mV
Adj.-channel power measurement	Channel spacing 10 kHz 12.5 kHz 20 kHz 25 kHz
Measurement range (signal/interference power)	0 to 89.9 dB
Weighting	rms value
Error limits	±1 dB
Indication	3 digits

General data

Rated temperature range	+10 to +45 °C
Storage temperature range	−40 to +70 °C
AC supply	115/125/220/235 V ±10%, 47 to 420 Hz (100 to 120 VA depending on configuration)
Dimensions and weight of complete test assembly	492 mm×401 mm×436 mm, 37 kg

Ordering information

Order designation	▶ Radiotelephone Test Assembly SMDU

Single instruments for combination as test assembly

	Order No.
Signal Generator SMDU	
Radiotelephone model	249.3011.06 **or**
Radiotelephone model stereo-compatible	249.3011.09 **or**
Radiotelephone-navigation model	249.3011.07
Power Test Adapter SMDU-Z2	242.4012.52 **or**
AM Unit SMDU-Z1/30 W	242.2010.52 **or**
SMDU-Z1/60 W	242.2010.53

Compact test assemblies based on Signal Generator SMDU 06

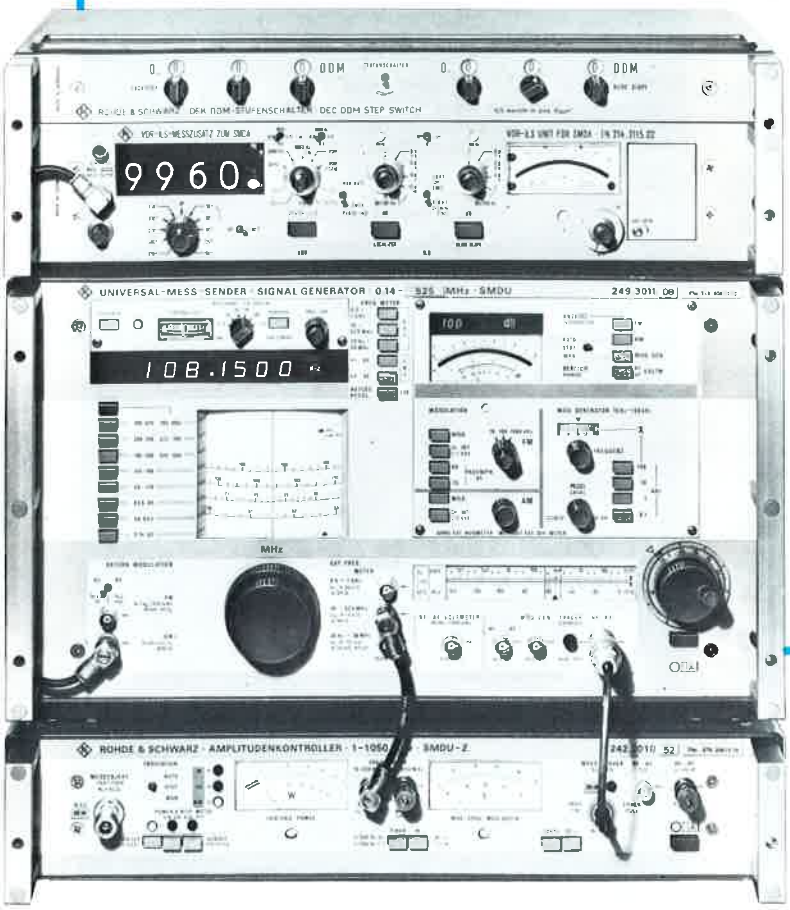
SMDU 52 with SMDU-B1 option and AM Unit SMDU-Z1/30 W	249.3011.52
SMDU 53 with SMDU-Z1/60 W instead of/30 W	249.3011.53
SMDU 56 with Power Test Adapter SMDU-Z2 instead of SMDU-Z1	249.3011.56

Accessories supplied	power cable, 1 BNC-BNC connecting cable (for SMDU-Z1, -Z2)

Recommended extras

Adjacent-channel Power Meter NKS	302.2410.02
Options (description on page 106)	
SMDU-B1: Synchronizer (standard equipment in test assembly)	249.6340.02
SMDU-B3: 1.05-GHz Frequency Range Extension	249.9484.02
SMDU-B4: 1-GHz Frequency Meter	250.0012.02
SMDU-B5: 1.05-GHz Frequency Doubler	275.1312.02
SMDU-B8: Amplitude Modulation 525 to 1050 MHz	295.2150.02
SMDU-B9: S/N Ratio Improvement	295.2189.02
SMDU-U3: Call Acknowledgement Modification Kit	295.2008.02

VOR/ILS Test Assembly



Test Assembly for Airborne VOR/ILS and Communication Equipment

♦ 0.14 to 1050 MHz

Complete test system from a single manufacturer; guaranteed data for system as a whole:

- Signal Generator SMDU in several models, with spuria-free and lownoise output, featuring excellent modulation characteristics
- VOR/ILS Unit with modulation generator, phase, modulation-depth and DDM meter as well as self-check for VOR/ILS output signals
- AM Unit with output-power meter, modulation-depth meter and automatic TX/RX switchover

Variants and options optimally combinable for all applications

The test assembly can be used for the development, production and servicing of airborne communication and VOR/ILS*) air navigation equipment. It offers highest reliability due to the built-in self-testing facility and thanks to the available instruments for absolute measurement of the VOR zero phase (see page 114). Thus it enables the user to strictly observe the relevant test specifications for VOR/ILS and communication equipment (e.g. ARINC 578 and 579).

The system concept allows the user to check the measurement accuracy in a simple way, which can normally be done only by the manufacturer, and thus meets the requirement of all institutions responsible for the safety of air traffic.

Moreover, the test assembly features a very favourable price/performance ratio since it is part of a modular system within the general measuring-instrument line.

The basic equipment, consisting of

Signal Generator SMDU (page 66),
VOR/ILS Unit and AM Unit,

can be varied with respect to the signal generator used (see ordering information). The SMDU navigation model (08) is preferred for the VOR/ILS Test Assembly whereas the SMDU radiotelephone & navigation model (07) contains in addition all measuring instruments required for FM transceivers, permitting, for instance, determination of deviation, distortion and SINAD ratio.

Several **options** are available; they can be incorporated in the signal generators upon delivery or added later without any adjustment.

Synchronizer SMDU-B1. This module improves the SMDU frequency stability to that of a synthesizer while maintaining its high spectral purity. Operation is greatly simplified thanks to the channel-to-channel stepping at the spacings 50, 100 and 150 kHz used by VOR/ILS services and to synchronized fine tuning with extremely high resolution.

1.05-GHz Frequency Range Extension SMDU-B3. This doubles the RF generator range of the SMDU while maintaining its excellent characteristics.

1-GHz Frequency Meter SMDU-B4. This module is required for external frequency measurements above 525 MHz. The overall range of the seven-digit frequency meter is then 15 Hz to 1 GHz with a resolution of 10 Hz at 1 GHz.

Overload Proteciton SMDU-B2. This module protects the RF attenuator and the output stage against inadvertent application of RF or DC voltages. This option is fitted as standard in the radiotelephone & navigation model.

---

*) VOR: VHF Omnidirectional Range. A radio-navigation method employing phase comparison of two 30-Hz signals.

ILS: Instrument Landing System (blind approach) with azimuth and glide-path links, providing a line of intersection between two directional lobes at a 90-Hz and a 150-Hz amplitude-modulated carrier frequency.

The **VOR/ILS Unit,** which produces all signals required for VOR/ILS measurements and checks those provided by the signal generator, is available with and without decade DDM step switch. In conjunction with this switch, an extremely fine adjustment of all DDM values in steps of 0.001 is possible, permitting precise linearity measurements on ILS systems (category III).

Another variation is possible using the **AM Unit** which measures power and modulation depth and permits automatic switchover between transmitter and receiver measurements. If only FM transceivers are to be checked out, the simpler and less expensive Power Test Adapter SMDU-Z2 can be used.

Calibration instruments

VOR Zero-phase Meter POR with 0.01° resolution in the most sensitive range (see page 114)

Characteristics of the test assembly for navigation measurements and modulation

- Suitable for all VOR and ILS test programs according to RTCA and ARINC
- VOR phase adjustable in steps and continuously from 0 to 360°
- Phase-angle indication in four digits and by indicator lamp with an accuracy of 0.05°
- DDM values separately adjustable for localizer and glide slope in standard steps of 0.001 DDM and continuously
- Expanded range for measurements around zero DDM; discrimination 0.001/scale division
- Modulation signal generation for measurements on marker receivers, radiotelephone systems and AF sections of VOR/ILS receivers (with signal tracing)
- Self-testing facility for the modulation characteristics, for modulation generator and monitor

Modes, modulation signals, indications

Mode	Signal	Simultaneous checks M: meter C: counter	Light signal (range)	Signal modification *) "On" signalled by flashing lamps
VOR	30 Hz (variable phase)	M: % dev. from 30 % mod.	Δ mod. 5 %	*) 30 Hz with freq. variation by ±0.5 % and ±1.5 % steps *) ±25 % amplitude variation of 30-Hz and 9960-Hz components Ext. AM (0 to 10 kHz, up to 80 %) of mod. 9960-Hz subcarrier (interference simulation DVOR) Ext. AM (0 to 10 kHz, up to 80 %) for complete VOR signal Addition of external interference signals Fine modulation-depth adjustment
	9960 Hz (CW)	M: % dev. from 30 % mod. C: frequency	Δ mod. 5 % Hz	
	9960 Hz freq. mod. with 30 Hz (480 Hz deviation)	M: % dev. of freq. dev.	± dev. 5 %	
	VOR signal Phase setting: 30° steps and continuous; 180° switch	C: phase of signal	bg. φ	
	VOR sig. + communication sig. 1020 Hz	C: phase of signal	bg. φ	
ILS Localizer	90 Hz, 150 Hz } for left/right	M: % dev. from 20 % mod.	Δ mod. 5 %	*) 90 Hz and 150 Hz with freq. variation by ±0.5 % and ±1.5 % steps *) Phase relation of components switchable: −12/0/+12° (referred to 30 Hz) One component cut off (90 Hz or 150 Hz) Left/right switching (in localizer mode) Up/down switching (in glide slope mode) Addition of external interference signals Fine modulation-depth adjustment
	In steps: Points / DDM / dB 0 / 0 / 0	M: DDM	DDM 0.02	
	1.5 / 0.0465 / 2.0 3 / 0.093 / 4.0 5 / 0.155 / 6.57 10 / 0.310 / 12.39 Cont. 0 to 12.9 / 0 to 0.4	M: DDM	DDM 0.2	
	With Decade DDM Step Switch: in steps of 0.001 from 0.000 to 0.400 DDM	M: DDM	DDM 0.2	
ILS Glide slope	90 Hz, 150 Hz } for up/down	M: % dev. from 40 % mod.	Δ mod. 5 %	
	In steps: Points / DDM / dB 0 / 0 / 0	M: DDM	DDM 0.02	
	1.3 / 0.0455 / 0.99 2.6 / 0.091 / 1.97 5 / 0.175 / 3.76 Cont. 0 to 22.8 / 0 to 0.8	M: DDM	DDM 0.2	
	With Decade DDM Step Switch: in steps of 0.001 from 0.000 to 0.800 DDM	M: DDM	DDM 0.2	
Marker signal/communication	All modulation frequencies continuously adjustable	Indication on modulation unit of signal generator		

Test Assembly for Airborne VOR/ILS and Communication Equipment (cont'd from page 111)

VOR/ILS Unit with
Decade DDM Step Switch

Measurements on air-navigation receivers

For testing VOR/ILS receivers, the RF carrier of the Signal Generator SMDU is amplitude-modulated with the signals which have been processed in the VOR/ILS Unit.

VOR signals

Two 30-Hz signals of mutually variable phase are produced in the generator section of the VOR/ILS Unit – reference signal (30 Hz) frequency-modulated upon 9960-Hz carrier.

Possibilities of setting the phase: 30° steps, continuously variable by >30° and phase reversal (180°). The phase shift of the AF signals demodulated from the RF carrier is indicated by four numerical indicator tubes providing for a resolution of 0.03°. Controls are provided for adjusting the generation and output of the individual components allowing simultaneous measurement of the modulation depth, its variation or that of the components of the VOR signal as well as percentage variation of the modulation frequencies according to the requirements of standard specifications. Built-in modulators and adder inputs are provided for the simulation of interference.

ILS signals

The 90-Hz and 150-Hz ILS signals are derived in rigid phase relation from a 1800-Hz squareware signal (see block diagram showing signal processing) by the action of a frequency divider and a wave converter.

The various depths of modulation are automatically set by switching the modes of operation between "localizer" or "glide slope". Standard DDM values can be set in each mode, intermediate values in position "continuous".

The Decade DDM Step Switch permits accurate adjustment of DDM values in steps of 0.001, the sum of the modulation depths of the signals remaining constant.

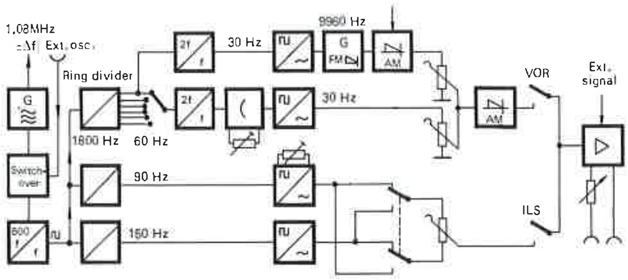
Separate controls are provided for blanking the individual components, for phase shift and changing the components in compliance with the requirements of the standard specifications.

According to the mode of operation selected, a meter displays either the modulation depth Δmod. (0.2% per scale division, 5% fsd), the DDM zero (0.001 per scale division, 0.02 fsd) or the DDM values adjusted (0.01 per scale division, 0.2 fsd) of the demodulated RF signal.

The VOR/ILS Unit is equipped with a self-testing facility for checking its essential subassemblies.

Modulation signal processing

All modulation signals are derived from an oscillator which can be varied by ±0.5% and ±1.5%. The VOR signals (30-Hz reference and 30-Hz variable-phase) and the ILS signals of 90 Hz and 150 Hz are provided by separate frequency dividers.



Generator section of the VOR/ILS Unit; processing of modulation signals

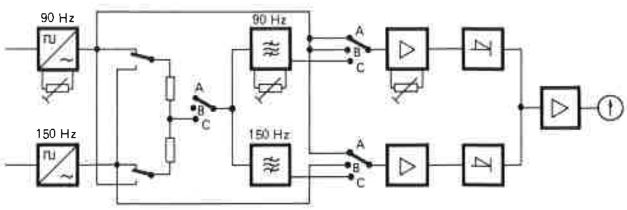
After conversion from squarewave to sinewave shape, the 30-Hz reference signal modulates the frequency of a 9960-Hz oscillator, while the variable signal is added to the reference signal after the squarewave-to-sinewave conversion.

The digitally processed 90-Hz and 150-Hz signals are also taken through a squarewave/sinewave converter and are added in resistive network after the DDM divider. An output amplifier provides the appropriate signal level for the SMDU, the other AF output (continuous) is for general AF measurements.

Self-testing facility of the VOR/ILS Unit

By means of the built-in self-testing facility, the VOR/ILS Unit can be adjusted exactly to the rectified voltage of the signal generator (SMDU) and the measuring systems as well as their error limits checked.

The VOR phase meter is checked by connecting it to a point of zero reference phase in the generator section and adjusted, if required. The free-running 1.08-MHz signal can be compared with a 1.08-MHz crystal-oscillator frequency and subsequently adjusted.



Self-testing facility of the VOR/ILS Unit (ILS section)

The ILS signals can be adjusted as follows. In switch position A, the same signal is applied to both measuring channels to ensure identical gain setting. In position B, the 90-Hz and the 150-Hz signals are separately applied to the measuring channels and their amplitudes adjusted with respect to each other (to DDM zero). In position C, the insertion loss in the measuring paths can be checked and the differences compensated for.

Specifications

Frequency range	0.14 to 525 MHz; 0.14 to 1050 MHz using option SMDU-B3
Setting, indication	on drum scale, 7-digit readout (crystal 10 MHz, aging 5×10^{-8}/month)
Scale resolution	up to 50 MHz: 1 or 10 Hz; up to 800 MHz: 10 or 100 Hz; above 800 MHz: 0.1 or 1 kHz
Fine tuning using synchronizer	option
Steps corresponding to channel spacing	12.5/20/25/50/100/150 kHz
Tuning range	20 to 160 kHz
Frequency instability after warmup	
Free-running oscillator	<1.5 to <6 kHz for 0.14 to 1050 MHz
Using synchronizer	$<5\times10^{-8}$ (+10 Hz for f ≧525 MHz)
Spectral purity	
Spurious frequencies	down >110 dB (>90 dB for 0.14 to 50 MHz and 392 to 525 MHz)
S/N ratio at 20 kHz from carrier, test band 1 Hz	>135 dB (>130 dB below 50, >125 dB above 525 MHz)
Spurious AM	down >80 dB
RF output I	Z_{out} = 50 Ω; N female connector, adaptable
Output EMF and power	0.05 µV to 2 V = −139 to +13 dBm
Frequency response, attenuator error	up to 500 MHz <±1 dB; up to 1.05 GHz <±2 dB
VSWR	<1.2 (above 525 MHz: <1.4)
RF overvoltage protection	automatically disconnects RF output
Max. permissible power	50 W (or 50 V DC)
RF output II (rear panel)	>20 mV into 50 Ω (without AM)

Frequency meter/ with option	15 Hz to 525 MHz /	0.5 to 1 GHz
Sensitivity	10 mV	30 mV
Resolution	1 Hz (10 Hz, above 20 MHz: 10/100 Hz)	10 Hz (100 Hz)

Specifications for

	Navigation model	Radiotelephone navigation model
AF generator/modulation unit/measuring instruments		
Modulation frequencies	15 Hz to 150 kHz, continuous	0.3/0.4/1/2.7/3/6 kHz, 0.03 to 30 kHz cont.
Output voltage	5 mV to 1 V into 600 Ω	1 mV to 5 V into 200 Ω
Distortion	<0.2 (0.5) %	<0.5% (0.1 to 10 kHz)
Voltmeter ranges	10 mV to 3 V	10 mV to 10 V
Error limits	± (2% of rdg + 1.5% of fsd)	± (2% of rdg + 1.5% of fsd)
Rectifier response/weighting filter	average	rms/CCITT
Deviation meter, distortion meter, SINAD ratio meter, CCITT filter	see Radiotelephone Test Assembly on page 109	

VOR/ILS modulation
VOR/ILS Unit

VOR modulation signal, consisting of:

30-Hz signal	
Fixed-frequency error limits	$\pm3\times10^{-4}$
Incremental tuning	±0.5% and ±1.5%
Distortion	<0.5%
Phase shift between the 30-Hz signals in steps of	30°
continuously between steps	>30°
9960-Hz auxiliary carrier	
Frequency accuracy	$\pm2\times10^{-3}$
Frequency deviation	480 Hz
Distortion	<1%
1020-Hz communication signal	
Frequency accuracy	±1.5%
Distortion	<0.5%

ILS modulation signals

90-Hz and 150-Hz signals	
Frequency accuracy	$\pm3\times10^{-4}$
Incremental tuning	±0.5% and ±1.5%
Distortion	<0.5%
Deviation of signal amplitudes at DDM 0	$<5\times10^{-4}$

Indicator section (measurement of demodulated generator signal)

VOR signals:	
Digital phase readout	four digits
Resolution	0.02°
Error	<0.05°
Modulation-depth indication	for 30 Hz and 9960 Hz
Range	nominal value ±5%
Error	<1%
Frequency-deviation indication	
Range	±5% (from nominal value)
Error	<1%
ILS signals:	
Modulation-depth indication	for 90 Hz and 150 Hz
Range	nominal value ±5%
Error	<0.5%
Analog indication of DDM values	
Ranges	0.02 and 0.2
Error	<4% from DDM value + 2% of fsd
Resolution of indication per scale division (1.2 mm)	0.001 for zero DDM; 0.01 for remaining DDM values

VOR/ILS Unit with Decade DDM Step Switch

Sum of individual depths of modulation	constant
Error of steps	0.1%
Error of DDM steps via Signal Generator SMDU	
up to 0.175 DDM	< (2% of DDM value +0.0005)
up to 0.310 DDM	<3% of DDM value
for max. DDM value	approx. 5% of DDM value

Power measurement	SMDU-Z1	SMDU-Z1
Measurement ranges	0.05 to 0.3/1/3/10/30 W	0.1 to 0.6/2/6/20/60 W

Modulation measurement

Measurement ranges	0 to 40/100%	0 to 40/100%
Input power	0.1 to 30 W	0.2 to 60 W

General data

Rated temperature range	+10 to +45 °C
Storage temperature range	−40 to +70 °C
AC supply	115/125/220/235 V ±10% (130 to 160 VA)
Dimensions, weight	492 mm×555 mm×436 mm, 46 kg
Vibration test	in accordance with VDE 0411

Ordering information

Order designations for VOR/ILS Test Assemblies (please order units separately) ▶ Order No.

Signal Generator SMDU	
Navigation model	249.3011.08
Navigation model with Synchronizer option B1	249.3011.38
Radiotelephone & navigation model	249.3011.07
VOR/ILS Unit	
with Decade DDM Step Switch	214.3115.10
without Decade DDM Step Switch	214.3115.02
AM Unit SMDU-Z1/30 W	242.2010.52
SMDU-Z1/60 W	242.2010.53
VOR/ILS Test Assembly SMDU-V with Decade DDM Step Switch	249.3011.80

Options

SMDU-B1: Synchronizer	249.6340.02
SMDU-B2: Overload Protection	249.7346.02
SMDU-B3: 1.05-GHz Frequency Range Extension	249.9484.02
SMDU-B4: 1-GHz Frequency Meter	250.0012.02
SMDU-B5: 1.05-GHz Frequency Doubler	275.1312.02

Recommended accessories

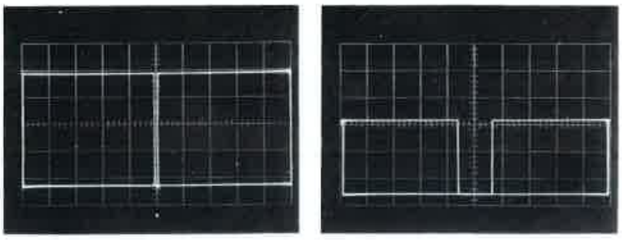
Signal Generator SMDU, standard version	249.3011.02 (for two-signal measurements)
VOR Zero-phase Meter POR	242.0017.92 (data on page 114)

POR

VOR Zero-phase Meter POR

- Resolution 0.01° in the most sensitive range
- Accuracy can be checked directly with an oscilloscope
- Deviation checking facility (display of modulation index)

The **POR** is a maintenance-free, high-sensitivity instrument for measuring the phase difference (up to 10°) between the variable and reference-phase components of a VOR signal and for checking the deviation of the VOR subcarrier. The VOR signal consists of the sum of a 30-Hz signal (variable component) and a 9960-Hz subcarrier which is frequency-modulated with a 30-Hz signal (reference component); the standard deviation of the subcarrier is 480 Hz corresponding to a modulation index of 16.



Output at test socket 2.
Left: correctly functioning instrument, the gap in the oscillogram is narrow; right: with a phase error of 0.017° in the 9960-Hz branch, the width of the gap in the oscillogram is 10% of the entire display width.

Uses

The precision zero-phase meter is suitable for use in the calibration laboratories of

- ▷ airline companies
- ▷ ATC authorities
- ▷ manufacturers for VOR transmitting and receiving equipment
- ▷ maintenance companies.

The zero-phase condition of VOR signals from sources such as VOR generators, ramp testers and VOR ground equipment can be measured with great accuracy. In addition, the POR is suitable for tracing signals in the subassemblies of VOR transmitting and receiving equipment. The phase of the test signal can be shifted +30° for checking the direction of phase rotation of resolvers and VOR generators.

In the deviation mode, the deviation of the VOR subcarrier is measured and the associated modulation index indicated.

The instrument is outstanding in its ease of operation: it is only necessary to perform a minimum setting with the input signal.

Self-testing

Two test sockets (test voltages) on the rear panel permit checking of the accuracy of the instrument using an oscilloscope.

Test socket 1 permits checking the effectiveness of the phase compensation section in the 30-Hz branch.

Test socket 2 enables display of the test voltage on an oscilloscope, the resolution being such that the highest possible resulting error is less than 0.01°; see oscillograms above.

Specifications

Phase indication	
Ranges	0.3°/1°/10°
Resolution in 0.3° range	0.01°
Amplitude controls	
coarse	ten-turn helipot
fine	potentiometer
Error of the zero phase in the 0.3° range	<0.02°
Indication error (phase measurement)	
0.3° range	<10% of rdg ±1.5% of fsd } plus zero error
1° and 10° ranges	<5% of rdg ±1.5% of fsd } plus zero error
Deviation indication	
Indication range	modulation index 0 to 20
Indication of standard modulation index	mark at m = 16
Indication error	
for m = 16, f = 30 Hz ±1% in the temp. range +20 to +30°C	≦1%
otherwise for f = 30 Hz ±1%	<5% of rdg ±1.5% of fsd
Test input	BNC female connector
Level requirement	200 to 700 mV
Input impedance	>10 kΩ
Maximum permissible DC component	5 V
General data	
Rated temperature range	+10 to +45°C
Storage temperature range	−45 to +70°C
AC supply	115/125/220/235 V ±10% (47 to 440 Hz); 9 VA
Dimensions, weight	484 mm×105 mm×336 mm, 8 kg

Ordering information

Order designation	▶ VOR Zero-phase Meter POR 242.0017.92
Recommended extras	1 RF connecting cable 100.6945.10 (for test input, BNC male connectors, 1 m long)

Adjacent-channel Power Meter NKS ♦ 25 to 950 MHz

NKS

- Power test receiver complying with standard specifications
- Extends the SMDU RT Test Assemblies for the measurement of all characteristics including adjacent-channel power

The **Adjacent-channel Power Meter NKS** is used in conjunction with the SMDU RT Test Assembly to measure and evaluate all unwanted (power) spectral components of a transceiver in the adjacent channel.

The **power-test-receiver technique** used in the NKS determines the adjacent-channel power by means of an rms rectifier. This permits the total power to be measured and evaluated continuously and irrespective of the type of modulation. The NKS complies with all standard specifications for power test receivers.

Configuration of test assembly. Combined with the SMDU Radiotelephone Test Assembly according to the block diagram on page 108, the Adjacent-channel Power Meter measures the interference in the adjacent channel and indicates the ratio of carrier power to unwanted power in dB in three digits.

Measurement of adjacent-channel power involves nothing more than selection of the desired channel spacing (10/12.5/20 or 25 kHz) and the upper or lower adjacent channel. An automatic test program provides digital indication of the ratio of carrier to unwanted signal. The absolute power of the interfering signal is calculated from the power indication on the SMDU-Z1 or -Z2 and the ratio shown on the NKS.

Another use of the NKS is the selective **measurement of spurious signals.** In the mode "store carrier" the level of the carrier is stored. If the oscillator of the SMDU is then tuned to the frequency of the spurious signal, the ratio of carrier to unwanted signal is indicated in dB. The test assembly thus does the work of an analyzer.

Measurement of adjacent-channel interference due to transients – until now performed only roughly with an analyzer – is now possible with the NKS. Thanks to the precise performance of the memory circuit of the NKS, such interference can now be measured accurately.

Description

The NKS converts the **signal of the test item** to an IF of 455 kHz ± channel spacing. The Signal Generator SMDU, with its high spectral purity, is used as an auxiliary oscillator. A control voltage, which permits automatic tuning of the frequency of the SMDU over a range of about 600 kHz, is derived from the IF of the NKS by a pulse discriminator.

For **selection of the adjacent-channel power** of a radio set, high-grade 455-kHz mechanical bandpass filters are used, ensuring the required carrier suppression and covering the bandwidths specified for the various channel spacings. In conjunction with the SMDU, the IF is adjusted via the control loop so that the adjacent channel being investigated is within the passband of the associated filter.

Specifications

Frequency range	25 to 950 MHz
RF input	$Z_{in} \approx 50\ \Omega$, BNC female connector
Input voltage range	0.1 to 2 V (max. permissible 5 V)
Input power range	
via SMDU-Z1 52 and Z2	0.1 to 30 W
via SMDU-Z1 53	0.2 to 60 W
LO input (rear)	$Z_{in} \approx 50\ \Omega$, BNC female connector
Input voltage range	0.05 to 0.2 V matched to SMDU
IF output	BNC female connector (rear)
Frequency/output voltage	455 kHz/0.2 V into 50 Ω
Adjacent-channel power measurement	complies with CEPT and FTZ specifications channel spacing 10 kHz 12.5 kHz 20 kHz 25 kHz
Selectable spacing from useful channel	±1 and ±2 channels
Indication	carrier-to-unwanted-power ratio in three digits
Measurement range	0 to 89.9 dB in 10-dB steps, error limits ±0.5 dB
Weighting	rms value (crest factor 10)
Indication error after 15-min warmup period	±3 dB (typ. ±2 dB)
Storage times	
Carrier reference:	
normal operation	automatic resetting every 2 min approx.
storage operation	±1 dB deviation after 15 min ±1 kHz deviation after 15 min
Measurement of transient behaviour	start delayed by 10 (±2) ms and 50 (±5) ms, duration 3 s

General data

Rated temperature range	+10 to +45 °C
Storage temperature range	−40 to +70 °C
Power supply	115/125/220/235 V ±10%, 47 to 420 Hz (20 VA)
Dimensions, weight	492 mm×78 mm×434 mm, 5 kg

Ordering information

Order designation .... ▶ Adjacent-channel Power Meter NKS 302.2410.03

Accessories supplied

Connecting cables: LO input/SMDU RF output II
AFC/BCD outputs of SMDU
RF input/Frequency Meter SMDU-Z

Power cable

Recommended extras

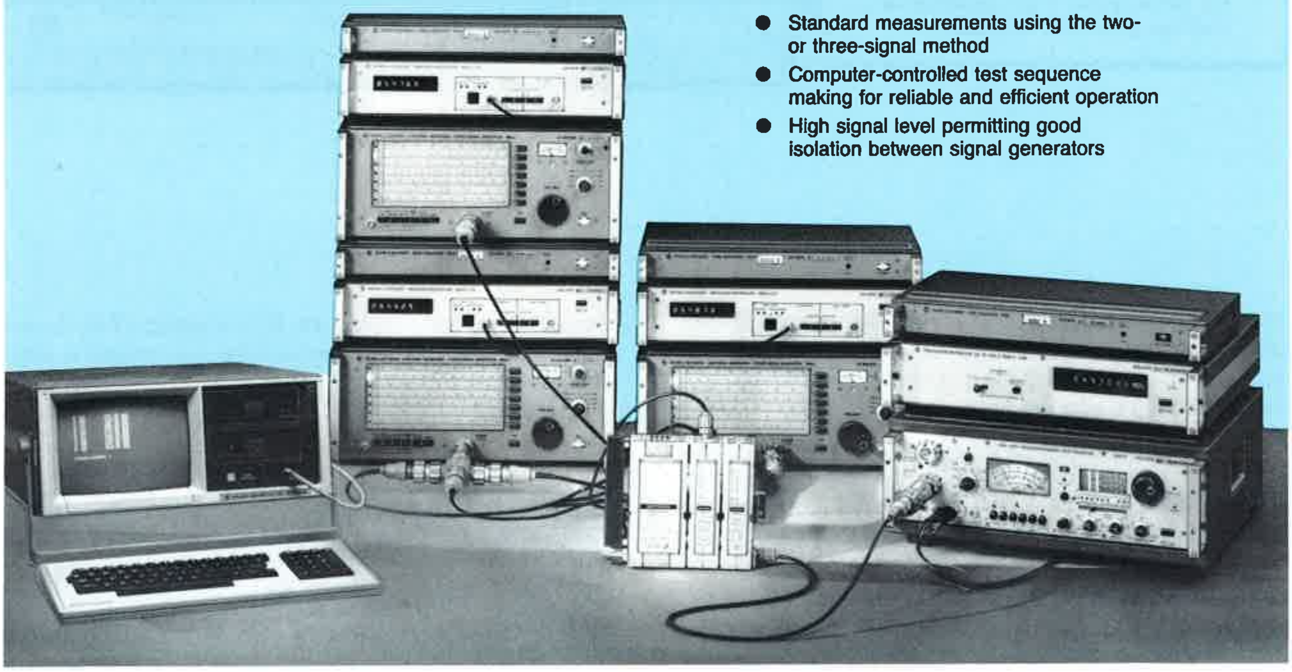
IEC-bus Interface NKS-Z 195.1475.02

IM/CM Test Assembly

Automatic Test Assembly for Intermodulation and Crossmodulation Measurements

♦ 25 to 1000 MHz

- Standard measurements using the two- or three-signal method
- Computer-controlled test sequence making for reliable and efficient operation
- High signal level permitting good isolation between signal generators



IEC 625 Bus

Definitions and test procedures for RF distortion

When processing and transmitting RF signals, intermodulation and crossmodulation products occur due to the nonlinearity in the characteristics of active and passive components. This distortion is defined as follows:

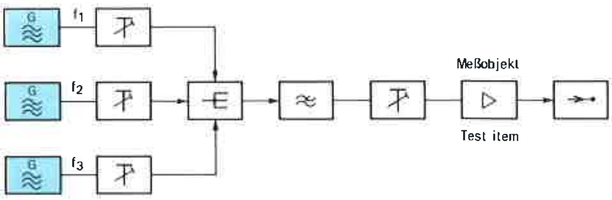
Intermodulation. If an input signal consists of several fundamental frequencies (e.g. picture carrier f_p, sound carrier f_s, colour subcarrier f_{sc}), unwanted combination frequencies are produced in the transmission channel ($f_{unwanted} = f_p+f_s-f_{sc}$) causing a moiré effect in the television picture.

Crossmodulation. Crossmodulation is the modulation of the useful signal by an interfering transmitter signal.

Test procedures. The procedures for measuring the receiver characteristics with respect to these two types of unwanted modulation are practically identical and they are laid down in standard specifications, such as DIN 45 004 (test procedures for antenna amplifiers), VDE 0855, or IEC and ZVEI recommendations.

These standards and the relevant specifications require measurements using the three-signal method in which a composite input signal is produced by interconnecting three signal generators in CW operation.

In the alternative **two-signal method** the combination frequencies produced are outside of the TV channel so that this test method is suitable only for evaluating broadband amplifiers.



Principle of test assembly for intermodulation and crossmodulation measurements using the three-signal method

The above-mentioned measurements require numerous, complicated operations and are time-consuming and expensive in the manual mode. If, however, modern computer control is used, these tests can be performed in a few seconds and a hard-copy test report obtained.

Automatic test assembly

This automatic test assembly is used for standard measurements of intermodulation (DIN 45 004, method K) and crossmodulation (method B) suppression to 75 dB using the three-signal method. In addition, intermodulation measurements according to the two-signal method and gain and frequency-response measurements are possible.

Applications. The computer-controlled RF test assembly permits saving of costs wherever frequent measurements of nonlinear distortion are to be performed on test items, such as

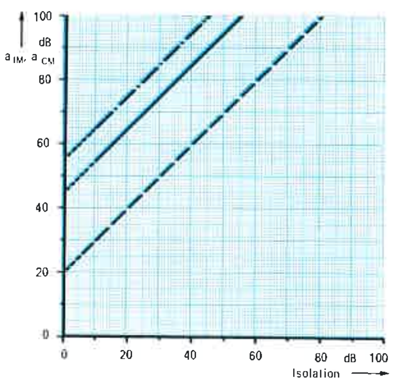
- ▷ channel amplifiers for centralized antenna systems
- ▷ wideband amplifiers for cable networks and CATV
- ▷ semiconductors and modules for amplifiers.

In addition to intermodulation measurements, other tasks such as in the production of RF cables, filters, tuners or antennas can be easily solved using the appropriate instrument configuration.

Ease of measurement due to basic software – versatility. An automatic test assembly has a very wide range of application. The basic software – permitting control of the instruments integrated into the test system – is designed such that it can be used as the foundation for specific test programs. Thus, using the appropriate instruments, individual requirements can be met with a minimum of programming.

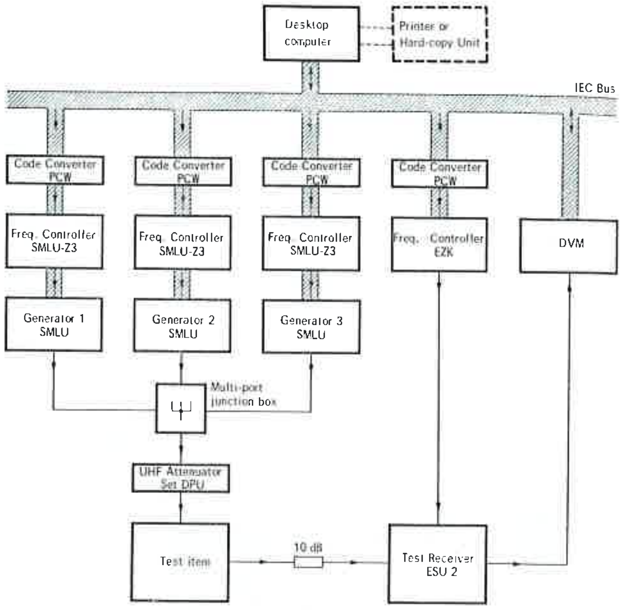
To measure for instancce intermodulation, it is sufficent to enter the channel frequency and the desired output level. The computer takes care of the rest in a few seconds: calculating and setting the correct frequency spacings and level ratios, setting the required output level, measuring the intermodulation product and calculating its relation to the sync peak.

Configuration – function. The nucleus of the test assembly for intermodulation and crossmodulation measurements is three or two (depending on the method used) Power Signal Generators SMLU covering the wide frequency range 25 to 1000 MHz. The high output power level of up to 2 W permits a high degree of isolation between the generators so that their outputs do not interact. For residual intermodulation products down 80 dB, the level applied to the test item is still 115 dBµV (see diagram below). No external filters are required due to the good harmonics suppression of the SMLU of 40 dB.



Intermodulation and crossmodulation suppression a_{IM} and a_{CM} of SMLU as a function of isolation;
solid line: three-signal IM suppression referred to sync peak;
dashed line: two-signal IM suppression referred to carrier;
chain-dotted line; CM suppression

A Frequency Controller SMLU-Z3, which is driven from the desktop computer, is used for programmed frequency setting of each signal generator. The Code Converters PCW establish the connection to the IEC bus and permit level programming. The selective VHF-UHF Test Receiver ESU 2 measures and indicates the unwanted products. Its frequency as well as the sensitivity switchover are programmed by the computer via the Frequency Controller EZK and an additional PCW. The DVM converts the ESU 2 output DC voltage, which is proportional to the measured value, and applies the digital result to the computer.



Block diagram of the Automatic RF Test Assembly for intermodulation and crossmodulation measurement

Specifications

(for specifications of the individual instruments see the corresponding type in the catalog)

Frequency range	25 to 1000 MHz
Frequency error	
with free-running SMLU	≦±2%
Frequency Controller SMLU-Z3	±10 kHz
Frequency resolution	
with SMLU-Z3	1 kHz or 10 kHz
SMLU output level	up to 595 MHz: +33 dBm (2 W) 10 V into 50 Ω
	up to 1000 MHz: +30 dBm (1 W) 7.07 V into 50 Ω
Attenuation of output power	
Signal Generator SMLU	coarse: 35 dB in 5-dB steps fine: 10 dB
UHF Attenuator Set DPU	0 to 140 dB in 1-dB steps; error ±0.05 to 1 dB
Measurement range of VHF-UHF Test Receiver ESU 2	−10 to +120 dBµV
Measurement error	≦±1 dB for V_{in} ≧1 µV
Frequency instability using Frequency Controller EZK	<100 Hz
Frequency indication	7 digits
Basic software	2 kbyte
Storage capacity of magnetic-tape cartridge	256 kbyte
Print format	72 characters/line
Grafic display	19 cm × 14 cm

Ordering information

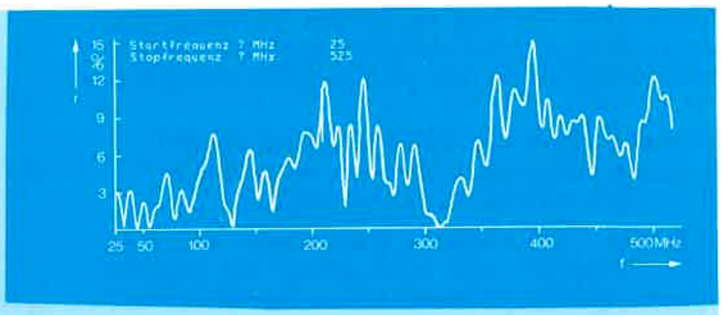
Order designations (order units separately)

Quantity	Designation		▶ Order No.
3 (2)	Power Signal Generator	SMLU	200.1009.03
3 (2)	Frequency Controller	SMLU-Z3	242.5019.92
4 (3)	Code Converter	PCW	244.8015.92
3 (2)	Coding Board for SMLU	PCW-Z	245.2610.02
1	Coding Board for EZK	PCW-Z	291.1113.02
1	VHF-UHF Test Receiver	ESU 2	252.0010.55
1	Frequency Controller	EZK	255.0010.02
1	UHF Attenuator Set	DPU	100.8960.50
1	Four-Port Junction Box	DVU 4	201.4018.02
	Three-Port Junction Box	DVU 3	100.5203.50
5	Cable for IEC Bus (24-core)	PCK	see page 19
1	Process Controller	PUC	see page 14
1	Digital Voltmeter	URV 4	292.5012.03
1	Cable for IEC-Bus (24/25-core)	SMPU-Z8	216.0188.02
1	Floppy disk (software)	SMLU-K1	240.9952.02

CABLE Test Assembly

Automatic Test Assembly for RF Cables
⧫ 25 to 1000 MHz

- Cable measurements in accordance with specifications of IEC 96-1 or DIN 47 250
- Automatic calculation of results from measured values
- Computer controlled test sequence excluding operator errors



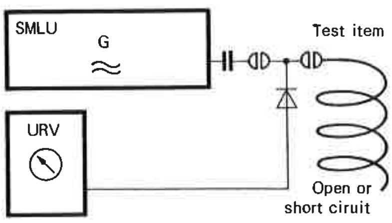
IEC 625 Bus

Definitions and test procedures for cable characteristics

For distortion-free singal transmission RF cables should exhibit certain characteristics whose determination is specified in IEC recommendation 96-1 and, with almost the some wording, in standard DIN 47 250. The following RF parameters are to be measured:

1. mean characteristic impedance
2. uniformity of impedance
3. attenuation.

All these measurements can be performed automatically using this test assembly. If the screening efficiency is also to be determined automatically, a programmable test receiver (e.g. ESU 2) has to be added. Since, however, this measurement is required only for type approval of braided cables, it depends on the individual case whether automatic determination is of advantage.



Test assembly for cable resonance-frequency measurement

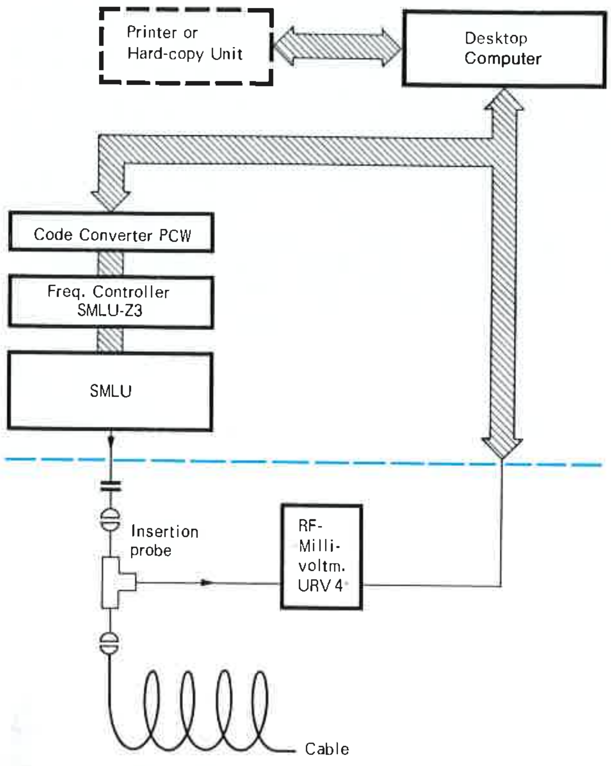
For determination of the **mean characteristic impedance** a cable of suitable lenght, with its free end open or shorted, is loosely coupled to a generator. The value is found from the frequency spacing of the resonance maxima determined by a freqeuency response measurement and the total cable capacitance.

For measuring the **uniformity of impedance** a reflectometer is used: the frequency is varied in steps or continuously and the reflection coefficient plotted as a frequency function on the connected display unit or recorder; see diagram. This measurement is used for locating frequency-dependent reflection which is caused by imperfections distributed periodically over the full cable lenght.

The **attenuation** can be determined by a two-port method – preferable for cables of higher attenuation – or from the width of the resonance peak. The resonance method is used to advantage for extremely low-loss cables or for lines whose far end is not accessible for a two-port measurement. The required test asembly corresponds to that for determining the mean characteristic impedance.

Automatic test assembly for RF cables

Control of the test sequence from a desktop computer replaces the time-consuming manual checkout, permitting an advantageous combination of automatic measurement and calculation of results. It prevents wrong results due to operator or arithmetic errors and furnishes a neat, reproducible test report.

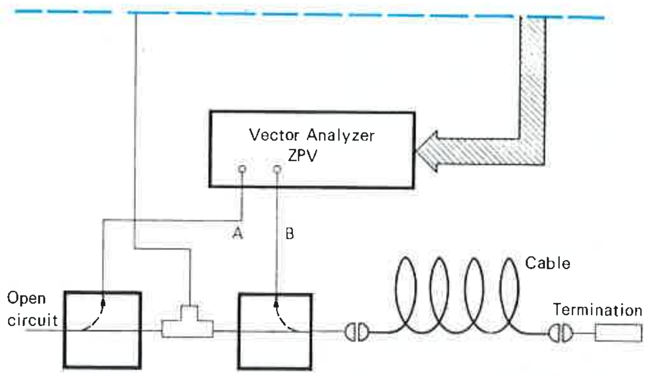


Block diagram of test assembly for RF cables

It contains displays which also permit graphic computing and uses the BASIC language. Thus program preparation and modification is very easy (see section 1).

The Vector Analyzer ZPV is used for measuring the reflection coefficient for evaluation of the uniformity of the characteristic impedance. The reflection coefficient is represented as a function of frequency on a display or recorder; frequency variation is in steps or continuous.

Extension of test assembly for RF cables by Vector Analyzer ZPV (e.g. for measuring impedance uniformity)



Versatility of application, basic software

The basic programs required for driving the connected measuring instruments have been designed to permit other measuring problems also to be solved. The fundamental principle in determining cable characteristics is a frequency response measurement; thus programs for related tasks can be readily established in a similar way. The basic routines required for later extension of the test assembly by R&S instruments are already available so that a variety of different automatic measurments is possible over the entire frequency range up to 1000 MHz.

Configuration and function

The RF generator included in the automatic test assembly is the Power Signal Generator SMLU, which is particularly suitable for general use thanks to its wide frequency range (25 to 1000 MHz) and high output level (2 W). A frequency controller, which is driven from the desktop computer, is used for programmed setting of the SMLU output frequency. For cable measurements, the high output power permits use of a wideband and thus easily operated meter. The RF Millivolt-meter URV 4 measures the resonance voltage at the cable end. The proportional output voltage of the millivolltmeter is applied, after A/D conversion, to the computer.

Control of the instruments and entry of the measured values into the computer are carried out by way of the international-standard IEC bus, which enables ready interconnection of all measuring instruments fitted with this interface. The Process Controller PUC from R&S is available for controlling the test sequence.

Specifications

(for specs of individual instruments see corresponding type in catalog)

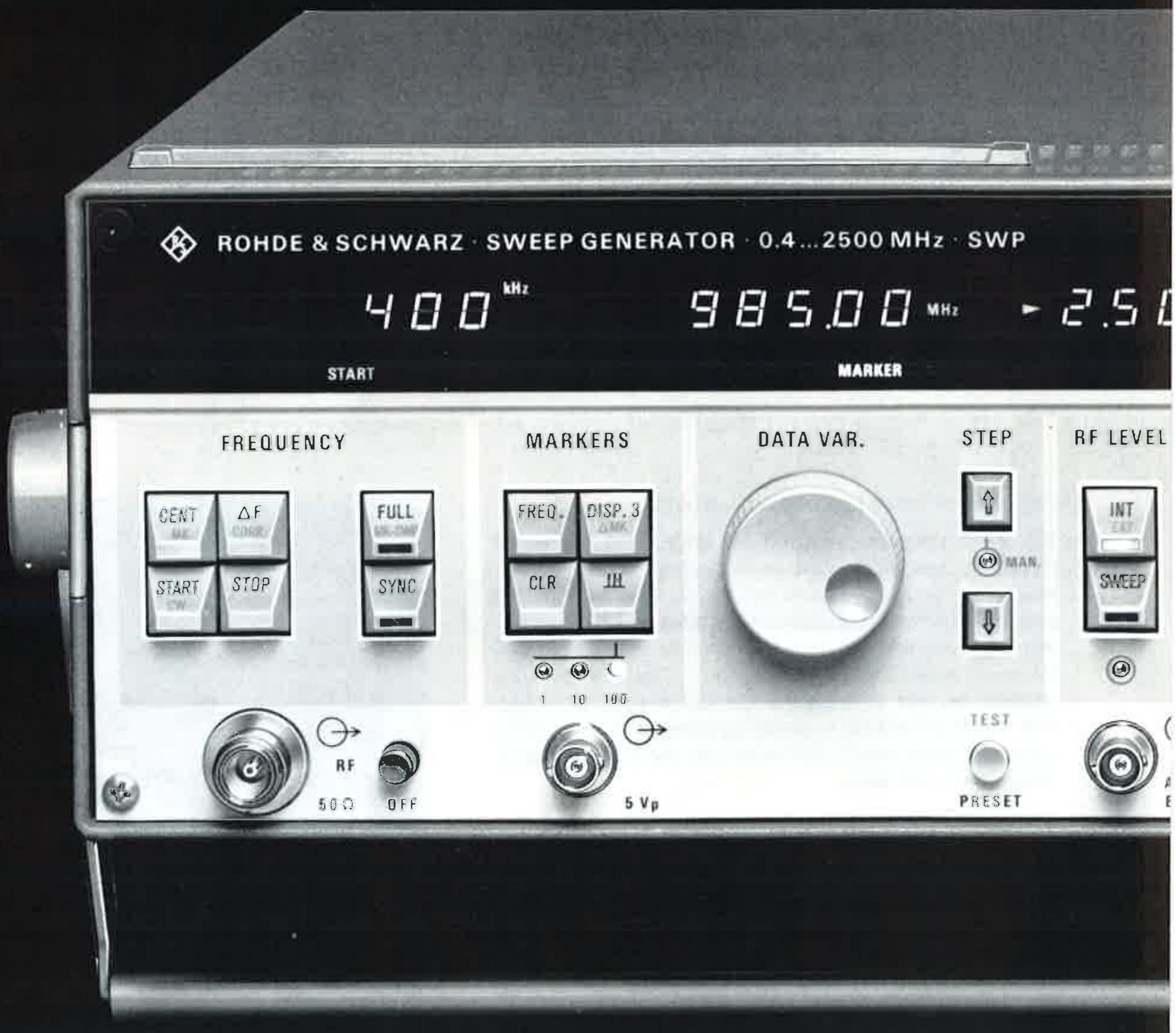
Frequency range	25 to 1000 MHz
Frequency resolution	10 kHz or 1 kHz
Frequency error	10 kHz or 1 kHz + timebase error
SMLU output level	up to 595 MHz: +33 dBm (2 W) up to 1000 MHz: +30 dBm (1 W)
Attenuation measurement range	39.5 dB in 0.5-dB steps
Meas. range of RF millivoltmeter	0.7 mV to 10 V
Measurement error	1.5% of rdg + freq.-resp. error (average: 1%; max. 15%)
Characteristic-impedance measurement	
Measurement error	±0.2% + error of capac. meas.
Attenuation measurement	
Measurement error	±0.2 dB

Ordering information

▶ **Order designations** of individual instruments

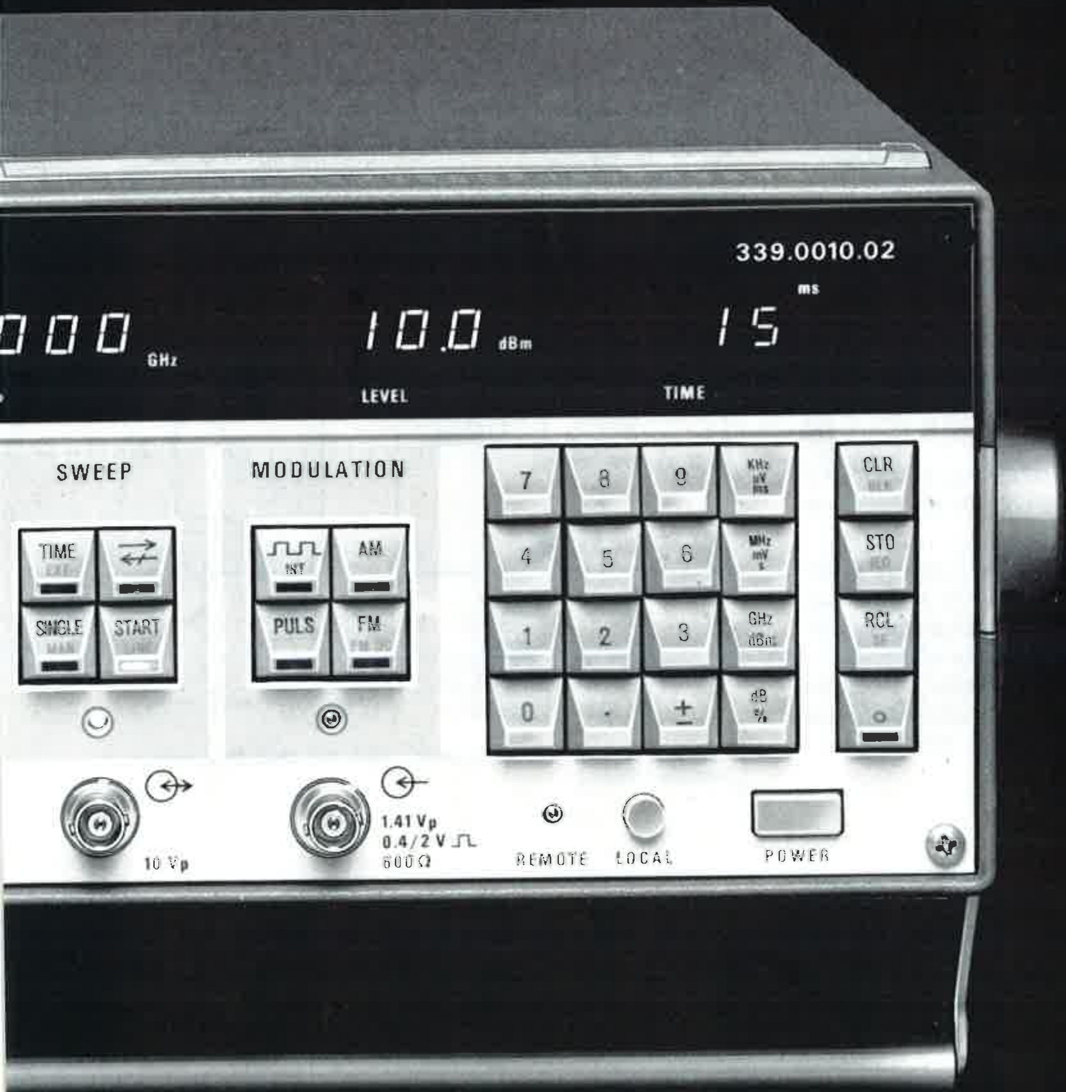
Control units, software	
Process Controller PUC	see page 14
Floppy disk (software) for PUC, SMLU-K3	240.9952.02
Code Converter PCW	244.8015.92
Cable PCK for IEC bus, 24-core	292.2013.10 (1 m long) 292.2013.20 (2 m long)
Signal generators	
Power Signal Generator SMLU	200.1009.03
Frequency Controller SMLU-Z3	242.5019.92
Coding Board for SMLU, PCW-Z	245.2610.02
Indicators	
Vector Analyzer ZPV	291.4012.92
Tuner ZPV-E2	292.0010.02
IEC-bus option ZPV-B1	292.3610.02
s-parameter option ZPV-B2	292.3810.02
Insertion Adapter ZPV-Z1 (2 req'd)	292.2713.50
Feed Unit ZPV-Z2	292.2913.50
Directional Coupler ZPV-Z3 (2 req'd)	292.3110.50
RF Millivoltmeter URV 4	292.5012.03

Sweep Generator SWP,
sweeper/signal generator/synthesizer combined in a single unit,
0.1 to 2500 MHz;
details on page 126



4

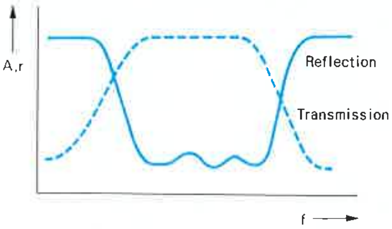
sweep generators, sweep testers network analyzers



Rational measurements using sweep testers

The increasing complexity of electronic circuits requires more accurate measurement results over ever wider frequency ranges. Swept-frequency measurements are a satisfactory solution which can also be applied to rationalized test methods. At present this is probably the most important and largest field of RF measuring technology.

The **advantages** are obvious: automatic curve display considerably reduces the measuring time, i.e. no variation of the characteristc occurs during the test procedure; as against point-by-point measurement, rapid variations of the measured values (dips) are evident. Moreover, the effects of interventions, such as alignment work, are discernible simultaneously and immediately even for several paramenters over the entire range of interest.



Simultaneous display of two parameters

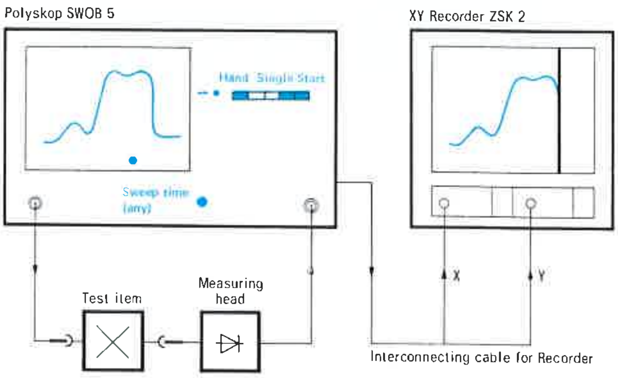
Even if computer-controlled point-by-point measurement is increasingly offered as an alternative, this technique cannot be used for a rapid overview or for continuous display of the variations occurring during alignment. However, with swept-frequency measurements, even the advantage of logging the results need not be sacrificed; see the setup opposite using Polyskop SWOB 5.

Sweep generators. The Sweep Generator SWP is an RF generator of the latest state of the art corvering a continuous frequency range from 0.1 to 2500 MHz. It can be universally used since it combines the functions and characteristics of a sweeper, a signal generator and a synthesizer in a single unit; it has memory capacity for complete device settings and can be remotely controlled via the IEC bus, which makes it suitable for use in automatic systems.

Sweep Generator SWP

Compact sweep assemblies combining the sweep generator, display and marker generator in one unit like the SWOB 5, permit particularly economic and easy-to-use test setup configurations; see also page after next under configuration of sweep testers.

In addition to the sweep generators and compact test assemblies described on the following pages and to the swept-frequency test equipment listed in the table, the Rohde & Schwarz line offers a number of signal generators and measuring instruments for various applications which include or can be equipped with a swept-frequency capability, for example the Synthesizer Generator XPC on page 58 or the Vector Analyzer ZPV on page 142.



Logging of test results in single sweep (sweep time about 30 s) using XY Recorder ZSK 2

Sweep generators and sweep assemblies (overview)

Frequency range	Designation	Type	Order No. (complete No. see text)	Subranges	Sweep width	Sweep frequency Sweep time	Output EMF
1 Hz to 1.3 MHz	Generator	SPN/ SMLU-Z	336.3019.02	1	entire range	10 ms to 1 s 2 to 200 s	10 V
0.1 to 130 MHz	Sweep Generator	SMUV/ SMLU-Z	301.0120 ...	3 (1)	entire range	10 ms to 1 s 2 to 200 s	1 V (10 V) −133 to +33 dBm
25 to 1000 MHz	Power Sweep Generator	SMLU/ SMLU-Z	200.1009 ...	7 (1)	entire range	10 ms to 1 s 2 to 200 s	10 (7) V into 50 Ω −13 to +33 dBm
new 0.1 to 2500 MHz	Sweep Generator	SWP	339.0010 ...	1	entire range	10 ms to 100 s	−110 to +10 dBm
0.1 to 1000 MHz	Polyskop	SWOB 5	333.0019 ...	1	0.1 to 1000 MHz 5 to 1000 MHz 0.3 to 50 MHz and 0	20 ms to 2 s and manual control sawtooth	300 µV to 1 (2) V
0.1 to 1300 MHz	Polyskop	SWOB 5	333.0019.53	1	0.1 to 1300 MHz 7 to 1300 MHz 0.3 to 50 MHz and 0	20 ms to 2 s and manual control sawtooth	300 µV to 1 (2) V

Applications of RF swept-frequency measurements

Division into different application groups gives a better overview of the wide field in which swept-frequency measurements can be used to advantage. Essentially there are three groups which are determined by the tasks to be solved and the parameters to be measured:

- measurement on two- and four-terminal networks to determine the reflection and transmission characteristics by magnitude (scalar network analyzers)
- measurement on two- and four-terminal networks to determine the reflection and transmission characteristics by magnitude and phase (network analyzers)
- measurement or examination of generator signals with the aid of scanning receivers (spectrum analyzers)

The following text deals only with sweep assemblies used for the first group of measurements (for the second group see page 142 ff. and for the third group section 7). The first group is divided into wideband and narrowband swept-frequency measurements.

For the display, a high sensitivity and wide dynamic range, flat frequency response, simultaneous display of several curves and the largest possible screen – in particular for use in production – are required. If the advantages of swept-frequency measurements are to be fully used, it is essential to have clear, easy-to discern frequency markers permitting satisfactory reading even on steep filter edges; moreover, when examining mixer configurations and tuners, suppression of an unwanted signal occurring at the test-item output due to the mixer should be possible during the return sweep.

The present, advanced state of thin-film and thick-film technology permits the construction of amplifiers featuring an almost flat amplitude-frequency response and good input and output matching over very wide ranges. Only modern sweep testers meeting the above requirements enable measurements on these modules.

Wideband swept-frequency measurements

In wideband wept-frequency measurements a large bandwidth, high spectral purity (harmonics and spuria), excellent amplitude stability, a low output reflection factor and a precise output-voltage divider are of primary importance for the generator. The possibility of switching over different preprogrammable generator settings, such as sweep width and frequency, at the push of a button is a desirable feature for use of the equipment in production and quality control.

Narrowband swept-frequency measurements

In narrowband swept-frequency measurements, in particular the spectral purity of the generator close to the carrier should be very high since the test items are mainly sharp-cutoff filters, especially crystal filters. To cover the high stopband attenuation of such filters, a wide dynamic range is required for the indicator, necessitating highly selective tracking receivers.

Configuration of sweep testers

Sweep testers determining by magnitude the quantity to be measured are used everywhere, however, especially in production and test departments since there normally only the magnitude of reflection coefficients and transmission factors is of interest. When aligning to minimum or optimum values, complex evaluation is also not required in most cases.

The simplest type of sweep tester comprises a sweep generator, a diode detector and, as the display unit, an oscilloscope whose horizontal deflection is driven from the generator. Compact sweepers are available for frequencies up to 1.3 GHz, the sweep generator, indicator and display secition being combined in one set. Such a compact sweeper has the following advantages: ease of operation since setting the sweep separately on the generator and on the display is not necessary and interconnections between the individual units are not required; high indication sensitivity since special amplifiers matched to the measuring head are used.

Assembly for	Voltage required for full picture height RF	Frequency-response flatness in sweep operation	Internal frequency markers	Dimensions in mm (W×H×D)	Text on page
600/50/≈5 Ω	0 to +1.3 V	≈3 dB	—	245×154×349	44
50 Ω	(0 to +10 V)	< ±1 dB	adjustable over entire range	492×290×514	60
50 Ω		≦ ±0.8 dB	adjustable over entire range	484×260×436	70
50 Ω			6; 1/10/100 MHz	470×162×483	126
50 Ω 75 Ω		V_{out}: <±0.5 dB	1/10/100 MHz	484×328×436	132
50 Ω		V_{out}: <±0.5 dB	1/10/100 MHz	484×328×436	132

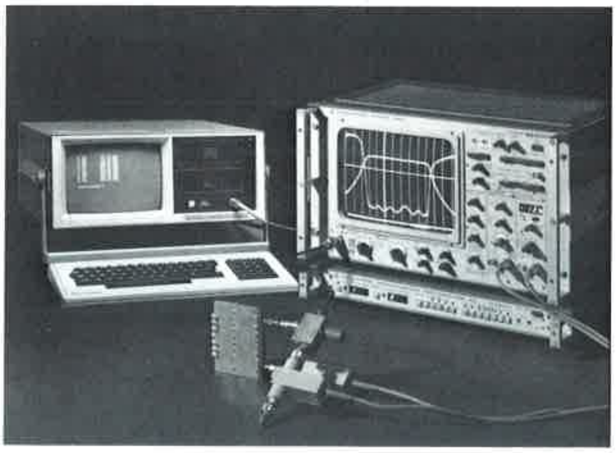
Extension of sweep testers

Accessories are required to make full use of the sweptfrequency measurement capability. **Directional couplers** or **VSWR bridges** are available for measuring standingwave ratios or reflection. While a directional coupler is not to be recommended for wideband measurements since it has a frequency-dependent coupling attenuation, the VSWR bridge with its flat frequency response is especially suitable for this purpose.

If the voltage curves at the input and output of a test item are to be observed simultaneously or the input voltage applied to the test item is to be displayed along with the reflection coefficient, **insertion heads** are required. These units consist of a certain length of coaxial line, the voltage being measured across the inner conductor.

Another possibility of extending a compact sweep tester is to use an **active demodulator** which considerably increases the measuring sensitivity. Demodulators of this type consist of a wideband preamplifier with low input reflection and an extremely flat frequency response plus a detector circuit at the amplifier output.

The new Digital Display Store BDS offers a number of additional functions and improves the measurement accuracy. Thanks to the constant readout time the display remains flickerfree even with slow sweeps. Correction or reference curves can be stored and combined by addition or subtraction with the sweep curve, so it is possible to compensate for frequency-response errors or to readily align any item being tested to a given response.

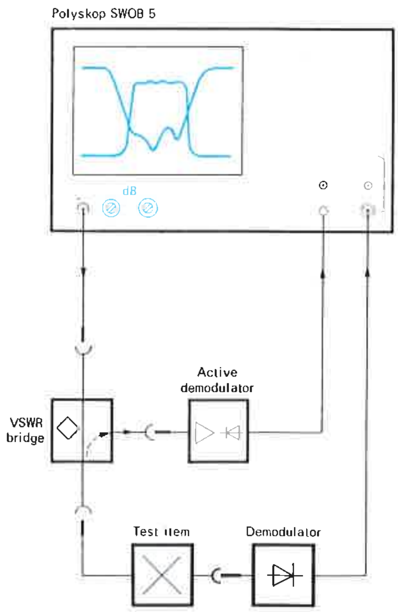


Wideband sweep assembly: Polyskop SWOB 5 (equipped with Logarithmic Amplifier SWOB5 E3), Digital Display Store BDS and Process Controller PUC (for data storage)

An IEC-bus interface in the BDS opens up the way for entirely new applications with the sweep tester. The connection of a desktop computing system makes it possible to read out, convert and re-enter all memory contents. In production and quality tests, for example, the entire amplitude/frequency characteristics of tested items can be transferred to the computer, checked for adherence to the tolerance limits and processed for statistical evaluation.

Wideband sweep tester

As has been mentioned above, the main application of sweep testers which measure quantities by magnitude is the display of the amplitude response and of the VSWR or return loss as a function of frequency. The test setup used in the example below consists of a compact Rohde & Schwarz sweeper – SWOB 5 (frequency range 0.1 to 1300 MHz), a VSWR bridge and an active demodulator. The test item is a bandpass filter.



Wideband sweep tester 0.1 to 1300 MHz

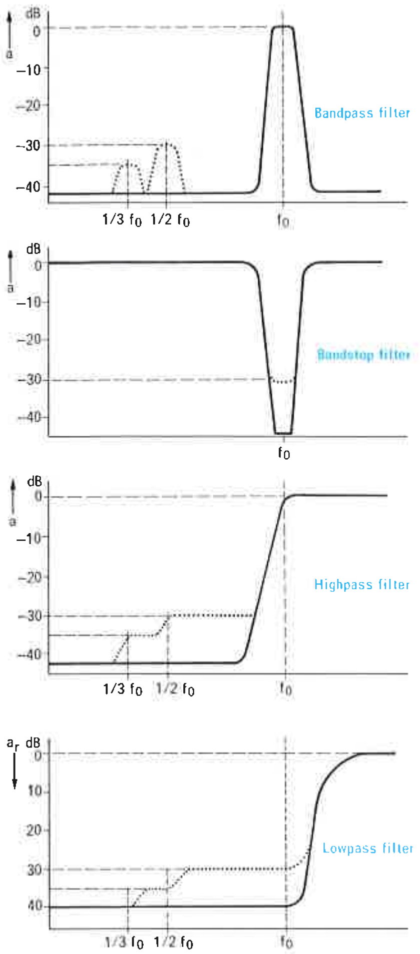
The sweep generator voltage is applied to the VSWR bridge. The item under test is connected to the test output of the bridge, the test-item output being taken directly to the RF input of the sweep generator through the measuring head so that measurement of the voltage after the test item is possible with the correct termination. The voltage reflected at the filter input is measured via the bridge output with the aid of the Active Demodulator SWOB5-Z4.

Since the VSWR bridge has an attenuation of 6 dB between the test voltage input and the test item connector, a filter attenuation of more than 63 dB can still be displayed with a generator output of 0.5 V and a display input sensitivity of 170 µV.

Measurement error in wideband sweeping

caused by harmonics and spuria

Wideband detectors are almost exclusively used in sweep testers which measure quantities by magnitude; for this reason errors may occur especially when measuring filters if the suppression of harmonics and spuria in the sweep signal is lower than the stopband attenuation or return loss to be measured; see the following examples:



Bandpass filter. When reaching an integral submultiple of the passband frequency, the corresponding harmonics are allowed to pass through the filter and are evaluated. Below the passband, apparent attenuation dips are produced. The difference between the peak attenuation of these dips and the true passband attenuation of the filter corresponds to the suppression of the related harmonic.

Bandstop filter. Wehen passing through the stopband, all harmonics are evaluated simultaneously since they fall into the passband. This simulates too low a stopband attenuation. The maximum measurable stopband attenuation corresponds to the harmonics suppression at the stop frequency.

Highpass filter. While the fundamental passes through the stopband, the harmonics consecutively fall into the passband and are evaluated. A stepped stopband attenuation is displayed decrasing in accordance with the harmonics present; the difference between each point on the step curve and the amplitude in the passband corresponds to the suppression of the related harmonic.

Lowpass filter. Here errors may occur when measuring the return loss. While the test frequency sweeps throgh the passband of the filter where little reflection occurs (high return loss), the associated harmonics fall into the stopband, are heavily reflected and simulate a rising, staircase-like reflection characteristic.

Measurement errors of the above-mentioned type can be neglected to a large extent with a Polyskop test setup since spurious frequencies are typically 60 dB down (up to 1000 MHz) and harmonics are typically 40 dB down. Other advantages of these sweep test assemblies are the size of the screen (16 cm×22 cm), the display of vertical frequency markers covering the full screen height and the possibility of inserting three different horizontal lines at any position of the screen. In this way all details of the display can be easily recognized and evaluated.

Narrowband sweep tester

The photo below shows an example of a narrowband sweep tester consisting of the following instruments: Sweep Generator SWP (0.1 to 2500 MHz), Vector Analyzer ZPV (0.1 to 1000 or 0.3 to 2000 MHz) as selective tracking receiver and XY Recorder ZSK 2 as output unit. A crystal filter with very steep cutoff and high stopband attenuation is used as test item. This test setup enables logarithmic measurement over a dynamic range of more than 100 dB. The low spurious FM of the Sweep Generator SWP allows even extremely steep filter edges to be represented satisfactorily. The SWP delivers the deflection voltage for the recorder while the vector analyzer is automatically synchronized to the test frequency. The greatest possible sweep width is 1 MHz. Errors normally occurring with wideband sweeping do not take place, since the measurement is selective and no harmonics of the test signal fall within the sweep band due to the relatively small frequency variation with respect to the absolute frequency (for frequencies >1 MHz).

Narrowband sweeper
for 100 kHz to 2 GHz

SWP

Sweep Generator SWP ⧫ 0.1 to 2500 MHz

- Sweeper, signal generator and synthesizer combined in a single unit
- All functions are programmable; settling time <100 ms
- IEC-bus-compatible

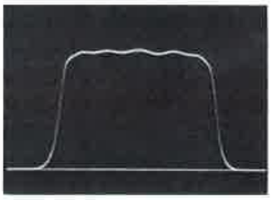
IEC 625 Bus

new

Outstanding performance

SWEEPER

Continous sweep



Wide frequency range:
0.4 to 2500 MHz

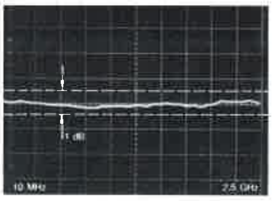
Low content of harmonics and spurious signals:
typically 40 and 50 dB down

Six variable frequency markers – level sweep –

Sweep time 10 ms to 100 s

SIGNAL GENERATOR

Aplitude frequency response



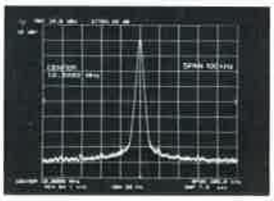
Amplitude modulation with low distortion

Pulse and frequency modulation

Calibrated output level
+10 to −110 dB max., resolution 0.1 dB

SYNTHESIZER

Spectral purity



Crystal-referenced frequency setting

Low spurious FM:
< 5 Hz (CCITT weighting)

Frequency resolution 1 kHz

Short settling time, continuous sweep

Fields of application (examples on page 130)

▶ General sweep techniques

Measuring magnitude of reflection and transmission factors

▶ Network analysis

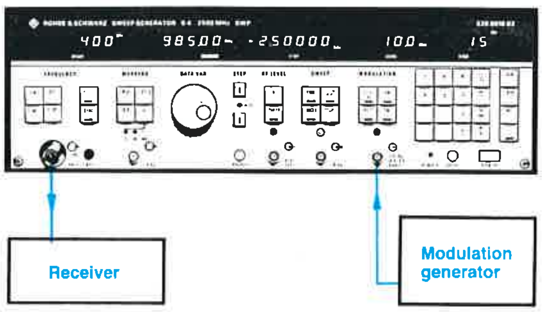
Ideal signal source for impedance, group-delay and s-parameter measurements using Vector Analyzer ZPV

▶ Multi-source measurements (using 2 or 3 SWPs)

Transposer, mixer, tuner and intermodulation measurements

▶ Multi-source applications
(AM, FM, pulse modulation)

Use as a universal signal generator



User-friendly design

- Keyboard entry for all parameters
- Variation through step key or knob
- Memory capacity for 10 full front-panel setups (saved in CMOS RAM)

Marker section

Six freely selected markers between 0.4 and 2500 MHz

Crystal reference through Synchronizer option

Additional harmonic markers 100/10/1 MHz (with option)

Programmability

All functions set from IEC bus (fitted as standard)

Listener, talker, learn mode, service request

Access to CMOS RAM in both directions via IEC bus

Short setting times

Functional features

The Sweep Generator SWP is a general-purpose signal generator for use in development, production and servicing. The output signal can be continuously swept over the **frequency range** from 0.1 to 1.1 MHz and 0.4 to 2500 MHz.

The **Synchronizer** option permits CW operation and narrow-band sweeping with low spurious FM. Frequency resolution is 1 kHz and settling time <100 ms.

Output level. The **output level** is calibrated and presents a very flat frequency response; harmonics and spurious signals are typically down 40 and 50 dB, respectively – extraordinary values for a sweep generator; level setting is possible from +10 to 0 dBm with 0.1 dB resolution. Levels down to −110 dBm can be set in conjunction with the **Attenuator** option.

Level sweep facilitates, for example, the determination of the compression points of amplifiers and the compensation for frequency-response roll-off in the test configuration.

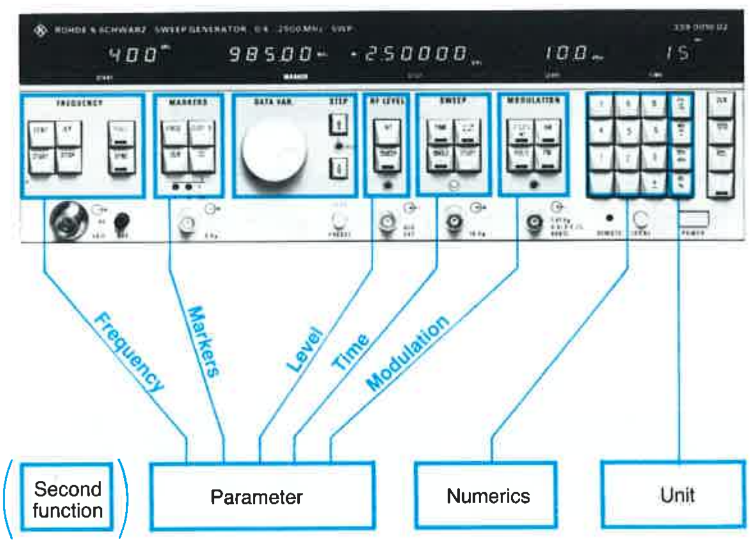
Modulation. The SWP has been designed for different types of **modulation:** squarewave modulation with an internal signal; AM, FM and pulse modulation with an external signal. This affords the SWP great versatility as a signal source.

Frequency markers. A total of six variable **frequency markers** can be entered, the frequency of any one marker being indicated on the display. When the Synchronizer option is incorporated the markers are crystal referenced. The **Harmonic Marker** option produces **additional markers** at 100/10/1-MHz intervals. The marker identifying the displayed frequency and the 100-MHz or 10-MHz marker are highlighted by widening of the marker pulse.

Storage/recall. Up to nine* full front-panel setups can be stored and recalled with a single keystroke when needed.

* Ten including the last operating setup, which is stored when the unit is switched off.

Data entry through keypad

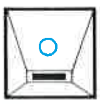


Operating convenience

Operation

The clear arrangement of operating controls and displays and the optimized number of keys make operation very easy.

Second functions

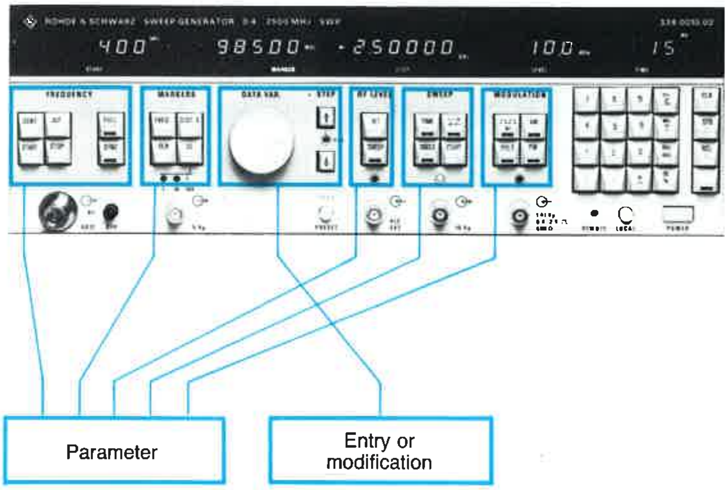


A separate key (bottom of row to the right of the keypad) is provided to call up additional and special functions, offering a maximum of capabilities without restraining the ease of operation.

SWP – Sweep Generator

Operating convenience

Data entry or modification
through ROTARY KNOB



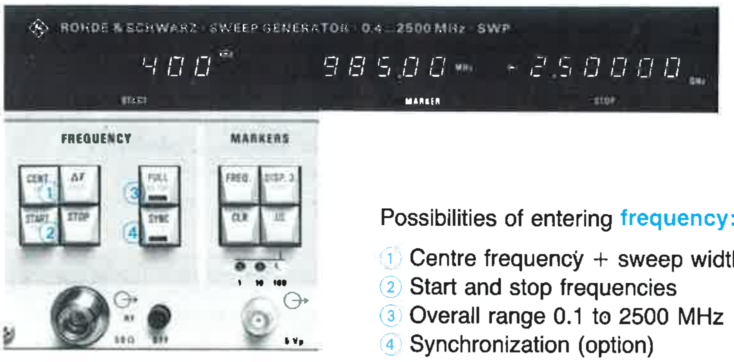
through STEP KEYS

All settings can be affected in the same way as with the use of the rotary knob.

Step size is selectable through the keypad.

All settings can be varied using the rotary knob with the corresponding parameter key pressed.

Frequency and marker setting



Possibilities of entering **frequency:**

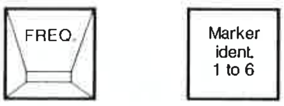
1. Centre frequency + sweep width
2. Start and stop frequencies
3. Overall range 0.1 to 2500 MHz
4. Synchronization (option)

Markers:

Total of six variable markers

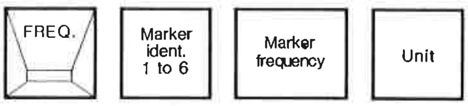
Marker presentation

One marker

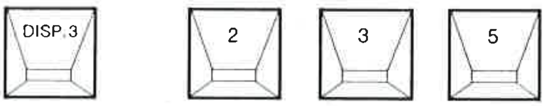


Marker pulse output widened

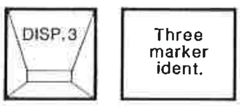
Example



Three markers (display of markers 2, 3 and 5)



Keypad



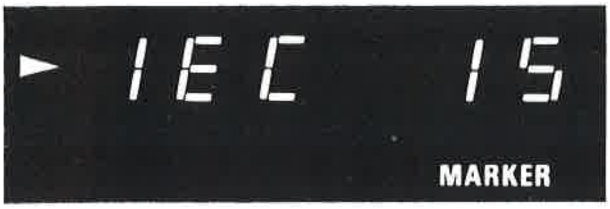
The three markers selected are highlighted by widened marker pulses.

Display

In this case there is no display of start and stop frequencies or of centre frequency and sweep width.

Programming

IEC-bus interface. The Sweep Generator SWP has an IEC-bus interface and is therefore particularly suitable for **use in automatic test systems.** All functions can be remote-controlled. In addition, the IEC-bus address can be changed via the keypad and read out on the display.



IEC-bus address displayed on SWP

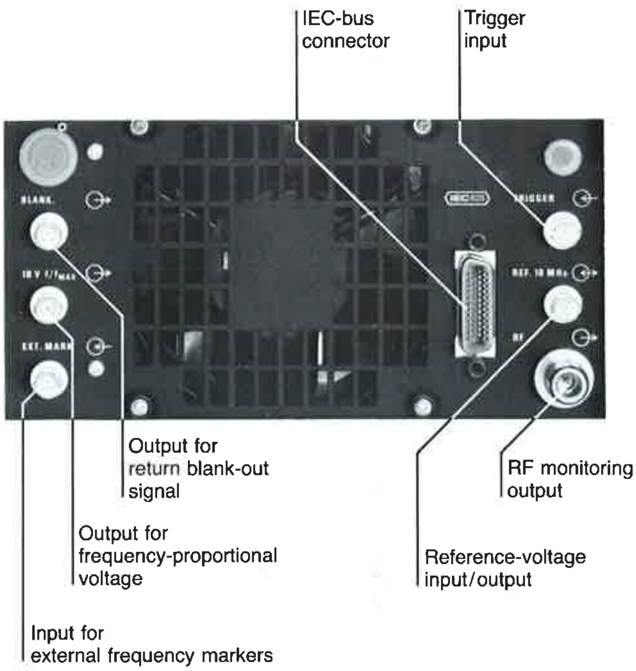
Functions. In addition to the conventional **listener function,** the SWP provides for "talker", "learn mode" and "service request".

In the **talker mode** all SWP settings and the self-test results can be transferred to the bus.

With the **learn mode,** manually entered settings can be stored in the external computer (of the test system) and sent back at any time. This greatly facilitates programming work.

Service request is important when a fault occurs in the equipment; moreover it is useful, for example, when a sweep is terminated.

In designing the IEC-bus control of the SWP particular importance has been attached to easy programmability.



Rear panel of SWP

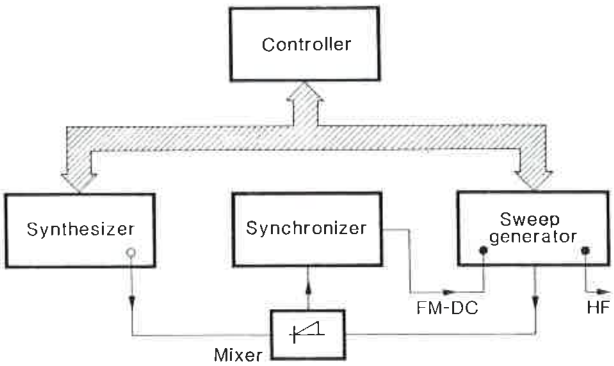
Extensions (options)

Synchronizer SWP-B1. In conjunction with the Synchronizer option the Sweep Generator SWP offers synthesizer performance with a lower frequency limit of 100 kHz. All **frequency settings,** including the markers, are **crystal-referenced** and spurious FM is greatly reduced. This opens up numerous and novel applications for the sweep generator.

Use of the Synchronizer option is particularly interesting for **narrowband sweeping** ($\Delta f<1$ MHz) and for **CW operation** ($\Delta f = 0$), permitting measurements on crystal filters to be performed with the SWP.

Synchronization occurs at 1-kHz intervals. Settling time is <100 ms. In the wideband sweep mode the frequency counter ensures accurate setting of the start frequency and of the variable frequency markers.

SWP + Synchronizer replaces several instruments. With crystal-referenced frequency setting the SWP performs tasks which up to now called for several instruments; an example is shown below.



Example of conventional test assembly

Conventional systems for high frequencies require for the accurate frequency setting of the sweeper either an external synthesizer and a synchronizer or a microwave counter and – in many cases – a controller.

All this accessory equipment is superseded by the Sweep Generator SWP fitted with the Synchronizer option. This simplifies the test assembly and cuts down on purchase cost.

Reference Oscillator SWP-B11. This option improves the frequency stability of the Synchronizer (reducing the effects of temperature and crystal aging).

Attenuator SWP-B7. Using the Attenuator option the output level can be set in 0.1-dB steps from +10 dBm to −110 dBm.

Harmonic Marker SWP-B9. This option permits the display of markers with 100/10/1-MHz spacings. The markers representing the higher value (10 or 100 MHz) are highlighted by broader marker pulses. External marker signals can also be applied.

SWP – Sweep Generator

Second functions

Additional settings,
activated through key ...

Parameter Key	Function	Display
FREQUENCY		
MK	Centre frequency is replaced by any selected marker frequency	CENT MARKER
CORR.	In operation without Synchronizer, frequency correction up to 10 MHz can be made with the rotary knob and is preserved in the case of frequency changes	C...
MK-SWP	Start and stop frequencies each correspond to a freely selectable marker. Application: sweep magnifier	START MARKER STOP MARKER
CW	CW mode can be called up directly (not only through Δf = 0)	
MARKERS		
ΔMK	Instead of the marker frequency the difference between two selectable markers is displayed. Application: bandwidth measurements	MARKER.–.
RF LEVEL		
EXT	External ALC	
SWEEP		
EXT	Sweeping through external saw. tooth	
MAN	Change of generator frequency within selected sweep bandwidth using rotary knob	
LINE	AC supply-synchronized sweep	
MODULATION		
FM-DC	Coupling for external FM-DC signal. Application: external synchronization	
STEP		
MAN	The step size for the data variation using the STEP keys can be selected through the keypad	
BLK	All multiplex displays are switched off	
IEC	Display of the set IEC-bus address. This address can simultaneously be changed through the keypad	IEC..
SF	Call of special functions	SF..
TEST	With the second function of the PRESET key a self-test of the SWP functions can be triggered. More than 20 DC, AF and RF measurements are carried out and any faults (tolerances exceeded) indicated on the display.	

Fields of application

- **General sweep techniques**

  Clear display of start and stop frequencies, marker frequencies (up to six markers) level and sweep time

  All settings variable by rotary knob

  Rapid switchover to a maximum of nine front-panel setups

  Crystal-filter measurement, linearity measurement on active test items by level sweep (compression measurement)

- **Network analysis**

  The SWP is an ideal add-on to the Vector Analyzer ZPV in the range 100 kHz to 2000 MHz for vector measurements, impedance measurements, transmission measurements, group-delay measurements, s-parameter measurements

- **Multisignal measurement**

  SWP 1 for automatic sweep
  SWP 2 for single sweep triggered by SWP 1

  Synchronized sweep of two or more SWPs with frequency offset (e.g. of IF)

- **Use as signal generator (AM or FM)**

  Low spurious FM (with Synchronizer option) and versatile modulation capabilities open for the Sweep Generator SWP fields of application reserved formerly to conventional signal generators, for example, measurements on receivers.

Specifications (without options)

Frequency range/sweep range	0.4 to 2500 MHz
Frequency/sweep setting	via keypad or rotary knob a) start and stop frequencies or b) centre frequency and sweep width
Frequency display	6 digits in GHz, MHz or kHz; resolution: 10 kHz
Resolution of sweep-width setting	
up to 20 MHz	10 kHz
>20 to 250 MHz	60 kHz
>250 to 2500 MHz	600 kHz
Error limits of frequency setting (CW or START)	±12 MHz ±0.5 MHz/°C
Output level (with attenuator option see below right)	
CW	0 to +10 dBm or 224 to 707 mV, 50 Ω
AM	0 to +4 dBm or 112 to 353 mV into 50 Ω
Setting	via keypad or knob
Display	4 digits in mV, µV or dBm/dB; resolution: 1% of setting or 0.1 dB
Output level error	≦ ±0.5 dB at 100 MHz
Frequency-response flatness	≦ ±1 dB (typ. ±0.5 dB), referred to 100 MHz
Output (N female connector)	50 Ω, VSWR ≦1.25
Spectral purity	
Spurious FM (sweep width <20 MHz)	<5 kHz peak (30 Hz to 20 kHz)
Harmonics	>30 dB, typ. >40 dB down
Spurious signals	≧50 dB down at 0.4 to 2000 MHz ≧35 dB down at >2000 to 2500 MHz
Level sweep	
Setting	via keypad or knob
Setting range	0 to 10 dB
Display/resolution	4 digits in dB, mV, µV/0.1 dB
RF monitoring output	N female connector on rear panel, Z ≈ 50 Ω
Level into 50 Ω	≈ 26 dB below RF output level
with Attenuator option	≈ −18 dBm CW ≈ −24 dBm with AM

External level control	suitable for external detectors with positive detection voltage
Connector	BNC female, Z ≈100 kΩ
Frequency sweep	internal or external
Internal sweep	0.01 to 100 s
Setting	via keypad or knob, resolution: 1/10/100 ms
External sweep[1]	via BNC female connector, Z ≈100 kΩ
Sweep voltage	0 to 10 V
Frequency markers	6 adjustable markers
Setting	via keypad or knob, resolution: 10 kHz ±0.1% of sweep width setting
Display	6 digits in GHz, MHz, kHz; 1 or 3 markers
Error limits	±12 MHz ±0.5 MHz/°C
Marker output	BNC female connector, ≈5 V
Reference oscillator	10 MHz
Crystal aging	$< \pm 1 \times 10^{-6}$/month
Temperature effect	$< \pm 1 \times 10^{-6}$/°C
Output/input (switched internally)	BNC female connector on rear panel
Output level	TTL
Input requirement for external reference	≈0.5 V rms
Amplitude modulation	internal and external
Modulation frequencies	
Internal, squarewave	1 kHz
External, AM	carrier freq. / mod. freq. >10 to 2500 MHz / 0 to 10 kHz >1 to 10 MHz / 0 to 3 kHz 0.4 to 1 MHz / 0 to 1 kHz
Modulation depth	0 to 80%
Setting	via keypad or knob
Display	3 digits
Resolution for 0 to 9.9% mod.	0.1% steps
10 to 80% mod.	1% steps
Error	≦8% of mod. depth
Modulation distortion with undistorted ext. signal	≦5% for f_{mod} = 1 kHz and 80% modulation
Input for ext. signal	BNC female connector, Z = 600 Ω
Input requirement	1 V ±1% or 1.41 V with DC
Frequency modulation	external
Frequency range	DC to 100 kHz (±1.5 dB)
Frequency deviation	0 to 10 MHz
Setting	via keypad or knob
Display	3 digits in MHz or kHz
Resolution	≦1.2% or 125 Hz
Error	≦3% + 60 Hz for f_{mod} = 1 kHz
Modulation distortion with undistorted mod. signal	≦1% for f_{mod} = 1 kHz and Δf ≦500 kHz
Input for ext. signal	BNC female connector, Z ≈600 Ω
Input requirement	1 V ±1% or 1.41 V with DC
Pulse modulation	external
Carrier frequency range	20 to 2500 MHz
Rise and fall times	<0.1 µs
Pulse repetition frequency	50 Hz to 50 kHz
Minimum pulse width	10 µs
On/off ratio	>80 dB (test bandwidth ≦10 kHz)
Input for ext. signal	BNC female connector, Z ≈600 Ω
Input requirement	>2 V/<0.5 V (for on/off), max. 5 V
Blanking output	BNC female connector on rear panel
Level	TTL High on forward sweep Low on return sweep
Output for frequency-proportional voltage	BNC female connector on rear panel, Z ≈100 Ω
Level	−10 V for f_{max} = 2500 MHz
Maximum load	≧10 kΩ
Remote control	for all operating modes and for data transfer in listener and talker functions
IEC-bus interface	in line with IEC 625-1, connector: 24-way Amphenol
Functions	SH1, AH1, T6, L4, SR1, RL1, PP1, DC1, DT1

Data of options

Synchronizer SWP-B1

Frequency range	100 kHz to 2500 MHz, Δf ≦1 MHz
Resolution	
Start-frequency setting	
Sweep width 0 to 1 MHz	1 kHz
>1 MHz	≈10 kHz
Marker frequency	
Sweep width ≦10 MHz	1 kHz
>10 to 50 MHz	10 kHz
>50 MHz	50 kHz
Frequency (CW)	as for reference oscillator
Marker-frequency error	reference error $\pm 1.5 \times 10^{-3}$ of sweep width set $^{+2}_{-1}$ kHz
Sweep-width resolution	0.25 to 1.6 kHz (for Δf ≦1 MHz)
Typical spurious FM (CW operation, FM on)	
Weighting	peak CCIR (30 Hz to 20 kHz) / CCITT
Frequency range	
0.1 to 20 MHz	25 Hz / 5 Hz
>20 to 200 MHz	<100 Hz / <15 Hz
>200 to 2500 MHz	<250 Hz / <50 Hz
Spurious responses at >200 kHz from carrier	≧50 dB/≧35 dB down (0.1 to 2000 MHz/2000 to 2500 MHz)
Amplitude modulation	0 to 50% (external only)
Frequency modulation[2]	
FM frequency range	
0.1 to 20 MHz	0.05 to 50 kHz
>20 to 2500 MHz	0.05 to 20 kHz
Frequency response flatness	≦ ±2 dB referred to 1 kHz
Frequency deviation	
0.1 to 20 MHz	max. 100 kHz
>20 to 100 MHz	0 to $5 \times \frac{f\,(\text{MHz})}{f_{mod}\,(\text{kHz})}$ kHz, 100 kHz max.
>100 to 2500 MHz	0 to $\frac{500}{f_{mod}\,(\text{kHz})}$ kHz, 100 kHz max.
Resolution	
up to 10 kHz deviation	10 to 375 Hz
100 kHz deviation	0.1 to 3.75 kHz
Error	typ. <5% +0.5 × resolution
Modulation distortion with undistorted ext. signal	≦0.5% with f_{mod} = 1 kHz
Pulse modulation	not possible with synchron. switched on

Reference Oscillator SWP-B11

Crystal aging	$< \pm 1 \times 10^{-6}$/year
Temperature effect	$< \pm 1 \times 10^{-7}$ in range 0 to 50 °C

Attenuator SWP-B7

Attenuation range	120 dB in 2-dB steps
Attenuation error	≦ ± (0.2 dB +1.3% of attenuation), 1 dB max.
Typical error	± (0.1 dB +0.6% of attenuation), 0.5 dB max.
Characteristic impedance	50 Ω
VSWR up to 1 GHz	≦1.2
up to 2.5 GHz	≦1.4
Output level of SWP fitted	
with attenuator	−110 to +10 dBm (0.7 µV to 707 mV)
with AM	−116 to +4 dBm (0.35 µV to 353 mV), into 50 Ω; resolution 0.1 dB

Harmonic Marker SWP-B9[3]

Marker spacing selectable via keypad	100/10/1 MHz
Marker output	≈5 V, BNC female connector
Frequency error	$<1 \times 10^{-6}$/month/$<1 \times 10^{-6}$/°C ±0.2% of sweep-width setting ±2 kHz
External marker input	BNC female connector on rear panel
Level requirement	−3 to +3 dBm
Marker-frequency range	5 to 2500 MHz; Δf ≧4 MHz

General data

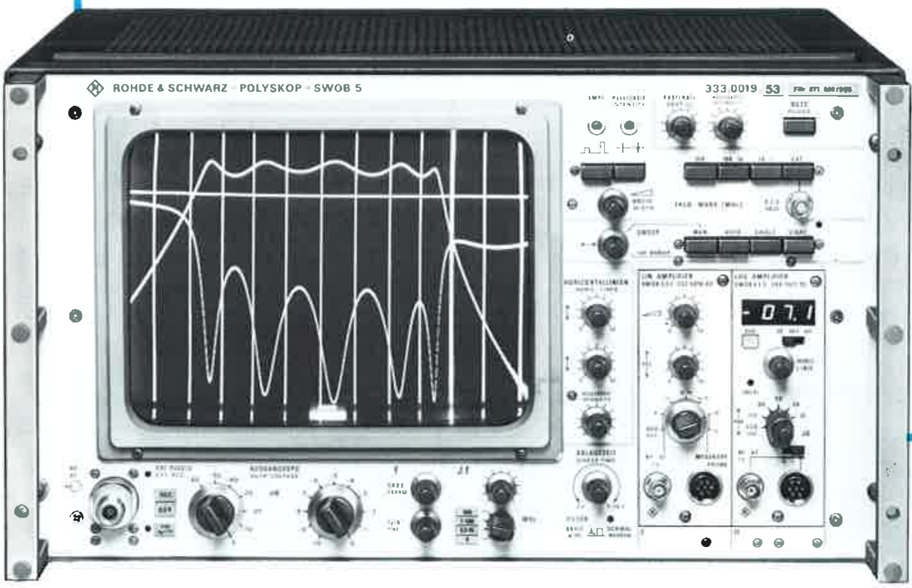
Rated temperature range	+5 to +45°C
Storage temperature range	−40 to +70°C
Power supply	100/120/220/240 V ±10%, 47 to 63 Hz (180 VA max.)
Dimensions, weight	470 mm×162 mm×483 mm, 22 kg

Ordering information

Order designation		▶ Sweep Generator SWP
SWP for 0.4 to 2500 MHz		339.0010.02
SWP for 0.4 to 1000 MHz		339.0010.04
Accessories supplied		Power cable
Options		
Synchronizer	SWP-B1	339.5158.02
Reference Oscillator	SWP-B11	339.9618.02
RF Attenuator	SWP-B7	339.9718.02
Harmonic Marker	SWP-B9	339.4716.02

[1]) No marker generation is possible with external sweep.
[2]) With FM, spurious frequencies may occur at ≦300 Hz from the carrier.
[3]) With mismatch (p>0.5) and RF output levels ≧0 dBm, individual markers may drop out at sweep times <50 ms.

SWOB 5



Polyskop SWOB 5 ◆ 0.1 to 1300 MHz

- Compact sweep tester for singlechannel or dual-channel display with linear or logarithmic amplification (variable configuration)
- Wide dynamic range (75 dB) throgh low inherent noise and high output voltage
- Calibrated level line with logarithmic amplification plus two independently shiftable level lines
- Pulse or vertical-line frequency markers with crystal accuracy

Characteristics and uses

Polyskop SWOB 5 combines in a compact unit all the measuring facilities needed in an up-to-date sweep tester:

sweep generator with an output EMF of 1 V (+6 dB if required), with output attenuator covering 70 dB;

display section with linear or logarithmic amplifiers, with a dynamic range of 76 dB; large-size screen, marker generator, calibrated level marker and additional horizontal reference lines.

The display section can be equipped with different amplifiers, see next page.

SWOB 5 is ideal for **use** in laboratories, test and production departments and wherever ease of operation is required together with large-screen display, high dynamic range and accurate results for either one-off tests or long series of measurements.

As the sweep width of SWOB 5 covers the whole frequency range, the frequency response of very wideband test items can be easily displayed within and even outside their service ranges.

Although wideband frequency-response and matching measurements are the most frequent applications, the very small spurious FM and high frequency stability also permit narrowband test items to be measured.

For accessories and test examples see pages 124 and 125

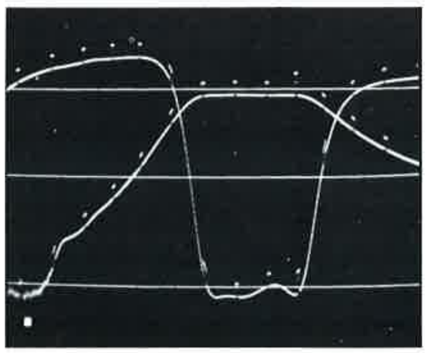
Description

The **Sweep Generator** delivers the swept RF in one band from 0.1 to 1000 MHz or 0.1 to 1300 MHz with model 53. Four modes can be switch-selected for sweep width:

1000 MHz	1300 MHz
5 to 1000 MHz	7 to 1300 MHz
0.3 to 50 MHz	0.3 to 50 MHz
0	0 (CW mode without sweeping and return blanking)

The output voltage of 0.5 into 50 Ω (for 1 V into 50 Ω by switchover on the rear) or 0.35/0.7 V for the 75-Ω model ensures an excellent dynamic range for the whole instrument. Even with the doubled output voltage the frequency response is guaranteed in the range from 5 to 300 MHz (flatness typically ±0.25 dB, plus 0.2 dB with voltage doubling).

Reflection-coefficient and attenuation curves of 25-MHz bandpass filter with pulse frequenecy markers



The low spurious FM of typically 3 kHz allows a sharp display of steep filter slopes. Good harmonic suppression is also important when filters are to be checked without measurement errors (refer to page 125); the typical value for SWOB 5 is 40 dB.

The Display Section consists of two units:

measuring head and
deflection amplifier.

Terminating probes and insertion units with different characteristic impedance and high-impedance probes are available for use as **measuring head.**

The **deflection amplifiers** are in the form of plug-in units, permitting optimum adaptation of the set to different measurement tasks and to the customer's requirements for price and performance. The following amplifier combinations are possible for linear and/or logarithmic display.

1. One linear amplifier (low-priced single-channel version)
2. Two linear amplifiers
3. One linear and one logarithmic amplifier
4. Two logarithmic amplifiers (high comfort for most exacting requirements).

The **linear amplifier** boosts the detected voltage from the measuring head for display. It may be used wherever a display range of 20 to 30 dB and a defleciton factor of about 2 mV/cm are adequate.

The **logarithmic amplifiers** have, in conjunction with a terminating probe or insertion unit, a noise limit of typically 170 μV, corresponding to a dynamic range of 70 dB with a sweep-generator output voltage of 0.5 V (even 76 dB is obtainable if the maximum output voltage of the sweep generator is changed to 1 V with the rear switch).

Use of the **Active Demodulator SWOB5Z4** gives a limit sensitivity of 20 μV. With a permissible driving level of 50 mV for the Active Demodulator, the dynamic range is then about 70 dB.

Characteristics of logarithmic amplifier plug-ins

Logarithmic Amplifier SWOB 5 E1

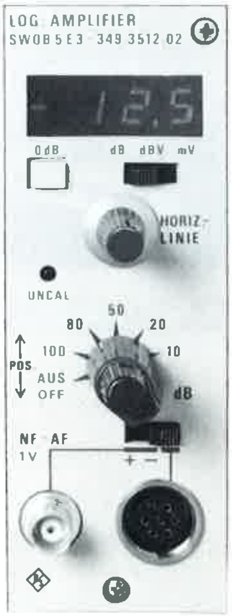
Range. The display range on the screen can be switched to 80/60/40/20 or 10 dB and shifted by more than 70 dB with the aid of a potentiometer. Any part of the display can thus be spread.

A shiftable **calibrated horizontal line** facilitates accurate level measurement. A ten-turn helical potentiometer permits vertical shifting with 0.1 dB resolution. The zero position can be varied with a control knob, the detent position of which corresponds to a reference level of 1 V. A lamp lights when the knob is not in this calibrated position. A filter can be switched into circuit for the observation of very small signals on the screen.

Compensation of spurious signals. Spurious signals such as may arise, for example, from the oscillator voltage of a tuner and which may limit the useful dynamic range are measured by both the linear and logarithmic amplifiers during the return sweep – while the RF is blanked – and compensated for.

Logarithmic Amplifies SWOB 5 E3

The Logarithmic Amplifier plug-in SWOB 5 E3 (photo) operates with the same wideband probes as the Logarithmic Amplifier SWOB 5 E1, namely: demodulator, insertion unit, logarithmic probe or active demodulator.



Front panel of Logarithmic Amplifier plug-in SWOB 5 E3

The **dynamic characteristics** – maximum input voltage 1 V, typical noise level 170 μV – make for a dynamic range of 76 dB. The display range can be switch-selected for 100, 80, 50, 20 or 10 dB. The horizontal graticule of the SWOB 5 screen thus provides scales of 10, 8, 5, 2 and 1 dB/div. A positioning potentiometer allows shifting of the display over more than 70 dB, so any detail of the display curve may be spread.

The main **advantages of this plug-in** are:

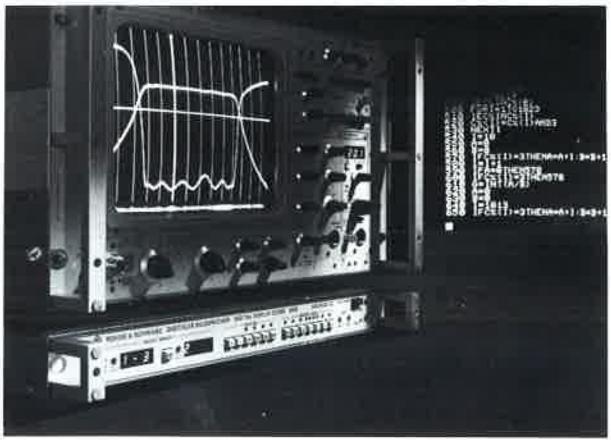
- AF input for the connection of test item with a built-in rectifier,
- digital level indication,
- automatic setting of reference levels,
- signalling of excessive spurious levels,
- gain of active demodulator taken into account in level measurements.

The characteristics when using the **AF input** are the same as for operation with an RF probe: maximum test voltage 1 V, noise level 170 μV, dynamic range 76 dB, display range 100, 80, 50, 20 or 10 dB and vertical-positioning range greater than 70 dB. Positive or negative polarity can be selected with a switch.

Polyskop SWOB 5 – Log. amplifier

Logarithmic Amplifier SWOB 5 E3 (continued)

With the aid of a horizontal line, which is calibrated in level and can be shifted through about 100 dB with a frontpanel potentiometer, the level can be accurately measured at any point of the curve.



Filter characteristics (transmission/reflection) and level line on Polyskop SWOB 5 with plug-in E3 and Digital Display Store BDS

It is also possible to set the reference level by removing the test item and connecting the measuring head directly to the RF output of the Polyskop. If the reference line is shifted to make it coincide with the display line and the "0 dB" button is pressed, the dispay is calibrated with reference to the sweep-generator output level.

To prevent measuring errors being introduced by superposed **spurious signals** a **pilot lamp** is provided on the amplifier plug-in. A spurious signal is produced when the RF probe connector is used, for example in tuner measurements, through the local-oscillator reradiation that is practically always present; its maximum permissible level is 40 mV (4 mV with an active demodulator). Superposed DC of as much as ± 6 V is permissible at the AF input. The spurious voltage is measured during the return sweep and the pilot lamp lights whenever the permissible limits are exceeded.

If an **active demodulator** is connected to the amplifier plug-in, the calibrated level line is automatically lifted by 20 dB (gain of active demodulator), so in absolute measurements the level actually present at the input of the active demodulator is displayed. The noise level with the active demodulator is about 20 µV or −94 dBV. Since the calibrated level line covers a range of about 100 dB (0 to −100 dBV) this level can be measured accurately.

Level indications on the log. amplifier is in 3½ digits. The measured value can be indicated as an absolute value in dBV or mV or as a relative value in dB.

Autoranging is provided for **absolute measurements** in mV, the display ranges being 20, 200 and 2000 mV. The resolution of the digital display is 10 µV, 100 µV or 1 mV depending on the voltage range, or 0.1 dB for dBV or dB indication.

The **reference level for relative measurements** can be set at any point between 0 and −100 dBV. For this purpose the level switch is set to "dB", the calibrated level line adjusted to the desired position and the "0 dB" button pressed. The digital display is thus set automatically to 0 dB and when the level line is shifted the measured level is indicated in ±dB referred to the reference level. It is of course possible, by changing the level-switch position, to display the absolute level again whilst retaining the reference-level setting.

The automatic setting of the reference-level display is very expedient in transmission-factor measurements: the level line is adjusted to the input level of the test item.

The level switch is set to "dBV" and the level line adjusted to this reference value, then the level switch changed to "dB" and the "0 dB" button pressed. The level line can now be adjusted to the point of the displayed curve where the transmission factor is to be determined, for instance the maximum of a filter characteristic. The gain or attenuation of the test item is then read out in dB.

The **display** of the results is obtained on a long-persistence screen. The screen size of 21 cm×16 cm enables unstrained working. Four level lines (configuration with two amplifiers) and crystal-controlled vertical-line markers yield a coordinate grid of excellent clarity.

Frquency markers. Pulse or vertical-line markers provide a scale on the frequency axis with the decades identified by higher intensity; see illustration on page 132. A bright bar at the lower edge of the screen marks the adjusted sweep range on a scale.

IF markers option. An IF marker generator is available for measurements on TV tuners; see specifications under recommended extras. This option permits IF markers for the vision and sound carriers to be generated and to be displayed in addition to the other markers.

A **recorder output** with pen-lift contact and the possibility of triggering a counter connected at the rear by means of a manually adjustable brightup marker complete the outstanding measuring capabilities of SWOB 5.

Digital Display Store BDS

The **Digital Display Store BDS** – described in detail on page 138 – yields a flicker-free display even with slow sweep times and considerably extends the applications of the sweep tester thanks to a number of additional functions. The characteristic features of the BDS are:

- display of slow sweeps as a stationary pattern
- four independent memories
- combination of contents of any memory by addition or subtraction
- insertion of additional frequency markers
- IEC-bus capability with option

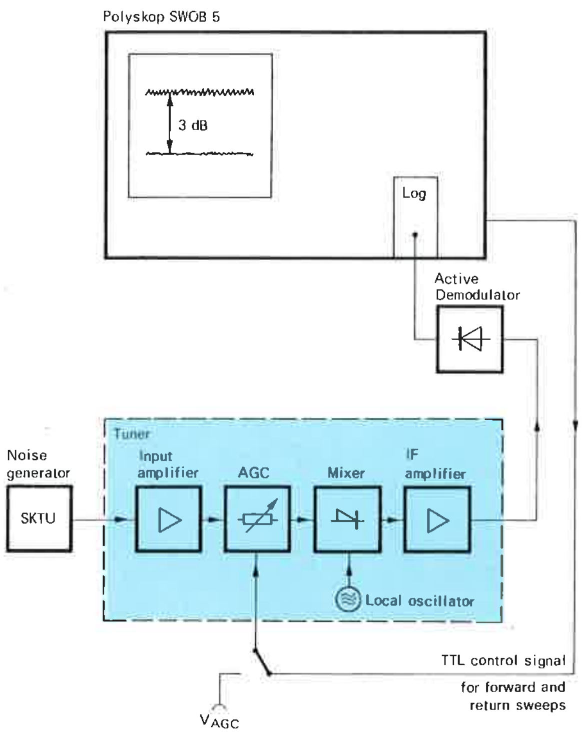
Moreover, an additional option to the Digital Display Store permits noise suppression by taking the average over several sweeps.

The Digital Display Store is an ideal extension for the Polyskop SWOB 5 and especially designed for use with this instrument. The flat, 78-mm high unit as a bottom or top add-on has the same width and depth as the SWOB 5 and is connected to the Polyskop via a 36-way female connector strip.

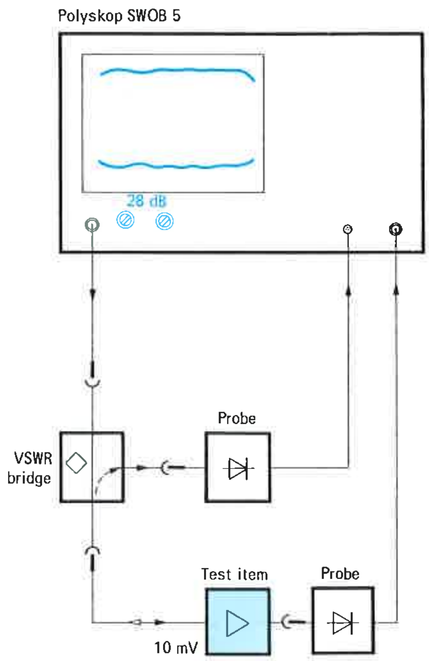
For operation of the SWOB 5 in conjunction with the BDS, the Display-store Interface Option SWOB5B6 is required (Order No. 333.5410.02). Instruments from Serial No. 871 551 on are ready for the interface to be fitted.

Examples

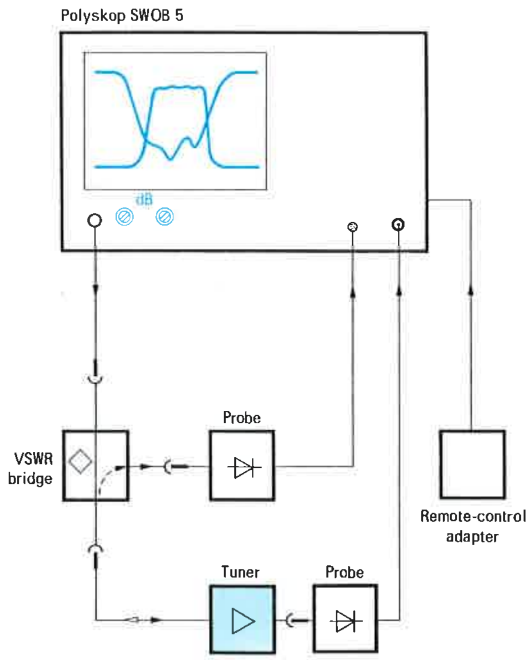
Task. Measurement of noise characteristics of TV tuners.



Task. Measurement of amplitude/frequency response and matching on active broadband test items, suchc as cable-TV and antenna amplifiers.



Task. Measurement of amplitude/frequency response and matching on TV tuners using automatic sweep-width adjustment.



Polyskop SWOB 5 — Specifications

Specifications of SWOB 5

(Values in parentheses are valid for model 53)

Frequency range	0.1 to 1000 MHz (0.1 to 1300 MHz) (in one band; only centre frequency and sweep width need be adjusted)
Sweep width	four ranges
1000 (1300)	full frequency range
5–1000 (7–1300)	variable: 5 to 1000 MHz (7 to 1300 MHz)
0.3–50	variable: 0.3 to 50 MHz
0	no sweep (CW)
Spurious FM (NARROW)	5 kHz, typ. 3 kHz (test bandwidth 50 Hz to 10 kHz)
Sweep linearity	1 : 1.01
Linearity of display	better than 1 : 1.1
Sweep adjustment	Δf and centre frequency (coarse/fine)
external	via remote-control input
Scale error of range indication	±3% of fs
Remote control	via 7-pole female connector on rear
Centre-frequency adjustment	≈ 3 to 8 V
Sweep-width adjustment (ext. potentiometer ≈ 5 kΩ)	0 Ω for Δf_{min}, R_{max} for Δf_{max}
Sweep time	0 to 5 V for 2 to 0.02 s
RF monitoring output	50 mV into 50 Ω BNC female connector on rear
Output EMF	50 Ω: 1 V ±5%; 75 Ω: 0.7 V ±5% (can be increased by 6 dB rear switch)
Connector	N female
Frequency-response flatness of output voltage with match-termination	< ±0.5 dB (typ. ±0.25 dB) for 0.1 to 1000 MHz (0.1 to 1300 MHz), <0.15 dB for 10 MHz sweep
with 6-dB increase	±0.2 dB in addition (5 to 300 MHz, otherwise +1 dB)
Output attenuator	0 to 70 dB in 1-dB steps
Error coarse (10-dB steps)	≦ ±0.5 dB } overall error
fine (1-dB steps)	≦ ±0.2 dB } overall error
Harmonics (for EMF = 1 V or 0.7 V)	
0.1 to 1 MHz	≧30 dB down
>1 to 1000 MHz (0.5 to 1300 MHz)	≧36 dB (typ. 40 dB) down
Non-harmonic spurious signals	
0.1 to 1000 MHz	≧40 dB down
up to 1300 MHz	>30 dB down

Frequency sweep

Mode	AUTO	forward/return with RF blanked during return
	MAN	manual sweep adjustment
	SINGLE	triggered by button or external trigger signal, recorder operation
Sweep time	AUTO	forward 0.02 to 2 s, continuously adjustable; return 0.01 to 0.3 s
	SINGLE	≈ 0.02 to 2 s, continuously adjustable
Triggering		in SINGLE mode
Ext. trigger level		≈ +5 V (at rear input)

Frequency markers internal[1])	100 MHz; 100/10 MHz; 10/1 MHz; error < ±1 × 10^{-4}
external	1 to 1300 MHz, ≈ 0.2 V (50 Ω)
Marker type	pulse and vertical-line markers
Oriented along frequency axis (internal)	marker amplitude or brightness modulated to highlight the decades
Brightup marker	by MAN adjustment in AUTO mode
Trigger signal for counter	TTL H during unblanked period (>10 ms), BNC female connector (TTL L by changing internal connection)
Level lines	two; separate adjustment of vertical position; common adjustment of intensity
Useful display area	21 cm×16 cm; screen type: M 28-12 GM
Recorder output	±2.5 V for max. X deflection; 2.5 V for max. Y deflection; R_{out} ≈ 5 kΩ
Connector	6-pole female (1 channel) or BNC female (2 channels)

[1]) Spurious markers may appear with increased output level (rear switch on +6 dB setting).

External X deflection	±1 V (symmetrical about zero) for full display width; rising edge: forward 0.02 to 2 s, falling edge: return 0.01 to 0.3 s
Connector	7-pole female on rear

Amplifier plug-ins

Logarithmic Amplifier SWOB5 **E1**

Measurement range (full display height)	10/20/40/60/80 dB
Noise level (with Demodulator SWOB5 Z1 or RF Insertion Unit SWOB5 Z3)	typ. 170 µV (with filter)
Max. test voltage	1 V (with SWOB5 Z1 or Z3)
Display adjustment range	>70 dB
Level line, calibrated in dB	
Reference level	shiftable by −12 dB; detent position calibrated at 1 V = 0 dB
Adjustment range	0 to < −100 dB, resolution 0.1 dB
Error limits	typ. ±1.5 dB (with SWOB5 Z1 or Z3)
Lowpass filter	switch-selected, indicated
3-dB point	≈ 40 Hz
Connector for measuring head	7-pole female
Compensation of spurious signals	25 mV RF (2.5 mV with active demodulator)

Logarithmic Amplifier SWOB5 **E3**

	AF	Meas. head
Inputs	AF	Meas. head
Connector	BNC female	7-pole female
Input impedance	≈100 kΩ	suitable for measuring heads SWOB5 Z1, Z2, Z3 Z4

Measurement using Demodulator SWOB5 Z1 or RF Insertion Unit SWOB5 Z3

Measurement range	10/20/50/80/100 dB
Display adjustment range	>70 dB
Noise level	typ. 170 µV
Error limits	typ. ±1.5 dB
Max. test voltage	1 V (measuring-head RF input)

Measurement via AF Input

Measurement range (full display height)	10/20/50/80/100 dB
Display adjustment range	>70 dB
Noise level	typ. 170 µV
Error limits	typ. ±1 dB (down to −60 dBV)
Max. test voltage	1 V
Max. permissible input voltage	14 V

Level line calibrated in mV, dBV and dB

Adjustment range, absolute measurement	10 µV to 1 V/−100 to 0 dBV		
relative measurement	0 to 100 dB		
Level indication	3½ digits		
Voltage indication range	20 mV	200 mV	2000 mV
Resolution	10 µV	100 µV	1 mV
dBV and dB ranges	>100 dB		
Resolution	0.1 dB		
Indication error	0.1 dB or 2% ±1 digit		
Lowpass filter	switch-selected on basic unit, indicated		
3-dB point	≈40 Hz		

	AF	Meas. head
Compensation of spurious signals	±6 V	40 mV RF (4 mV with Active Demodulator)

A pilot lamp lights when the spurious level exceeds the permissible limit.

Linear Amplifier SWOB5 **E2**

Inputs	**AF**[2])	**Meas. head connector**
Input impedance	500 kΩ	500 kΩ
Connector	BNC female	7-pole female
Input selector positions	+/−/+≈/−≈	=/≈ (compensation for spurious RF signals in test item)
Deflection coefficient	0.2 mV/cm	
Voltage required for full display height with max. sensitivity	<3 mV	<15 mV
Max. permissible input voltage	10 V (= or ≈)	5 V (=) or 10 V (≈)

[2]) Connector for probe or test item containing a demodulator.

Measuring heads

Demodulator SWOB5 Z1 (with built-in termination)

Impedance	50 Ω	75 Ω
Connector	N male	N male
Frequency range	0.1 to 1300 MHz	0.1 to 1000 MHz
VSWR	≦1.1 up to 1000 MHz ≦1.2 up to 1300 MHz	≦1.1
Frequency-response flatness 0.4 to 1000 MHz	≦ ±0.5 dB typ. ±0.25 dB	≦ ±0.5 dB typ. ±0.25 dB
0.1 to 1300 MHz	≦1 dB	
Max. test voltage, rms	1 V	
Max. permissible input voltage	5 V AC or 10 V DC	
Connection to lin/log amplifier	via cable (1 m) and 7-pole male connector	

RF Insertion Unit SWOB5 Z3

Impedance	50 Ω	75 Ω
Connector	N male	N male
Frequency range	0.1 to 1300 MHz	0.1 to 1000 MHz
VSWR	≦1.15 up to 1000 MHz ≦1.3 up to 1300 MHz	≦1.25
Frequency response flatness 0.4 to 1000 MHz	≦ ±0.5 dB typ. ±0.25 dB	≦ ±0.5 dB typ. ±0.25 dB
0.1 to 1300 MHz	≦1 dB	
Max. test voltage, rms	1 V	
Max. permissible input voltage	5 V AC or 10 V DC	
Connection to lin/log amplifier	via cable (1 m) and 7-pole male connector	

Log. Probe SWOB5 Z2

Impedance (depending on frequency and attenuator)	>3 kΩ to >20 MΩ ‖ 0.5 to 2.5 pF
Frequency range	0.1/10/5 to 500 MHz (rough indication up to 1300 MHz)
Frequency response flatness	< ±1 dB
Attenuation of probe tips	0/20/40 dB
Input voltage range	0.2 mV to 1 V/2 mV to 10 V/ 20 mV to 100 V (rms)
Input circuit	unbalanced, non-floating

Demodulator SWOB3-Z (probe with BNC male connector)

Frequency range	0.5 to 400 MHz (rough indication up to 1300 MHz)
Input impedance at 50 MHz	≧30 kΩ ‖ 2 to 3 pF
at 200 MHz	≧10 kΩ
Input voltage	min. 50 mV for full display height, max. permissible 5 V RF, superimposed DC up to 100 V
Output signal[3]	+ DC ≧5 mV into >500 kΩ, for 50 mV_{rms} (0.5 to 400 MHz)

Active Demodulator (50 or 75 Ω depending on model)

Input voltage range	20 µV to 50 mV
Frequency-response flatness	≦ ±2 dB for 5 to 1300 MHz
Input VSWR	≦1.3

Specifications of recommended extras

VSWR Bridge	**SWOB4-Z** 50 or 75 Ω	**ZRB** 50 Ω
Frequency range	10 to 1000 MHz	5 to 2000 MHz
Test-item connector	N male	N female
RF input	N female	N female
Output to detector	N female	N female
Directivity	≧40 dB	≧46 dB
Insertion loss	≈6.5 dB	≈6.5 dB

Overvoltage Protection (for RF input or output)

Response threshold	4 V DC or RF
Switching time	≦3 ms

Digital Display Store .... see next page

Extension (options)

(mounting with electrical connections via irreversible connectors of basic unit)

External Control SWOB5 B1

Switchover	int./ext. via slide switch: lamp lights in ext. mode
Input	7-pole female connector for RF Insertion Unit SWOB5 Z3
Voltage adjustment	0.1 to 0.5 V, continuous

Slow Sweep

X voltage	±2 V for max. deflection
Y voltage	1 V for max. deflection
Sweep time	0.02 to 2 s; ≈ 30 s with recorder cable plugged in
Connectors	6-pole female (1 channel) 3 BNC female

IF Markers SWOB5 B3/B4

Input	frequency markers
Frequency range	0.5 to 150 MHz
Input impedance	50 Ω
VSWR	≦1.15 in range 5 to 150 MHz
with lowpass filter	≦1.3 in range 5 to 150 MHz
Input voltage for perfect marker display	min. 10 mV (1 mV in range 5 to 150 MHz), max. 200 mV
Max. permissible input voltage	5 V AC or 10 V DC
Number of markers	2, produced by plug-in crystal oscillators
Marker frequencies	33.4 MHz, 38.9 MHz
Max. frequency error	2×10^{-5}

Display-store Interface

SWOB5 B6	required for operation of SWOB5 with BDS; units from serial No. 871 551 on are prepared for retrofitting
Connector	50-pole female, suitable for connection of BDS

General data

Rated temperature range	+5 to +40°C
Storage temperature range	−25 to +60°C
Power supply	110/125/220/235 V ±10%, 47 to 63 Hz (180 VA)
Dimensions, weight	484 mm×294 mm×436 mm, 25 kg

Ordering information

Order designation .... ▶ Polyskop SWOB5

SWOB5, without amplifier plug-ins:		
50-Ω model, 0.1 to 1000 MHz		333.0019.52
50-Ω model, 0.1 to 1300 MHz		333.0019.53
75-Ω model, 0.1 to 1000 MHz		333.0019.72
Amplifier plug-ins:		
Log. Amplifier	SWOB5 E1	333.5610.02
Log. Amplifier	SWOB5 E3	349.3512.02
Lin. Amplifier	SWOB5 E2	333.5010.02
Measuring heads:		
Demodulator	SWOB5 Z1	
50-Ω model		333.7513.52
75-Ω model		333.7513.72
RF Insertion Unit	SWOB5 Z3	
50-Ω model		333.8010.52
75-Ω model		333.8010.72
Log. Probe	SWOB5 Z2	333.9016.02
Demodulator Probe	SWOB3-Z	241.2116.00
Active Demodulator	SWOB5 Z4	
50-Ω model		333.8510.52
75-Ω model		333.8510.72

Accessories supplied .... power cable

Recommended extras and extensions (options)

VSWR Bridge	SWOB4-Z	
50-Ω model		912.7003.00
75-Ω model		912.7303.00
VSWR Bridge	ZRB	335.2819.50
Overvoltage Protection	SWOB5-Z5	333.9316.52
Recorder Adapter Cable	SWOB4-Z	289.5450.02 (for ZSK2)
Recorder Adapter Cable	SWOB4-Z	289.5450.03 (for ZSKT)
RF connecting cable (1 m, 50 Ω, N male conn.)		100.7670.10
(1 m, 75 Ω, N male conn.)		100.7687.10

Extensions (options)

External Control Option	SWOB5 B1	333.6700.02
Slow Sweep Option	SWOB5 B2	333.9616.02
IF Markers Option		
Motherboard	SWOB5 B3	333.9716.02
additionally required: Crystal Oscillator	SWOB5 B4	
33.4 MHz and 38.9 MHz		333.9916.30

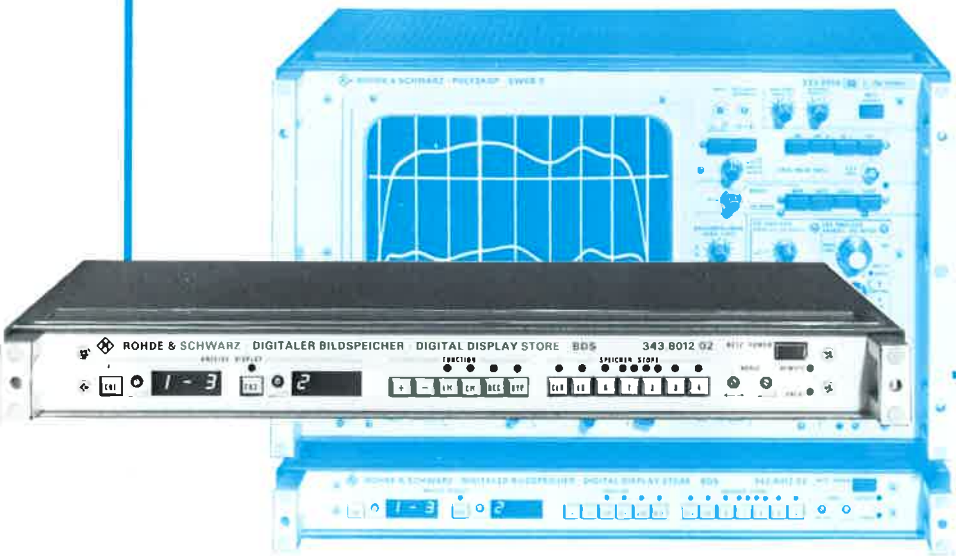
Accessories

Digital Display Store BDS		343.8012.02
Display-store Interface	SWOB5 B6	333.5410.02
IEC-bus Interface	BDS-B4	343.9602.02
Average-value Memory	BDS-B5	343.9802.02
Basic Software for control of BDS/SWOB5 via Process Controller PUC	BDS-K1	358.1919.02

[3]) Non-linear signal characteristic: up to ≈30 mV (V_{RF}) squarewave, from ≈0.5 V (V_{RF}) linear.

BDS

Digital Display Store BDS



♦ Stores four curves

- Flicker-free display even with slow sweep speeds
- Error compensation by storage and addition or subtraction of correction curves
- Memory space for a total of four curves
- Noise suppression by taking the average over several sweeps
- IEC-bus compatible

Characteristics, uses

In conjunction with Polyskop SWOB 5, the **Digital Display Store BDS** permits simultaneous, flicker-free display of two curves plus the associated frequency markers, level lines and frequency range. The 1024-point horizontal and 256-point vertical resolution of the pattern yields an accurate representation of the original curve.

Moreover, the Digital Display Store offers a number of functions which considerably extend the applications of the Polyskop SWOB 5.

Memory space. In addition to the two curves represented as a flicker-free pattern, two further curves can be saved in additional memories. But data can also be stored in the buffer memories used for displaying the instantaneous values measured, so that a total of four curves can be stored.

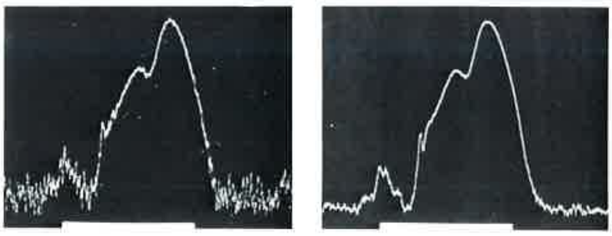
A built-in battery ensures that the stored data are maintained even in the case of AC supply failure or after the Digital Display Store has been switched off.

Modes. Both channels permit the sum or difference of any two memory contents to be displayed; thus **error correction** and displaying the **drift from nominal** are possible.

Additional frequency markers. An additional memory permits markers to be inserted at any position in addition to the SWOB 5 frequency marker graticule; in this way, frequencies which are of special interest can be highlighted, for instance.

Recording. The stored curves can be output via a built-in interface directly to an XY recorder. In this mode, the sweep time increases to about 60 seconds.

Noise suppression. To complement the basic version of the BDS, an option is available permitting the average to be taken over 4, 8 or 16 successive sweeps. Thus random interference on the sweep curve, e.g. noise, can be suppressed to a large extent.

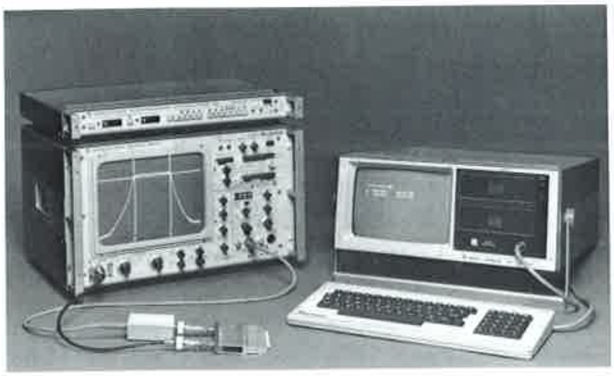


Frequency response display: (left) signal with heavy noise component and (right) after taking the average over successive sweep with the corresponding BDS option

Computer-aided evaluation of sweep curves on Polyskop SWOB 5

The **IEC-bus Interface Option BDS-B4** enables not only the transfer of all stored data but also problem-free computer-aided evaluation of the results on the sweep system SWOB 5 using for instance the R&S Process Controller PUC. The advantages of using a computer become most evident where previously lengthy manual settings or calculations were required. Via the **bidirectional data interface** (IEC bus) of the BDS the resulting curves and markers can be directly displayed on the Polyskop screen.

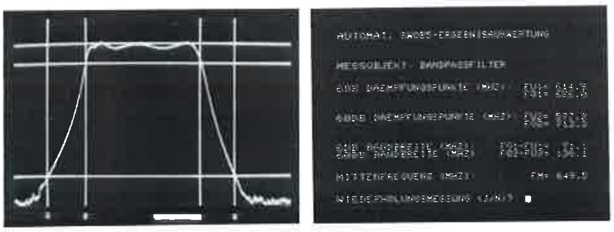
Measurement examples. The position of any **frequency markers** or **level lines** can be easily and accurately calculated and output on the PUC; on the other hand markers and lines can be superimposed on the Polyskop screen at exactly defined positions.



Computer-aided sweep test assembly with Polyskop SWOB 5, Digital Display Store BDS and Process Controller PUC

For measurements on amplifiers and filters, criteria like the **3-dB point** can automatically be selected from the measured data, the associated frequencies be recorded and the corresponding markers be superimposed on the screen.

It is not only possible to evaluate individual measuring points numerically, but to convert **complete curves into any other waveform** and output it again, for example if the VSWR is to be determined from the measured return loss or if a frequency axis with linear scale is to be converted into one with logarithmic scale.



Measured curve with additionally superimposed frequency markers and level lines as well as displaying on PUC

BDS software. In order to relieve the user from lengthy programming, a BDS software BDS-K1 has been prepared. It offers a great number of applications in the form of single routines which are mostly independent of each other. These routines can be combined by means of a few program steps for the evaluation of whole test sequences; this evaluation can be made very rapidly since most of the subroutines are written in machine language.

Description

The analog signal corresponding to the test voltage (Y axis) on the Polyskop is converted in the BDS into digital signals of 8-bit word lenght. 1024 addresses are available on the X axis for this purpose; they can be processed completely in about 20 ms. Four 8-kbit CMOS memory chips enable the separate storage of four different curves. Additional CMOS memories preserve the information on frequency markers, frequency range and level lines. The low current drain of the CMOS RAMs permits the data to be stored for extended periods with the aid of dry cells. The overall function of the unit is controlled by a clock system with a fundamental frequency of about 600 kHz.

The nucleus of the Average-value Memory Option is a 12-bit adder and a 12-bit memory, where the intermediate results and finally the result of a maximum of 16 sweeps are temporarily stored. The function of the IEC-bus Interface Option calls for its use as a listener and as a talker.

Specifications

Screen	
Display refresh time	approx. 20 ms
Minimum sweep time	approx. 20 ms
Resolution: horizontal	1024 points
vertikal	256 points
Inputs	36-way female connector
X input	Z_{in} >100 kΩ, deflection voltage positive-going; max. amplitude 10 V position of starting point can be set between −10 and 0 V
Y input	Z_{in} >100 kΩ, V_{in}: nominal 0 to 2.5 V, maximum voltage adjustable from 2 to 3 V
Trigger input	TTL low triggers forward sweep
Frequency-marker and level-line inputs	SWOB 5 compatible
Outputs	36-way female connector
X output	Z_{out} <1 kΩ } output corresponds to input voltage
Y output	Z_{out} <1 kΩ } output corresponds to input voltage
Trigger output	TTL low triggers forward sweep
Frequency-marker and level-line outputs	SWOB 5 compatible
Recorder outputs	
X output	Z_{out} <1 kΩ } output corresponds to input voltage
Y output for level reference line	Z_{out} <3 kΩ } output corresponds to input voltage
with AF signal	Z_{out} <1 kΩ } output corresponds to input voltage; connectors: BNC female
Pen lift	connector on rear panel
Curve display and storage	
Number of curves	
displayed simultaneously	2
saved	2 (can be expanded to 4)
in intermediate storage	2
total storable	4
Storage without AC supply voltage	max. 6 months depending on charge remaining in internal dry batteries, state-of-charge check provided
Functions	a) addition and subtraction of contents of two memories b) insertion of additional frequency markers c) slow sweep in chart recording mode (approx. 60 s)
with option	averaging over 4, 8 or 16 sweeps to reduce noise component
IEC-bus connector	interface in accordance with IEC 625-1, 24-way Amphenol connector
Interface functions	AH1, SH1, L4, T8, DC1
General data	
Operating temperature range	+5 to +45 °C
Storage temperature range	−40 to +70 °C
Power supply	100/120/220/240 V ±10% 47 to 63 Hz (20 VA)
Dimensions	492 mm×78 mm×383 mm
Weight	5 kg

Ordering information

Order designation	▶ Digital Display Store BDS 343.8012.02
Accessories supplied	power cord
Extensions (options)	
IEC-bus Interface BDS-B4	343.9602.02
Average-value Memory BDS-B5	343.9802.02
Display-store interface SWOB5-B6	333.5410.02
Basic Software BDS-K1	358.1919.02

Characteristic features of a network analysis system

With the aid of network analysis the response of a test item with respect to reflection and transmission (transmission factor and attenuation ratio) can be investigated. In the RF range this is usually made by measurement of complex voltages, in particular of the s-parameters. At lower frequencies – especially in the AF range – a current-voltage measurement is however also possilbe.

System design

A network analysis system is made up of four components:

generator,
receiver,
display unit and
accessories.

In addition there is often the possibility of controlling all functions of the network analyzer via a process controller, e.g. via the IEC-bus data interface. This **further component** is not absolutely necessary, but has gained an increasing importance in the past years since the requirements are for a greater number of test parameter evaluations with higher accuracy (see three-point error correction) but shorter measuring times.

System generator. Depending on the particular application, either a **sweep generator** or a **synthesizer/signal generator** is used as generator in the system. The advantage of a sweeper is that a wide frequency range can be swept through within a short time (e.g. a range of 1 GHz in 100 ms), with continuously varying output signal and the test item not requiring time for settling upon every change of frequency. The deviation from the absolute frequency accuracy (a few MHz for sweepers operating in the GHz range) and the relatively high spurious FM of a few kHz do not however allow measurements on narrowband test items such as crystal filters. Therefore, synthesizers are used in such cases which feature very high frequency accuracy and stability, but a spurious FM in the Hz range. Their disadvantage is however that there is no continuous frequency change and that they require longer settling times then the sweeper. In automatic systems synthesizers are preferably used for point-to-point measurement.

Sweeper and synthesizer in one unit. The Sweep Generator SWP introduced by Rohde & Schwarz in April 1982 combines the advantages of a sweeper and a synthesizer in one unit to the latest standard (frequency range 0.1 to 2500 MHz, see also page 126). Now continuous sweeping of both narrowband and broadband test items is possible with just one generator.

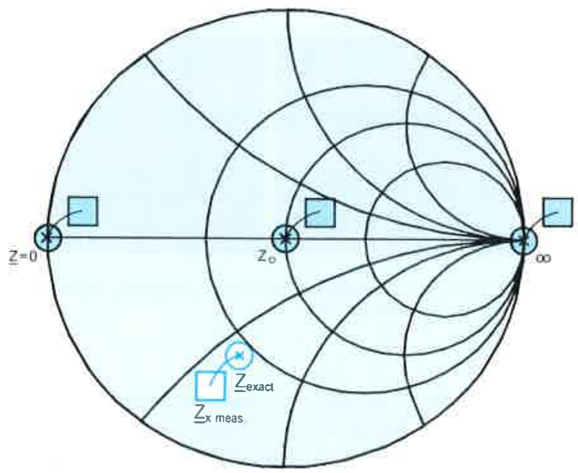
Receiver. Broadband demodulators, which are for instance used in scalar network analyzers (SWOB 5), are not suitable for measuring the network parameters by magnitude **and phase.** Therefore **tracking receivers** and receivers operating on the sampling principle are used. Both types of receiver carry out selective measurements with small bandwidth and usually have a lower sensitivity limit of 1 µV which corresponds to a dynamic range of about 120 dB referred to 1 V.

Display unit. A screen, pointer instrument, LED, recorder, plotter or similar can be used.

The accessories of the system are also significant for the measurement; they include directional couplers and VSWR bridges (see page 152) as well as an adapter for the test item.

Reflections on accuracy

Three-point error correction is employed to eliminate errors caused by the test setup as far as possible. According to this method the **shortcircuit** ($\underline{Z} = 0$), matching ($\mathbf{Z_0}$) and **opencircuit** (∞) are measured at a certain frequency f_1 by the network analyzer (see following diagram) and are transformed in an external computer into the ideal values plotted on the horizontal axis of the Smith chart. When connecting now an unknown test item to the test setup and transforming the measured value ($Z_{x\ meas}$) as before, the accurate impedance value ($Z_{accurate}$) of the test item is obtained.



Three-point error correction at frequency f_1
□ =measured values,
⊗ =transformed values

The error in measurement is only about 1% referred to the reflection coefficient even on the outer circle of the Smith chart. Additional errors caused by inaccurate frequency setting of the generator can be largely avoided by using a synthesizer. For more than one test frequency calibration routines must be available for each further frequency.

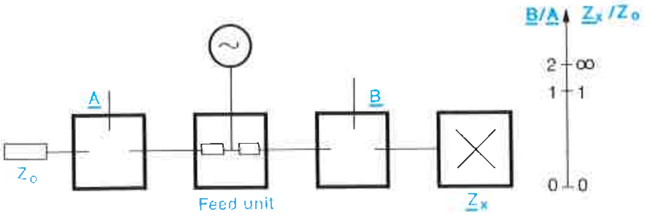
The **advantages of the three-point error correction** are convincing:

- improvement of accuracy (see above),
- error correction referring to complete test setup, including calibration of adapters and cables between directional couplers or VSWR bridges and test item,
- measurement even possible in coaxial systems of different standard (e.g. measurement on an item using 75-Ω system with a 50-Ω network analyzer).

Reflection measurement without bridges and couplers

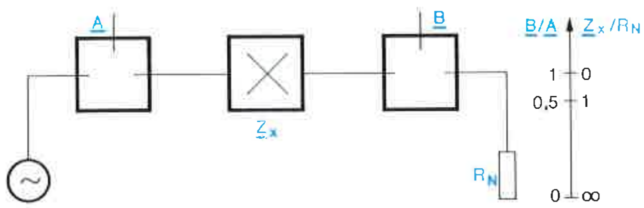
Even when using the three-point error correction, the network analyzer cannot differentiate between impedance values from 10 kΩ to ∞ due to the residual error of about 1% on the outer circle.

The following diagram shows the simplest method of reflection measurement without VSWR bridge or direction coupler. As can be seen from the nomogram, a small error in the measurement of the voltage ratio $\underline{B}/\underline{A}$ entails a great error in the measurement of Z_x at high impedances ($\gg Z_0$). There is no network analyzer whatsoever on the market which could employ this method for high impedances.



Result from $\underline{B}/\underline{A}$ ratio measurement as a function of impedance $\underline{Z}_x$ (in reflection measurement)

If the network analyzer is however also able to operate on the voltage division principle (see diagram below) and to convert the measured values into impedances, measurement in the MΩ range is also possible.



Result from $\underline{B}/\underline{A}$ ratio measurement as a function of impedance $\underline{Z}_x$ (when using voltage division principle)

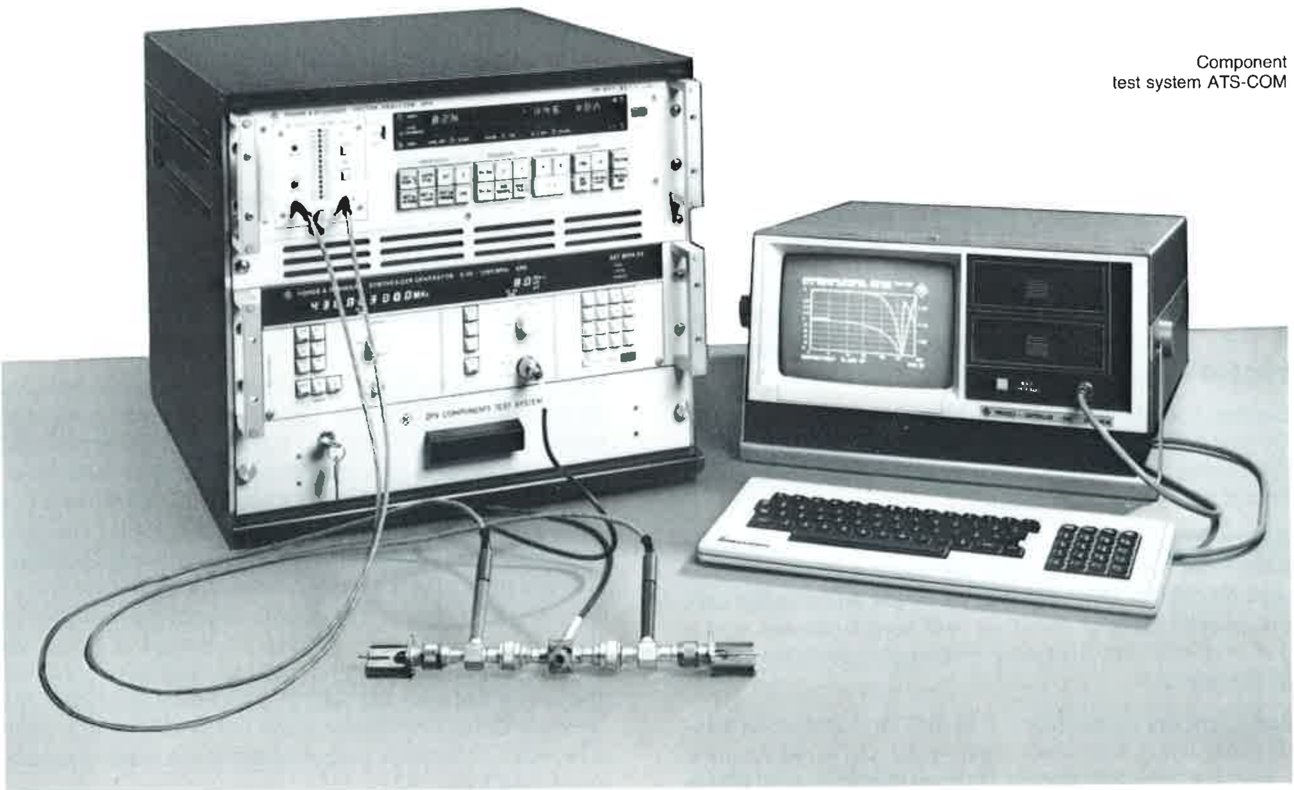
Applications

From the great number of possible applications of network analyzers the measurement on components such as RF chokes and capacitors is to be dealt with in greater detail.

In practical operation it is for instance necessary to measure a capacitor with respect to its C and tanδ values at its intended operating frequency. The VSWR bridges available on the market only allow a measurement below 10 MHz; this does not directly give a clue to the RF response of the capacitor.

A network analyzer system made up of the Synthesizer Generator XPC (page 58), the Vector Analyzer ZPV (page 142) and the Process Controller PUC (page 14) enables measurements of R, L, C, Q and tanδ up to 1 GHz. The error for tanδ values of 10^{-4} is about 15%. The same applies to measurements on RF chokes with respect to self-inductance, self-resonant frequency and quality at a certain test frequency. This measurement is based on an analysis of parallel-resonant circuits.

The measuring system as shown on the photo below can be supplied by Rohde & Schwarz including the software. The test assembly is also suitable for measurements on crystals (to IEC 444) and diodes.



Component test system ATS-COM

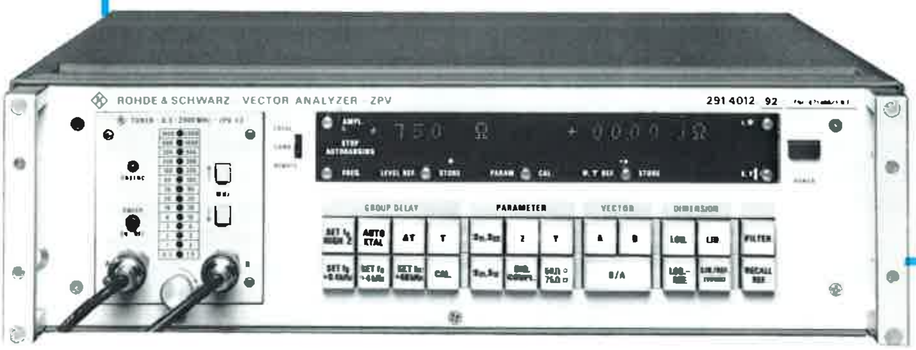
ZPV

Vector Analyzer ZPV

♦ 10 Hz to 2 GHz

- Digital vector voltmeter with direct reading of s-parameters as well as y- and z-parameters
- Reflection and impedance measurement with directional couplers, VSWR bridges or T junction
- Group-delay measurement
- Autoranging; IEC-bus-compatible

Detailed application note on request



IEC 625 Bus

Characteristics and uses

The **Vector Analyzer ZPV** implements a novel technique for the measurement of complex quantities. Its functional principle is that of a dual-channel vector voltmeter measuring amplitude and phase. As in conventional vector voltmeters, the frequency is synchronized in the reference channel, so that a selective measurement is performed at one frequency.

Combined with a **microprocessor,** the ZPV decisively simplifies all complex measurement procedures. All functions are fully automated and the required value is read out directly on the display. Thus the ZPV surpasses conventional analog vector voltmeters in operating convenience and display possibilities. Its typical applications are control engineering, crystal, antenna, amplifier and filter measurements.

The ZPV is equipped for **voltage measurements by magnitude and phase.** Automated measurement of **twoport parameters** and of **group delay** is additionally possible.

Using different tuners (see next page) and the appropriate measuring facilities (directional couplers, etc., see recommended extras on page 152) the Vector Analyzer can be fittet to meet the user's specific requirements with respect to frequency range and test method.

Display possibilities. The two digital readouts of the ZPV indicate both components of the measured complex quantity. The display can be in cartesian or polar coordinates, linear, logarithmic, absolute or relative.

Autoranging. Range selection is fully automatic due to the built-in microprocessor so that the measured value can be read off directly after selecting the mode and physical unit. For swept-frequency operation and special display modes the amplitude and frequency autoranging facilities can be disconnected.

Automatically tuned filter. The ZPV incorporates an automatically tuned filter which provides for stable indication of noise-corrupted test signals. The microprocessor analyzes the stability of the signal and determines the time constant required for fluctuation-free display of the result.

Calibration at the push of a button. For complex measurements a reference plane has to be defined. This is done in the ZPV at the push of a button, determining phase zero, magnitude = unity and reference characteristic impedance. These values are stored in the built-in microprocessor and maintained even when changing the test mode so that new calibration is required only if the test setup is modified.

Swept-frequency operation, recorder outputs. Control voltages monitored by the microprocessor ensure that high-precision signals are always available at the X and Y outputs. Transient response of the synchronization stage due to sampling is suppressed. Consequently the Vector Analyzer ZPV can also be used in swept-frequency operation; however, the sweep rate of the ZPV, which is slow compared with sweeper display units, has to be considered. The test results obtained in swept-frequency checkouts can be plotted on a recorder or displayed on a storage oscilloscope up to a dynamic range of 110 dB. For narrowband sweeping, for instance in crystal testing, additional special outputs are available.

System compatibility. All functions of the Vector Analyzer are fully programmable. The IEC bus permits both settig of all modes on the instrument and outputting of all test results. Various methods of data transfer ensure optimum data transmission speed. In addition to the separate output of real and imaginary components or magnitude and phase, the complete complex quantity can be transmitted as one data word. The readout is either dependent on the measurement time or independent of time so that optimum use of the measuremet speed is made. Manually selected modes can be output via the IEC bus. Comprehensive software packages are available for instance for the R&S Process Controller PUC, the Tektronix Computing System 4051 or the HP Desktop Computer 9835, to facilitate programming of automatic measurements; see page 152.

Vector measurement

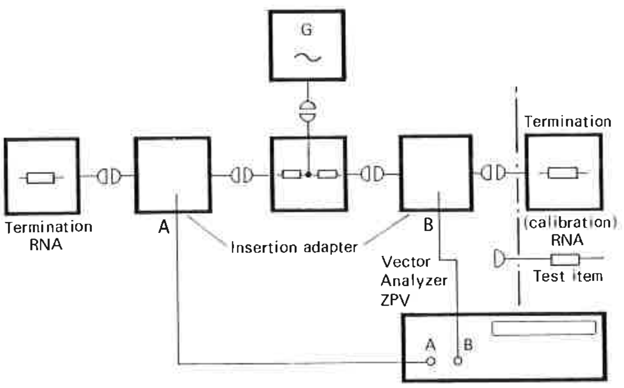
In this mode the ZPV measures the voltages in channels A and B and indicates them in absolute mV or dBm values and relative to any presettable reference value in dB. Simultaneously the phase difference between channels A and B is read out. The voltage ratio between the two channels can be indicated linearly and logarithmically – in absolute or relative values – or with its real and imaginary components.

Two-port measurement

The s-parameters, impedance and admittance values can be read out on the digital ZPV display either in cartesian or in polar coordinates. Impedance and admittance are indicated both in absolute values and normalized to the characteristic impedance, the reference being either 50 or 75 Ω. The ZPV permits impedance calculation for test setups based on the voltage measurement method. High impedances can be measured by the voltage-divider method with all tuner plug-ins. The type used is entered with the aid of a pushbutton.

The **s-parameters** are read out linearly or logarithmically. Direct indication of the VSWR is also possible. The reference plane is defined at the push of a button, the reference phase and amplitude being automatically stored in the ZPV. The **s-parameter accuracy-improvement software** available for the recommended computers permits extremely accurate transmission and reflection measurements with respect to reference values; see page 148.

For two-ports in the range <100 MHz the voltage measurement method can be used (see figure below) whereas use of an impedance-match bridge or directional couplers is to be preferred at higher frequencies (>100 MHz) because of the increased accuracy.



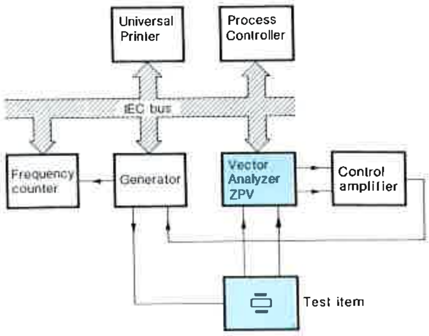
Two-port measurement based on the voltage method

Group-delay measurement

Combined with an FSK generator the ZPV can be used to mesure group delay with high resolution (typ. 1 ns). From the phase variation resulting from the frequency shift, the equipment calculates the group delay and gives a direct readout in nanoseconds. An automatic calibration routine calibrates the frequency shift of the signal generator.

Measurement of crystal equivalent-circuit parameters

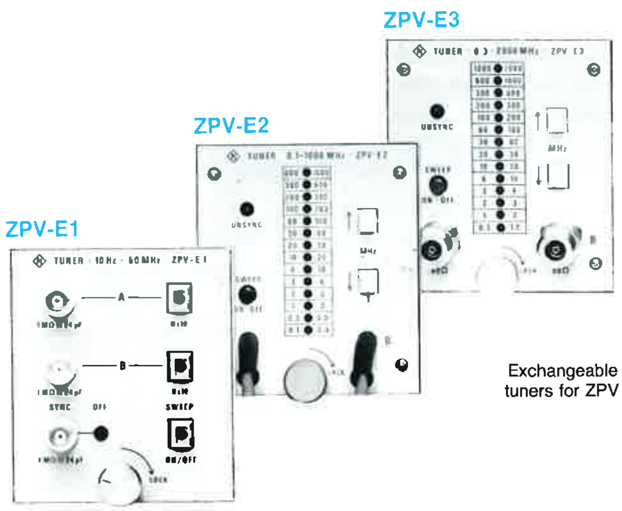
Furthermore, the ZPV permits all crystal data to be determined within seconds. Together with a Z measurement the resonant impedance can be displayed without the use of an external computer.



Computer-controlled crystal test assembly based on Vector Analyzer ZPV

Description (modes)

The ZPV is of modular construction; the tuner is therefore exchangeable.

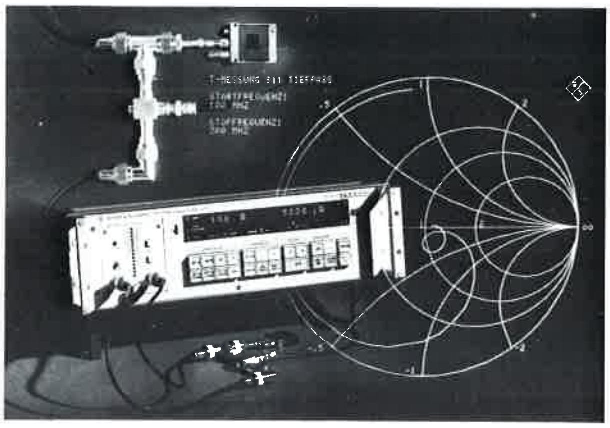


Exchangeable tuners for ZPV

Tuner ZPV-E1. The ZPV-E1 covers the frequency range from 10 Hz to 50 MHz. It has a wide dynamic range and is suitable for use at low frequencies – e.g. measurements on control loops and in acoustics – as well as for video measurements, group-delay measurements and impedance measurements from the VLF to the HF range.

The ZPV-E1 has two high-impedance inputs fitted with BNC female connectors permitting connection of probes or 10:1 attenuator probes (e.g. the R&S 10:1 Attenuator Probe UTKS). Insertion adapters enable measurements in systems using 50-Ω coax too, for instance impedance measurements with the VSWR Bridge ZRB.

Vector Analyzer ZPV – measuring procedures



Vector Analyzer ZPV fitted with Tuner ZPV-E3 used for filter measurement according to T-junction method

Tuner ZPV-E2. The ZPV-E2 covers the frequency range of 100 kHz to 1 GHz (typ. 1.2 GHz). Its two associated probes permit voltages to be measured with high impedance. Insertion units are combined with the probes for measurements in coaxial systems. Directional couplers can also be connected through the insertion units.

Tuner ZPV-E3. The ZPV-E3, in conjunction with the basic unit ZPV, permits vector measurements, two-port measurements and group-delay measurements in coaxial systems over a wide range of frequency and signal level. It is thus possible to take full advantage of the measuring and processing capabilities offered by the ZPV (see page 142). The frequency coverage of 300 kHz to 2000 MHz is twice that of the tuner with probes, ZPV-E2, and thereby considerably extends the range of possible applications of the basic unit.

The input impedance of the test inputs, which are fitted with female N connectors, is 50 Ω. This permits simple and straightforward test setups since the test circuits used can be connected directly to the ZPV-E3. There is no need for the insertion unit and associated termination required with the ZPV-E2.

Description of ZPV Tuners

With the **Tuner ZPV-E1,** a frequency counter determines the precise input frequency and a microprocessor drives the mixer/oscillator in order to obtain an intermediate frequency of 20 kHz. Narrowband filters extract the desired frequency spectrum, the filters being automatically connected depending on the input frequency and input level.

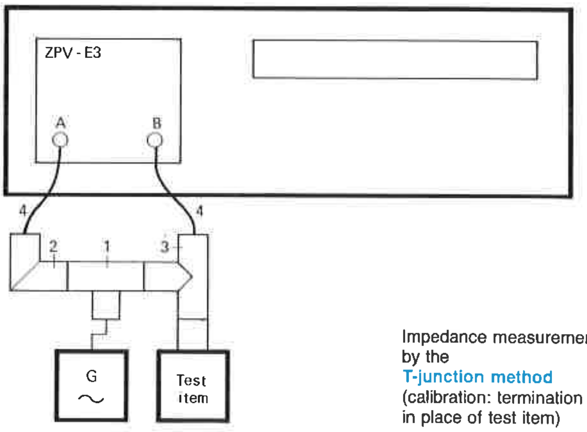
The **Tuners ZPV-E2 and ZPV-E3** convert the input signals of the channels A and B with the aid of two sampling mixer stages over a wide frequency range to an intermediate frequency of 20 kHz, the fundamental of the input signals being retained with amplitude and phase fidelity. The shape of the curve is also more or less retained unless the spectral components of the input signals exceed 1000 or 2000 MHz. The IF signals are available at the outputs of the basic unit. Only the fundamental is used for signal evaluation. The tuners cover 14 frequency subranges. The required subrange is selected either manually or automatically under the control of the basic unit. Tuning to the fundamental of the input signal of channel A takes place automatically within the subranges. Channel B is then tuned to the same receive frequency.

Measuring methods

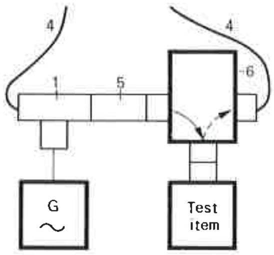
Reflection-coefficient and impedance measurements can be made with **directional couplers** or **VSWR bridges** (figure in the middle) or by the simple **T-junction method** (top), a new measuring method that greatly simplifies the test setup and, as a result, drastically cuts down its costs. After entry of the type of desired test setup at the push of a button on the basic unit the parameter of interest can be determined using the calculating power of the internal microprocessor and is read out digitally. Whereas the entire frequency range of the Tuner ZPV-E3 is utilized with this T-junction method, directional couplers or VSWR bridges restrict the frequency range according to their particular characteristics. The last figure shows how simple it is to carry out transmission-factor measurements.

Legend

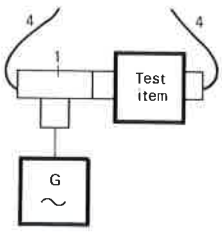
1 = Feed-in	4 = Pair of measuring cables
2 = Angle piece	5 = Two-way plug
3 = T junction	6 = VSWR bridge



Impedance measurement by the **T-junction method** (calibration: termination in place of test item)



Impedance measurements with **VSWR bridge** (calibration: shortcircuit in place of test item)



Transmission-factor measurements (calibration: without test item)

ZPV-Z5

S-parameter Test Adapter ZPV-Z5
♦ 5 to 2000 MHz

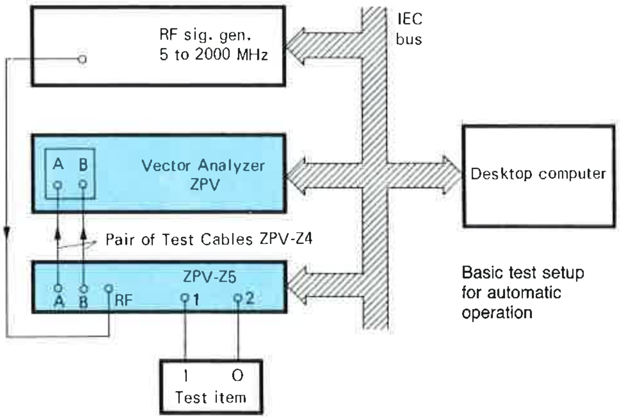
- Measurement of all four s-parameters without modification to the test setup
- High directivity: 46 dB
- IEC-bus-compatible

In conjunction with a suitable network analyzer, e.g. the Vector Analyzer ZPV, the **S-parameter Test Adapter ZPV-Z5** permits measurement of all four s-parameters without modification to the test setup.

Characteristics and uses

High directivity, wide frequency range. Thanks to the high directivity of the VSWR bridges of 46 dB, even items with very small reflection coefficients can be tested. The Test Adapter covers almost the entire frequency range of the Tuner ZPV-E3 due to its wide bandwidth of 5 to 2000 MHz; it can of course also be used with the Tuner ZPV-E2 in the range 5 to 1000 MHz.

IEC-bus compatibility. The Test Adapter can be controlled via the IEC bus and thus combined with an IEC-bus-compatible signal generator and a desktop computer to form an attractively priced, automatic network analyzer.



Basic test setup for automatic operation

Connections, settings, measurements. The Test Adapter is connected to the RF generator and to channels A and B of the Vector Analyzer (see above). The test item input and output are taken to ports 1 and 2 of the ZPV-Z5.

In manual operation the s-parameter to be measured is selected by pressing the corresponding front-panel key; in automatic operation it is set via the IEC bus by a desktop computer, e.g. the Process Controller PUC or the Tektronix 4051, 4052.

The key labeling and the programming commands correspond to the s-parameters to be measured. To measure for instance the input reflection coefficient s_{11}, S11 is simply entered via the computer.

Description

The ZPV-Z5 is of symmetrical design to permit the measurement of input and output parameters. The reference branch includes a line for compensating the electrical lengths in the test branches; tedious length compensation by adding a suitable line section is thus no longer required. If a test item cannot be linked up directly to the test sockets of the ZPV-Z5, the input and output of the test item need simply be connected via identical cable sections and a third section of the same lenght inserted into the reference branch. To provide a power supply for active components, two DC Feed Units ZPV-Z6 can be connected.

Specifications of ZPV-Z5

Frequency range	5 to 2000 MHz
Input and output impedance	50 Ω, N female connectors
Input loading	≦0.5 W
Directivity	46 dB
Insertion loss	
RF input – reference output A	8 dB
ports 1, 2	15 dB
test output B	22 dB
Measurement error	
Variation with frequency of magnitudes of reflection coefficient and transmission factor	≦ ±1.2 dB (difference-frequency response between test output B and reference output A)
Frequency-proportional phase error	±6° × f (f in GHz) (between test output B and reference output A)
Measurement error due to inherent reflection	$\leqq \pm 0.05 \times \lvert r\rvert^2$ (up to 1000 MHz) $\leqq \pm 0.1 \times \lvert r\rvert^2$ (up to 2000 MHz) where r is the reflection coefficient of the test item
Phase error due to inherent reflection	$\pm 6° \times \lvert r\rvert^2$ (up to 2000 MHz)
VSWR mismatch (ports 1, 2)	r ≦10% (uo to 1000 MHz) r ≦15% (up to 2000 MHz)
Relay switching time	30 ms (life: 1×10^6 switching actions)
Programming	
System	IEC 625-1 (IEEE 488) 24-way Amphenol connector
Factory-set address	23
Interface functions	AH1, L2, RL1

General data

Rated temperature range	+18 to +30 °C
Operating temperature range	+10 to +45 °C
Storage temperature range	−45 to +70 °C
AC supply	115/125/220/235 V ±10%, 47 to 440 Hz (25 VA)
Dimensions, weight	492 mm × 116 mm × 514 mm, 7.7 kg

Ordering information

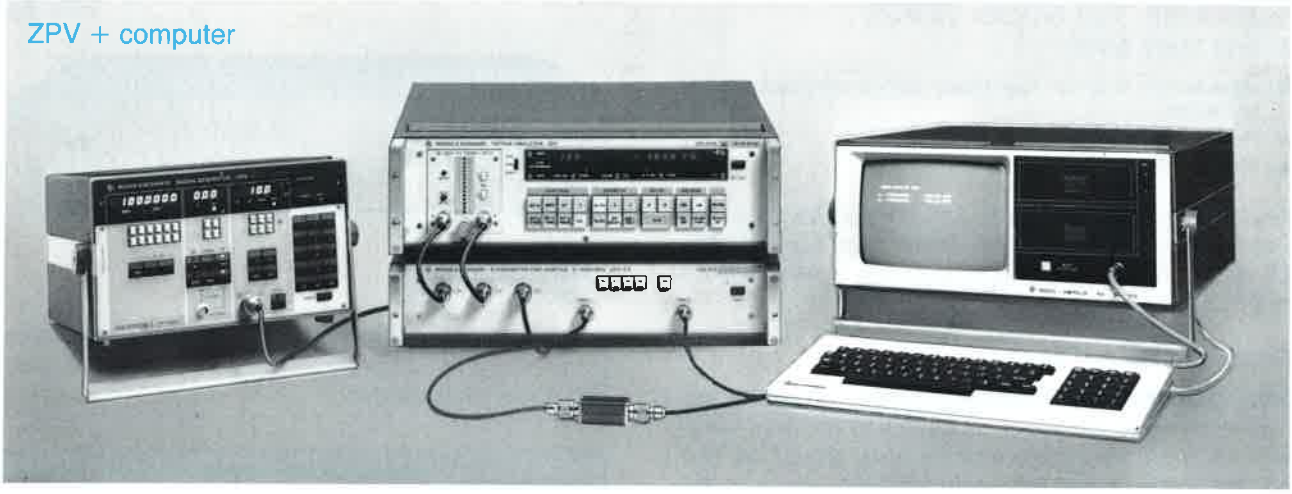
Order designation	▶ S-parameter Test Adapter ZPV-Z5 335.1112.50

Recommended extras

IEC-bus Cable PCK, 1 m	292.2013.10
Precision Termination RNA, 50 Ω	272.4510.50
Termination RNB, 50 Ω; only required with ZPV-E2	272.4910.50 (2 units required)
Shortcircuit connector 50 Ω (N)	017.8080.00
Pair or Test Cables ZPV-Z4; only required with ZPV-E3	335.1012.50
DC Feed Unit ZPV-Z6	265.3512.02 (specifications see below)
For computer-controlled operation	Basic Software and S-parameter Accuracy-improvement Software see pages 148 and 152

Specifications of DC Feed Unit ZPV-Z6

Frequency range	5 to 2000 MHz
Voltage/current (max. values)	50 V/200 mA
Connectors: RF	50 Ω, N female
RF + DC	N female
DC	telephone jacks (4 mm)



Computer-controlled Network Analyzer
♦ 10 Hz to 2000 MHz

- Fully automated measurement of all two-port parameters
- Graphic display
- High measurement rate
- Expandable with IEC-bus-compatible equipment

System configuration, characteristics

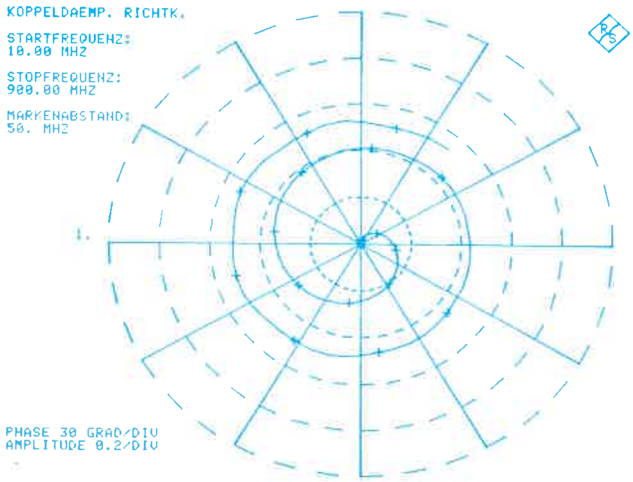
When combining the Vector Analyzer ZPV with a programmable frequency generator and a controller, a fully automatic network analyzer system is obtained.

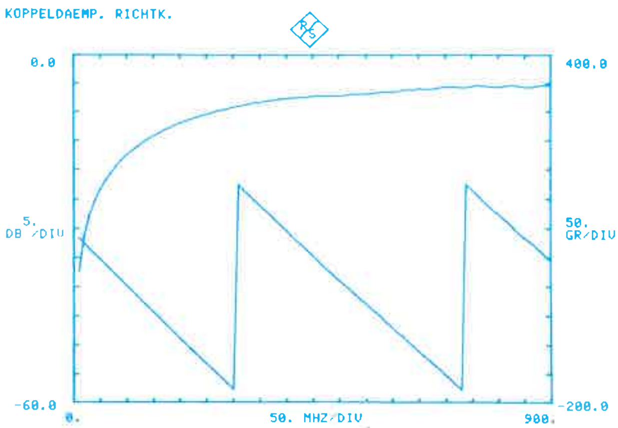
Controller. For controlling the ZPV, the Rohde & Schwarz Process Controller PUC and the Tektronix Systems 4051 and 4052 are especially well suited. For details on computers see section 1. In addition, the HP 9835 and HP 9845 computers can also be employed.

Generator. Various Rohde & Schwarz generators are suitable for use with the ZPV. For somewhat less stringent frequency-accuracy requirements, the Power Signal Generator SMLU can be used in the range from 25 MHz to 1 GHz. The Synthesizer Generator XPC and the Signal Generator SMS permit precision measurements in the ZPV range up to 1 GHz. The Sweep Generator SWP which covers the entire frequency range of the ZPV Tuner ZPV-E3 is also suitable. The Generator SPN is available for network analysis in the AF range.

Software. For this combination of instruments, Rohde & Schwarz offers easy-to-handle software (see pages 147 and 148) so that a minimum of time is required to get acquainted with the application of the network analyzer. The preprogrammed measurement and display modes can be called up with code numbers. Graphic display in particular shows the efficiency of the basic software: the curves plotted can be made available directly as hardcopy documentation (for examples of programming and graphic display see to the right).

The resulting automatic network analyzer system (see figure above) is superior in many respects to the computer-controlled systems used hitherto: the high intelligence of the ZPV makes operation and programming simple and easy to understand. The test speed, in particular for impedance and admittance measurements, is very high since computing and control are performed to a large extent in the ZPV at optimum speed.





Coupling attenuation of a directional coupler represented in polar coordinates (top) and in cartesian coordinates (bottom); output on hardcopy unit greatly reduced scale)

Measurement capabilities, operation

The system fully automates all measurements that are possible with the ZPV, i.e. depending on the ZPV version:

voltage measurements by magnitude and phase,
s-parameter, impedance and admittance measurements,
group-delay measurements.

Comprehensive basic software facilitates not only the operation of the analyzer system but also programming. The user need not learn any programming language. Ready-made test routines can be called up by means of code numbers.

Basic software

The **Basic Software** (ZPV-K1, -K4 or -K10 depending on type of computer) permits both easy programming of point-by-point measurements as they are required for final inspection and graphic display of continuous frequency-dependent curves (for two examples of such curves output on the hardcopy unit, see preceding page). There are different ways of outputting the test result: numerical display on the screen or by a printer and graphic display on the screen or output on a hardcopy unit. Comparing of nominal and actual values is also possible. For the table compiling the setting commands see below and for an extract of the list of code numbers associated with the Basic Software see righthand column, top.

Accuracy-improvement software permitting high-accuracy s-parameter measurements is available for the recommended computers (see next page).

Setting commands

AR..	amplitude range
FR..	frequency range
GØ	tendency indication OFF
G1	tendency indication ON
HZ..	frequency value
KØ	recorder output OFF
K1	recorder output ON
PO..	phase offset
SH	high measurement speed
SL	low measurement speed
TE	external triggering
TI	internal triggering
TR	reference value (10 ASCII characters)
TS	device status word (10 ASCII characters)

Computer-controlled network analyzer assembly comprising Vector Analyzer ZPV, Sweep Generator SWP (synthesizer), S-parameter Test Adapter ZPV-Z5 and Process Controller PUC

Extract of code number list for Basic Software ZPV-K1

As an example only the **input data** and the **graphics output** are listed in detail (for complete list see data sheet 292 401).

Program start Y = 1 generator SMPU
Y = 2 generator SMLU
Y = 3 generator SPN
Y = 4 generator SMS
Y = 5 generator XPC/SMPC
Y = 6 generator SWP

Input data	Physical unit	Code No.
Test frequency	MHz	2
Test level	dBm	3
Shift of reference plane	cm	6
Relative dielectric constant		7
Sweep start frequency	MHz	9
Sweep stop frequency	MHz	10
Sweep step width	MHz	11
Number of markers		13
Frequency deviation for group-delay measurement	kHz	14
Operational settings		17 to 26
Calibration/reference values		27 to 31
Output of single-shot measurements		33, 34
Output of swept-frequency measurements		35, 37
Program execution		39 to 43
Individual measurements		
Vector measurement		45 to 59
Parameter measurement		62 to 78
Group-delay measurement		82, 83
DC voltage measurement		84
Graphic display		
Diagrams		85 to 92
Graphic data output		
Smith chart or polar coordinates		96
Magnitude (real component) in cartesian coordinates		97
Phase (imaginary component, group delay) in cartesian coordinates		98

Example of programming for Tektronix Graphic Computing System 4051 using Basic Software ZPV-K1

```
100 INIT
110 Y=1
120 GOSUB 1
130 Y=10
140 GOSUB 9
150 Y=900
160 GOSUB 10
170 Y=10
180 GOSUB 11
190 GOSUB 78
200 Y1=-60
210 Y2=0
220 S$="DB"
230 T$="KOPPELDAEMP. RICHTK."
240 GOSUB 90
250 GOSUB 97
260 Y1=-200
270 Y2=400
280 Y$="GR"
290 GOSUB 92
300 GOSUB 98
310 END
```

ZPV Software

High-accuracy s-parameter measurement using accuracy-improvement software for ZPV

The **accuracy-improvement software** (see righthand column and recommended extras) for use with the Network Analyzer (page 146) permits fully automatic and extremely accurate s-parameter measurements over the entire frequency range of the tuner plug-ins.

The accuracy-improvement software includes the proven elements of the basic software (page 147) plus an extension to enable corrected measurements. For this purpose, the test setup is measured prior to the test run using calibration standards. During the actual measurement the readings obtained from the ZPV are corrected in the desktop computer using the values specific to the test setup that were determined during calibration. The high-accuracy test result is displayed graphically or numerically on the screen of the computer.

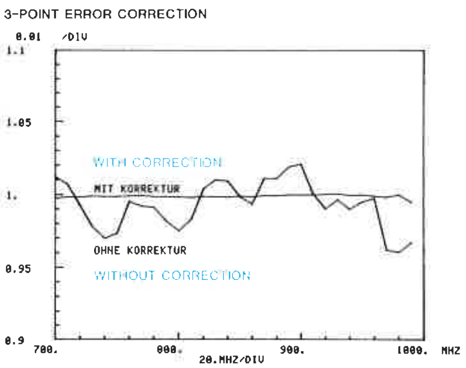
Sources of error, requirements for correction. Basically measurements of the transmission factor and of the reflection coefficient have to be distinguished.

In **transmission measurements** errors are caused mainly by the frequency response of cables, test adapters and the instrument itself. All frequency-response errors can be eliminated by the so-called **simple error correction.**

In reflection measurements – using bridges or directional couplers – there are three main sources of error: a) directivity, b) mismatch at the test port, c) frequency response or frequency-dependent coupling attenuation between the test port and the test output. These errors are eliminated by so-called **three-point error correction** (using the accuracy-improvement software dispenses with the coupler in the reference channel).

Simple error correction can be used both for transmission measurements and reflection measurements with insertion heads or T junctions in the region of $|r| = 0$. It is based on the capability of the ZPV to perform measurements related to a reference value. For measurements over a wide frequency range, the reference values are stored in the desktop computer.

Three-point error correction is employed exclusively for reflection-coefficient measurements using bridges or directional couplers. In this case the ZPV readings are converted in the desktop computer after the correction factors have been established in the form of three complex constants by calibrated measurements (K_1 for the directivity of the test bridge, K_2 for the frequency response of the test setup and K_3 for the reflection coefficient of the bridge test port).



Reflection measurement with and without three-point error correction

Example of s-parameter correction software

for the desktop computers

PUC from Rohde & Schwarz,
Tektronix 4051 and 4052,
Hewlett Packard 9835 and 9845 (no graphics)

Measurements	Physical unit
45 s_{11} or s_{22} measurement without correction	no dimension, degrees
46 s_{11} or s_{22} measurement with correction	no dimension, degrees
47 s_{11} or s_{22} measurement with 3-point correction	no dimension, degrees
49 s_{21} or s_{12} measurement without correction	no dimension, degrees
50 s_{21} or s_{12} measurement without correction	dB, degrees
51 s_{21} or s_{12} measurement with correction	no dimension, degrees
53 s_{21} or s_{12} measurement with correction	dB, degrees
54 B/A measurement without correction	no dimension, degrees
55 B/A measurement without correction	dB, degrees
57 B/A measurement with simple correction	no dimension, degrees
58 B/A measurement with simple correction	dB, degrees
59 Z-measurement without correction	Ω, jΩ
61 Z-measurement with simple correction	Ω, jΩ
62 Z-measurement with 3-point correction	Ω, jΩ

Measurements using S-parameter Test Adapter ZPV-Z5

70 s_{11} measurement	73 s_{21} measurement
71 s_{22} measurement	74 s_{12} measurement

Calibration

33 calibration for simple correction
35 calibration for 3-point correction
63 calibration for simple correction
65 calibration for 3-point correction | only for logarithmic diagram

Numerical output of measurements

37 output on display
38 output on printer

Specifications

Automatic Network Analyzer

corresponding to page 146

Frequency range	10 Hz to 2000 MHz
Resolution	depending on signal generator
Measurement capabilities	voltage lin or log, vectors in polar or cartesian coordinates s parameters; impedance/admittance; group delay
Dynamic range (depending on tuner)	−110 to +110 dB
Minimum input level with	
ZPV-E3	5 µV
ZPV-E2	3 µV
ZPV-E1	1 µV
Display	digital and graphic
Time required	
for display of complete locus	10 to 20 s (about 50 measuring points)
for complex measurement	200 ms for levels >100 µV
Programming	IEC-bus (IEC 625-1), IEEE 488

Specifications

ZPV basic unit

Display of measured quantities

Vector measurement

P Polar-coordinate representation

Magnitude of voltage (channel A or B)

Lin indication	3 digits with floating decimal point, max. resolution 1 µV
Log indication (absolute) in dBm (0 dBm corresponding to 1 mW into 50 Ω)	4 digits, resolution 0.1 dB
Log indication (relative) in dB	4 digits, resolution 0.1 dB (for values <1 dB: 0.01 dB)
Indication of reference value for relative voltage measurements in dBm	4 digits, resolution 0.1 dB

Magnitude of ratio

Lin indication	3 digits with floating decimal point, max. resolution 0.001
Log indication	4 digits, resolution 0.1 dB

Phase

Readout in degrees	4 digits, resolution 0.1°
Range	−180 to +180°
Indication of phase reference value in degrees	4 digits, resolution 0.1°

C Cartesian-coordinate representation

Lin indication	3 digits with floating decimal point, max. resolution 0.001
Calibration of reference phase and level	automatic by pushbutton

s-parameter measurement

Test method	for frequencies <100 MHz: direct voltage measurement for frequencies >100 MHz: use of directional coupler or VSWR bridge
Calibration of reference phase and level	automatic by pushbutton
Characteristic impedance	50 Ω/75 Ω, switch-selected

P Polar-coordinate representation

Lin indication of magnitude	3 digits with floating decimal point, max. resolution 0.001
Log indication of magnitude	4 digits, resolution 0.1 dB
Indication of phase in degrees	4 digits, resolution 0.1°
VSWR	4 digits with floating decimal point

C Cartesian-coordinate representation

Lin indication	3 digits with floating decimal point, max. resolution 0.001

Impedance or admittance measurement

Characteristic impedance	50 Ω/75 Ω, switch-selected

P Polar-coordinate representation

Absolute indication of magnitude in Ω or mS	3 digits with floating decimal point, max. resolution 0.1 Ω or 0.1 mS
Normalized indication of magnitude	4 digits, resolution 0.01
Indication of phase in degrees	4 digits, resolution 0.1°

C Cartesian-coordinate representation

Normalized indication	3 digits with floating decimal point, max. resolution 0.01
Absolute indication in Ω, kΩ or mS, µS	3 digits with floating decimal point, max. resolution 0.1 Ω or 0.1 µS

Group-delay measurement

Indication	3 digits with floating decimal point, max. resolution 1 ns
Frequency shift	0.4/4/40 kHz, switch-selected
Measured quantities	group delay and group-delay variation
Modes	single-shot and continuous measurement

Programming

System	IEC 625-1 (IEEE 488)
Connector	24-way Amphenol

Interface functions

T6, TE6	talker capability with secondary address, series polling and automatic unaddressing
L4	listener capability with automatic unaddressing
SR1	service request (switch-selected)
DC1	device clear
DT1	device trigger

Timing (typical values)

Time required for addressing	1 µs
Time required for data transfer	0.5 to 2 ms
Period between reception of talker address and output of first data word	0.5 ms
Max. data output time/character	0.5 ms
Code	ISO 7-bit
Figure representation	decimal
Delimiters	16 different characters can be set (factory setting: CR)

Test outputs

X and Y outputs for recorder

Output-voltage range	0 to +1.25 V DC
Output impedance	1 kΩ
Connector	BNC

r and φ output for narrowband sweeping

Output voltage range r	0 to 1 V DC
Output voltage range φ	−0.5 to +0.5 V
Output impedance	1 kΩ
Test bandwidth	1 kHz (30 Hz for channel B voltages ≦100 µV)
Connector	BNC

IF outputs for channels A and B

Output frequency	20 kHz
Output impedance	1 kΩ
Connector	BNC

DC voltage test input

Input voltage range	0 to +10 V, resolution 2.5 mV
Input impedance	>100 kΩ
Connector	BNC

For specifications of ZPV plus Tuners ZPV-E1 to E3 see next page

General data (basic unit)

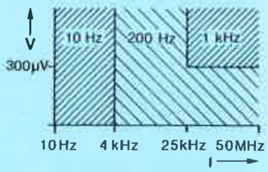
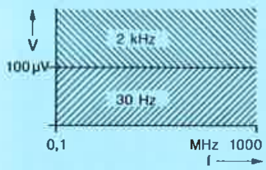
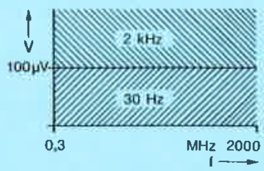
Rated temperature range	+10 to +45°C
Storage temperature range	−40 to +75°C
Power supply	115/125/220/235 V ±10%, 47 to 420 Hz (110 VA), safety class 1 (VDE 0411 or IEC 348)
Overall dimensions (W×H×D)	492 mm×161 mm×514 mm
Weight (including options and Tuner ZPV-E2)	16 kg

For **order designations** see page 152

Specifications

ZPV plus Tuner

(ZPV-E2, ZPV-E3: accuracy specifications apply with frequency autoranging switched off)

	ZPV-E1	ZPV-E2	ZPV-E3
Frequency range	10 Hz to 50 MHz	0.1 to 1000 MHz	0.3 to 2000 MHz
Frequency subranges	10 Hz to 25 kHz (no swept operation) 20 to 80 kHz 70 to 170 kHz 150 to 360 kHz 320 to 730 kHz 670 kHz to 1.5 MHz 1.3 to 3.1 MHz 2.8 to 6 MHz 5.6 to 12 MHz 11 to 25 MHz 22 to 52 MHz	0.1 to 0.3 MHz 0.3 to 1 MHz 1 to 2 MHz 2 to 3 MHz 3 to 6 MHz 6 to 10 MHz 10 to 20 MHz 20 to 30 MHz 30 to 60 MHz 60 to 100 MHz 100 to 200 MHz 200 to 300 MHz 300 to 600 MHz 600 to 1000 MHz	0.3 to 1 MHz 1 to 2 MHz 2 to 3 MHz 3 to 6 MHz 6 to 10 MHz 10 to 20 MHz 20 to 30 MHz 30 to 60 MHz 60 to 100 MHz 100 to 200 MHz 200 to 300 MHz 300 to 600 MHz 600 to 1000 MHz 1000 to 2000 MHz
Range overlap	typ. 10%	typ. 10%	typ. 10%
Range setting	automatic	automatic or by hand	
Tuning	automatic to signal at SYNC input	automatic to signal in channel A	
Hold range	—	0.2 to 0.4 MHz (f <1 MHz) 1 to 3 MHz (f = 1 to 1000 MHz)	
Resolution of internal frequency counter (frequency output only via IEC bus)	0.1 Hz (f <25 kHz) 1 kHz (f >25 kHz)	—	—
Swept operation		within frequency subranges	
Maximum sweep rate	2 MHz/s (f >100 kHz) 0.2 MHz/s (25 kHz <f <100 kHz)	0.3 to 3 MHz/s (f <1 MHz) 3 to 30 MHz/s (f >1 MHz)	
Input impedance	A, B, SYNC input: 1 MΩ || 17 pF	probes: 50 kΩ || 2 pF with 100:1 attenuator probe: 6 MΩ || 2 pF	50 Ω VSWR <1.2 (up to 1.5 GHz) <1.9 (up to 2 GHz)
Maximum input voltage without demage	10 V (AC), ±30 V (DC)	3 V (AC), ±50 V (DC)	5 V_{rms}, ±15 V (DC)
Crosstalk attenuation	≧100 dB (50 Hz f <5 MHz) ≧95 dB (5 MHz <f <40 MHz) ≧90 dB (f >40 MHz)	≧100 dB (f <500 MHz) ≧80 dB (f >500 MHz) (referred to signals at probe tips)	≧100 dB (f <500 MHz) ≧80 dB (500 MHz <f <1000 MHz) ≧70 dB (f >1000 MHz)
Input sensitivity			
Channel A	5 µV (30 Hz <f <50 kHz) 1 µV (50 kHz <f <25 MHz) 3 µV (f >25 MHz)	1200 µV, typ. 400 µV (f <1 MHz) 400 µV, typ. 150 µV (f >1 MHz)	1200 µV, typ. 400 µV (f <1 MHz) 1000 µV, typ. 300 µV (f >1 MHz)
Channel B	same as channel A	3 µV, typ. 1 µV	5 µV, typ. 3 µV
SYNC channel	20 mV (f <25 kHz) 10 mV, typ. 6 mV (f >25 kHz)	—	—
Maximum measurable input voltage			
Channels A and B	1 V, 9.999 V with 10:1 probe and U×10 buttons pressed	0.3 V (f <1 MHz) 1 V (f >1 MHz)	0.3 V (f <1 MHz) 1 V (f >1 MHz)
SYNC channel	max. 1 V	—	—
Test bandwidth (selectable as desired via IEC bus)			

Vector measurement

P Polar-coordinate representation

	ZPV-E1	ZPV-E2	ZPV-E3
Magnitude of voltage Measurement error with constant input level of	50 mV[1]: ±0.1 dB (20 Hz <f <1 MHz) ±0.2 dB (1 MHz <f <10 MHz) ±0.3 dB (f >10 MHz) (see also table on page 151)	100 mV: ±0.4 dB (f <0.3 MHz) ±0.2 dB (0.3 MHz <f <100 MHz) ±0.6 dB (100 MHz <f <500 MHz) ±1.5 dB (f >500 MHz)	100 mV: ±0.2 dB (f <100 MHz) ±0.5 dB (100 MHz <f <500 MHz) ±1.2 dB (500 MHz <f <1500 MHz) ±1.2/−2.3 dB (f >1500 MHz)
Magnitude of ratio B/A Measurement range within permissible input level range	−110 to +110 dB	−90 to +70 dB	−90 to +70 dB
Readout error at fixed frequency with calibration button (linearity)	±1.5% (V_{in} >1 mV) ±5% (100 µV <V_{in} <1 mV) (see also table on page 151)	±1.5% (at f >250 MHz for V_{in} <0.3 V only)	1.5% (at f >1000 MHz for V_{in} <0.3 V only)
without calibration button (difference between A and B)	±2% (f >20 Hz)	±3% (f <100 MHz) ±6% (f >100 MHz)	±3% (f <500 MHz) ±6% (500 MHz <f <1500 MHz) ±12% (1500 MHz <f <2000 MHz)
Phase	see also table on page 151 and footnote[1]		
Measurement range	−180° to +180°	−180° to +180°	−180° to +180°
Nonlinearity at fixed frequency (level applied to both test inputs)	<0.5° at $V_A = V_B$ = 50 mV	<0.5° at $V_A = V_B$ = 100 mV	<0.5° at $V_A = V_B$ = 100 mV
Effect of frequency variation	see table on page 151 reference frequency 100 kHz	< ±3° (f <0.3 MHz) < ±1° (0.3 MHz <f <100 MHz) < ±4° (100 MHz <f <500 MHz) < ±6° (500 MHz <f <1000 MHz) reference frequency 10 MHz	< ±1° (f <100 MHz) < ±4° (100 MHz <f <500 MHz) < ±6° (500 MHz <f <1500 MHz) < ±12° (1500 MHz <f <2000 MHz) reference frequency 10 MHz
Effect of level variation	see table on page 151	<0.05°/dB <3° over entire range	<0.05°/dB <3° over entire range (referred to 2× 100 mV at both test inputs)

C Cartesian-coordinate representation

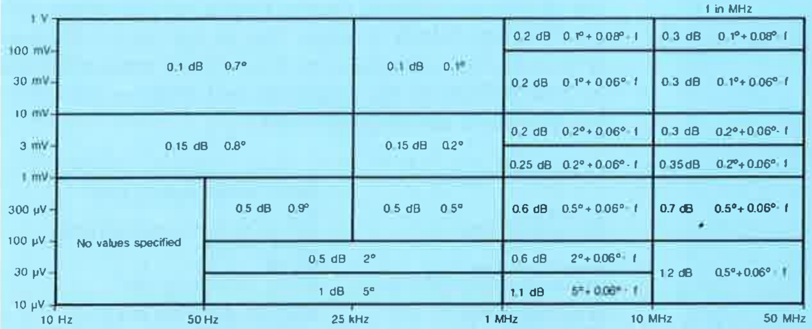
	ZPV-E1	ZPV-E2	ZPV-E3
Error of polar → cartesian conversion	<0.1%	<0.1%	<0.1%

[1]) Additional measurement error at 20 kHz due to direct reception of input frequency: 1% and 0.6°.

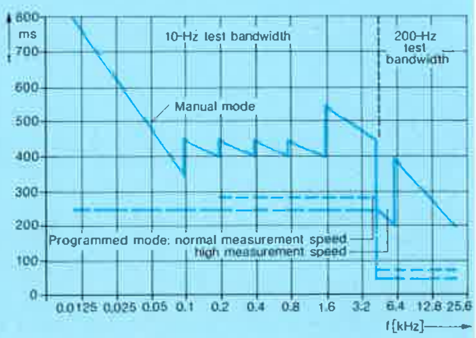
ZPV plus Tuner

	ZPV-E1	ZPV-E2	ZPV-E3
		(accuracy specifications apply with frequency autoranging switched off)	
s-parameter measurement			
Measurement ranges and measurement errors	see vector measurement of magnitude of ratio and phase; in addition, errors and measurement limits of the test setup used must be taken into account		
Impedance/admittance measurement			
Measurement error	see vector measurement of magnitude of ratio and phase		
Measurement range			
Z measurement	0 to 9999 Ω	same as for ZPV-E1	same as for ZPV-E1
HIGH-Z button pressed	0 to 9999 kΩ		
Y measurement	0.1 to 9999 mS		
HIGH-Z button pressed	0.1 µS to 9999 mS		
Group-delay measurement			
Frequency shift 40 kHz			
Measurement range	1 to 10,000 ns, resolution 1 ns	1 to 10,000 ns, resolution 1 ns	1 to 10,000 ns, resolution 1 ns
Measurement error (for V_{in} >30 mV)	< ±3% ±3 ns (f >25 kHz)	< ±3% ±3 ns (f = 0.1 to 1000 MHz)	< ±3% ±3 ns (f >1 MHz)
Frequency shift 4 kHz			
Measurement range	10 ns to 100 µs, resolution 10 ns	same as for ZPV- E1	same as for ZPV-E1
Measurement error (for V_{in} >30 mV)	< ±3% ±30 ns		
Frequency shift 400 Hz			
Measurement range	100 ns to 1 ms, resolution 100 ns	same as for ZPV-E1	same as for ZPV-E1
Measurement error (for V_{in} >30 mV)	< ±3% ±300 ns		
Measurement shift Δf as desired			
Measurement range	10 ns to 9999 µs, resolution 10 ns (f >25 kHz) 1 ns to 9999 µs resolution 1 ns (f <25 kHz)	—	—
Resolution of internal frequency counter	0.1 Hz (f <25 kHz) 1 kHz (f >25 kHz)	—	—
Measurement times			
Time required for synchronization (autom.)	f <25 kHz: none 25 kHz <f <10 MHz: 15 ms 10 MHz <f <50 MHz: 30 ms (typ. 20 ms)	<20 ms	<20 ms
vector or s-parameter measurement	10 Hz <f <25 kHz: see diagram below 25 kHz <f <50 MHz: 35 ms (1-kHz bandwidth, normal measurement speed) 70 ms (1-kHz bandwidth, high measurement speed)	30 ms (level >100 µV) 80 ms (level <100 µV)	30 ms (level >100 µV) 80 ms (level <100 µV)
impedance measurement	same as for vector measurement +25 ms	50 ms (level >100 µV) 100 ms (level <100 µV)	50 ms (level >100 µV) 100 ms (level <100 µV)
group-delay measurement	same as for vector measurement +120 ms (level >30 mV) +370 ms (level <30 mV)	150 ms (level >30 mV) 400 ms (level <30 mV)	150 ms (level >30 mV) 400 ms (level <30 mV)
General data (ordering information see next page)			
Rated temperature range	+18 to +30°C	same as for ZPV-E1	same as for ZPV-E1
Operating temperature range	+10 to +45°C		
Storage temperature range	−40 to +75°C		
Overall dimensions (W×H×D)	93 mm×105 mm×440 mm		
Weight	2.7 kg	2.2 kg	2.2 kg

Error of voltage and phase magnitude when using **Tuner ZPV-E1** as a function of input voltage and frequency. All the values specified are ± values referred to 50 mV and 100 kHz.



Time required for vector or s-parameter measurement over the frequency range from 10 Hz to 25 kHz using Tuner ZPV-E1



Vector Analyzer ZPV

Order designations

Basic unit

ZPV without tuner ▶ Vector Analyzer ZPV 291.4012.93

Tuners

ZPV-E1	10 Hz to 50 MHz		303.0510.02
ZPV-E2	100 kHz to 1 GHz		292.0010.02
including	2 BNC adapters	237.5650.00	
	3 ground terminals	237.5150.00	
	2 insulators	237.5020.02	
	2 100 : 1 dividers	237.2550.02	
	1 probe tip	237.5520.00	
	1 accessory case	292.0827.00	
ZPV-E3	300 kHz to 2 GHz		301.7018.02

Options (for retrofitting)

IEC-bus Option	ZPV-B1	292.3610.02 (including 2 m IEC-bus cables)
S-parameter Option	ZPV-B2	292.3810.02
Group-delay Option	ZPV-B3	292.3910.02 (including calibration cable for 50 ns)

Recommended extras

Insertion Adapter (N female/male connectors)	ZPV-Z1	292.2713.50 (at least two units required)
Feed Unit, 50 Ω (connectors: generator – BNC, others – N female)	ZPV-Z2	292.2913.50
Directional Coupler, 45 dB, 50 Ω (RF input: N male, others N female)	ZPV-Z3	292.3110.50 (at least two units required)
Pair of Test Cables, 50 Ω, N male	ZPV-Z4	335.1012.50
S-parameter Test Adapter	ZPV-Z5	335.1112.50
DC Feed Unit	ZPV-Z6	265.3512.02

VSWR bridges

VSWR Bridge 50 Ω	ZRB	335.2819.50
50 Ω	SWOB4-Z	912.7003.00
75 Ω	SWOB4-Z	912.7303.00

Terminations, attenuators, couplers etc.

Precision Termination	RNA	272.4510.50
Termination	RNB	172.4910.50
Shortcircuit N male connector		017.8080.00
Attenuator, 10 dB	DNF	272.4210.50
Adapter, N male/BNC female	N/BNC	118.2812.00
Couplers, angle connectors, T junctions		see page 295
Feedthrough Termination (with ZPV-E1 only)	RAD	289.8966.00

Equipment and accessories to expand the ZPV into an automatic network analyzer

Controllers

Process Controller PUC without keyboard		344.8900.10
Standard Keyboard	PUC-Z1	345.2011.04
User Keyboard	PUC-Z2	345.2111.06
Pedal Switch	PUC-Z3	345.2211.02

Software

Basic Software for		
Process Controllers PUC	ZPV-K10	291.8818.02
Tektronix 4051, 4052	ZPV-K1	292.2113.02
HP 9835 and 9845	ZPV-K4	292.2413.02
S-parameter Accuracy-improvement Software for		
Process Controller PUC	ZPV-K11	291.8918.02
Tektronix 4051, 4052	ZPV-K2	292.2213.02
HP 9835 and 9845	ZPV-K5	292.2513.02

Options

Second Floppy Drive	PUC-B2	345.2711.02
RS-232-C Interface	PUC-B5	343.6103.02
High-resolution Graphics Adapter	PUC-B6	345.3118.02
I/O Interface	PUC-B7	345.2811.02

Signal generators

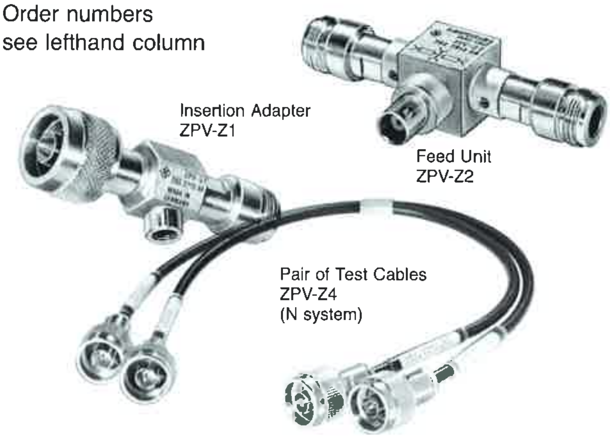
Signal Generator	SMS	302.4012.22
Sweep Generator	SWP	339.0010.02
Synthesizer Generator	XPC	337.8014.52
Generator	SPN	336.3019.02

Additional items

IEC-bus cable, 1 m	PCK	292.2013.10

Photos of important extras for ZPV

Order numbers
see lefthand column



VSWR Bridge ZRB

ZRB

♦ 5 to 2000 MHz

The ZRB permits accurate measurement of reflection coefficient for magnitude and phase and is particularly suitable for use in conjunction with the Vector Analyzer ZPV (page 142) or the Polyskop SWOB 5 (page 132).

Directivity	>46 dB
Characteristic impedance	50 Ω, connectors: N female
Reflection coefficient at test-item connector	<0.09
Measurement error	$0.005 + 0.09\ r^2$ (r = measured reflection coefficient)
Attenuation	
Input to test-item connector	6.5 dB
Test-item conn. to output	6 dB
Max. load	0.5 W
Dimensions (without connectors)	66 mm×50 mm×24 mm

Order designation ▶ VSWR Bridge ZRB 335.2819.50

SWOB 4-Z

VSWR Bridge SWOB 4-Z

♦ 10 to 1000 MHz

For reflection-coefficient measurements in conjunction with the Polyskop SWOB 5 (page 132) or the Vector Analyzer ZPV (page 142). Depending on the indicator used, either the magnitude alone or the magnitude and phase of the reflection coefficient can be determined.

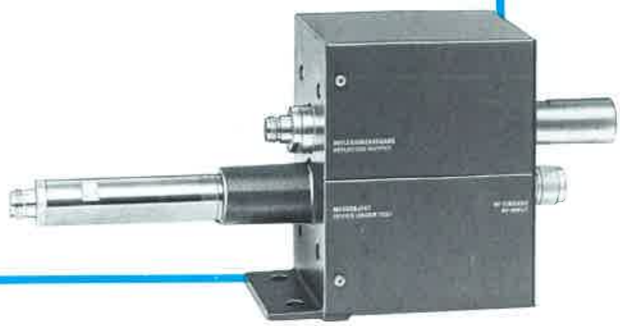
Characteristic impedance	50 or 75 Ω, connectors: N male (test item) N female (input/output)
Directivity	≧40 dB
Measurement error	$0.01 \pm 0.12\ r^2$ (r = measured reflection coefficient)
Transmission loss	6.5 dB
Dimensions (without connectors)	57 mm×35 mm×28 mm

Order designation ▶ VSWR Bridge SWOB 4-Z

50-Ω model	912.7003.00
75-Ω model	912.7303.00

Directional Coupler ZPV-Z3 for measuring s-parameters

ZPV-Z3



- 1 to 1000 MHz
- High precision due to directivity >45 dB
- Universal application with high and low power levels at test item
- Robust construction

Principle and characteristics

The measurement of current by magnitude and phase (vector measurement) remains a difficult problem. It has therefore become common practice to evaluate derived quantities, i.e. forward wave (a) and reflected wave (b) instead of current and voltage.

$$\text{Forward wave } a = \frac{V}{2\sqrt{Z_L}} + \frac{I\sqrt{Z_L}}{2}$$

$$\text{Reflected wave } b = \frac{V}{2\sqrt{Z_L}} - \frac{I\sqrt{Z_L}}{2}$$

These wave quantities can be measured with good accuracy in a relatively simple way using directional couplers.

The **directional coupler,** by definition, combines current and voltage according to these formulas and delivers at its outputs voltages proportional to a and b. It is mainly characterized by its directivity, which expresses in dB the degree to which a clear distinction is possible between forward wave and reflected wave.

The Rohde & Schwarz directional couplers here proposed for s-parameter measurements feature high directivity; it is >45 dB, affording an error <0.6%.

s-parameter measurement. When the input and output waves (a_1, b_1; a_2, b_2) are measured instead of currents and voltages at a two-port (see diagram), the s-parameters are represented by the following ratios:

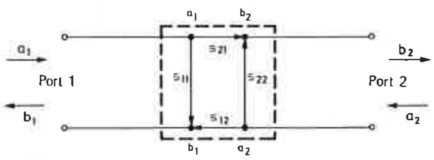
$b_1/a_1 = s_{11}$ **Input reflection coefficient** at port 1 with port 2 match-terminated

$b_2/a_1 = s_{21}$ **Forward transmission coefficient** from port 1 to port 2 with port 2 match-terminated

$b_2/a_2 = s_{22}$ **Output reflection coefficient** at port 2 with port 1 match-terminated

$b_1/a_2 = s_{12}$ **Backward transmission coefficient** from port 2 to port 1 with port 1 match-terminated

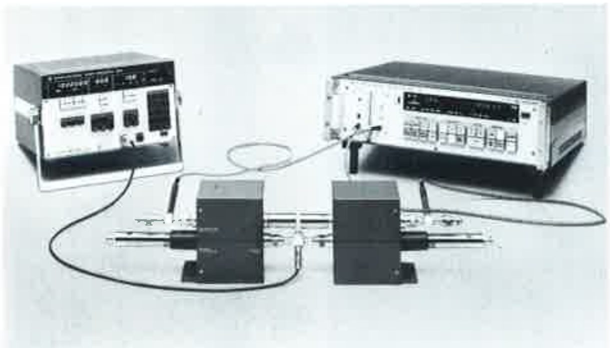
Explanation of s-parameters



For measuring s-parameters one directional coupler for the input quantities, one for the output quantities and a third (reference coupler) for the voltage required to form the ratio are needed.

Construction

The directional couplers are of symmetrical design. It is therefore possible to interchange the connections to the test item and to the indicator, thereby applying alternatively a high level (e.g. for power amplifiers) or a low level (e.g. for antenna amplifiers) to the test item. This opens up a wide range of applications in RF measurements.



Reflection measurement using Signal Generator SMS, Vector Analyzer ZPV and Directional Couplers ZPV-Z3

Specifications

Frequency range	1 to 1000 MHz
Characteristic impedance (both ends)	50 Ω
Directivity	45 dB
Coupling attenuation at 1 GHz	3 dB
Max. permissible forward power	0.5 W
Connectors at input	N male
to instrument	N female
to test item	precision N female
Dimensions, weight	360 mm×150 mm×100 mm, 2.8 kg
Order designation	▶ Directional Coupler ZPV-Z3 292.3110.50

Recommended extras

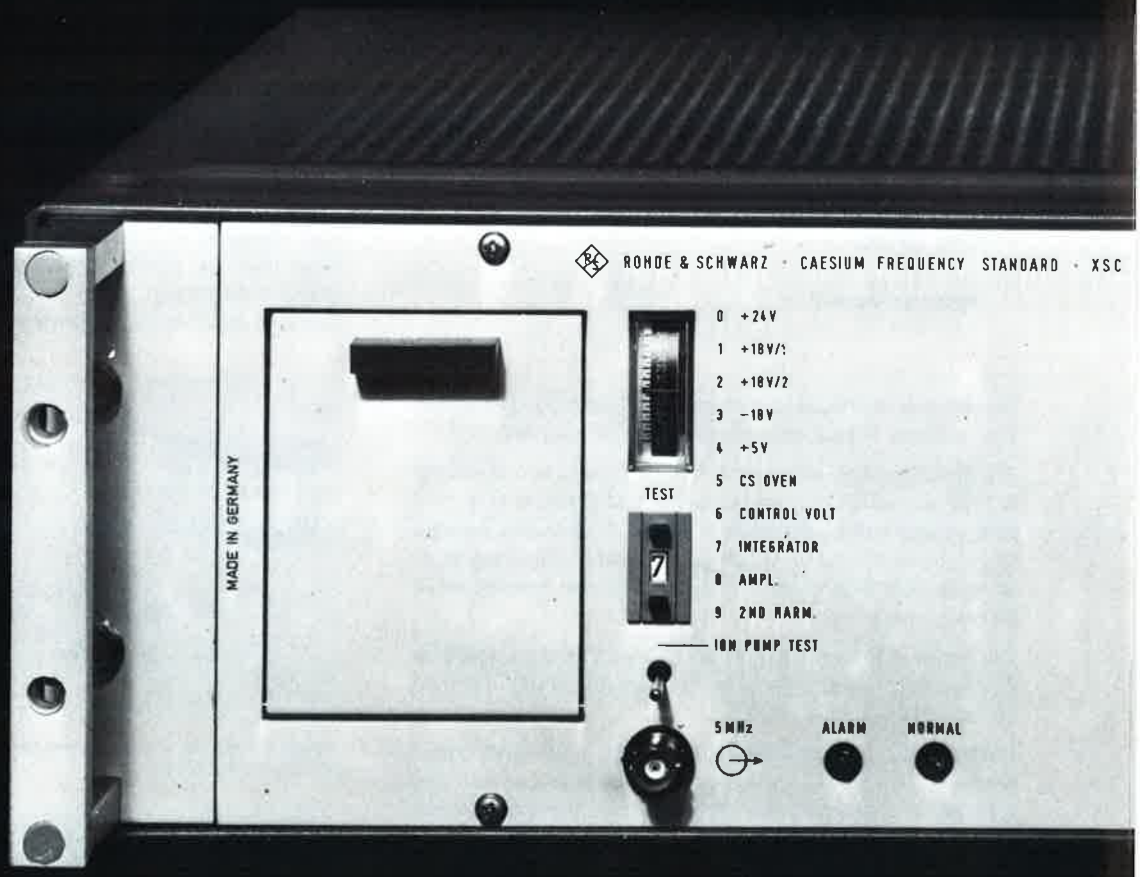
Termination RNA	272.4510.50
1 set of charts DIN-A3 format	274.1619.00

Impedance meters and signal generators

Vector Analyzer ZPV	page 142
Power Signal Generator SMLU	page 70

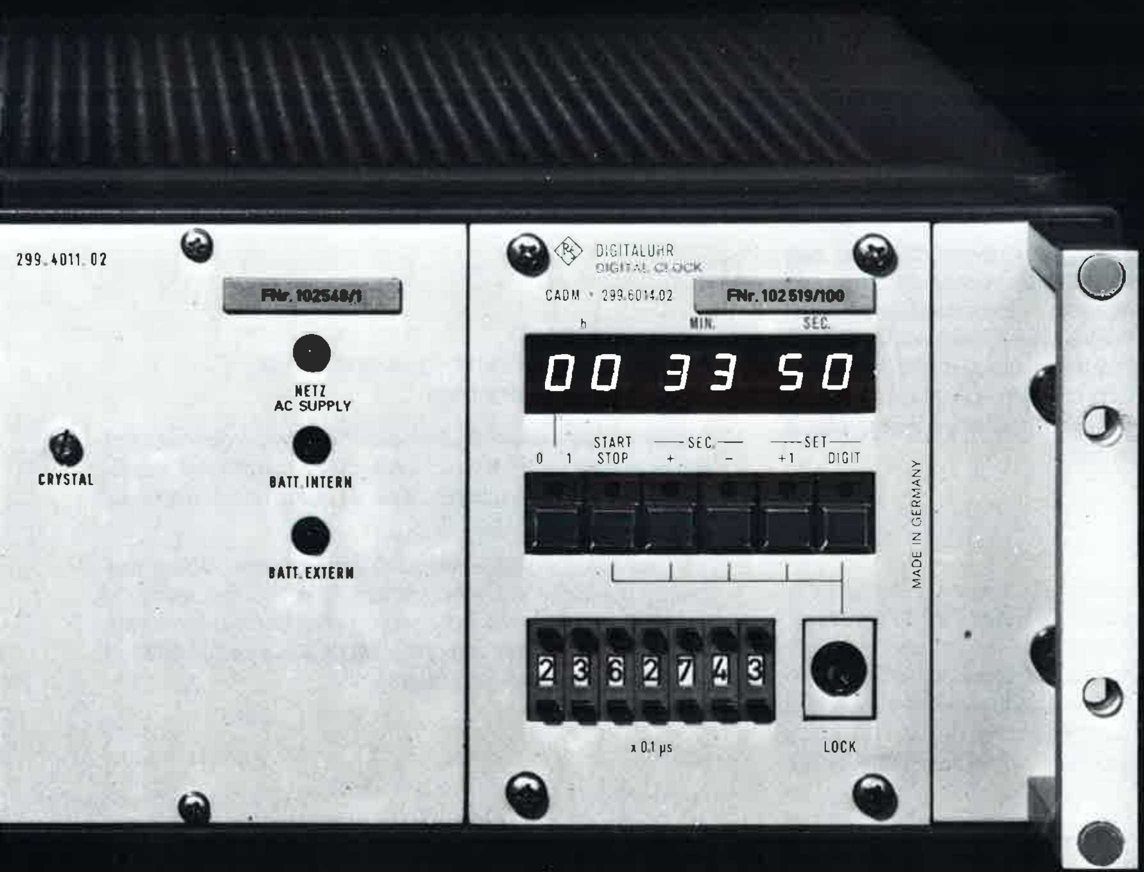
(For other signal generators see section 2)

Caesium Frequency Standard XSC
with Digital Clock CADM;
details on page 158



5

standard-frequency and standard-time systems



Frequency standards

Frequency standards are the heart of many test and communications sets, governing their frequency accuracy. Supplying at least one signal with a very stable period which is not affected by environmental conditions and which is always an integral fraction of a second, frequency standards are also time standards.

There exist primary and secondary standards as for mechanical measurements.

Primary frequency standards produce the output frequency with a caesium beam atomic clock as defined by the 13th general conference on weights and measures of October, 1967. Such units are used for scientific purposes, for navigation and for calibration tasks.

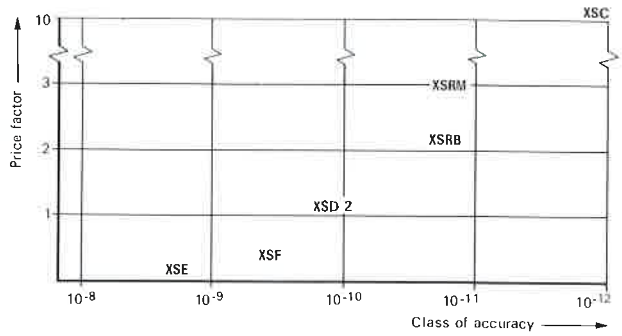
Secondary frequency standards are used to a much greater extent, particularly in electronic measurements and communications engineering. Their accuracy and stability, though inferior, still amply fulfil the practical requirements. Moreover, with the aid of commercially available equipment (frequency controllers, standard frequency receivers and phase recorders: XKE 2, XKP) the secondary standards can be corrected at any time by radio – automatically, if necessary – against primary standards. The advantages of simpler design make up for the reduced accuracy of the secondary standards: high reliability and relatively low purchasing and operating costs. Primary standard frequency transmissions can be received all over the world.

Class of accuracy. A secondary frequency standard is characterized by the **aging** of its oscillator. This is the monotonic frequency drift which is independent of environmental influences. All Rohde & Schwarz frequency standards are so designed that the frequency error due to external effects is of the same order as the guaranteed daily aging. This value determines the class of accuracy, which is **typical** of the quality of the standard.

Stability is the general term for **accurate** information about the frequency drift caused by aging and environmental influences (long-term and short-term frequency stability and frequency drift).

Instrument models. Rohde & Schwarz makes frequency standards of **different frequency stability** to meet a wide range of requirements. The sets also differ in other features, such as automatic frequency correction capability (XSD 2, XSRM), built-in standby battery, higher or lower setting accuracy of the frequency trimmer. A suitable frequency standard can thus be selected for every application.

The frequency standards of high stability (XSC, XSRM and XSD 2) are designed for continuous operation because aging decreases with the operating time. Shortness of warmup time is less important than low power consumption to save the built-in or external battery. In contrast, the oscillator modules XSRB, XSE and XSF have a particularly short warmup time, small dimensions and low weight.



Relation between price and accuracy (stability) of frequency standards

R&S line of standard-frequency and standard-time modules

The new generation of R&S modular standard-frequency and standard-time units allows economical, customized standard-frequency and standard-time systems to be made up (overview on page 160).

The individual modules are compact functional blocks that can be combined into systems exactly in line with technical requirements. This flexibility permits adaptation to the user's needs and, moreover, fitting of additional modules if different technical needs arise at a later date.

Electrical characteristics

All modules are designed for **supply** with 22 to 32 V DC. Connection to all conventionally used AC supply voltages is possible by means of the **Power Supply XSRM-Z** laid out for a maximum permanent output current of 1.6 A. The XSRM-Z contains a 0.8-Ah NiCd cell battery for buffer operation, which feeds the units connected (e.g. the XSRM for a maximum of one hour) in case of an AC supply failure. The buffer circuit is also effective when modules are fed direct from an airborne 28 V DC supply.

When a Rubidium, Frequency Standard XSRM and other modules have a common power supply, the XSRM automatically has priority during its warmup phase (about 20 minutes) of higher current drain, meaning that the other modules connected are not fed via the associated connectors during this period.

Once the warmup phase is completed, the current consumption of the XSRM drops to about 0.7 A, so that 0.9 A is available to feed other modules. Only one XSRM can be operated at a time from one power supply. The standby power supply of the Caesium Frequency Standard XSC functions in a similar way, offering 0.55 A for feeding other modules only after a warmup period of about 20 minutes. Here again a NiCd cell battery ensures continuity of operation in case of an AC supply failure.

Connecting cables. Two-pole connecting cables, both ends equipped with LEMO connectors, are used to convey the supply voltage from the Power Supply XSRM-Z or the Caesium Frequency Standard XSC to the modules.

For the connection of two loads to one DC output of the Power Supply XSRM-Z it is recommended to use the DC connecting cable with order number 346.2015.02 (0.5 m long, fitted with LEMO connectors).

Two-pole cables with one LEMO connector and two banana plugs are provided for **feeding the modules from an external battery.** One such cable is supplied with each module. RF and control signals are transmitted via coaxial cables with BNC male connectors.

Typical current drain after warmup at 24 V DC and +25 °C ambient temperaturte:

XSRM	0.7 A*	XSRM-Z3	0.18 A
XSC	1.05 A	XSRM-Z	0.09 A
XSD 2	0.06 A	(freq. conv.)	
XKE 2	0.40 A	CADM w/o	0.25 A
		with LED display	0.30 A

*During warmup approx. 1.8 A.

Construction, functional blocks

The modules are compact units with a front-panel width of

50 mm (XSRM-Z, XSRM-Z3) or
100 mm (XSRM, XSD 2, XKE 2, CADM, Power Supply XSRM-Z) or
200 mm (XKP)

and a height of 133 mm, in line with DIN and ANSI recommendations.

Individual modules can be combined into stable functional setups (see also page 160 for possible combinations) in the following ways:

For 19″ racks, 19″ cabinets, DIN racks
A 19″ frame (237.6840.02), which may be inserted in 19″ racks or 19″ cabinets (237.7317.02) or mounted in DIN racks with the aid of adapters, accommodates any modules of 50, 100 and 200 mm width up to an overall width of 400 mm.

The standard frame has two 50-mm and two 100-mm wide blank panels screwed to both its front and rear sides, leaving space for 100 mm module width.

Smaller module groups (except XKP) of 250 mm maximum width may be incorporated into a smaller cabinet of 5/8 of 19″ width with a fixed frame (237.6040.02). Blank panels of 100 mm and 50 mm for both the front and rear are included.

The **Caesium Frequency Standard XSC** is always incorporated in a special 19″ frame and delivered with a cabinet. Instead of the blank panel a module of 100 mm width (or two of 50 mm) can be inserted.

Overview

Output frequencies	Designation	Type	Order No.	Frequency error	Stability (aging after 10 days of operation)	Output voltage EMF	Source impedance Ω	Text on page
Frequency standards								Module system: 160
5 MHz	Caesium-Frequency Standard	XSC	299.4011.02	7×10^{-12}	$<3\times10^{-12}$ for the whole tube life	2 V	50	158
5 MHz	Rubidium Frequency Standard	XSRM	238.4011.02	—	$<1\times10^{-11}$/month typ. $<8\times10^{-12}$/month	1 V	50/100	162
5 MHz	Crystal Oscillator	XSD 2	283.6010.02	—	$<2\times10^{-10}$/day	1 V	50/100	163
Oscillator modules								
5 MHz	Rubidium Oscillator	XSRB	216.0213.03	—	$<2\times10^{-11}$/month	1 V	50	168
1 to 10 MHz	Crystal Oscillator	XSE	100.7641 ... (complete No. see text)	—	$<3\times10^{-9}$/day	0.5 V	500	170
5 MHz	Crystal Oscillator	XSF	100.5578.02	—	$<5\times10^{-10}$/day	0.5 V	500	170

XSC

Caesium Frequency Standard XSC ♦ 5 MHz

- Frequency error $<7\times10^{-12}$
- Modular design
- Standby power supply
- Small dimensions

While secondary frequency standards, such as the Rubidium Frequency Standard XSRM and the Rubidium Oscillator XSRB (which are dealt with later), require recalibration in spite of their high frequency stability, this is not necessary for primary frequency standards.

The **Caesium Frequency Standard XSC** is a primary frequency standard whose frequency is basically determined by the beam tube principle so that it requires no recalibration during its whole life.

Caesium Frequency Standard XSC and Digital Clock CADM

Characteristics and uses

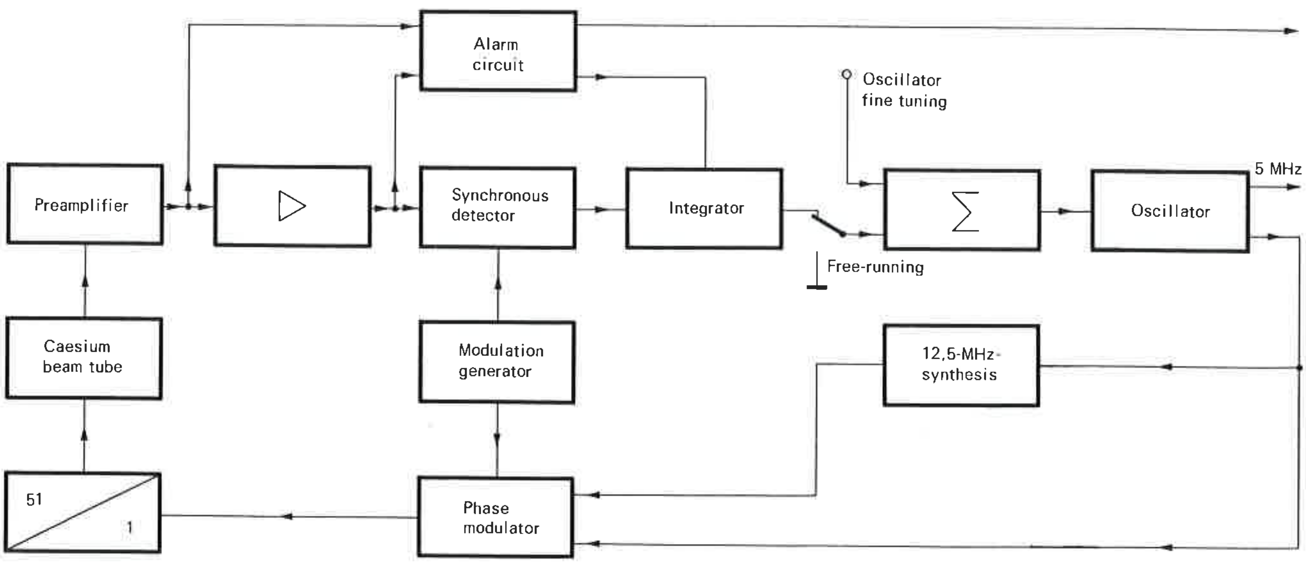
The XSC is ideal for all applications in which frequency recalibration is not feasible, e.g. in mobile use, or where it is impossible to receive a standard reference frequency.

The Caesium Frequency Standard XSC features the most modern design, small dimensions and low power consumption. In the case of AC supply failures, a standby power supply automatically takes over and is recharged when the AC supply voltage is present again.

Extension units

For extending the XSC, the R&S standard frequency module line is available (see page 160). In addition to the standard frequency of 5 MHz, the Frequency Converter XSRM-Z delivers output signals at 0.1 MHz, 1 MHz and 10 MHz.

Block diagram of Caesium Frequency Standard XSC



The Phase Comparator XSRM-Z3 permits easy phase comparison between the Caesium Frequency Standard XSC and external test items at the frequencies 1/2/3 to 10 MHz.

In conjunction with the Digital Clock CADM the XSC constitutes a clock of absolute accuracy which can be used for control purposes and as a mobile time reference.

Operation

The XSC is extremely easy and convenient to operate. A number of its functions can be readily checked with the aid of a front-panel switch,. The frequency-determining elements are protected by a flap to prevent unauthorized access to the instrument settings.

Front panel of Caesium Frequency Standard XSC

Description

The Caesium Frequency Standard XSC uses a hyperfine level transition in the caesium-133 atom as a reference to keep a 5-MHz crystal oscillator in phase lock. The caesium beam tube used is an ultramodern development meeting higherst requirements with respect to reliability, long life and other essential characteristics. The 5-MHz crystal oscillator features extremely low noise and aging.

Specifications

Output frequency .... 5 MHz, with option XSRM-Z: 0.1/1/5/10 MHz
Output EMF .... 2 V_{rms}
Output impedance .... 50 Ω
Connectors .... BNC female on front and rear panel
Harmonics .... >40 dB down
S/N ratio with offset from carrier
- 1 Hz .... 80 dB (test bandwidth 1 Hz)
- 10 Hz .... 120 dB (test bandwidth 1 Hz)
- 100 Hz .... 140 dB (test bandwidth 1 Hz)
- 1 kHz .... 140 dB (test bandwidth 1 Hz)

Frequency stability
Error at 0 to 50°C .... $\leqq 7\times10^{-12}$
Reproducibility .... $<3\times10^{-12}$
Setting error .... $\leqq 2\times10^{-13}$
Long-term drift (referred to tube life) .... $<3\times10^{-12}$
Short-term drift
- for $\tau = 1$ s .... 3×10^{-11}
- 10 s .... 1×10^{-11}
- 100 s .... 5×10^{-12}
- 1000 s .... 2×10^{-12}
- 10,000 s .... 5×10^{-13}
- 100,000 s .... 3×10^{-13}

General data
Operating temperature range .... 0 to +50°C
Storage temperature range .... −20 to +50°C
Humidity .... max. 95% (for operating temperature range)
Vibration MIL-STD-167-1
Power supply
- AC supply .... 115/230 V ±20%, 47 to 440 Hz (70 VA)
- External battery .... 22 to 28 V, max. 40 W
- Internal battery .... backup time (standby): 0.5 h

Dimensions, weight (XSC alone) .... 492 mm×161 mm×514 mm, 23 kg
Guarantee period for caesium beam tube .... 3 years

Ordering information

Order designation .... ▶ Caesium Frequency Standard XSC 299.4011.02

Accessories supplied
1 two-core connecting cable (for external battery)
1 RF connecting cable (0.5 m, BNC)
1 connecting cable (0.1 m, for standby power supply)
1 power cable

Options (see page 166)
Frequency Converter XSRM-Z 238.0616.02
Phase Comparator XSRM-Z3 ...... 278.9314.02
Digital Clock CADM 299.6014.02

Standard-frequency module system

The Rubidium Frequency Standard **XSRM** and the Crystal Oscillator **XSD 2** (if required in conjunction with the Standard Frequency Receiver **XKE 2**) are the basic units of a modular system which can be extended step by step by a power supply, frequency converter and phase comparator and also augmented for time indication and clock control with highest accuracy.

Available standard cabinets for housing the modules:

Cabinet

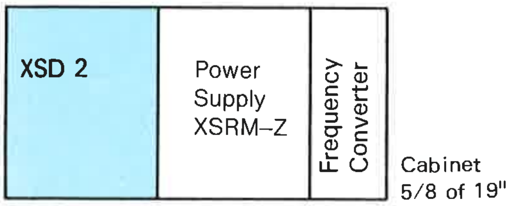
a) ⅝ of 19″, with frame and blank panels ▶ Order No. 237.6040.02

b) 19″, without frame ▶ Order No. 237.7317.02
(required frame must be ordered separately)

Frame

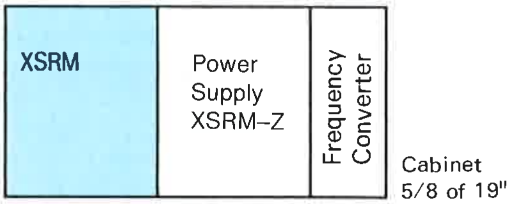
with blank panels, for insertion into 19″ racks and 19″ cabinets ▶ Order No. 237.6840.02

1



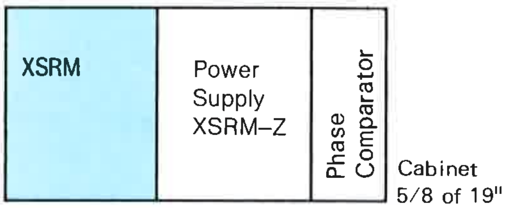
Low-priced precision crystal standard, also for mobile use; long-term drift: $<6\times10^{-9}$/month

2



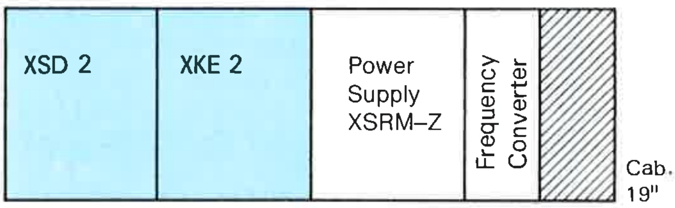
Atomic frequency standard, also for mobile use; long-term drift: $<1\times10^{-11}$/month

3



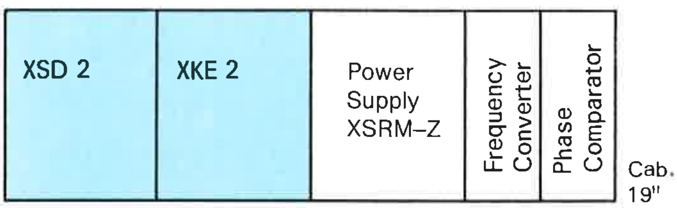
Test assembly for crystal oscillator recalibration, also for mobile use; long-term drift: $<1\times10^{-11}$/month

4



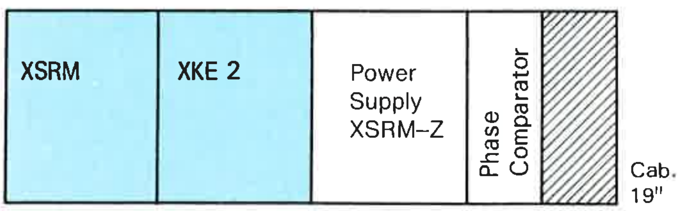
Controlled crystal standard, for stationary use only; long-term drift: $\approx5\times10^{-10}$/without limit, depending on local receiving conditions

5



Test assembly for crystal oscillator recalibration; with controlled crystal standard for stationary use only; long-term drift: $\approx5\times10^{-10}$/without limit, depending on local receiving conditions

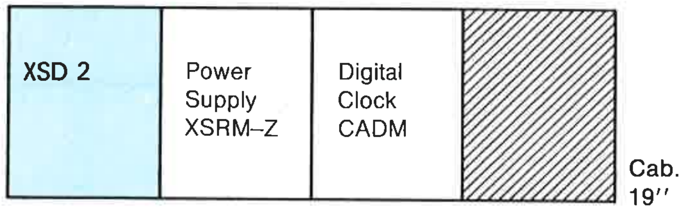
6



Controlled atomic frequency standard, for stationary use only; long-term drift: $\approx2\times10^{-11}$/without limit, depending on local receiving conditions; using phase comparator: test assembly for crystal oscillator recalibration

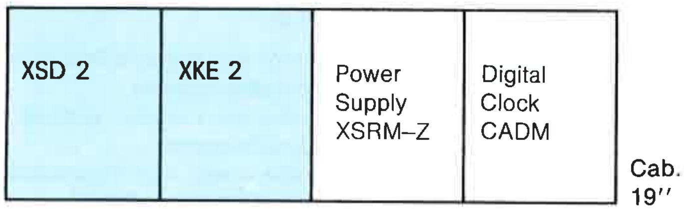
Standard-frequency/standard-time module system

7



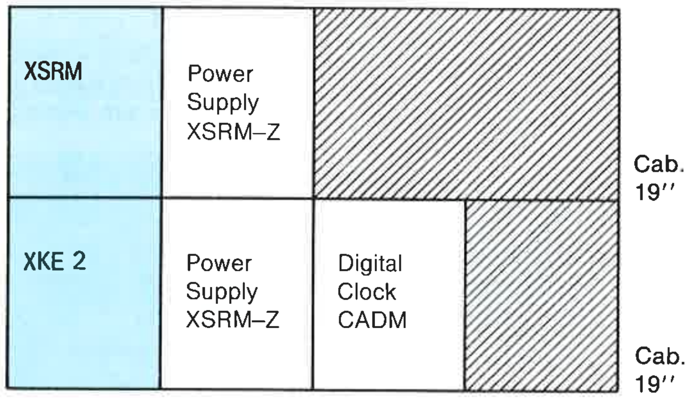
Free-running crystal clock, particularly low-priced and suitable for mobile use

8



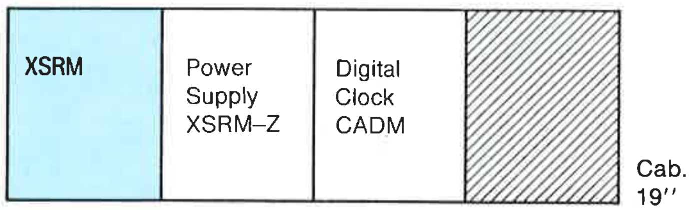
Controlled crystal clock, normal version for stationary use

9



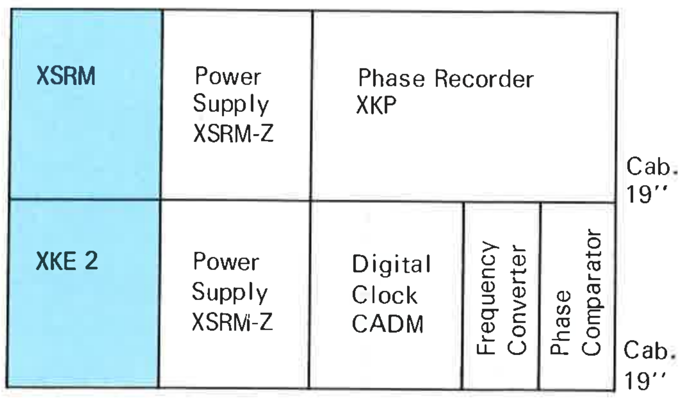
Controlled atomic clock, maximum possible accuracy; no recalibration required; for stationary use only

10



Free-running atomic clock, maximum accuracy; for mobile use; suitable as mobile time reference

11



Controlled atomic frequency and time standard, basic equipment for institutes and laboratories requiring precise frequency and time signals

XSRM

Rubidium Frequency Standard XSRM

♦ 5 MHz

- Long-term drift $<1\times10^{-11}$/month (typ. 8×10^{-12})
- High spectral purity of output signal (signal-to-noise ratio ≧125 dB)
- High reliability and long life
- Three years guarantee for spectral lamp and resonant cell

The design of this compact **Rubidium Frequency Standard** is based on R&S's more than 40 years of experience in building standard-frequency equipment. Up-to-date technology has been employed, resulting in a very small and favourably priced instrument. In addition to the excellent technical performance, high reliability is of great importance, particularly for controlling TV transmitters.

The XSRM is the basic unit of a modular system and can be expanded by a standby power pack (see power supply) and a plug-in frequency converter which delivers several coherent frequencies. These 19" subunits form a modular system and can be combined according to the requirements (see page 160).

Output frequency, stability. The XSRM delivers a 5-MHz sinusoidal output voltage (1 V EMF) of extremely high spectral purity (S/N ratio ≧125 dB). The frequency drift due to aging is less than 1×10^{-11}/month. In conjunction with the Frequency Converter XSRM-Z frequencies of 10 MHz, 5 MHz, 1 MHz and 100 kHz can be generated.

Description

The XSRM makes use of one of the atomic resonances of Rb 87, an isotope of the alkali metal rubidium. The Rubidium Frequency Standard operates on the gas-filled cavity-resonator principle with optical excitation and optical scanning. A precision crystal oscillator is continuously controlled, compensating for the drift due to aging.

Power supply. The basic unit is for DC voltage. The builtin stabilizer handles voltages varying from 22 to 32 V.

The optional power pack enables operation from the AC supply. Should the AC supply fail, a built-in battery automatically takes over and is recharged when AC power is restored (see page 166).

Applications

Due to its excellent characteristics, the XSRM opens up a variety of applications, such as

- ▷ control of standard-frequency and standard-time systems
- ▷ mobile and fixed radionavigation systems
- ▷ satellite communications and time multiplex systems
- ▷ geodesy, research in natural resources
- ▷ single-sideband transmission at very high frequencies
- ▷ control of TV transmitters with precision offset
- ▷ colour TV – central control of studio sync generators
- ▷ radar systems, signal encoders
- ▷ calibration of synthesizers and counters.

With its high short-term stability, the XSRM is suitable for buffer operation of caesium standards, which feature even higher frequency accuracy but worse short-term stability.

Specifications

Output frequency	5 MHz (sinusoidal)
Output EMF	1 V_{rms} ±10%
	Z_{out} = 50 Ω ±10% (rear socket)
	Z_{out} = 100 Ω ±10% (front-panel socket)
Harmonics	>30 dB down
S/N ratio (at ≧100 Hz from carrier)	≧125 dB (1-Hz bandwidth)
Non-harmonic spurious frequencies	≧120 dB down
Stability	
Long-term drift	≦1×10^{-11}/month, typ. 8×10^{-12}/month
Short-term drift (standard deviation)	≦3×10^{-12} with τ = 1 s
Effect of ambient temperature	≦2×10^{-12}/°C
Effect of supply voltage	≦2×10^{-11}/10%
Frequency correction	
Setting range	
mechanical, with potentiometer	2×10^{-9}
Setting error	≦5×10^{-12}
electrical, via control input	1×10^{-9} ≙ 0 to +10 V DC
Nominal conditions	
Rated temperature range	−20 to +45°C
Storage temperature range	−40 to +70°C
Warmup time for $\Delta f/f<10^{-10}$	typ. 25 min at 25°C
General data	
Power supply	22 to 32 V (DC)
Current drain	max. 1.8 A during warmup approx. 0.7 A after warmup at 24 V and +25°C
Dimensions, weight	100 mm×132 mm×390 mm, 3.7 kg

Ordering information

Order designation	▶ Rubidium Frequency Standard XSRM 238.4011.02
Recommended extra modules	see pages 160 and 166

Guarantee period for spectral lamp and resonant cell: 3 years

Crystal Oscillator XSD 2

XSD 2

♦ 5 MHz

- Classe of accuracy 10^{-10}
- High spectral purity of output signal
- Input for frequency-correction voltage

The **Crystal Oscillator XSD 2** is a particularly low-priced frequency source in the R&S standard-frequency module line. It features low aging and high short-term stability, and is very little affected by temperature variations.

The XSD 2 can be combined with any of the other units of the modular system (see pages 160/161).

When used with the Power Supply XSRM-Z (see page 166) the Crystal Oscillator has a backup time of more than 6 hours.

Output frequency, stability. The Crystal Oscillator delivers a 5-MHz sinusoidal signal of high spectral purity directly at two outputs (output EMF 1V). The frequency drift due to aging is less than 2×10^{-10}/day.

For different frequencies, the XSD 2 can be used in conjunction with the Frequency Converter XSRM-Z (see page 166) so that signals of 10 MHz, 5 MHz, 1 MHz and 100 kHz are available in phase lock.

Frequency correction. The frequency of the XSD 2 can be corrected with the aid of a calibrated potentiometer and via a control-voltage input, for instance with the Standard Frequency Receiver XKE 2.

Power supply. The XSD 2 uses 24 V DC, but the built-in regulator handles supply fluctuations between 22 and 32 V without affecting the accuracy.

XSD 2 used in a setup for calibration laboratories

Example of application

The combination of XSD 2 plus XKE 2 is a particularly lowpriced setup for producing precise frequencies for use in calibration laboratories – although, if the accuracy requirements are more stringent, the combination of the Rubidium Frequency Standard XSRM and the XKE 2 is to be preferred.

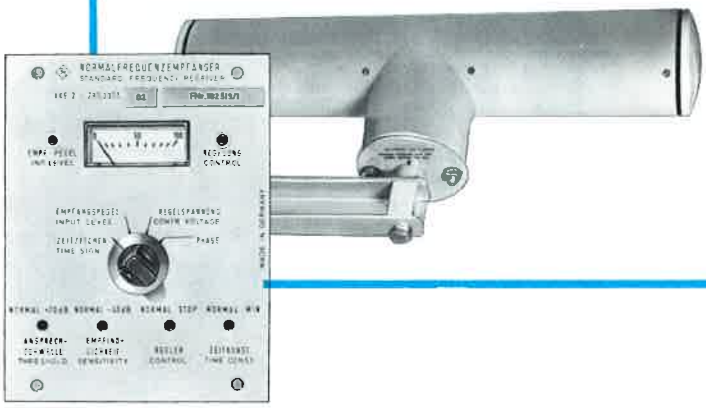
Specifications

Output frequency	5 MHz
Output EMF	1 V_{rms} ±10%, Z_{out} = 50 Ω ±10% (rear socket) Z_{out} = 100 Ω ±10% (front-panel socket)
Harmonics	>30 dB down
S/N ratio (at ≧100 Hz from carrier), 1-Hz test bandwidth	>130 dB
Connectors	BNC female
Stability	
Long-term drift	
after 5 days of cont. operation	$<5 \times 10^{-10}$/day
after 30 days of cont. operation	$<2 \times 10^{-10}$/day
Short-term drift (standard deviation)	$<5 \times 10^{-12}$ for $\tau = 1$ s
Effect of ambient temperature	$<5 \times 10^{-11}/°C$
Effect of supply voltage variations	$<1 \times 10^{-11}$/10%
Effect of load (open circuit/50 Ω)	$<1 \times 10^{-10}$
Frequency correction	mechanical and electronic
with ten-turn potentiometer on front panel	2×10^{-7}
by external DC voltage 0 to +10 V	$+4 \times 10^{-8}$
Nominal conditions	
Rated temperature range	−20 to +50 °C
Storage temperature range	−40 to +70 °C
Warmup time for $\Delta f/f \leqq 10^{-8}$	1.5 h (referred to frequency after 12 h)
General data	
Power supply	22 to 32 V DC
Current drain	max. 300 mA (approx. 60 mA after warmup at 24 V and +25 °C)
Dimensions, weight	100 mm × 132 mm × 390 mm, 2.5 kg

Ordering information

Order designation	▶ Crystal Oscillator XSD 2 283.6010.02
Recommended extra modules	see pages 160 and 166

XKE 2 + Ferrite Antenna



Standard Frequency Receiver XKE 2

♦ 10 kHz to 200 kHz

- Recalibration of crystal and atomic frequency standards
- Selectable receive frequencies (plug-in boards)
- High sensitivity and excellent protection against interference thanks to preselection
- Time-signal output
- Worldwide reception of OMEGA-navigation transmitters

The **XKE 2** is a universal standard frequency receiver which permits control of crystal and atomic frequency standards. It is available for all frequencies in the range 10 to 200 kHz, including the frequencies of the OMEGA-navigation transmitters in use all over the world.

Characteristics and uses

The receiver includes a preselection circuit, thus featuring excellent characteristics with respect to sensitivity and protection against interference. In addition, the Standard Frequency Receiver XKE 2 uses ALC so that high reliability is ensured even under adverse conditions of reception.

The combination of Standard Frequency Receiver XKE 2 and the Crystal Oscillator XSD 2 (see page 163) replaces the time-proven setup XKE/XSD and is a particularly low-priced solution to the problem of producing precise standard frequencies.

The accuracy is increased when using the combination XKE 2/XSRM (Rubidium Frequency Standard, see page 162). Thanks to the higher inherent stability of the XSRM, a considerably longer control time constant can be selected, enabling improved averaging of the frequency variations of the received signal caused by propagation fluctuations.

The frequency accuracy of the XKE 2/XSRM combination corresponds to an unlimited long-term drift of 2×10^{-11}. The receiver is designed for a control time constant which can be extended up to 148 days.

The broadband, active Ferrite Antenna XKE 2-Z1 (see photo) is particularly suitable as receiving antenna. Its 50-Ω output impedance matches the receiver. The antenna is weatherproof and can be installed either indoors or outdoors depending on the receiving conditions; power supply: 10.5 V DC ± 10%, max. 6 mA.

Description

The Standard Frequency Receiver comes as a subunit for a 19″ chassis and can be combined with all other modules of the R&S standard-frequency system.

The XKE 2 is equipped with a time-signal output so that when receiving time-signal-modulated standard-frequency transmitters the corresponding time information is simultaneously available.

Specifications

Receive frequency f_1	standard model: 60/75/77.5 kHz; internally selectable; other frequencies possible in the range 10 to 200 kHz
Input voltage of receive frequency f_1	1 µV to 10 mV, switchable to 100 µV to 1 V
Input impedance	50 Ω ±20%
Controlled frequency f_2	1/2/5/10 MHz
Input voltage of controlled frequency f_2	200 mV to 2 V
Input impedance	>500 Ω
Capture range for controlled frequency f_2 ($\Delta f/f$)	$>1 \times 10^{-7}$
Control time constant	8 time-constant factors internally selectable: 16/32/64/128/256/512/1024/2048 × 6.25×10^{-7} (s/V); for accelerated control: $1 \times 6.25 \times 10^{-7}$ s/V externally switchable to smallest factor
Control inputs	
Time-constant switching	TTL levels or switch; logic 0 = smallest control time constant
Control stop	TTL levels or switch; logic 0 = control stop
Receiver-sensitivity switching	TTL levels or switch; logic 0 = 40-dB attenuation
Outputs	
Control voltage	0 to +10 V, max. 5 mA; short-circuit-proof
Phase difference	0 to +10 V, max. 5 mA; short-circuit-proof; 0 to 100 µs phase difference
Received-signal level	0 to +10 V, max. 5 mA; short-circuit-proof; approximated logarithmic indication ≈ 4 dekades
Time signal	TTL levels
Fault signal	TTL levels
1-MHz standard frequency	200-ns pulse, 1 V_{pp} Z_{out} = 50 Ω; phase-locked to receive frequency
General data	
Phase error as function of ambient temperature	<1 µs/10 °C (<5 µs for OMEGA frequencies)
Rated temperature range	0 to +50 °C
Storage temperature range	−40 to +70 °C
Power supply	22 to 32 V DC
Current drain	max. 400 mA
Dimensions, weight	100 mm × 132 mm × 390 mm, 2.5 kg

Ordering information

Order designations	▶ Standard Frequency Receiver XKE 2 291.0017.02
Filter XKE 2-B1 for 60, 75 and 77.5 kHz	299.3015.02
for other frequencies (on request)	299.3015.49

Accessories supplied

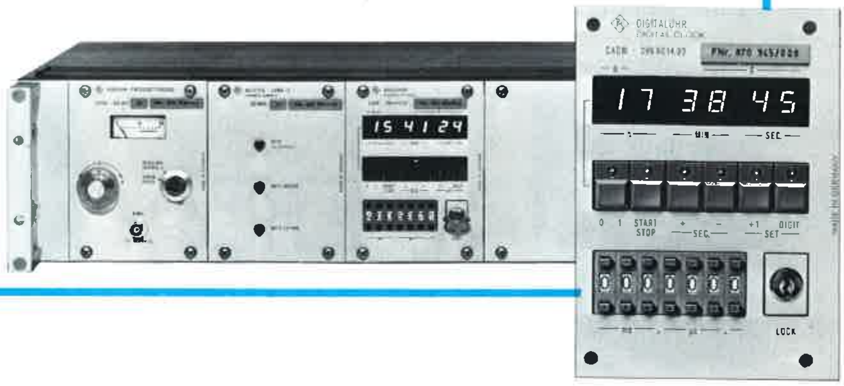
1 two-core connecting cable (for external battery)
2 RF connecting cables (BNC)
1 connecting cable (for control voltage)
1 two-core connecting cable (for standby power supply)

Recommended extras	Ferrite Antenna XKE 2-Z1 299.3515.50
	RF connecting cable (BNC) 25 m, 103.1238.00

Digital Clock CADM

CADM

- Years/days/hours/minutes/seconds
- Time information in BCD code
- Phase adjustment with a resolution of 0.1 µs
- Control output for slave clocks
- Seconds pulses produced from 5 MHz
- Synchronization input



The **Digital Clock CADM** is an extension of the R&S standard-frequency module line permitting standard-time systems to be set up. It can be combined with the Crystal Oscillator XSD 2, the Rubidium Frequency Standard XSRM and the Caesium Frequency Standard XSC.

Characteristics, uses

The CADM features interference rejection which meets the most stringent requirements so that even in the case of heavy ambient disturbance, for instance in mobile use, no time error occurs.

In conjunction with atomic frequency standards the CADM is a high-quality precision clock complying with the strictest specifications stipulated for time standards. It can be used in time-signal systems, for master clock control, for scientific purposes and as a mobile time standard.

The accuracy of the clock is determined by the frequency stability of the time interval generator. The R&S product range includes interval generators accurate to 10^{-10}/day and the high-accuracy Caesium Frequency Standard XSC (5×10^{-12} with no systematic drift).

Time display, setting and readout. The time is read out digitally in hours, minutes and seconds on the CADM front panel. Calendar display can be selected with the aid of the DIGIT button, the current number of the day of the year (0 to 364 or 365) being read out plus a year figure. The year figure is counted in cycles from 0 to 3, with 0 marking a leap year. The Digital Clock can be advanced and run backwards using pushbuttons. The time can be set with high accuracy thanks to a digitally adjustable phase shifter with a resolution of 0.1 µs. The CADM can be started automatically via a synchronization input, and a key switch prevents unauthorized access to the instrument settings.

In addition to the digital time display on the front panel the time information is also available as a BCD code at the female multiway connector on the rear panel. The CADM also supplies a time advance signal whose polarity alternates every 1 s or 1 min for controlling **external time systems** (e.g. slave clock systems from Siemens).

Pulses of 20 µs duration, delayed or undelayed, are available at two BNC outputs for time comparison measurements and synchronization purposes.

An automatic monitoring circuit indicates interruptions of normal operation, detecting even momentary faults.

Specifications

Readout	6 digits (LEDs), can be blanked
Display of	
time of day	hours 00 to 23 minutes 00 to 59 seconds 00 to 59
calendar	day of the year 0 to 364 (365) year figure 0 to 3 (0 = leap year)
Time setting	in least increments of 0.1 µs, setting error ±0.1 µs
Control, signal inputs	
Input for timebase signal	
Input frequencies	1/2/2.5/5/10 MHz
Input level	0.2 to 2 V_{rms}
Input impedance	>500 Ω, BNC female connector
Synchronizing input	TTL levels, positive; BNC female connector
Synchronizing error	1.5 µs ±0.5 µs
Signal outputs	
Seconds pulses	
undelayed (clock normal)	
Output EMF	+2 to +20 V (adjustable)
Output impedance	50 Ω, BNC female connector
Rise time	<20 ns, duration 20µs
delayed (clock delay)	identical with undelayed seconds pulses, except for phase position
Phase of delayed seconds pulse referred to undelayed seconds pulse	adjustable from 0 to 0.9999999 s with phase shifter (0.1-µs steps)
Control signal for clock systems	
Waveform	squarewave of alternating polarity, each polarity of 1 s or 1 min duration (switch-selected)
Output voltage	±12 V or ±24 V (int. selectable)
Output current	±20 mA max.
Connector	37-way female (Cannon)
Time information given	years (year figure), days, hours, minutes, seconds
Output levels	TTL (BCD code), negative or positive logic selectable
Connector	37-way female (Cannon)
Performance monitoring	
Fault monitoring	interruptions of normal operation are automatically stored and indicated
Tamper-proofing the time setting	by disabling the operating controls with the exception of the time-of-day/calendar selector
General data	
Rated temperature range	+5 to +45 °C
Storage temperature range	−20 to +70 °C
Power supply	22 to 32 V DC
Current drain	0.25 A (LED display switched off) 0.3 A (LED display switched on)
Dimensions, weight	100 mm × 132 mm × 375 mm, 2 kg

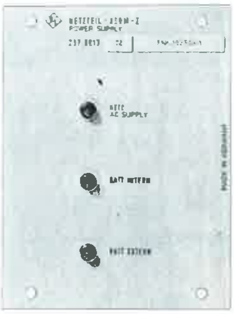
Ordering information

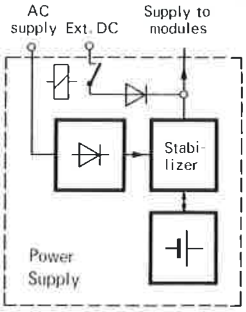
Order designation .... ▶ Digital Clock CADM 299.6014.02

Accessories supplied:
Power cable for connection to standby power supply; battery cable for connection to an external battery; RF connecting cable (2 BNC connectors); 37-way Cannon connector; adapter board for operating individual plug-in cards when withdrawn from the unit

Additional units of standard-frequency module system (overview see pages 160 and 161)

Power Supply XSRM-Z





The Power Supply XSRM-Z contains a maintenance-free NiCd cell battery which feeds the instruments connected (e.g. XSRM or XSD 2) for one to six hours in the case of AC supply failure. The XSRM-Z delivers a peak current of 1.6 A.

During AC supply operation, the battery is automatically charged. Switchover from AC-supply to battery operation is also automatic.

The self-heating effects is only slight since high efficiency is obtained by a control circuit making use of the angle of current flow. The XSRM-Z can also be fed from an external battery. Three front-panel lamps indicate the mode of operation (AC supply/internal battery/external battery). The internal-battery lamp starts flashing if the charge falls below a threshold level.

Specifications of Power Supply XSRM-Z

Input voltage .... 230/115 V_{rms} ±20% (47 to 400 Hz)
Power consumption .... max. 70 VA
Input for external battery
(input voltage) .... 24 to 28 V
DC output
Voltage during AC supply operation .... 23 V, regulated
Voltage during battery operation .... 22 to 30 V
Max. output current .... 1.6 A (2 A for max. 15 min)
Internal battery
Useful capacity .... 0.8 Ah
Mean backup time (e.g. with XSRM), battery operation at 25 °C .... 1 h

General data

Rated temperature range .... −20 to +45 °C
Storage temperature range .... −20 to +50 °C
Dimensions, weight .... 100 mm×132 mm×342 mm, 5.2 kg

Ordering information

Order designation .... ▶ Power Supply XSRM-Z 237.8013.02

Accessories supplied

Power cable
1 two-core connecting cable (for XSRM)
1 two-core connecting cable (for external battery)

Frequency Converter XSRM-Z

The Frequency Converter XSRM-Z is driven with the 5-MHz signal delivered by the XSRM, XSC or XSD 2. Each of the frequencies – 10 MHz, 5 MHz, 1 MHz and 0.1 MHz – is available at two parallel outputs on the front and rear panels. All signals are sinusoidal and phase-locked to the input signal.

The Frequency Converter can be powered from the Power Supply XSRM-Z.

Specifications of Frequency Converter XSRM-Z

Input

Frequency .... 5 MHz
Permissible range of input voltage .... 0.2 to 2 V_{rms}
Input impedance .... ≧500 Ω
Connector .... BNC female

Output

Frequencies .... 0.1 MHz, 1 MHz, 5 MHz, 10 MHz
Output voltage .... 1 V_{rms}, sinewave
Harmonics .... >30 dB down
Output impedance
Outputs on front panel .... 100 Ω ±10% (BNC female connectors)
Outputs on rear panel .... 50 Ω ±10% (BNC female connectors)

General data

Supply voltage .... 22 to 32 V DC
Current drain .... max. 90 mA
Rated temperature range .... −20 to +45 °C
Storage temperature range ...... −20 to +60 °C
Dimensions, weight .... 50 mm×132 mm×342 mm, 1 kg

Ordering information

Order designation .... ▶ Frequency Converter XSRM-Z 238.0616.02

Phase Comparator XSRM-Z3

The Phase Comparator XSRM-Z3 is used for checking and recalibrating control frequencies, derived for instance from crystal oscillators in counters and synthesizers.

Any 5-MHz source of appropriate accuracy (e.g. XSRM, XSD 2) can be used as the reference. Frequency differences between 1×10^{-6} to 1×10^{-9} can be determined directly on the panel meter. The recorder output permits considerably smaller errors to be logged or frequency and phase deviations to be recorded over a longer period of time.

Any test item with a frequency of 1 MHz or an integral multiple of it (up to 10 MHz) can be measured. A rotary switch on the front panel permits the Phase Comparator to be set to the corresponding input frequency.

Specifications of Phase Comparator XSRM-Z3

Input frequency f_{st}	5 MHz
Input voltage range	0.1 to 2 V_{rms}
Input frequency f_x	1/ to /10 MHz
Input voltage range	0.1 to 2 V
Indication of phase difference	0 to 1 μs (= 0 to 360°)
Recorder output	0 to 5 V (= 0 to 1 μs), 5 mA max.
Output impedance	>10 Ω

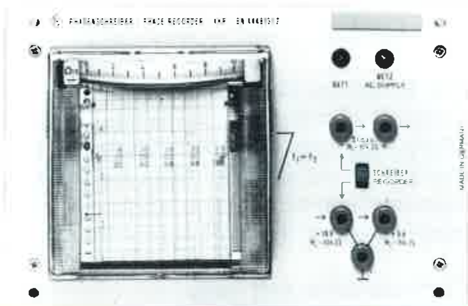
General data

Rated temperature range	−20 to +45°C
Storage temperature range	−40 to +70°C
Supply voltage	22 to 32 V DC
Current drain	180 mA max.
Dimensions, weight	50 mm×132 mm×342 mm, 0.9 kg

Ordering information

Order designation	▶ Phase Comparator XSRM-Z3 278.9314.02

XKP



Phase Recorder XKP for standard frequency comparison

- Frequency and phase recording at 50 Hz to 5 MHz
- Linear indication (sawtooth) 0 to 360°
- Frequency evaluation over one hour to within $\pm2\times10^{-12}$
- DC input for YT recording

A simple method of determining the difference between two almost identical frequencies is to measure the mutual phase deviation within a set time interval. The Phase Recorder XKP serves this purpose.

The test result is recorded in the form of a sawtooth voltage with constant amplitude (corresponding to 360° phase difference). The instantaneous value of this voltage corresponds to the phase difference between the frequencies being compared. The voltage variation within a set time interval is a measure of the frequency difference.

The main application of the XKP is the monitoring of standard-frequency and standard-time systems. Due to its wide frequency range, it is suitable for determining the relative frequency error of atomic frequency standards (accuracy 10^{-12} to 10^{-13}) and for measuring at lower frequencies down to the AC supply frequency. The XKP can also be used as a YT recorder (DC input voltage: 0 to 5 V/0 to 10 V), e.g. together with the XKE 2 or XSRM-Z3.

The set is AC-supply and/or battery operated, the battery taking over only on AC supply failure. The XKP comes as ½ of a 19″ unit and fits in the modular standard-frequency system XSRM-Z. Two Phase Recorders XKP can be accommodated side by side in a 19″ Frame XSRM-Z 237.6840.02. The XKP can also be inserted into the Cabinet XSRM-Z (⅝ of 19″, Order No. 237.6040.02).

Specifications of Phase Recorder XKP

Frequency range	50 Hz to 5 MHz
AC input voltage	0.3 to 10 V_{rms}
Input impedance (frequency-dependent, mostly inductive)	
at 50 Hz	>60 Ω
above 1 kHz	>1 kΩ
Input connectors	2 BNC female, floating (on rear panel)
DC input voltage (for use as YT recorder)	0 to +5 V/0 to +10 V; Z_{in} = 5 kΩ/10 kΩ, telephone jacks (on front and rear panel, connected in parallel)
Indication	wax-paper dot recorder
Paper feed	20 mm/h and 120 mm/h, selectable; error (with battery operation) $<5\times10^{-4}$/°C
DC output voltage	0 to +5 V corresp. to 0 to 360° phase difference, 5 mA max. (short-circuit-proof), Z_{out} <10 Ω
Zero drift	$<2\times10^{-5}$ of fsd/°C
Output connectors	telephone jacks (front panel)

General data

Rated temperature range	−10 to +50°C
Storage temperature range	−20 to +70°C
Power supply	
AC supply	115/125/220/235 V +10/−15%, 50 Hz (6 VA); 60 Hz if required
Battery (external)	11 to 16 V, 320 mA, internally selectable 21 to 32 V (not to be charged from XKP)
Dimensions, weight	202 mm×132 mm×370 mm, 4.5 kg

Ordering information

Order designation (½ of 19″ unit)	▶ Phase Recorder XKP 156.3541.02
Accessories supplied	power cable, connecting cable (1.5 m) for external battery, evaluation disk, 1 roll of recording paper

XSRB

Rubidium Oscillator XSRB

⧫ 5 MHz

- Compact module at low cost
- Rapid warmup, wide working-temperature range
- High precision and stability: long-term drift $\leqq 2\times10^{-11}$/month

The **Rubidium Oscillator XSRB,** which features similar electric characteristics to the Rubidium Frequency Standard XSRM (see page 162) is available for incorporation into instruments and systems. This competitively priced module has been designes as a compact module to be used by other manufacturers in their own equipment.

Characteristics and uses

The XSRB is suitable for inclusion in all mobile and stationary instruments and systems calling for an extremely precise frequency reference as a control or monitoring signal.

Output signal. The output of the XSRB is a sinusoidal signal at 5 MHz. The EMF is 1 V and the signal-to-noise ratio is better than 130 dB. Thorough screening ensures that the effects of external magnetic fields are kept to a minimum. Two auxiliary outputs allow the use of an external meter for continuous monitoring of the oscillator or for checking that the control voltage remains within the permissible range. A frequency-correction input is also provided so that the oscillator frequency can be trimmed by comparison with an even more precise signal such as a standard-frequency broadcast. If the oscillator fails, an alarm signal is given at a separate output.

Frequency stability. The XSRB is over a hundred times more accurate than conventional crystal oscillators – thereby guaranteeing an adequate safety margin. The frequency drift of the XSRB due to aging is less than 2×10^{-11} per month. The unit can therefore replace precision crystal oscillators – a substitution which can also be justified on economic grounds particularly since the long-term stability and precision of the output signal eliminate the need for costly readjustments.

Applications. High-stability signals (standard frequencies) are called for in communications and navigation systems; typical examples are

precision offset operation of TV transmitters,
control of standard-frequency systems,
SSB transmission at very high frequencies,
satellite radio and geodesy,
extraterrestrial communications.

Further applications are found in microwave spectroscopy. More generally the XSRB is ideal for controlling precision counters, synthesizers and crystal oscillators.

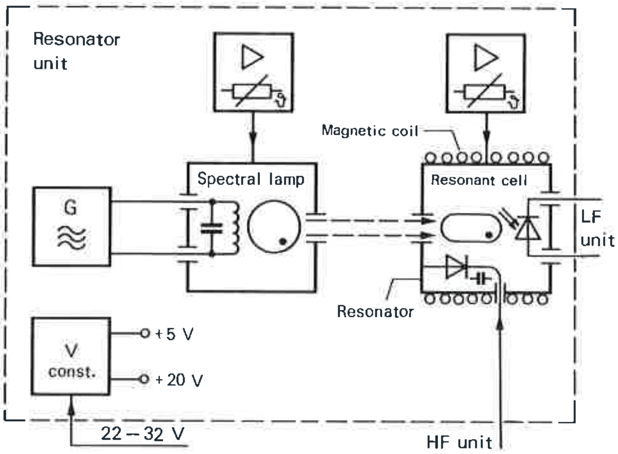
Description

The **standard frequency source** in the XSRB is a resonant mode of atoms of rubidium 87, an isotope of the alkali metal rubidium. By means of a spectral lamp and a resonant cell a control signal is developed and used to compensate for the aging of a crystal oscillator.

A typical application of the XSRB: precision-offset operation of a TV transmitter

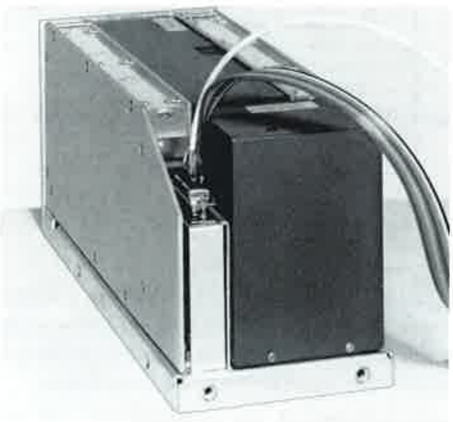
Subassemblies. The XSRB consists of four subassemblies:

1. Resonator unit with spectral lamp, resonant cell and their respective ovens; this unit is electrically and magnetically screened (see block diagram)
2. HF unit (frequency division and comparison)
3. LF unit (control signal processing)
4. Crystal oscillator unit with oven



Resonator unit

Installation. The front of the XSRB serves as both mounting plate and heatsink. The temperature measured on this plate should never be outside the range −25 to +60 °C, which is also the admissible ambient temperature range.



Input/output connector of XSRB

Power requirements. The oscillator is designed for operation from a DC supply voltage. This may vary within the range 22 to 32 V thanks to the action of the built-in stabilizer. Operation from any standard battery supply of the appropriate voltage is therefore feasible.

The XSRB is extremely easy to service. The spectral lamp can be changed very rapidly.

Specifications

Output frequency	5 MHz
Output EMF (sinusoidal)	1 V ±10%; Z_{out} = 50 Ω
Connector	Cannon male connector strip DAM – 11 W 1 P
Harmonics	>30 dB down
Signal-to-noise ratio (≧100 Hz from output frequency)	≧130 dB (1-Hz measurement bandwidth)
Non-harmonic frequencies	≧120 dB down

Stability

Long-term drift	≦2×10^{-11} per month
Short-term (1 s) drift (standard deviation)	≦1×10^{-11}
Effect of ambient temperature	≦4×10^{-10} across the specified temperature range
Effect of operating voltage	≦2×10^{-11}/10%
Effect of external magnetic field	≦$4\times10^{-13}/\frac{A}{m}$
Effect of atmospheric pressure	≦5×10^{-13}/mbar for altitudes between 0 and 10,000 m

Frequency correction

Adjustment range	
using potentiometer	2×10^{-9}
Setting error	≦5×10^{-12}
using external control input	1×10^{-9}
Control voltage range	0 to +10 V DC

General data

Alarm signal output	changeover contact
Rated temperature range (temperature of mounting plate)	−25 to +60 °C
Storage temperature range	−40 to +70 °C
Warmup time for frequency error less than 1×10^{-9}	approx. 10 min. at +25 °C
Supply voltage requirement (negative earth)	22 to 32 V DC
Current drain	
during warmup	2.2 A max.
during normal operation	approx. 0.7 A at 24 V and +25 °C
Dimensions	see drawing below
Weight	3.3 kg

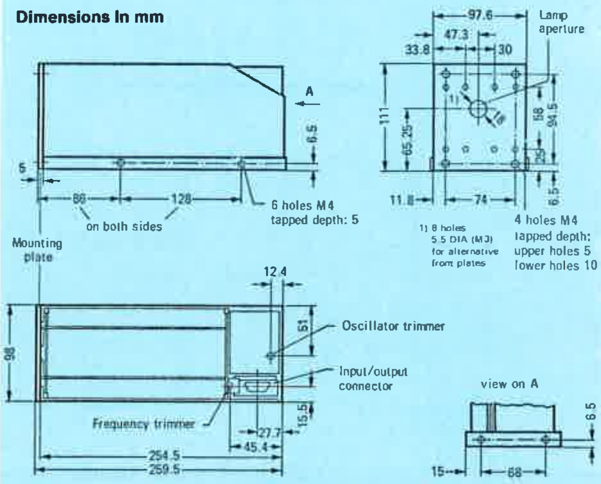
Ordering information

Order designation .... ▶ Rubidium Oscillator XSRB 216.0213.03

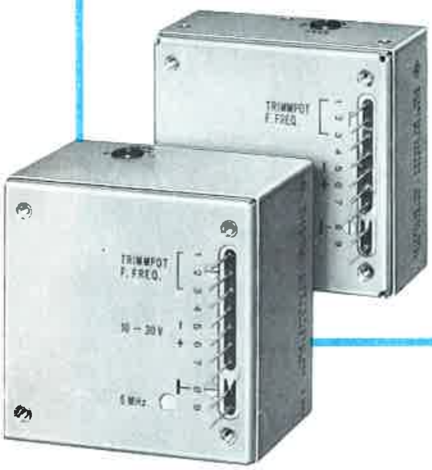
Accessories supplied: tool for changing spectral lamp, 1 female connector strip with mating male connector.

The spectral lamp and the resonant cell carry a 3-year guarantee.

Dimensions in mm



XSE/XSF



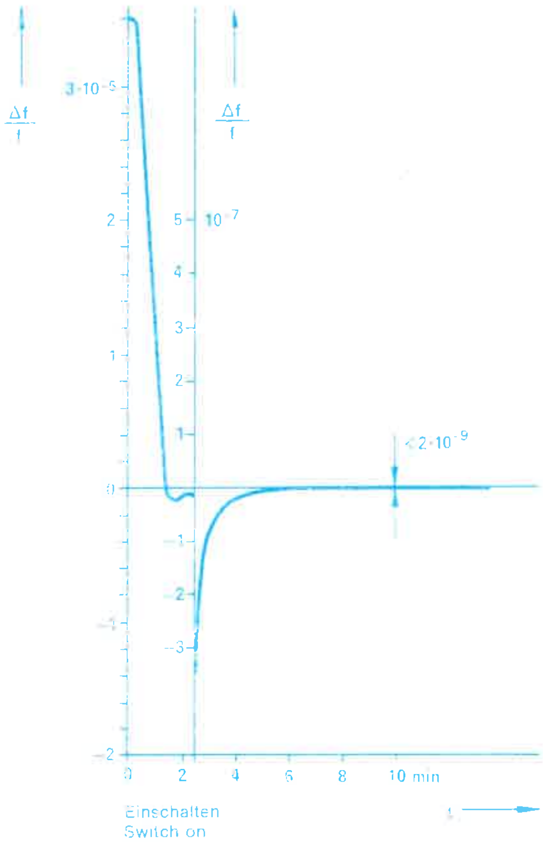
Crystal Oscillator XSE ♦ 1 to 10 MHz
Crystal Oscillator XSF ♦ 5 MHz

- Class of accuracy 10^{-9} for XSE, 10^{-10} for XSF
- Extremely short warmup period
- Operating range 10 to 30 V, −40 to +65 °C

Plug-in Crystal Oscillators XSE (top) for 1 to 10 MHz and XSF for 5 MHz; shown on larger scale than usual

The **Crystal Oscillators XSE and XSF** are suitable for incorporation into high-quality frequency counters, standard frequency generators and decade exciters.

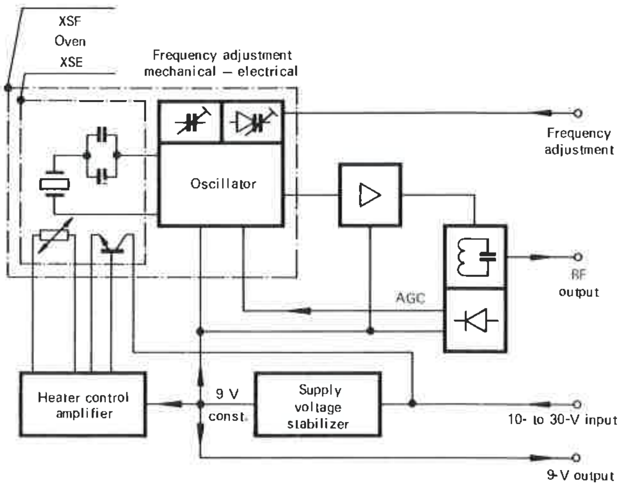
The main differences between the two types are in the frequency stability, warmup time (see table) and available output frequency. The **XSF** is designed for 5 MHz whereas the **XSE** is available for 1, 5 or 10 MHz; other frequencies between 1 and 10 MHz on request.



Warmup response of XSE using 5-MHz crystal (3rd harmonic) referred to values obtained after 60 minutes of operation

Common specifications and construction

The unusually wide ranges of temperature and operating voltages permit use of the crystal oscillators under extreme ambient conditions with negligible effect on frequency accuracy.



Block diagram of Crystal Oscillators XSE and XSF

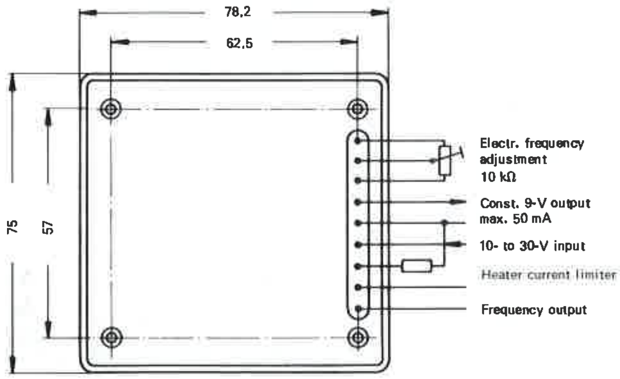
The crystal frequency can be adjusted with a trimmer (coarse) and varactor (fine). An external potentiometer must be connected to drive the varactor. The required stabilized reference voltage is available from the crystal oscillator.

Both modules (XSE and XSF) are equipped with an oven. In the XSE, only the crystal and the frequency-determining components are kept at a constant temperature while in the XSF the oscillator circuit is also accommodated in the oven.

Rapid warmup of the oven is possible by connecting a wire link between two solder tags. If a suitable resistor is inserted instead of the link, any heater current below maximum can be selected to suit the capacity of the available power supply. Since high ripple voltage is permissible for warmup, the operating voltage need not be stabilized in many cases.

The sudden change from maximum heater current to normal operating current can be utilized for the delayed connection of further loads via relays.

The XSE and XSF have identical **pin assignments.** The pins are arranged such that the modules can be connected directly to a printed circuit board.



Pin assignments of Crystal Oscillators XSE and XSF

Specifications of XSE and XSF

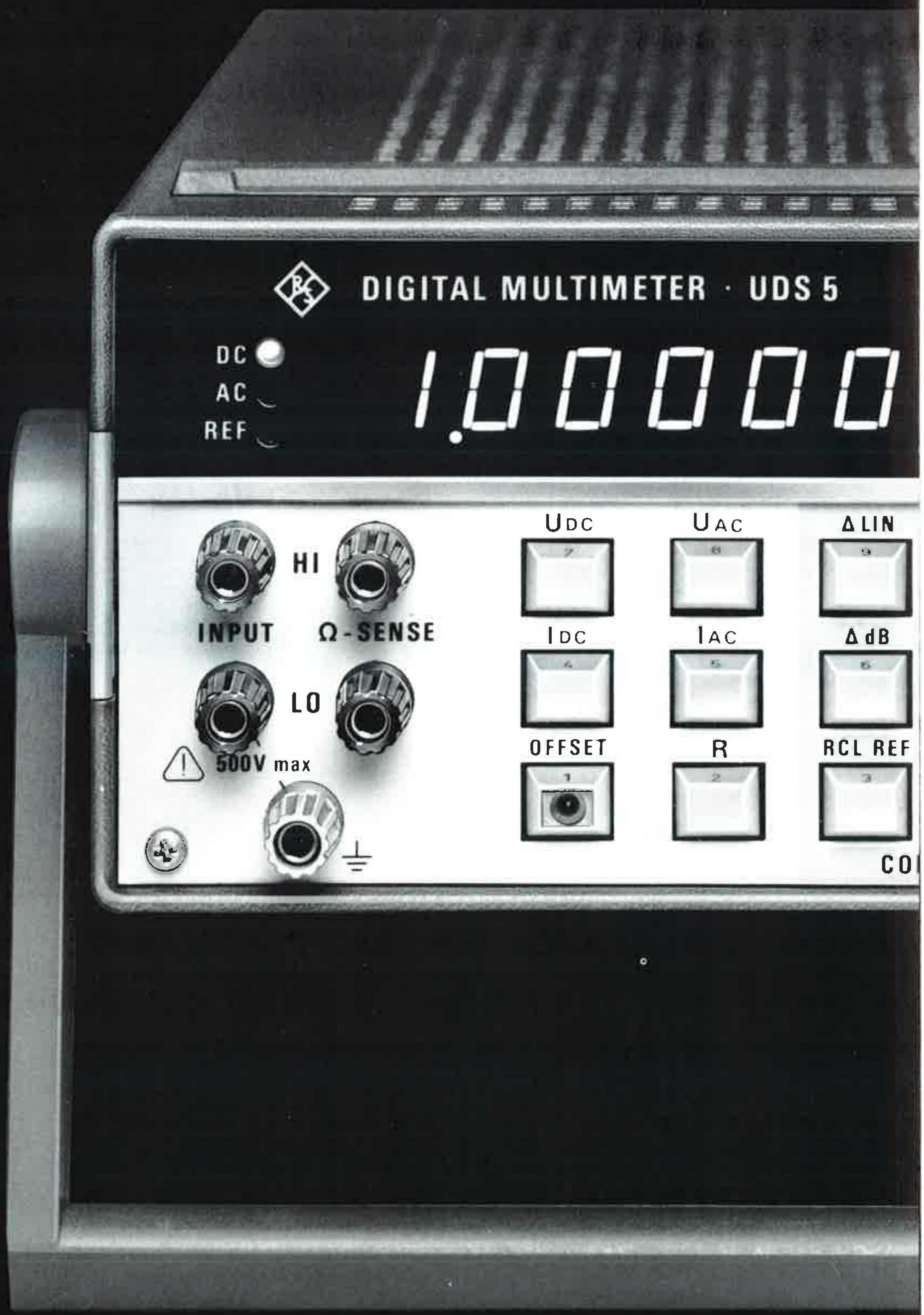
	Type and output frequency	
	XSE 1 to 5 MHz 5 to 10 MHz	**XSF** 5 MHz
Stability		
Freq. error with ambient temp. of 25 °C and rapid warmup		
after 1.5 min	$<1\times10^{-6}$	
after 4 min	$<1\times10^{-7}$	
after 7 (5) min	$<1\times10^{-8}$	$<1\times10^{-6}$
after 30 min		$<1\times10^{-8}$
Aging after 30 days of continuous operation	$<3\times10^{-9}/d$ $<2\times10^{-9}/d$	$<2\times10^{-10}/d$
Short-term drift for $\tau = 1$ s (standard deviation)		$\leq2\times10^{-11}$
Output EMF	>0.5 V	>0.5 V
Output impedance	500 Ω	500 Ω
S/N ratio (referred to 1-Hz bandwidth, spacing from carrier >100 Hz)	>110 dB >120 dB	>120 dB
Nominal operating voltage	10 to 30 V	10 to 30 V
Heater current (adjustable)	0.17 to 0.6 A	0.4 to 0.8 A
Average current requirement at +22 °C ambient temperature and		
V_s = 12 V	160 mA	175 mA
V_s = 24 V	80 mA	100 mA
Warmup time at 30 V, I_{max} +22 °C amb. temp.	1 min	3 min
General data		
Operating temperature range	−40 to +65 °C	−40 to +65 °C
Storage temperature range	−50 to +80 °C	−50 to +80 °C
Weight	200 g	300 g

Ordering information

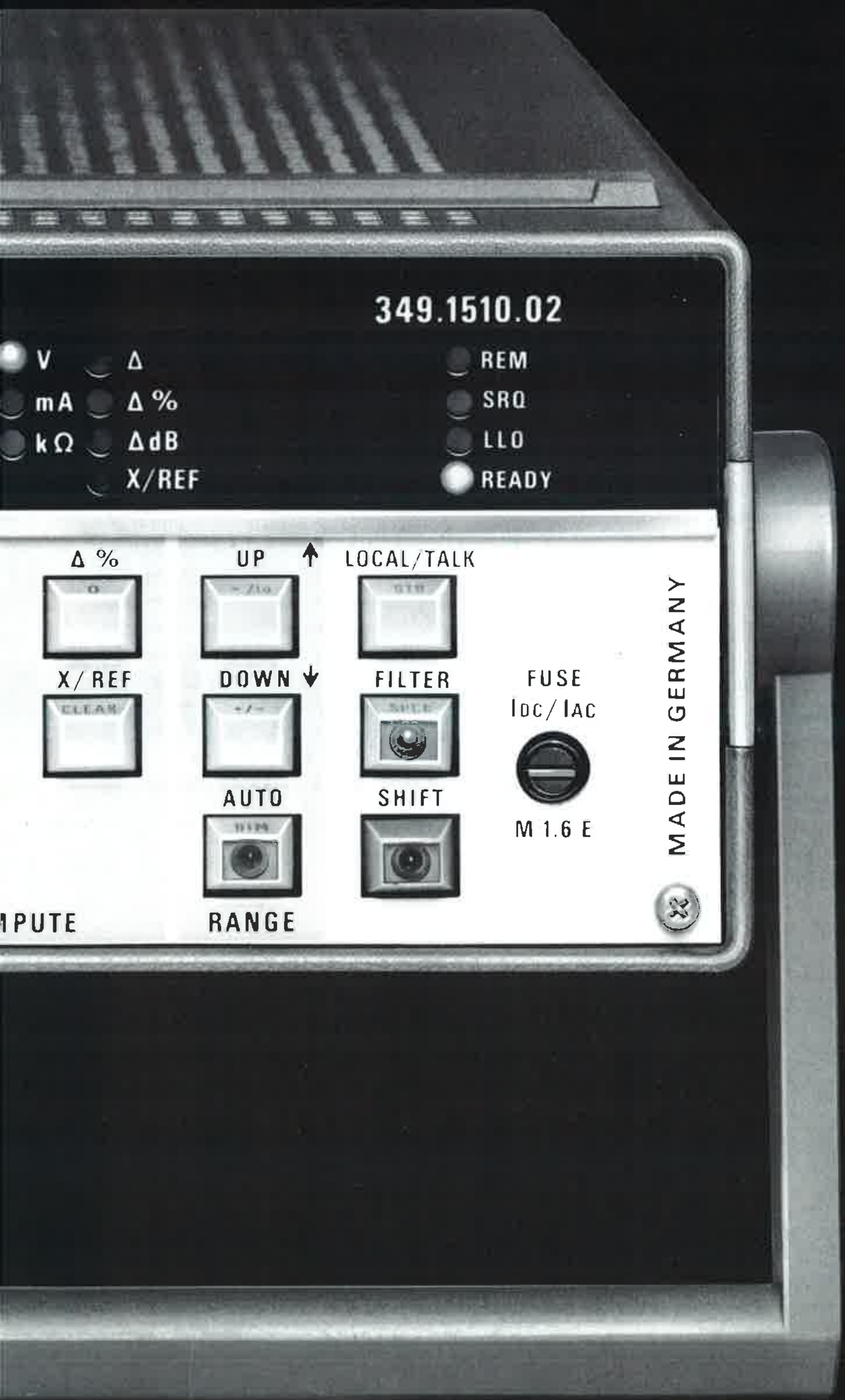
▶ **Order Nos.**		
1 MHz output frequency	100.7641.02	100.5578.02
5 MHz output frequency	100.7641.05	
10 MHz output frequency	100.7641.10	
PAL colour subcarrier	100.7641.04	
Other frequencies	100.7641.49	

(please specify frequency in order)

Digital Multimeter UDS 5,
DC 1µV to 1200 V,
AC 500 µV to 800 V (20 Hz to 200 kHz),
IEC-bus-compatible;
details on page 182



voltmeters · power meters



Electronic voltmeters

Rohde & Schwarz makes voltmeters of high sensitivity and for applications over a very wide frequency range. In addition to the indicator section these instruments comprise **electronic circuitry** such as broadband and selective amplifiers, mixers, oscillators, log converter circuits and rectifiers.

All the models presented in this catalog are electronic voltmeters; they are tabulated in two main groups, each possessing particular common features:

1. DC and broadband voltmeters
2. Selective voltmeters (section 7)

Whereas the selective voltmeters are dealt with separately in section 7 of this catalog, all **DC and broadband voltmeters,** both with analog and digital readout and including system units, are described in the present section.

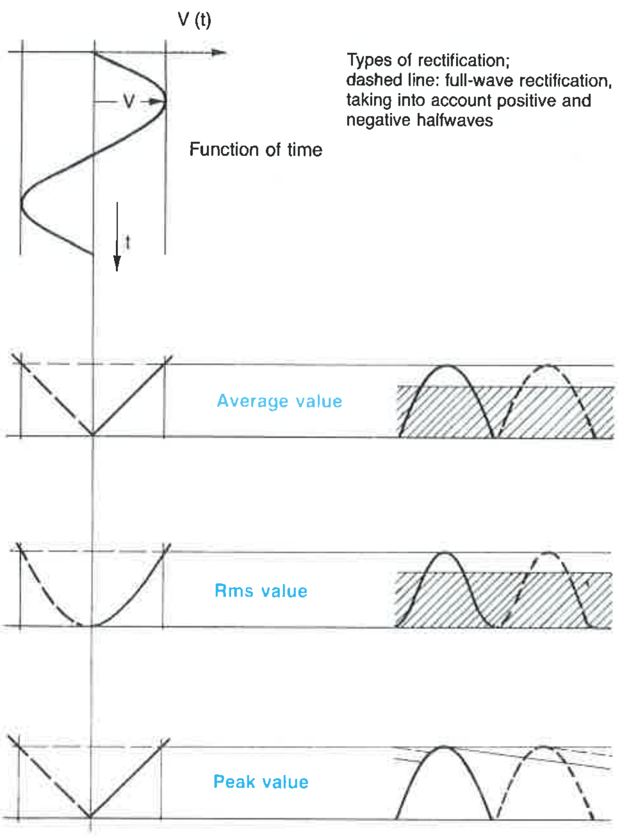
The **table on page 178** gives an overview, the broadband voltmeters being listed according to their use as digital multimeters, DC voltmeters, AC/RF voltmeters.

Following the general description of voltmeter features, the characteristics typical of each group are briefly outlined.

General characteristics of voltmeters

Meter rectifiers

An AC voltage must be rectified for measurement. Three types of rectification are distringuished according to the weighting of the waveform: average, response, rms response and peak response.



Types of rectification; dashed line: full-wave rectification, taking into account positive and negative halfwaves

Average-responding rectification (see diagram below left). The average value (V_{av}) of an AC voltage is the integral of the magnitude of the AC voltage over a period of time; this corresponds to the area between the function of time and the zero line, averaged over the period of observation T_i. Voltmeters with average-responding rectifier are calibrated so that they indicate the rms value for sinewave voltages. The voltmeters UDL 3 and UDS 6 are fittet with an average-responding rectifier and can be optimally used where sinewave AC voltages are to be measured; superimposed noise voltages are not entered into the measurement result as long as they are sufficiently small against the useful signal and comply with the following requirement: $V_{useful} \times f_{useful} > V_{noise} \times f_{noise}$ (valid for $f_{useful} < f_{noise}$)

RMS-responding rectification. The rms value (V_{rms}) is derived from the squares of the momentary voltages, averaged over the period of observation T_i. The square root is taken mainly to achieve a linear scale characteristic. The parabolic curve required for squaring is obtained through a circuit developed and patented by Rohde & Schwarz, whose outstanding features are high accuracy, a high crest factor and a wide frequency range. The Psophometer UPGR and the RMS Voltmeter URE from R&S operate on this principle. The URE is also able to measure the true rms value of AC+DC voltages. Voltmeters using rms-responding rectification are: UDL 4, UDS 5, UPGR, URE and (for low test voltages) URV, URV 3, URV 4.

Peak-responding rectification. Voltmeters with peak-responding rectifiers measure the peak value of the momentary voltage. They have a storage capacitor which is charged up to the peak value and discharged slowly so that there is sufficient time for reading. Distinction is made between positive (V_{p+}) and negative (V_{p-}) peak-responding rectification as well as peak-to-peak rectification (V_{pp}). The psophometer contains a peak-responding rectifier with defined rise and fall time constants for weighted noise measurements (quasi-peak-responding rectifier); the value $V_p/\sqrt{2}$ is indicated, i.e. the rms value for sinewaves. For test voltages >1 V the voltmeters URV, URV 3, and URV 4 measure the peak-to-peak value and indicate $V_{pp}2/\sqrt{2}$.

Rectification modes

Signal shape	Average value	Rms value	Peak value
General	$V_{av} = \frac{1}{T_i}\int_0^{T_i} \lvert v(t) \rvert \, dt$	$V_{rms} = \sqrt{\frac{1}{T_i}\int_0^{T_i} v^2(t)\, dt}$	$V_{pp} = V_{p+} + V_{p-}$
Sinewave	$V_p \times \frac{1}{\pi}\int_0^{\pi} \sin \omega t \, d\omega t$ $= V_p \times 0.638$	$\sqrt{V_p \times \frac{1}{\pi}\int_0^{\pi} \sin^2 \omega t \, d\omega t}$ $= V_p \times 0.707$	$2 \times V_p$ $V_p = V_{p+} = V_{p-}$
R&S voltmeters	UDL 3, UDS 6	URE, UPGR, UDL 4, UDS 5, (URV 3, 4)	UPGR (URV 3, 4)

Test signal shapes, factors

Crest factor C is the ratio of peak value to rms value of an AC voltage

$$C = \frac{|\text{peak value}|}{\text{rms value}} = \frac{|V_p|}{V_{rms}}$$

and is an essential criterion mainly for measuring non-sinusoidal AC voltages in which large short-time amplitudes alternate with longer intervals, so that high peak values are prevailing and the rms values are low. The measuring instrument must be able to transfer the peak amplitudes free of distortion to ensure error-free measurement.

Form factor F is the ratio of rms value to average value

$$F = \frac{\text{rms value}}{\text{average value}} = \frac{V_{rms}}{V_{av}}$$

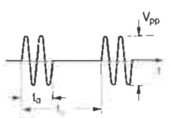
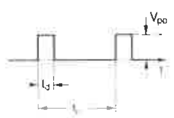
This factor is relevant for instruments with average-responding rectifier. Since the form factor for sinewave signals is

$$F = \frac{0.707}{0.637} = 1.11$$

The scale of such instruments is usually multiplied by a factor 1.11 so that for sinewave voltages the rms value can be read off. With different waveforms errors do however occur. A symmetrical squarewave for instance has the form factor $F = \frac{1}{1} = 1$, rms and average value are identical and the reading error for the rms value is +11%.

AC voltage functions
Sinewave/squarewave pulses

Terms and relationships of the two basic AC voltage functions, i.e. sinewave and squarewave pulses:

Term	Sinewave pulses	Squarewave pulses
		
Reciprocal duty cycle Duty cycle	$r = \frac{t_p}{t_d}$ $g = \frac{1}{r} = \frac{t_d}{t_p}$	t_d = pulse duration t_p = pulse period
Crest factor	$C = \sqrt{\frac{2}{g}} = \sqrt{2 \times r}$	$C = \sqrt{\frac{1}{g} - 1} = \sqrt{r - 1}$
Form factor	$F = \frac{\pi}{2} \times \frac{1}{\sqrt{2 \times g}}$ $= \frac{\pi}{2} \times \sqrt{\frac{r}{2}}$	$F = \frac{1}{2 \times \sqrt{g - g^2}}$ $= \frac{1}{2 \times \sqrt{\frac{1}{r} - \frac{1}{r^2}}}$
Average value	$V_{av} = V_{pp} \times \frac{g}{\pi}$	$V_{av} = V_{pp} \times 2\,(g - g^2)$
Rms value	$V_{rms} = V_{pp} \times \frac{1}{2}\sqrt{\frac{g}{2}}$	$V_{rms} = V_{pp} \times \sqrt{g - g^2}$

Input impedances

In electronic **voltmeters with amplifier input** the input impedance is generally well defined and can be represented by a resistance and a lossy capacitance in parallel. **Broadband voltmeters** normally have an input impedance of about 10 MHz shunted by 30 pF (e.g. URE). This amounts to ≈50 Ω at 100 MHz. The parallel capacitance of any connected coaxial cable (30 to 100 pF) makes the input impedance still lower. Improvement of the input conditions is possible using a **voltage divider probe.**

Diode probes include a capacitively coupled half-wave rectifier. Their input capacitance of ≈2 pF can be reduced to about 0.5 pF by plug-in dividers, but this involves a loss in sensitivity. Diode probes permit measurements with high impedance at frequencies up to 1 GHz.

Digital voltmeters for DC voltage measurements usually have an input impedance of 10 MΩ, high-grade instruments with R_{in} >10 GΩ permitting also measurement of voltages up to 16 V (UDS 5) or 14 V (UDS 6) without any loading. With a measurement range of 100,000 digital steps and an input impedance of 10 MΩ, a source impedance of 100 Ω causes an additional error in indication of 1 digit. The extremely high input impedance of >10 GΩ is therefore very important for measurements on sources with high impedances.

Noise voltages, reference potential

The voltage of a test point to common return (ground, earth) is to be determined in most measurement.

If both the test voltage source and the voltmeter are earthed through the earth conductor of the AC supply, noise pickup may result in the test circuit. This can often be remedied by plugging the source and the voltmeter into a twin wall socket.

Measurements using a broadband voltmeter are invalidated by noise voltages. The erroneous results is not immediately recognized unless the test voltage can be reduced to 0.

Noise pickup does not occur in a voltmeter with floating input, a facility required for measurements between two test points which both have a voltage to earth.

Measurements on balanced audio-frequency transmission systems call for instruments with balanced test input and high common-mode rejection.

A noise voltage may also originate in the input stages of the voltmeter and affect the result, especially in the most sensitive ranges. For example, a noise voltage of about 15 μV whose spectrum lies mainly below 10 kHz is produced in the amplifier input of a voltmeter with 1 MΩ ||30 pF. This noise component is negligible if the voltage source has a low impedance (e.g. 50 Ω).

Noise voltages

With **digital voltmeters** the suppression of noise voltages (e.g. AC hum) is dependent on the type of analog/digital conversion. With integrating A/D converters and suitable selection of the integration time, which must be exactly one or several AC periods, the AC hum suppression can be optimized.

Broadband voltmeters

DC voltmeters

The test signal (test voltage) passes through a DC amplifier of selectable gain and is applied to the meter.

A chopper amplifier first changes the test voltage into an AC voltage, which is amplified and then rectified in a synchronous rectifier. The chopper amplifier is outstanding for its low zero drift and is therefore used in DC voltmeters of very high sensitivity (UIG, URV).

Broadband voltmeters with rectifier input

A rectifier which covers a wide voltage range changes the unknown AC voltage into a DC voltage. This DC voltage is processed in the basic unit and indicated. The broadband coverage of this voltmeter type depends on the mechanical design of the meter rectifier and on the RF characteristics of the rectifier diodes.

A probe (if necessary, with plug-in divider) incorporating a capacitively coupled half-ware rectifier is used for measurements on non-coaxial circuits. It features high input impedance and very low input capacitance. The voltage indication depends on the type of ground connection and on the source impedance of the test voltage source.

Measurements in coaxial circuits are carried out with the aid of coaxial RF insertion heads. They incorporate a diode detector inserted in the inner conductor or connected via a piston attenuator and permit broadband voltage measurements to be made up to 2 GHz with low reflection. With match-termination, the indicated voltage equals the voltage of the forward wave. The voltage indication with mismatch lies between twice the voltage of the forward wave and 0.

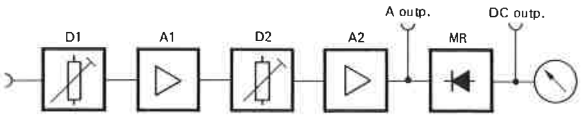
Broadband voltmeters with rectifier input measure the rms value of small test voltages up to 30 mV and the peak or peak-to-peak value (URV family) of voltages above 1 V. The meter reads the rms value of a sinewave in the entire measurement range.

The probes and insertion units of the millivoltmeters of the URV family have, in addition to the detector circuit for the RF voltage to be measured, a comparison detector of similar design to which the comparision voltage produced by a control loop in the basic unit is applied. The control loop provides for a voltage-proportional meter scale throughout the measurement range.

The measuring heads can be freely interchanged; the accuracy depends only on the degree of matching of the characteristics of the two diodes used in each measuring head for the measurement and comparison circuits. Any measuring head combined with any basic unit therefore complies with the data-sheet specifications.

Broadband voltmeters with amplifier input

Sensitive broadband (amplifier) voltmeters are normally designed according to the following principle:



Simplified diagram of an amplifier voltmeter

The high-impedance input divider D1 covers two or three steps and prevents overloading of the amplifier A1. This is followed by the low-impedance main divider D2 (10-dB steps). Both dividers together with the amplifiers A1 and A2 form a broadband amplifier which can also be used as a preamplifier (via amplifier output A outp.) for insensitive meters or recorders. The design of the final stage of the main amplifier depends on whether low-impedance or high-impedance driving of the meter rectifier MR and which type of rectification is used. The DC voltage output (DC outp.) permits the connection of a recorder or digital voltmeter.

Broadband voltmeters

with balanced amplifier input

The input section of the Psophometer UPGR consists of a balanced attenuator and a balanced amplifier which are accommodated in a shielding can and isolated from the rest of the circuitry by a broadband transformer and a transformer-coupled power supply. A high-impedance balanced input (100 kΩ) with very high common-mode rejection is thereby realized.

Weighted measurement of noise level

DIN, CCIR and CCITT specify weighted measurements for determining the noise levels in telephone and electroacoustic broadband transmission systems.

Simulation of the subjective noise effect is achieved with a psophometric weighting filter and the dynamic behaviour of the meter rectifier and movement.

The Psophometer UPGR permits noise voltage to be measured in compliance with the international standard recommendations.

Digital voltmeters and multimeters

With the development of digital multimeters digital measurement techniques have been applied in all fields of electronic and electrical engineering. LSI circuitry has allowed these instruments to become more compact and less expensive in spite of their higher degree of intelligence. Present day range of equipment encompasses simple pocket multimeters as well as system voltmeters with built-in memory and data manipulation functions.

Digital voltmeters offer some advantages as compared with analog-reading meters:

higher accuracy and resolution,
error-free reading,
greater operating convenience (auto-ranging),
system compatibility.

With short-time unstable voltages the purely digital indication may however be difficult to read and confusing. The combination of a digital display with an analog trend indication in a single unit – like in the Voltmeters URV 4 and URE from R&S – offers optimum operating convenience in such cases.

RMS Voltmeter URE; can also convert the measured values to different units

The RMS Voltmeter URE can read out the measured values in all customary units and can automatically calibrate itself. Thanks to the built-in, non-volatile memory all calibration data, the reference value and the reference impedance for readout in dBm are preserved when the instrument is switched off. The microprocessor-controlled error correction of the rms-value rectifier has made it possible to combine both high measurement speed and accuracy with wide bandwith.

The Digital Multimeter UDS 5 is a universal multimeter of high precision. Like the RMS Voltmeter URE it can display the measured values in different units and convert them into relative values. All measuring functions and ranges are calibrated via the built-in microprocessor. With a measuring rate of up to 80 measurements per second the UDS 5 is particularly suitable for use in systems.

Calculation and manipulation of measured data – a capability embodied in the intelligent System Voltmeter UDS 6 – opens up entirely new dimensions for measuring techniques; 10 built-in programs allow user-oriented display and evaluation of measured data, such as linearization of mechanical-electrical transducers and presentation of measured data in terms of mechanical quantities.

System voltmeters

The IEC bus, an international standard, makes it readily possible to set up automatic test assemblies using an IEC-bus controller, e.g. the Process Controller PUC.

The IEC-bus interfaces IEC 625-1 (IEEE 488) are already integrated into the latest models, as for instance in the Digital Multimeter UDS 5. The System Voltmeter UDS 6, the RMS Voltmeter URE and the RF Millivoltmeter URV 4 are available with IEC-bus interface on request. They cover a wide range of measurement tasks:

Precision measurement of DC voltage, AC current and resistance,

rms- or average-value measurements of AC voltages up to 200 kHz,

rms-value measurements of current up to 20 kHz,

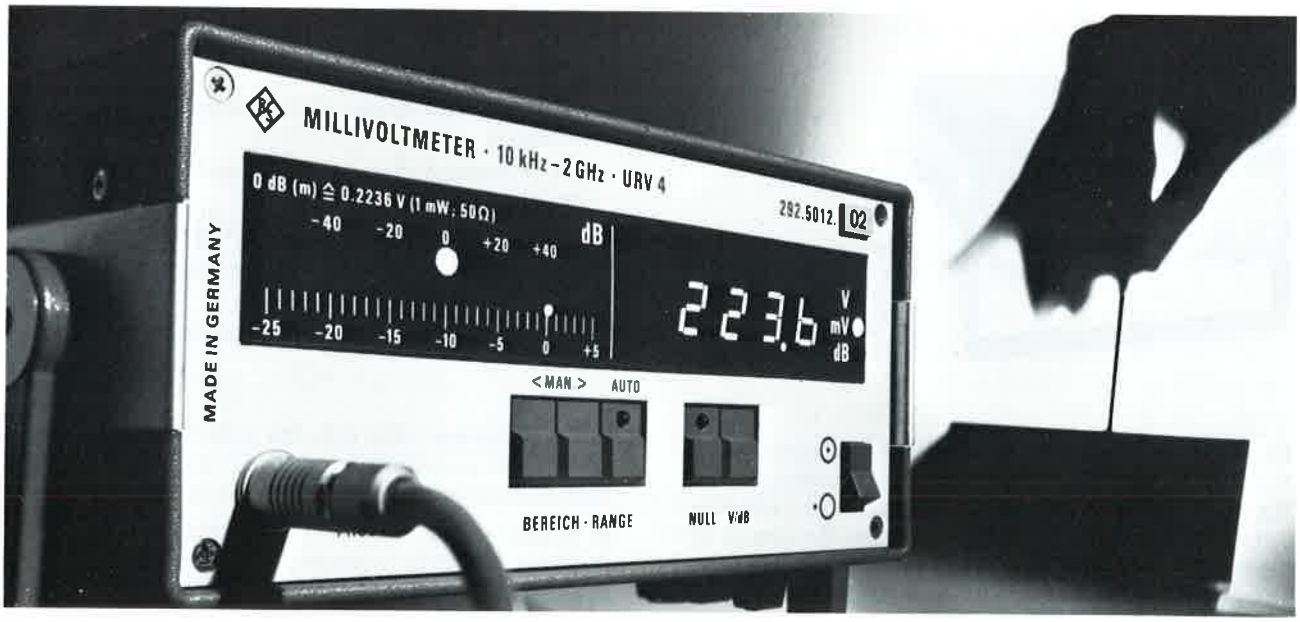
true rms-value measurements of AC and AC + DC voltages up to 20 MHz and

broadband measurements of RF voltages or levels up to 2 GHz.

With the Scanner UDS 6-Z1 the UDS 6 can form a test system with a maximum of 255 test channels which are controlled via the IEC-bus interface of the UDS 6.

In conjunction with other IEC-bus compatible instruments (overview in section 1) complex test assemblies for multiple applications and tasks can be set up.

Display (digits) Measured quantities	Designation	Type	Order No.	Measurement range	Resolution or fsd of lowest subrange	Error limits
Digital multimeters						
3½ V_{DC}, V_{AC} I_{DC}, I_{AC}, R	Digital Multimeter	UDL 3	346.7117.02	V: 100 µV to 1000 (700) V I: 1 µA to 2 A R: 100 mΩ to 20 MΩ	100 µV 1 µA 100 mΩ	0.1% 0.5% 0.2%
4½ V_{DC}, V_{AC} I_{DC}, I_{AC}, R	Digital Multimeter	UDL 4	346.7800.02	V: 10 µV to 1200 (1000) V I: 10 nA to 2 A R: 100 mΩ to 20 MΩ	10 µV 10 nA 100 mΩ	0.03% 0.2% 0.05%
5½ V_{DC}, V_{AC} I_{DC}, I_{AC}, R	Digital Multimeter	UDS 5	349.1510.02	V: 1 µV to 1200 V I: 100 nA to 1.6 A R: 1 mΩ to 16 MΩ	1 µV 100 nA 1 mΩ	0.003% 0.05% 0.004%
6½ V_{DC}, V_{AC} R	System Voltmeter	UDS 6	346.9210.02	V: 100 nV to 1100 V R: 100 µΩ to 14 MΩ	100 nV 100 µΩ	0.001% 0.001%
DC voltmeter						
DC voltage	DC Microvoltmeter	UIG	203.5111.02	0.2 µV to 320 V (30 kV) 1 pA to 320 mA	10 µV 10 pA	±1.5% —
AC/RF voltmeters						
15 Hz to 100 kHz	Psophometer	UPGR	248.1915.02	1 µV to 350 V −110 to +53 dB	10 µV	±2% —
10,000 steps I DC voltage II 10 Hz to 20 MHz	RMS Voltmeter	URE	342.1214.02	I 0 to +300 V II 50 µV to 300 V	1 µV 1 µV	0.1% +10 digits AC: see table page 204
I DC voltage II 10 kHz to 2 GHz	RF-DC Millivoltmeter	URV	216.3612.02	I 50 µV to 1050 V II 0.5 mV to 10.5 V (1050 V)	I 3 mV II 3 mV	I 1% II 1.5% of fsd (inherent error)
10 kHz to 2 GHz	Millivoltmeter	URV 3	302.9014.02	0.7 mV to 1050 V	3 mV	2% of fsd (inherent error)
4000 steps V_{AC}/level 10 kHz to 2 GHz	Millivoltmeter	URV 4	292.5012...	U: 700 µV to 1000 V V: −50 to +73 dBm	1 µV 0.01 dB	1% (inherent error)



VOLTMETERS OVERVIEW 6

Rectification (type of weighting)	Max. crest factor	Input impedance	Parallel capacitance	Special features	Dimensions in mm (W×H×D)	Text on page
Digital multimeters						
average		10 MΩ	100 pF	audible alarm	170× 89× 38	180
rms	5	10 MΩ	75 pF		216× 73× 225	181
rms	5.5	>10 GΩ 1 MΩ (V_{AC})	40 pF	**IEC-bus-compatible**	241× 110× 361	182
average		100 GΩ 1 MΩ (V_{AC})	150 pF	**IEC-bus-comp.** (with option) scanner available	443× 89× 465	188
DC voltmeter						
—	—	10/50 MΩ 1 Ω/1 kΩ/1 MΩ		max. gain 100 dB	162× 238× 302	198
AC/RF voltmeters						
peak rms	5	unbal. 1 MΩ bal. 600 Ω/ 10 kΩ/100 kΩ	40 pF	max. gain 70 dB	210× 184× 263	199
rms	5	10 MΩ	40 pF	**IEC-bus-compatible** DC output meas. value conversion	241× 110× 355	202
I — II peak rms		I 10 MΩ II probe or insertion unit	10 pF 2.5 to 0.5 pF	max. gain 50 dB	162× 238× 275	206
peak rms		probe or insertion unit	2.5 to 0.5 pF	recorder output	241× 110× 219	208
peak rms	10	probe or insertion unit	2.5 to 0.5 pF	**IEC-bus-compatible** log. recorder output	241× 110× 219	210

Photo left: URV 4
with digital and analog readout
of measured values (e.g. for adjustments)

UDL 3

Digital Multimeter UDL 3

♦ 100 µV to 1000 (700) V/1 µA to 2 A
100 mΩ to 20 MΩ

- 3½-digit multimeter with LCD-display – handy, built to take every-day rough usage and electrical overloads
- 29 ranges, full-scale reading of 1999; high precision: basic DC error just 0.1%
- Input impedance 10 MΩ
- Audible alarm for continuity, semiconductor and TTL testing
- Audible alarm during AC overload or accidental application of AC in ohms mode

Scale 1:2.5

The **Digital Multimeter UDL 3** is an extremely practical, small, battery-powered unit, which with its basic accuracy (0.1% error on DC) is as good as many a laboratory or bench instrument, yet which is also ideal for mobile/external applications thanks to its ruggedness, low weight (315 g) and large, high-contrast LCD display as well as to other advantages.

Range resolution. The UDL 3 has a total of 29 ranges, of which **DC and AC voltage** have five each with a maximum resolution of 100 µV.

DC and AC current have four ranges each, with a maximum resolution of 1 µA.

Resistance measurements can be made in six ranges up to 20 MΩ (19.99) with a high output voltage, or in five ranges with a low output voltage, with a resolution in the lowest range of 100 mΩ. When Hi-V is selected the opencircuit output voltage is around 2.8 V, and in the Lo-V mode around 250 mV.

Accuracy, display. The UDL 3 has an unusually high accuracy for an instrument in its price range. The maximum error ist just ±0.1% of reading +1 digit for DC and ±0.5% +4 digits for AC at frequencies between 50 and 500 Hz.

The large liquid crystal display (digits 13 mm high) is easy to read in all lighting conditions – including sunlight. The decimal point is positioned automatically; for negative voltages or currents a minus sign appears, otherwise the input is positive. If the input exceeds the range set then all the digits are blanked except for MSD, decimal point and sign.

An audible alarm is built into the UDL 3 for ease of use in the bottom three resistance ranges, to signal overload in the AC voltage ranges, to warn when AC voltage is applied by mistake when the unit is in the resistance mode, or when the input voltage is too negative.

Recommended extras

Carrying case UDL 3-Z1 .... 346.7317.02
Power supply UDL 3-Z2 .... 346.7369.02
Other accessories see under UDL 4 on page 181 and details on page 196.

Specifications

Voltage/current measurements

DC and AC **voltage** Nominal range	Resolution	DC and AC **current** Nominal range	Resolution
200 mV	100 µV	2 mA	1 µA
2 V	1 mV	20 mA	10 µA
20 V	10 mV	200 mA	100 µA
200 V	100 mV	2000 mA	1 mA
1000 V (700 V)	1 V	(Fused: 250 V/2 A)	

Maximum input voltage, DC ..... ±1000 V on all ranges
AC ...... 700 V_{rms}, 30 to 500 Hz, all ranges
630 V_{DC}, on 200-mV range
±1 kV_{DC}, on all other ranges
Input impedance .... 10 MΩ, for AC, in parallel with 100 pF
Error limits
DC voltage .... ±(0.1% of rdg +1 digit)
Temperature effect .... ±(0.01% of rdg +0.01% of range)/°C
AC voltage .... ±(0.5% of rdg +4 digits) for 50 to 500 Hz
±(1% of rdg +6 digits) at 30 Hz
Temperature effect .... ±(0.02% of rdg +0.02% of range)/°C
DC current .... ±(0.5% of rdg +1 digit)
Temperature effect .... ±(0.02% of rdg +0.01% of range)/°C
AC current .... ranges ≧20 mA
±(0.75% +4 digits) for 50 to 500 Hz
Temperature effect .... ±(0.03% of rdg +0.02%)/°C

Resistance measurements

Nominal range	Resolution	Output current at end of nominal range Hi-V	Lo-V
200 Ω	100 mΩ	2 mA	—
2 kΩ	1 Ω	1 mA	125 µA
20 kΩ	10 Ω	140 µA	12.5 µA
200 kΩ	100 Ω	14 µA	1.25 µA
2000 kΩ	1 kΩ	1.4 µA	125 nA
20 MΩ	10 kΩ	140 nA	12.5 nA

Maximum input voltage .... 500 V DC or AC
Open-circuit output voltage ...... 2.8 V (Hi-V), 250 mV (Lo-V)

Error limits	Hi-V	Lo-V
200-Ω range	±(0.2% +3 d)	—
2 to 2000 kΩ ranges	±(0.1% +1 d)	±(0.2% +2 d)
20 MΩ range	±(0.3% +1 d)	±(1% +2 d)

Temperature effect .... ±(0.01%/°C to 0.02%/°C)
Display .... 3½-digit LCD (digits 13 mm high), 1999 maximum count, floating point; polarity: minus if indicated, otherwise plus
Reading rate .... 2.5 readings/secound

General data

Operating temperature range .... 0 to +40°C
Power supply battery .... standard 9-V battery IEC 6F22; battery life 100 to 200 hours; alarm signal when battery has run down
AC supply .... via external power supply
Dimensions, weight (with batteries) .... 170 mm×89 mm×38 mm, 0.315 kg

Ordering information

Order designation .... ▶ Digital Multimeter UDL 3 346.7117.02
Accessories supplied .... test cable, terminals, battery

Digital Multimeter UDL 4 ♦ 10 μV to 1000 V/10 nA to 2 A 100 mΩ to 20 MΩ

UDL 4

- Inexpensive 4½-digit multimeter for lab and service applications; high resolution, wide range, excellent stability; CMRR >120 dB at DC
- 25 ranges; rms sensing; basic DC error as small as 0.03%
- AC supply or NiCd battery pack (charger is already installed)

Scale 1:2.5

The **Digital Multimeter UDL 4** provides laboratory accuracy, resolution, range and stability at a new low price for an instrument in this class.

The UDL 4 has circuitry for rms voltage and current measurements (20 Hz to 20 kHz, crest factors as high as 5). It can be powered either from a rechargeable battery pack or from the built-in AC line power supply, which doubles as battery charger. The UDL 4, light and easy to carry, is suitable for all lab and field applications.

Range, resolution. 25 ranges for DC voltages up to 1200 V and AC voltages up to 1000 V (both with maximum resolution of 10 μV), as well as DC and AC currents up to 2 A with up to 10 nA resolution, and resistance up to 20 MΩ with maximum resolution of 100 mΩ. Overranging up to 100%.

Accuracy. The basic error limits of just ±0.03% for DC voltage measurements and 0.4% for AC voltage measurements are outstanding for this class of instrument, as is the accuracy of 0.05% for resistance measurements up to 100 kΩ (0.1% at 1 MΩ).

Display. 7-segment LED, 11 mm high digits; polarity (+/−) displayed for all DC measurements. Overload indicated by blanking of all digits.

Extensive range of accessories. For use in many other applications, the capabilities of the UDL 4 can be expanded using accessories such as temperature sensors, current clamps and high-voltage probes: see recommended extras and details on page 196.

Recommended extras (* also suitable for use with UDL 3)

Carrying Case	UDL 4-Z1	346.8013.02
10-A Current Shunt*	UDL 4-Z2	346.8065.02
150-A Clamp-on Current Probe*	UDL 4-Z3	346.8113.02
1000-A Clamp-on Current Probe*	UDL 4-Z4	346.8165.02
19"-rack Adapter	UDL 4-Z5	346.8213.02
Temperature Probe*	UDL 4-Z6	346.8265.02
40-kV High-voltage Probe*	UDL 4-Z7	346.8313.02
NiCd Battery Pack	UDL 4-Z8	346.8365.02

For details see page 196

Specifications

Voltage/current measurements

DC/AC voltage Nominal range	Resolution	DC/AC current Nominal range	Resolution	Full scale display
100 mV	10 μV	100 μA	10 nA	199.99
1 V	100 μV	1 mA	0.1 μA	1.9999
10 V	1 mV	10 mA	1 μA	19.999
100 V	10 mV	100 mA	10 μA	199.99
1000 V	100 mV	1000 mA	100 μA	see below
(V_{DC}: 1200 V; V_{AC}: 1000 V)		(DC, AC: 1999.9 mA)		

Maximum inputs
- DC voltage: ±1200 V momentary, all ranges; ±1000 V continuous
- AC voltage: 1000 V_{rms} for 30 Hz to 10 kHz
- DC and AC current: limited to 2 A by fuse

Input resistance: 10 MΩ on all ranges; for AC, 75 pF in parallel

Error limits and interference rejection for

V_{DC}
- 100-mV range: ±(0.03% of input +2 d)
- Ranges ≧1 V: ±(0.03% of input +1 d)
- Temperature effect: ±(0.003% of input +0.001% of range)/°C
- CMRR: >120 dB at DC, >100 dB at 50 Hz
- Normal mode rejection ratio: 60 dB at 50 Hz

		Reading error (±)	Temp. effect (±)/°C
V_{AC}	50 to 500 Hz	0.4% of input +20 d	0.02% of input +0.02% of range
	2 to 20 kHz	1% of input +20 d	0.1% of input +0.02% of range
I_{DC}	Up to 10-mA range	0.1% of input +1 d	0.01% of input +0.001% of range
	Ranges ≧100 mA	0.2% of input +1 d	0.02% of input +0.001% of range
I_{AC}	50 Hz to 1 kHz	0.75% of input +20 d	0.03% of input +0.02% of range
	5 to 20 kHz	1.5% of input +20 d	0.1% of input +0.02% of range

Resistance measurements

Nominal range	Full scale display	Resolution	Max. current
1 kΩ	1.9999 kΩ	100 mΩ	1.8 mA
10 kΩ	19.999 kΩ	1 Ω	330 μA
100 kΩ	199.99 kΩ	10 Ω	35 μA
1000 kΩ	1999.9 kΩ	100 Ω	3.5 μA
10 MΩ	19.999 MΩ	1000 Ω	0.35 μA

Max. input voltage: 500 V DC or AC
Maximum open circuit voltage: 3.5 V

Error limits/temp. effect	of input (±)	of input (±)/°C
Range ≦100 kΩ	0.05% +1 d/	0.005% +0.001% of range
1000 kΩ	0.1% +1 d/	0.01% +0.001% of range
10 MΩ	0.25% +1 d/	0.02% +0.005% of range

Reading rate: 2.5 readings/secound

General data

Operating temperature range: −10 to +55 °C (0 to +40 °C using NiCd battery pack)
Power supply AC supply: 210 to 250 V, 47 to 400 Hz (3 VA)
battery: NiCd battery pack, to be ordered separately, 6 hours approx. between charges
Dimensions, weight: 216 mm×73 mm×225 mm, 1.1 kg

Ordering information

Order designation: ▶ Digital Multimeter UDL 4 346.7800.02

Accessories supplied: test cable, terminals, power cable

UDS 5

Digital Multimeter UDS 5

◆ 1 µV to 1200 V/100 nA to 1.6 A
1 mΩ to 16 MΩ

- AC, DC, resistance measurements with selectable readout in 3½, 4½ or 5½ digits
- Autocalibration for all functions
- Error 0.003% for V_{DC}, 0.25% for V_{AC}, 0.004% for R
- 80 measurements/second for V_{DC}, 3½ digits
- Linear, logarithmic or relative reading with freely selectable reference
- IEC-bus-compatible

Scale 1:2.5

IEC 625 Bus

new

The **Digital Multimeter UDS 5** is an extremely cost-effective intelligent and high-speed 5½-digit instrument with convenient readout. With its integrated IEC-bus interface it is fully system-compatible. Its compact design makes the UDS 5 ideal for use on the bench and in the rack.

Measurement functions

V_{DC}	● DC voltage
V_{AC}	● AC voltage, true rms measurement
I_{DC}	● DC current
I_{AC}	● AC current, true rms measurement
R	● resistance

These keys are used to select the measurement functions of the UDS 5. The corresponding unit V, mA or kΩ and the mode AC or DC are simultaneously displayed.

Display of measured value. The display panel of the UDS 5 is divided into several sections. A 7-segment LED display can be selected to read out 3½, 4½ or 5½ digits (details on page 184).

The LED array to the left of the display indicates AC or DC mode or reference. The LED array to the right of the display indicates the unit: V, mA, kΩ, ΔV, ΔmA, ΔkΩ, Δ%, ΔdB or X/REF.

Blinking of the display shows that the result is invalid, for example, because the range is exceeded in the functions V_{DC}, V_{AC}, I_{DC} and I_{AC}. When the range of resistance measurement is exceeded, an overflow indication appears.

The outer right LED array indicates the status of IEC-bus operation:

REM	remote
SRQ	service request
LLO	local lockout (switchover to manual not possible)
READY	value in output store valid

Measurement rate and display range. The UDS 5 features three different measurement rates, which are coupled to the integration time of the A/D converter and therefore involve displays of 3½, 4½ or 5½ digits.

The FILTER key is used to switch the lower two measurement rates. The highest rate (3½-digit display) can be selected via the IEC-bus or using special function 3. Up to 80 measurements/s are possible for V_{DC} in this mode. The shortest measurement duration with triggered operation is 15 ms with functions-dependent transient times being taken into account internally. The first value triggered and measured is thus correct. The highest resolution is obtained for 5½ digits with a maximum of 160000 steps (5 measurements/s for V_{DC}).

Measurement processing

ΔLIN ● measured value – reference

ΔdB ● $20 \log \frac{\text{measured value}}{\text{reference}}$

Δ% ● $100 \times \frac{\text{measured value} - \text{reference}}{\text{reference}}$

X/REF ● $\frac{\text{measured value}}{\text{reference}}$

These keys permit the measurement to be represented as different forms of relative values.

A measured value or a value entered via the keypad (second key functions) may serve a reference. Three reference values, one each for voltage, current and resistance, can be stored. These values can be transferred to the non-volatile memory using special function 2.

The reference values stored in the UDS 5 are read out on the display through the RCL REF key.

OFFSET ● measured value – offset

Using this key the displayed value can be subtracted from all subsequent measurements, thus suppressing unwanted offset voltages (zero correction with freely selected zero level).

Measurement – range selection is possible in three different ways:

1. Automatic range selection
   – AUTO key on
2. Locking of the selected measurement range
   – AUTO key off
3. Variation of the measurement range in steps
   – by pressing the UP↑ and DOWN↓ keys.
   When the UP↑ or DOWN↓ key is pressed, the nominal value of the new measurement range is momentarily displayed.

Second key functions. Pressing the SHIFT key activates the second key functions for numerical data entry and special functions (SPEC depressed):

0 ● Display test
1 ● Entry and checking of IEC-bus address
2 ● Permanent storage of reference values
3 ● 3½-digit measurement display
4 ● Calibration date (autocalibration)
5 ● Error message
6 ● Software check
... ● Check and test programs

Autocalibration. The calibration consists in the adjustment of the complete instrument for a total of 20 measurement ranges from the front panel or via the IEC-bus. It is only necessary to call up calibration function, enter nominal value, apply calibration voltage, current or resistance to the input terminals and to start calibration.

The calibration can be performed in any sequence or only for some of the measurement ranges. The calibration factors are retained in non-volatile memory and protected against inadvertent alteration.

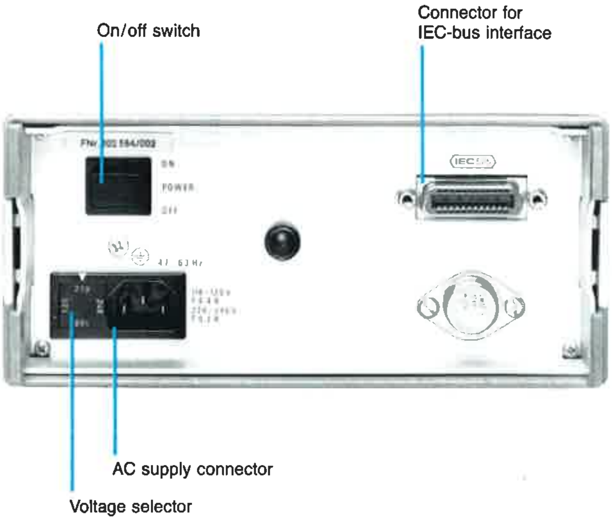
This reliable and intelligent autocalibration reduces maintenance times to minutes, affords high stability (no potentiometers) and enhances availability.

Measurement processing. The UDS 5 is a state-of-the-art multimeter offering:

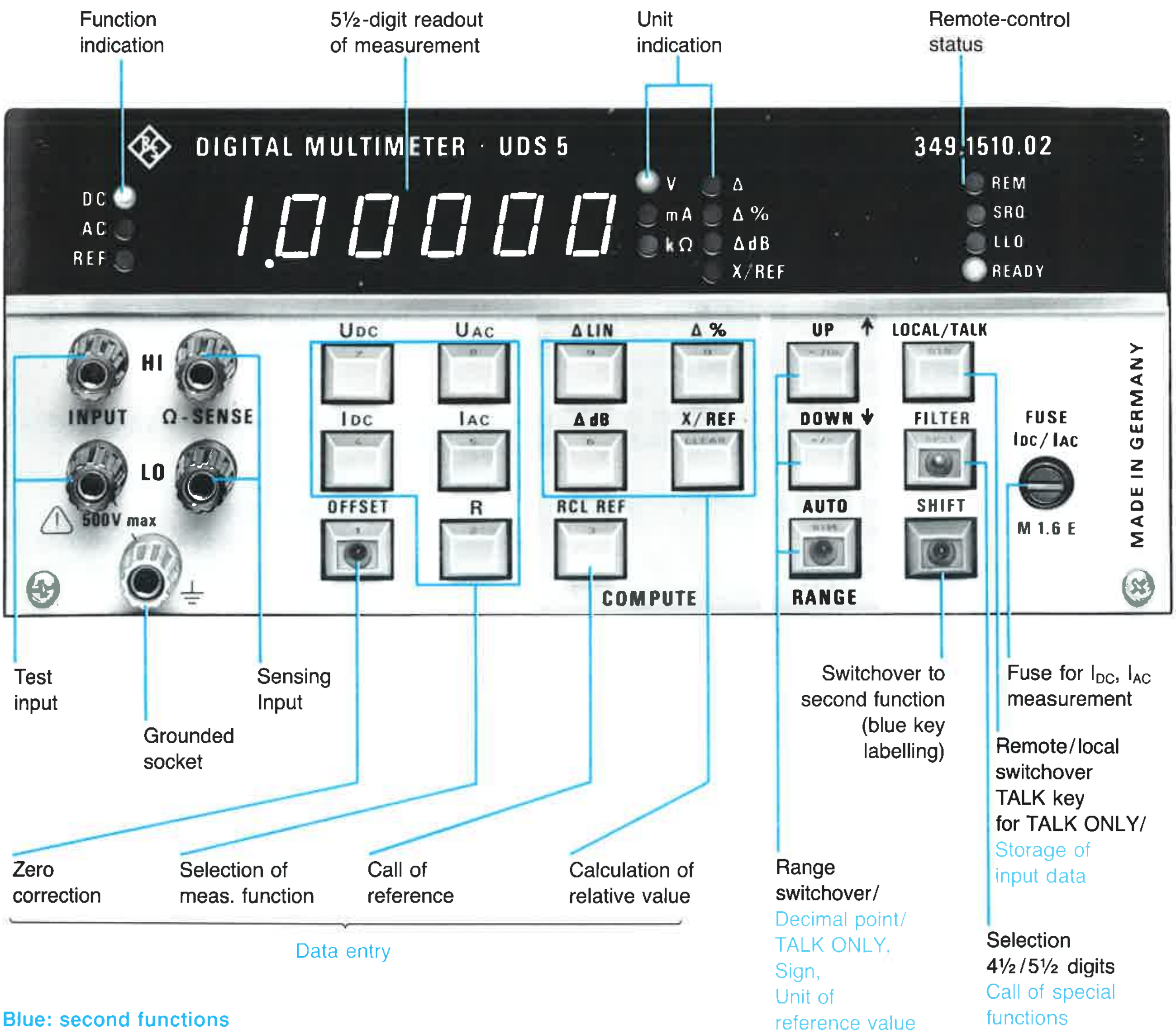
- High-impedance DC voltage mesurement >10 GΩ up to 16 V, 10 MΩ up to 1200 V
- True rms weighting of AC voltags and AC currents
- Integrating pulse-width conversion technique for high noise rejection
- Three different integrating times: 2, 20 and 200 ms
- Analog section with floating input via optocoupler

The integration times of 20 and 200 ms provide effective rejection of hum with DC voltage, DC current and resistance measurements (50 Hz at 20 and 200 ms, 60 Hz at 200 ms).

Construction. The Digital Multimeter UDS 5 is housed in a compact all-metal casing, which in conjunction with the shielded IEC-bus connector reduces radio interference. The well-organized layout on three circuit boards – analog section, processor, display/keyboard – together with comprehensive test and self-test programs makes servicing particularly easy.



Rear-panel details



Blue: second functions

Operation

Selection of display length

4½ ⇆ 5½ digits — 4½ ⇄ FIL-TER ⇄ 5½

3½ (4½) digits — SHIFT SPEC 3
→ 3½ → FIL-TER → 4½

Call of special function
e.g. LED test — SHIFT SPEC 0

IEC-bus address
Display of selected address — SHIFT SPEC 1 → SHIFT

Entry, e.g. 25 — SHIFT SPEC 1 2 5 STO

Reference value

Indication of funtion-dependent reference — RCL REF → RCL REF

Storage of reference, e.g. 100 (V, mA, kΩ depending on function) — SHIFT 1 0 0 STO

Retaining actual measurement as reference — SHIFT STO

Example: Current measurement acc. to $I = \frac{V}{R}$

R → Measurement R → SHIFT (Unit R) DIM (Unit V) STO UDC X/REF → Measurement V Indication X/REF → Interpretation in mA

Retaining three reference values in non-volatile memory — SHIFT SPEC 2

Remote control

The following tables list the functions, instructions and outputs for remote control of the Digital Multimeter UDS 5 from a controller via the IEC-bus. Further instructions provide for autocalibration and for the special functions.

Setting commands

Command	Function
C1	Basic setting: (DCL, SDC after addressing) FØ, NØ, OØ, UØ, RDUØ, W3, QØ, Y1
FØ F1 F2	Readout 5½ digits 4½ digits 3½ digits
NØ N1	Output with / without alphaheader
OØ O1	Offset calculation off on
UØ U3 U4 U5 U6	Direct (V, mA, kΩ) Δ LIN Δ% Δ dB X/REF } referred to function-dependent reference } Output unit
YØ Y1	Auto Zero off on
Y?	Query whether Auto zero on or off (SRQ generated with suitable coded SRQ byte)
RDU, RDUØ RDU1 RDU2 RDU3 RDU4 RDU5	Autoranging V_{DC} V_{DC} range 0.1 V 1 V 10 V 100 V 1000 V
RAU, RAUØ RAU1 to RAU5	Autoranging V_{AC} Ranges as for V_{DC}
RDI, RDIØ RDI1 RDI2	Autoranging I_{DC} I_{DC} range 10 mA 1000 mA
RAI, RAIØ RAI1 RAI2	Autoranging I_{AC} I_{AC} range 10 mA 1000 mA
RR, RRØ RR1 RR2 RR3 RR4 RR5 RR6	Autoranging R R range 0.1 kΩ 1 kΩ 10 kΩ 100 kΩ 1000 kΩ 10,000 kΩ

Interface commands

Command	Function
WØ W1 W2 W3 W4 W5 W6 W7 W8	NL CR ETX CR + NL EOI NL + EOI CR + EOI ETX + EOI CR + NL + EOI } Delimiters for string output
QØ Q1	SRQ function off on
H1	Auxiliary control character (PET timeout correction)

Data entry commands

Command	Function
DU/datum/ DI/datum/ DR/datum/	Reference for V_{DC}/V_{AC} measurement Reference for I_{DC}/I_{AC} measurement Reference for resistance measurement

Start commands

Command	Function
XØ X1 X2 X3 X4 X5	Clear command for X3/X4 Trigger command (= GET) Trigger command + retaining of measurement for reference Setting command for triggering on call of measurement Setting command for continuous triggering Trigger command + retaining of measurement as offset + offset calculation on
ZØ Z5	Output of reference according to function (V, I, R) Output of offset

Special commands

Command	Function
SØ S4 S5	LED test Display of date and condition of calibration according to function (V_{DC}, V_{AC}, I_{DC}, I_{AC}, R) Indication of any hardware malfunction in coded form

Delimiters

Symbol	Designation	ASCII decimal equivalent	Recommended use
,	Decimal point	44	Separator between commands
CR	Carriage return	13	End delimiters
NL	New line	10	End delimiters
ETX		3	End delimiters
EOI	Setting of the EOI line by the last character sent is also recognized as delimiter		

Service Request

Instrument status	Status byte (decimal)
Measured value ready	80
One of several text lines ready	85
Calibration value retained	86
Automatic offset on	87
Automatic offset off	88
Syntax error	96
Input datum error	98
Controller call for measurement without trigger	99
Hardware error	100
UDS 5 not ready for output	101
Calibration error	113

UDS 5 – Digital Multimeter

Specifications

DC voltage measurement

Nominal range	Resolution 5½ digits	Resolution 4½ digits	Resolution 3½ digits	Maximum reading (5½ digits)	Error limits at T_{cal}[1]), 5½ digits ± (% of rdg + counts) 24 h, ±1°C	3 months, ±5°C	1 year, ±5°C	Input resistance
0.1 V	1 µV	10 µV	100 µV	.160000 V	0.004 +2[2])	0.010 +2[2])	0.012 +2[2])	>10 GΩ
1 V	10 µV	100 µV	1 mV	1.60000 V	0.003 +2	0.009 +2	0.011 +2	>10 GΩ
10 V	100 µV	1 mV	10 mV	16.0000 V	0.003 +1	0.007 +1	0.009 +1	>10 GΩ
100 V	1 mV	10 mV	100 mV	160.000 V	0.004 +2	0.012 +2	0.016 +2	10 MΩ
1000 V	10 mV	100 mV	1 V	1200.00 V	0.005 +1	0.010 +1	0.014 +1	10 MΩ

Maximum input voltage
Hi to Lo, Hi to ground .... 1200 V peak
Lo to ground .... 500 V peak

Noise rejection DC, 50 (60) Hz ±0.05%

in dB with 1 kΩ in Lo lead

	Normal mode AC	Common mode AC	Common mode DC
5½ digits	64 (64)	130 (130)	>120
4½ digits	64 (14)	130 (80)	>120
3½ digits	—	65	>120

Temperature coefficient, ± (% or rdg + count)/°C

Range		
0.1 V	0.0005	+1
1 V	0.0005	+0.1
10 V	0.0004	+0.1
100 V	0.0007	+0.1
1000 V	0.0007	+0.1

Measurement rate (without range switching)

	Digits 5½	4½	3½
Manual operation	5/s	33/s	80/s
Computer control: interval between trigger and output of first byte[3])	216 ms	33 ms	15 ms

AC voltage measurement – true rms

Nominal range	Resolution 5½ digits	Resolution 4½ digits	Resolution 3½ digits	Maximum reading (5½ digits)	Input impedance
0.1 V	1 µV	10 µV	100 µV	.160000 V	
1 V	10 µV	100 µV	1 mV	1.60000 V	
10 V	100 µV	1 mV	10 mV	16.0000 V	1 MΩ ‖40 pF
100 V	1 mV	10 mV	100 mV	160.000 V	
1000 V	10 mV	100 mV	1 V	800.00 V	

Error limits over 1 year

Range	Error limits at T_{cal}[1]) ±5°C, 5½ digits, V >1% of nominal range sinewave voltage, ± (% of rdg + counts) 20 to 50 Hz	50 to 100 Hz	100 Hz to 10 kHz	10 to 20 kHz	20 to 50 kHz	50 to 100 kHz	100 to 200 kHz
0.1 V	2.4 +100	0.5 +100	0.30 +120	0.45 +120	1.2 +300	5 +900	20 +3000
1 to 350 V	1.8 + 50	0.5 + 50	0.25 + 70	0.35 + 70	0.7 +250	2.5 +850	10 +3000
350 to 800 V	2.0 + 50	0.6 + 50	0.40 + 70	0.50 + 70	0.9 +250	2.7 +850	— —

For 4½ digits: 1/10 number of counts
For 3½ digits: 1/100 number of counts +1

Maximum input voltage
Hi to Lo, Hi to ground .... 1200 V peak
1000 V DC
Lo to ground .... 500 V peak

Temperature coefficient, ± (% of rdg + counts)/°C
Range 20 Hz to 20 kHz .... 0.015 +5
Range >20 Hz .... 0.040 +10

Crest factor .... 5.5 at nominal value (100 000)
3.5 at FS (160 000)

Common mode rejection
DC to 60 Hz .... >100 dB
with 1 kΩ in Lo lead .... >65 dB

Measurement rate (without range switching)

	Digits 5½	4½	3½
Manual operation (change of display)	5/s	30/s	50/s
Computer control: interval between trigger and output of first byte	750 ms	600 ms	600 ms
max. deviation (counts)[4])	50	5	1

DC current measurement

Nominal range	Resolution 5½ digits	Resolution 4½ digits	Resolution 3½ digits	Maximum reading (5½ digits)	Error limits at T_{cal}[1]), ±5°C, 5½ digits 1 year, ± (% of rdg + counts) I <0.5 A	I >0.5 A
10 mA	100 nA	1 µA	10 µA	16.0000 mA	0.05 +10	— —
1 A	10 µA	100 µA	1 mA	1600.00 mA	0.07 +10	0.1 +30

For 4½ digits: 1/10 number of counts
For 3½ digits: 1/100 number of counts +1

Temperature coefficient, ± (% of rdg + counts)/°C
Ranges 10 mA, 1 A .... 0.005 +2

Voltage drop
Range 10 mA .... <170 mV
Range 1 A .... <550 mV

Input protection .... 250 V max. (1.6-A fuse)

Measurement rate (without range switching)

	Digits 5½	4½	3½
Manual operation	2,4/s	18/s	50/s
Computer control: interval between trigger output of first byte[3])	420 ms	55 ms	20 ms

1) T_{cal} = 20 to 25°C, 23°C on delivery
2) With offset correction
3) Δ calculation or offset compensation adds 5 ms on average (1 to 10 ms). The first measurement is correct if triggering is coincident with the test-signal entry
4) First measurement (>10% of nominal range); triggering coincident with test-signal entry

AC current measurement – true rms

Nominal range	Resolution 5½ digits	4½ digits	3½ digits	Maximum reading (5½ digits)	Error limits at T_{cal}[1]) ±5°C, 5½ digits, I >1% of nominal range sinewave voltage, 1 year, ± (% of rdg + counts) 20 to 50 Hz	50 Hz to 10 kHz	10 to 20 kHz
10 mA	100 nA	1 µA	10 µA	16.0000 mA	2 +50	0.5 +70	1 +90
1 A	10 µA	100 µA	1 mA	1600.00 mA	2 +50	0.5 +70	1 +90

For 4½ digits: 1/10 number of counts
For 3½ digits: 1/100 number of counts +1

Temperature coefficient, ± (% of rdg + counts)/°C
Ranges 10 mA, 1 A .... 0.02 +5

Voltage drop
Range 10 mA .... <170 mV
Range 1 A .... <550 mV

Measurement rate (without range switching)

	Digits 5½	4½	3½
Manual operation (change of display)	5/s	30/s	50/s
Computer control: interval between trigger and output of first byte	750 ms	600 ms	600 ms
max. deviation (counts)[4])	50	5	1

Resistance measurement

Nominal range	Resolution 5½ digits	4½ digits	3½ digits	Maximum reading (5½ digits)	Error limits at Tcal[1]), 5½ digits ± (% of rdg + counts) 24 h, ±1°C	3 months, ±5°C	1 year, ±5°C	Test current/ max. voltage
0.1 kΩ	1 mΩ	10 mΩ	100 mΩ	.160000 kΩ	0.005 +2[2])	0.013 +2[2])	0.016 +2[2])	1 mA/7.5 V
1 kΩ	10 mΩ	100 mΩ	1 Ω	1.60000 kΩ	0.004 +2	0.012 +2	0.015 +2	1 mA/7.5 V
10 kΩ	100 mΩ	1 Ω	10 Ω	16.0000 kΩ	0.004 +2	0.012 +2	0.015 +2	100 µA/7.5 V
100 kΩ	1 Ω	10 Ω	100 Ω	160.000 kΩ	0.006 +2	0.017 +2	0.020 +2	10 µA/7.5 V
1000 kΩ	10 Ω	100 Ω	1 kΩ	1600.00 kΩ	0.006 +2	0.020 +2	0.025 +2	10 µA/23 V
10000 kΩ	100 Ω	1 kΩ	10 kΩ	16000.0 kΩ	0.020 +2	0.130 +2	0.140 +2	1 µA/23 V

Maximum input voltage
Hi to Lo (f <500 Hz) .... 350 V peak, 250 V rms
Hi, Lo to earth .... 500 V peak

Temperature coefficient, ± (% of rdg + count)/°C
Range 0.1 kΩ .... 0.0010 +1
1 kΩ, 10 kΩ .... 0.0010 +0.1
100 kΩ, 1000 kΩ .... 0.0023 +0.1
10000 kΩ .... 0.0160 +0.1

Measurement rate (without range switching)

	Digits 5½	4½	3½
Range 0.1 to 1000 kΩ			
Manual operation	2.4/s	15/s	50/s
Computer control, interval between trigger and output of first byte[3])	420 ms	55 ms	20 ms
Range 10,000 kΩ			
Manual operation	2.2/s	11/s	11/s
Computer control: interval between trigger and output of first byte[3])	460 ms	100 ms	100 ms

[1]) T_{cal} = 20 to 25°C, 23°C on delivery
[2]) With offset correction
[3]) Δ calculation or offset compensation adds 5 ms on average (1 to 10 ms). The first measurement is correct if triggering is coincident with the test-signal entry
[4]) First measurement (>10% of nominal range); triggering coincident with test-signal entry

Additional characteristics

Measurement functions .... DC voltage, AC voltage rms, DC current, AC current rms, Resistance

Measurement ranges
DC voltage .... 1 µV to 1200 V
AC voltage .... 500 µV to 800 V, 20 Hz to 200 kHz
DC current .... 100 nA to 1.6 A
AC current .... 10 µA to 1.6 A, 20 Hz to 20 kHz
Resistance .... 1 mΩ to 16 MΩ, automatic two-wire/four-wire switchover
Range setting .... automatic or manual

Reference value .... key entry or actual measurement

Zero correction .... using offset key

Autocalibration .... from front panel or IEC bus for all measurement functions

Second key functions .... for data entry, entry and checking of IEC-bus address, test programs and autocalibration

Remote control .... IEC bus (IEC 625-1/IEEE 488)
Interface functions .... SH1, AH1, T5, L4, SR1, RL1, DC1 and DT1

Readout of measured value ...... linear, logarithmic or relative to freely selected reference
Units of measurement .... V, mA, kΩ, ΔV, ΔmA, ΔkΩ, Δ%, ΔdB or dimensionless quotient (X/REF)

General data

Operating temperature range ...... +5 to +45°C, class 1 to IEC 359 (no dewing)
Storage temperature range .... −40 to +70°C
Power supply .... 100/120/220/240 V ±10%, 47 to 63 Hz (30 VA)
Dimensions (W×H×D) .... 220 mm×109 mm×340 mm
Weight .... 4.4 kg

Ordering information

Order designation .... ▶ Digital Multimeter UDS 5 349.1510.02

Recommended extras
10-A Current Shunt .... UDL 4-Z2 ... 346.8065.02
150-A Clamp-on Current Probe .... UDL 4-Z3 ... 346.8113.02
1000-A Clamp-on Current Probe ... UDL 4-Z4 ... 346.8165.02
Temperature Probe .... UDL 4-Z6 ... 346.8265.02
High-voltage Probe .... UDL 4-Z7 ... 346.8313.02
19"-rack Adapter .... ZZA-22 ..... 078.8222.00

UDS 6

System Voltmeter UDS 6 ♦ 100 nV to 1100 V
100 μΩ to 14 MΩ

- Uses: both as a laboratory DVM and a system unit, e.g. for data storage/processing
- Time control of test programs over a maximum of 96 hours
- Versatile computational capability

IEC 625 Bus

The **System Voltmeter UDS 6** is a microprocessor-controlled precision instrument with a completely new concept which offers a degree of versatility never before available.

The UDS 6 is the answer to many complex test problems; depending on its use, it can be characterized as a

- precision voltmeter (multimeter) for laboratory applications and general measurement tasks,
- voltmeter for storing and processing the results,
- system unit for test setups using other interface-compatible instruments (see also page 192).

Measurement, evaluation and storage

Precision measurements. DC voltage, AC voltage and resistance. For DC voltage: resolution 100 nV, error 1×10^{-5}; variable integration time.

Measurement processing. A total of ten programs for multiplication, limit monitoring, statistics, etc. (see page 189), including time control of test programs lasting up to 96 hours; checkpoint selector (scanner) on page 193.

Data management. Automatically stores measurement data and results in 50 locations; further 30 locations for manual entry.

Stored data can be recalled at any time, for instance for further calculations. All the results can be replaced or entirely erased.

Outstanding features

Out of its range of excellent characteristics, the following features of the instrument should be particularly stressed: resolution 100 nV or 100 μΩ, extremely high linearity, variable scale length and integration time, input impedance >100 GΩ, and common-mode rejection 150 dB.

Reading rate. The UDS 6 can easily handle a flood of measurements – at the push of a button 330 readings per second can be obtained.

The **settling time** of the UDS 6 is extremely short: just 1.6 ms.

Filtering. A digital filter can be connected to ensure maximum accuracy and to suppress noise. In this case, the integration time is increased to 1.28 s and the measurement cycle is locked to the AC supply frequency.

Ease of operation

Despite its many capabilities and functions, the System Voltmeter is almost as easy to operate as an ordinary pocket calculator. The panel controls – pushbuttons with built-in LEDs to confirm the entry – are logically grouped and colour-coded with corresponding coloured legends to guide the user effortlessly through the most complex routines. If an entry has not been completed, the associated LED flashes to remind the operator.

The UDS 6 used as a laboratory digital voltmeter

The System Voltmeter can be used like any other precision DVM in the laboratory. The only difference with respect to conventional DVMs is the instrument's ability to record fully automatically 50 consecutive measurements, even in manual operation. The user can ignore the grey buttons and their corresponding legends. In the manual mode the UDS 6 will measure

DC voltage: the average value of the input signal during the selected integration time.

AC voltage: the mean value of the AC component of the input signal; the rms value is displayed if the input signal is sinusoidal.

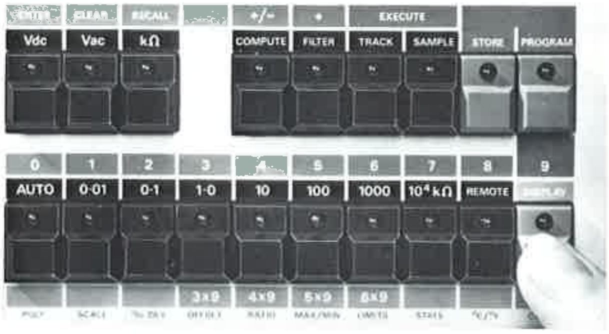
Resistance: the average value of the resistance measured during the selected integration time.

Panel controls for manual measurements. The pushbuttons for manual measurements are captioned white on black, the buttons themselves also being black. It is easy to see how to use them: a group of three is used to select the desired measurement function; the measurement range is selected by the buttons on the row beneath, autoranging is of course also possible. The range selected and the autoranging mode are indicated by a corresponding LED.

Indication cycle. The UDS 6 can display measurements either singly or repetitively, as selected by the SAMPLE or TRACK buttons. SAMPLE gives a single new reading each time the button is pressed whereas TRACK causes the display to be continuously updated for each measurement.

With the filter connected into circuit, the integration time is extended; the reading is then updated six times per second (with 6×9 scale length selected: every 1.28 s).

The **scale length and the integration time** of the A/D converter can be selected (3½ up to 6½ digits) with the (blue) DISPLAY button in conjunction with the buttons captioned 3×9 to 6×9 (white on vlue).



Panel controls for manual measurements, e.g. display and scale length (3×9 to 6×9) as well as integration time

The UDS 6 used as a DVM for measurement processing

The keyboard includes a (grey) PROGRAM button, which can help you solve a lot of measurement problems. Measurement data can be processed in accordance with the user's specifications thus providing more meaningful results than straightforward voltage or resistance indication.

Measurements are processed as they are made and the results are directly displayed on the UDS 6 after pressing a few buttons. The microprocessor not only controls the DVM functions but also offers true data processing capability.

Programs for measurement processing. To process the measurements, nine diffrent programs can be called up (see righthand column and table on next page), providing a total of 26 individual results. A tenth program using the UDS 6 internal clock as a time reference offers time control over the following measurement functions: start, stop, preset intervals. Programming to cover a maximum of 96 hours is possible. Thus the instrument can be left unattended for instance over the entire weekend, and the complete final results can be recalled at the beginning of the working week.

The programs can be used separately or consecutively. For instance, the mean room temperature can be continuously measured over 24 hours with any required interval between measurements.

Many of the programs can perform more than one type of calculation. With some programs the user can choose the calculation to be performed, with other programs he can choose the information to be displayed during the measurement and processing.

Below, the ten different programs are described in the righthand column, and summarized in tabular form with the individual calculations on the next page.

The 10 programs of the System Voltmeter UDS 6

1 **Multiplication** by constant c
Each measurement is multiplied by a constant c (>1 or <1) which is entered via the keyboard. Typical application: conversion of output signals from flow transducers, e.g. into litres/min.

2 **Percentage deviation** referred to nominal value n
Each measurement is compared with the entered nominal value n, and the percentage deviation is displayed. Typical application: quality control.

3 **Offset** by subtracting a constant from each measurement. Using a constant with negative value, addition is also possible. Application: measuring the output currents from sensor/transmitter system. In conjunction with program 1, conversion into engineering units is possible.

4 **Ratio** obtrained by division (measurement/nominal value). Three different calculations can be selected: linear, logarithmic (gain, etc. in dB), inverse ratio (e.g. for conductance calculation).

5 **Maximum and minimum** by storing and updating measurements (peak-to-peak value found by subtracting minimum from maximum); four different results can be displayed, see table on the next page.

6 **Limit monitoring** by entering two constants and comparing the measurement with the limits: an additional symbol may be displayed, e.g. a high bar if the upper limit is exceeded. Five different results can be selected; see table on next page.

7 **Statistics** by storing each measurement and carrying out the calculations internally. Application: quality assurance. The UDS 6 can carry out the following calculations for the five different results, in the middle of taking measurements (all the results are ready to be recalled at the end of a run):

0: each measurement

$$R = x$$

1: updated average

$$R = \frac{1}{i}\sum_{k=1}^{i} x_k = \bar{x}$$

2: updated variance

$$R = \frac{1}{i}\sum_{k=1}^{i} (x_k - \bar{x})^2$$

3: updated standard deviation

$$R = \sqrt{\frac{1}{i}\sum_{k=1}^{i} (x_k - \bar{x})^2}$$

4: updated rms

$$R = \sqrt{\frac{1}{i}\sum_{k=1}^{i} x_k^2}$$

8 **Temperature measurement using thermocouples**
The UDS 6 measures the output voltage of a thermocouple, linearizes it and displays the result in °C or °F. The linearization tables for four types of result are built into the memories; see table.

9 **Time** control of measurements and processing over a maximum of 96 hours.

0: program run in modes
SAMPLE: continuous to the end,
TRACK: continuously repeats measurement and displays latest reading

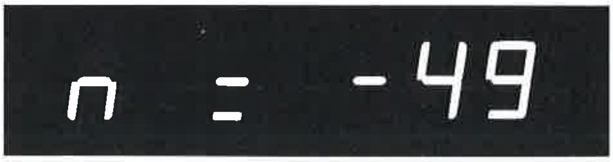
1: start/stop operation, with real time of day if desired

0 **Polynomial evaluation** by measurement and linearized display, for instance outputs from non-linear devices using the equation $R = c_0 + c_1x + c_2x^2 + c_3x^3$. The constants c_0 to c_3 are entered after calling up the program.

UDS 6 – System Voltmeter

Program summary

Program	Type of result	Display	Calculation		Entry	Recall sequence
1 Multi-plication	—	Product	R = cx	c: constant	c Multiplier	c Multiplier
2 % deviation	—	Δ% from nominal	$R = 100 \frac{x-n}{n}$	n: nominal	n Nominal	n Nominal
3 Offset	—	Offset	R = x – Δ	Δ: offset	Offset	Offset
4 Ratio	0 1 2 3	Meas./ref. dB Power Inverse ratio	R = x/r R = 20 log x/r $R = x^2/r$ R = r/x	r: reference value x/r must be positive r: resistance r: reference value	r Reference value r Reference value r Resistance r Reference value	(a) Type of result r (b) Reference value
5 Maximum/ minimum	0 1 2 3	Each measurem. Maximum Minimum Peak to peak	R = x R = max. x R = min. x R = max. x – min. x		— — — —	(a) Type of result H (b) Maximum L (c) Minimum PP (d) Peak to peak
6 Limit monitoring	—	Measurement value	x > H = HI x < L = LO H > x > L = GO Comparator fuzz <1 digit	H: upper limit L: lower limit	H Upper limit L Lower limit	nH (a) Number >H nL (b) Number <L nG (c) Number in tol. H, L (d, e)
7 Statistics	0 to 4	Measurement value	See pervious page under 7		—	(a) Type of result n/AV/VA/Sd/rS
8 Temperature of thermo-couple	0 1 2 3 4 to 7	°C for Cu/Con °C for Pt/PtRh °C for Fe/Con °C for NiCr/NiAl °F for each type above	$R = a + bx_p + cx_p^2 + dx_p^3$ $\left(\begin{matrix} x_p = x_i + a' + b'A + c'A^2; \\ a, b, c, a', b', c' \text{ stored} \end{matrix} \right)$		A Room temp. °C A Room temp. °F	(a) Type of function A (b) Room temp. in °C A (a) in °F
9 Time	0 1		Clock: locked to AC supply; time span 96 h Run time and interval between readings: max. 95 : 59 : 59 h Resolution 1 s		tr Progr. = run time t Time, tA Start tb, tc Interv., stop	(a) Type of timing otherwise as entry
0 Polynomial evaluation	—	Polynomial solution	$R = c_0 + c_1x + c_2x^2 + c_3x^3$		c_0 to c_3 (constant)	c_0 to c_3 (constant)



Preliminary information for calling up value from history file

Display, keyboard and entry

Large/small readings. Depending on the application and the measurement period, a considerable amount of data has to be handled and high values must be displayed, as in program 7. The UDS 6 can process over **1000 million readings** and display both very large and very small values.

If a number exceeds the display range of ±9 999 999, the display changes to exponent form. The range is then 10^{63} to 10^{-63}. A measurement of 3 mV for instance – divided by an assumed constant of 2000 – yields a reading of 1.5×10^{-6}.

Interactive display. In addition to showing voltmeter measurements and the results of processing, the UDS 6 display is used to set up programs and to recall processing results. The display and the keyboard constitute an **interactive system** for the operator: the display presents numbers, words, or a mixture (alphanumeric form) to guide the user as to the steps to be taken.

In the case of programs with several types of result, the one selected is displayed in addition to the program number Constants are displayed as they are keyed in. The display says FULL if more than three programs are called up.

Due to the limitations of the 7-segment format, special characters such as H for the entry of the upper limit (or L for the lower limit) have been selected. During the recall of the results, the UDS 6 display briefly indicates which result is about to appear, for example

nH followed by number of measurements "high"
nL followed by number of measurements "low"
nG followed by number of measurements "go"
H followed by upper (high) limit
L followed by lower (low) limit.

The interactive display of the System Voltmeter UDS 6 keeps the user informed on the steps he has to take next.

Keyboard. Easy operation is essential for a user-oriented test system. With the System Voltmeter UDS 6 this has been achieved by grouping the keys into logical patterns, the buttons being colour-coded with the corresponding coloured legend. In this way a minimum of keys is required.

Keyboard offers wide range of input, output, calculation and storage functions

Black buttons: for measurement functions and ranges (V, R)

Blue buttons: for scale length (number of digits)

Program button: this (grey) button causes all the others to adopt the functions labelled white on grey, e.g. switchover from simple DVM function to measurement processing.

Entry. Program numbers, types of result and constants are keyed in using the buttons on the bottom row marked 0 to 9; the polarity of constants and decimal points are entered via the buttons on the top row. The entries appear in the display as they are keyed.

ENTER is used to enter program numbers, etc., into the memory; a typical sequence could be:
Program 4 ENTER

CLEAR is used to erase the data in the display and in the memory; if program 9 is cleared, the internal clock is not reset. Example:
P 7 CLEAR

RECALL is used to recall all the results of a program at the end of a program run, since during the run only one result can be shown.

EXECUTE is a heading for the TRACK and SAMPLE buttons which are the start buttons for program execution (see also under program 9); after pressing these keys, the function of the keys reverts to the black captions.

COMPUTE is activated while the measurements are being processed (the built-in LED lights up); pressing this button stops the processing and the UDS 6 operates from then on as a normal DVM. The results processed so far can be recalled. To continue processing with the same data, it is merely necessary to press the COMPUTE button again.

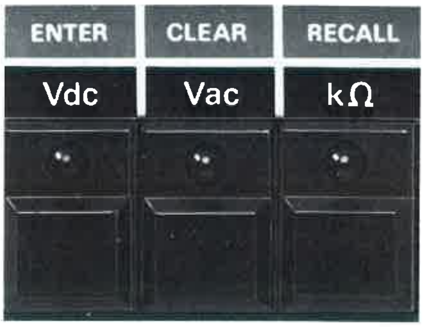
REMOTE switches the UDS 6 when operated via the RS-232 interface from manual to remote-controlled operation and vice versa; when using the IEC-bus interface, only switchover to manual operation; the LED lights up in both cases to show the remote control mode.

Data management

History file. It has already been mentioned that the UDS 6 can store 50 consecutive measurement values, automatically and independently of the mode selected (measurement processing or basic DVM function). To read from this memory, press the STORE button. In the STORE mode, the grey captions assume a slightly different significance than they have in the processing mode: the RECALL button is now used to read the stored data in sequence; the file can be accessed either forwards or backwards, as selected with the +/− button.

Data modification (manipulation). The UDS 6 contains a further area of memory with 30 locations for manual storage of any data, such as measurement values, programs or results. These data can be modified, updated, manipulated and erased. Stored measurements can be recalled as base data for further calculations. The STORE button is the key to a wide range of new possibilities in data management.

Data management via the keyboard. In the STORE mode the white-on-grey captions apply for the remaining buttons, as in the processing mode.



Area of keyboard for data management functions

The ENTER button is used to write data from the display into a selected memory location.

The CLEAR button is used to erase the displayed data (similar to the CE button on a pocket calculator), permitting operator mistakes while keying-in to be rectified without erasing stored data.

The RECALL button enables the contents of a specified memory location to be read out and displayed.

The buttons marked 0 to 9 are used to specify memory locations. In conjunction with +/− and the decimal point, the number keys can be used to enter constants which are to be stored.

The keyboard and the display are fully interactive. The address is displayed when the specified memory location is called up. Constants are built up digit by digit in the display, thus avoiding entering an incorrect figure.

Conclusion: The operation of the System Voltmeter UDS 6 is as easy as that of a pocket calculator; its computational capacity is, however, many times greater.

System Voltmeter UDS 6/UDS 6-B1

System use

Fitting the System Voltmeter UDS 6 with a system interface option (ordered separately) extends its range of application and makes it suitable for **use in automatic test systems.** In conjunction with a printer or a VDU, the instrument can operate as a simple, inexpensive test system without needing a controller.

System interface. The system interface adds the following new capabilities:

Comprehensive interactive data transfer between the user and the System Voltmeter as well as between the system controller (e.g. Process Controller PUC), the UDS 6 and all the other system components; the option is a combination of two data interfaces in one unit: the IEC bus, and RS 232 C (V.24).

Full system control using a system-compatible desktop computer.

Optimum flexibility of application, from use in the laboratory through to the fully automatic test system with realtime or preprogrammed operation.

The **IEC-bus interface** meets IEC 625-1 and IEEE 488; it is fitted with both a 24-way and a 25-way connector (see photo below). The following functions can be executed:

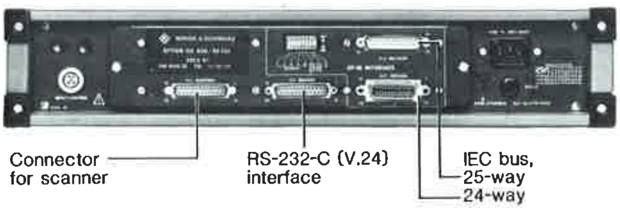
SH1 source handshake	RL1 remote/local
AH1 acceptor handshake	PP2 parallel poll
T5 talker	DC1 device clear
L3 listener	DT1 device trigger
SR1 service request	

RS-232-C interface (CCITT V.24). The interface comprises eight lines: four handshake and four communication lines, including protective ground and common.

Baud rate: 110, 150, 300, 600, 1200, 2400, 4800 and 9600.

Simple point-to-point communication. Measurements, processing or data management information in the UDS 6 can be called up via a data terminal which can then be used to display the results.

Preprogrammed control. Programming commands for setting the UDS 6 to different modes of operation can be transmitted via a data terminal.



Rear panel of System Voltmeter UDS 6 with connectors for Scanner UDS 6-Z1 plus IEC-625-1 and RS-232-C interfaces

Automatic control. If the data terminal has a mass storage device (magnetic-tape or floppy-disk unit) or the test system includes a system controller (microcomputer), the UDS 6 (fitted with option UDS 6-B1) can operate without operator intervention.

Program troubleshooting. The UDS 6 permits rapid fault locatoin when entering the program. In the case of a dubious result, each program parameter entered can be recalled by sending the ASCII character "?". Moreover, sending character "E" causes a complete listing of all the program parameters.

Data input. All the functions of the System Voltmeter can be controlled via the IEC-bus or the RS-232-C interface. All entries of measurement functions and ranges, programs and data-manipulation commands are coded in ASCII, individually or in strings. The instruction set of the UDS 6 is compatible with the two different types of interface.

Data output. The measurements are output in the form of an alphanumeric string:
Sp VDC Sp Sp + 1.23456E + 03

The first six characters – the alphanumeric header – can be suppressed if they cannot be read by the user's terminal.

Additional information is presented to the right of the measurement data, e.g. HI/LO information from program 6, measurement timing, or the program in use.

System expansion: Scanner UDS 6-Z1

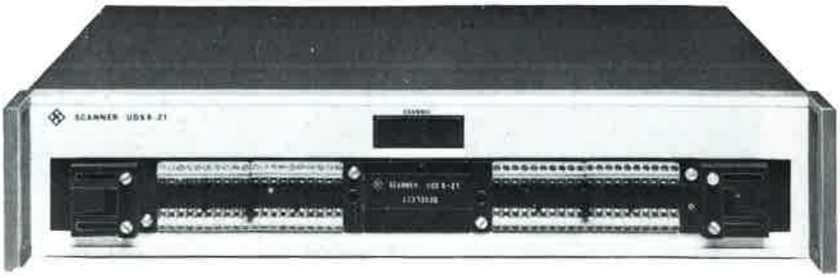
If measurements are to be taken not at a single point but in a rapid sequence at many different points, the **Scanner UDS 6-Z1** (for detailed description see next page) offers a neat and cost-effective solution. Neat because the Scanner is housed in a slim case which matches that of the UDS 6. Cost-effective because it contains 16 analog channels, and does not require an interface of its own: it is controlled by the voltmeter interface, connected via a single socket at the rear.

Specifications of UDS 6 on page 194

Scanner UDS 6-Z1
♦ 16 channels

- Checkpoint selector, an ideal DVM expansion for rapid data acquisition
- Typical scanning speed 130 channels/s
- Control and programming by the DVM via IEC bus or RS-232-C interface
- Four-terminal plus guard scanning

UDS 6-Z1



IEC625Bus In conjunction with UDS 6

The **Scanner UDS 6-Z1** is an extremely efficient and low-priced checkpoint selector whose internal and external design matches the System Voltmeter, expanding the UDS 6 into an automatic large-scale data acquisition system with a high scanning speed.

Characteristics

Number of checkpoints: terminals used. The Scanner is able to poll 16 different checkpoints, each input channel being of the four-terminal-plus-guard type. It can be used for either voltage or resistance measurement. The checkpoints of interest are connected via two screw-terminal blocks, each of eight channels. The channels are coded hexadecimally from 0 to F.

The actual scanner assembly has a switching speed of 130 channels per second (typical) with an extremely low inherent noise voltage.

To match the input terminals of the UDS 6, the analog signals are brought out at 4-mm rear sockets: there is a total of five lines, four for the analog signals as required for resistance measurement using the Kelvin bridge technique, and one as a guard line.

The control lines and the power supply are connected via a standard 25-way Cannon cable. The logic required for the scanner control is included in the System Voltmeter which also provides for channel selection. Expansion in blocks of 16 channels (up to a total of 255) is possible by the provision of a second connector socket.

Rear connectors of Scanner UDS 6-Z1

Four-terminal output

Connector for System Voltmeter and additional scanner

Systems use

In the simplest system configuration, an individual Scanner UDS 6-Z1 is controlled from a printing terminal (teletype) or a VDU with its keyboard. The System Voltmeter to which the Scanner is connected supplies the results to the data terminal. Thus up to 16 checkpoints can be scanned and the data and processing results logged.

Moreover, the Scanner can also be **used in larger systems** where a desktop computer or the Process Controller is included for control.

Specifications of Scanner UDS 6-Z1

Checkpoint switchover

Channels	16 (15 if unit is in block 0)
Switching elements	5-pole reed relays
Operating time	<1 ms
Settling time	6 ms (as set in DVM)
Release time	<1 ms
Life	$>5\times10^7$ operations (switching ≦10 V)
Thermal error	±5 µV

Maximum ratings

Input voltage (HI/LO)	130 V_{rms}, 200 V_p
LO to guard	10 V_p
Voltage between input and earth	200 V
Voltage between channel inputs	200 V
Switched signal voltage	200 V
Isolation between channel inputs	10 GΩ ‖ <50 pF
Signal connectors	2 screw-terminal blocks each with 8 channels

General data

Operating temperature range	0 to +50°C
Storage temperature range	−30 to +50°C
Power supply	from DVM used, e.g. UDS 6
Dimensions, weight	433 mm×88 mm×460 mm, 7 kg

Ordering information

Order designation	▶ Scanner UDS 6-Z1 346.9510.02
Accessories supplied	25-way control cable (connection of UDS 6 to UDS 6-Z1), 346.9584.02; 2 handles and 2 side panels for rack mounting; 2 Screw-terminal Blocks UDS 6-Z2, each for 8 channels

Recommended extras

5-way test cable UDS 6 to UDS 6-Z1	346.9384.02
5-way test cable UDS 6-Z1 to UDS 6-Z1	346.9378.02
Screw-terminal Block UDS 6-Z2	346.9578.02 (two items required)

System Voltmeter UDS 6

Specifications

DC voltage measurement

Digital filter selected

Nominal range	Resolution	Displayed full scale	Error limits at +20 °C 24 h, ±1 °C ± (% rdg + digits)		6 months, ±5 °C ± (% rdg + digits)		1 year, ±5 °C ± (% rdg + digits)		Input resistance
10 mV	100 nV	0.0140000 V	0.001	40	0.003	40	0.004	40	>100 GΩ
100 mV	100 nV	0.1400000 V	0.001	40	0.003	40	0.004	40	>100 GΩ
1 V	1 μV	1.400000 V	0.0006	4	0.003	4	0.004	4	>100 GΩ
10 V	10 μV	14.00000 V	0.0005	4	0.0018	4	0.0025	4	>100 GΩ
100 V	100 μV	140.0000 V	0.0008	6	0.003	6	0.004	6	10 MΩ
1000 V	1 mV	1400.000 V	0.0008	6	0.003	6	0.004	6	10 MΩ
Error limits (+/−) with reduced scale length		5×9	0.002	1 + 4 μV	0.004	2 + 4 μV	0.006	2 + 4 μV	
		4×9	—	1 + 4 μV	—	1 + 4 μV	—	1 + 4 μV	
		3×9	—	1	—	1	—	1	

Max. input voltage .... 1100 V (in 1-kV range)
Input current .... <20 pA (typ.)
Overload protection
with autoranging .... 1.1 kV
in manual mode .... 350 V (up to 10-V range)
1.1 kV (100/1000-V ranges)
Reading rate with scale length ..... 6×9 5×9 4×9 3×9
Measurement/s
(without filter; otherwise less) 6 43 182 330
Error limits .... valid for 6×9 scale length

Error in the case of high speed operation:
Without digital filter, an additional error of ± (25 μV + 1 digit) must be added to the above limits for all scale lengths.

Temperature effect (max. ±)
Ranges 10 mV to 1 V .... 0.0004% of rdg/°C
10 V .... 0.0003% of rdg/°C
100 V, 1000 V .... 0.0005% of rdg/°C
Zero drift (max. ±) .... 0.2 μV/°C

AC voltage measurement

Digital filter selected

Nominal range	Resolution	Displayed full scale	Error limits at +20 °C 24 h, ±1°C 50 Hz to 10 kHz ± (% rdg + digits)		40 Hz to 50 kHz ± (% rdg + digits)		6 months, ±5°C 50 Hz to 10 kHz ± (% rdg + digits)		40 Hz to 50 kHz ± (% rdg + digits)	
100 mV	1 μV	0.140000 V	0.03	20	0.1	20	0.05	20	0.15	20
1 V	10 μV	1.40000 V	0.03	20	0.1	20	0.05	20	0.15	20
10 V	100 μV	14.0000 V	0.06	20	0.2	20	0.08	20	0.25	20
100 V	1 mV	140.000 V	0.06	20	0.2	20	0.08	20	0.25	20
1000 V	10 mV	1400.00 V	0.06	20	0.2	20	0.08	20	0.25	20

AC voltage, continued

Nominal range	Error limits 1 year, ±5°C 50 Hz to 10 kHz ± (% rdg + digits)		40 Hz to 50 kHz ± (% rdg + digits)	
100 mV	0.07	20	0.2	30
1 V	0.07	20	0.2	30
10 V	0.1	20	0.3	30
100 V	0.1	20	0.3	30
1000 V	0.1	20	0.3	30

Max. input voltage .... 750 V_{rms} (up to 20 kHz)
200 V_{rms} (above 20 kHz)
DC component: 400 V
Input impedance .... 1 MΩ || <150 pF
Overload protection .... 250 V_p, ranges ≦1 V
1.2 kV, ranges ≧10 V

Error limits .... for input signals >2% FS;
5×9 scale length

Error limits with reduced scale length
(basic error of rdg same as in table above, however, different digit error)
Scale length .... 3×9 4×9
50 Hz to 10 kHz, digits 2 3
40 Hz to 50 kHz, digits 2 3
Response time .... without DC component, the first reading will reach 99.8% of a step input voltage
Upper frequency limit .... 1 MHz, typ. error ±1 dB
Reading rate with filter .... 0.5 measurements/s
without filter .... 1 measurement/s
Filter .... must be selected for f <400 Hz if specified accuracy is to be maintained
Temperature effect (max. ±)
Ranges 100 mV, 1V .... 0.005% of rdg/°C
≧10 V .... 0.01% of rdg/°C

Resistance measurement using four-terminal technique

Digital filter selected
6×9 scale length

Nominal range	Resolution	Displayed full range	Error limits at +20 °C: 24 h, ±1 °C ± (% rdg	+ digits)	6 months, ±5 °C ± (% rdg	+ digits)	1 year, ±5 °C ± (% rdg	+ digits)	Measuring current
10 Ω	100 μΩ	0.0140000 kΩ	—	80	0.006	90	0.01	90	1 mA
100 Ω	100 μΩ	0.1400000 kΩ	0.001	80	0.005	90	0.006	90	1 mA
1 kΩ	1 mΩ	1.400000 kΩ	0.001	8	0.005	9	0.006	9	1 mA
10 kΩ	10 mΩ	14.00000 kΩ	0.001	8	0.005	9	0.006	9	1 mA
100 kΩ	100 mΩ	140.0000 kΩ	0.002	8	0.006	9	0.007	9	10 μA
1 MΩ	1 Ω	1400.000 kΩ	0.002	8	0.006	9	0.007	9	10 μA
10 MΩ	10 Ω	14000.00 kΩ	0.005	8	0.015	9	0.015	9	1 μA
Error with reduced scale length			5×9						4×9 / 1 year
10 Ω			—	8	0.01	9	0.01	9	±(2 digits + 6 mΩ)
100 Ω			0.003	8	0.01	9	0.01	9	
1 kΩ			0.003	2	0.007	3	0.01	3	3×9 / 1 year
10 kΩ			0.003	2	0.007	3	0.01	3	±2 digits
100 kΩ			0.003	2	0.007	3	0.01	3	
1 MΩ			0.004	2	0.008	3	0.01	3	
10 MΩ			0.01	2	0.02	3	0.02	3	

Maximum dissipation
in test resistance .... 25 mW
Maximum input voltage .... 350 V_p
Source resistance .... 1 TΩ (protects external circuits)
Reading rate .... 6×9 5×9 4×9 3×9
Measurements/s (without filter) .. 6 43 182 330

Error in the case of high-speed operation:
Without digital filter, an additional error of ± (25 mΩ + 1 digit) must be added to the above limits for all scale lengths.

Temperature effect (max. ±)
Ranges 10 Ω to 1 MΩ .... (0.001% of rdg + 0.2 digits)/°C
10 MΩ .... (0.0025% of rdg + 0.2 digits)/°C
Zero drift (max. ±) .... 200 μΩ/°C

Additional characteristics

Interference rejection .... ratio in dB of peak interference to 1 digit reading error

Series-mode rejection

Max. permissible series-mode voltage .... 1.1 kV_p with autoranging; 1.1× FS in manual mode

DC voltage measurement .... values applicable for series-mode interference at 50, 60 and 400 Hz ±3%

	without filter Integr.-time	dB	with filter Integr.-time	dB
Scale length 6×9	160 ms	>90	1.28 s	>90
5×9	20 ms	>70	160 ms	>90
4×9	2.5 ms	—	160 ms	>90
3×9	0.3 ms	—	160 ms	>90

Common-mode rejection .... measured with R = 1 kΩ in LO input line

Max. permissible common-mode voltage .... 500 V DC or 500 V_p

DC voltage measurement
Common-mode rejection for DC .. >150 dB
AC .. >164 dB at 50 and 60 Hz

AC voltage measurement
Common-mode rejection for DC .. >150 dB
AC .. >50 dB at 50 and 60 Hz

The integration time is locked to the phase of the AC-supply frequency; full series- and common-mode rejection is ensured despite AC-supply fluctuations up to ±3%.

Temperature measurement ...... program 8 selected; the cold-junction temperature must be within 0 to 50 °C; scale length: 3×9

Type of thermo-couple	Measurement range in °C	Resolu-tion °C	Repeatability over 1 week °C	Error limits over 1 year °C
T	−100 to +400	0.1	0.9	±1.5
R	0 to 1000	0.25	6	±7
	1000 to 1750	1	3	±4
J	0 to 750	0.1	0.6	±1.5
K	−120 to +1370	0.1	0.9	±1.7

T: Cu/Con, R: Pt/PtRh, J: Fe/Con, K: NiCr/NiAl

General data

Operating temperature range ...... 0 to +50 °C
Storage temperature range .... −30 to +70 °C
Power supply .... 110 to 264 V (without switchover) 50, 60 or 400 Hz ±3%, changeover by links; 55 VA
Dimensions, weight .... 443 mm×89 mm×465 mm, 10 kg

Ordering information

Order designation .... ▶ System Voltmeter UDS 6
UDS 6 without IEC bus 346.9210.02
with IEC bus and RS 232 C .. 346.9210.03

Accessories supplied .... 1 test cable, red
1 test cable, black
2 crocodile clips (copper)
1 test probe, red
1 test probe, black
3 shorting links
2 handles for rack mounting
2 side panels for rack mounting
Power cord

Recommended extras

System Interface UDS 6-B1 (IEC-625-1 and RS-232-C interfaces) .... 346.9426.02 (factory-installed only)

Scanner UDS 6-Z1 .... 346.9510.02

Screw-terminal Block UDS 6-Z2 for 8 channels 346.9578.02

Cover Plate UDS 6-Z3 .... 346.9561.02

Connecting Cable UDS 6-Z4 (scanner to scanner) 346.9378.02

Connecting Cable UDS 6-Z5 for input on rear panel 346.9384.02

Accessories for UDL 3/UDL 4/UDS 5/UDS 6

Carrying cases and a wide range of accessories are available for the Digital Multimeters **UDL 3** and **UDL 4** described on pages 180 and 181 to extend their range of applications.

Some of these accessories can also be used with the Multimeters **UDS 5** and **UDS 6** and are identified accordingly:

3) 4) 5) 6) below the photo implies that the accessory is suitable for use with the corresponding instrument, e.g. 3) for UDL 3 or 5) for UDS 5.

Overview

Carrying cases

UDL 3-Z1

UDL 4-Z1

These two carrying cases protect the multimeters while the UDL 4-Z1 also has room for accessories.

Order designation ▶	Carrying Case
UDL 3-Z1	346.7317.02
UDL 4-Z1	346.8012.02

For **specifications and ordering information** of the **following accessories see next page**

Power Supply

UDL 3-Z2

3)

Battery Pack

UDL 4-Z8

4)

10-A Current Shunt

UDL 4-Z2

3) 4) 5) 6)

Clamp-on Current Probes

UDL 4-Z3

3) 4) 5)

UDL 4-Z4

3) 4) 5)

40-kV High-voltage Probe

UDL 4-Z7

3) 4) 5) 6)

Temperature Probe

UDL 4-Z6

3) 4) 5) 6)

Rack Adapter

UDL 4-Z5

4)

Characteristics

Specifications/ordering information

Power Supply — UDL 3-Z2

It permits the Digital Multimeter **UDL 3** to be operated from the AC supply. When the supply cable is connected to the voltmeter, the internal battery is automatically switched off.

Power supply	220 V, 50 Hz
Output voltage	9 V DC
Max. output current	30 mA
Insulation	to VDE 055/1
Order designation	▶ Power Supply Adapter UDL 3-Z2 346.7369.02

Battery Pack — UDL 4-Z8

The battery pack permits the **UDL 4** to be operated independently of the AC supply. When the multimeter is connected to the AC supply, the battery pack is recharged via the internal power supply (also when the UDL 4 is switched off).

Operating time when fully charged	approx. 6 hours
Charging time	max. 16 hours
Order designation	▶ Battery Pack UDL 4-Z8 346.8365.02

10-A Current Shunt — UDL 4-Z2

This shunt extends the current measurement ranges of the Digital Multimeters **UDL 3, UDL 4, UDS 5** and **UDS 6** up to 10 A. It can also be used with other multimeters.

Measured current	0 to 10 A, briefly up to 20 A
Output voltage	10 mA/A
Error limits	±0.5% from 0 to 400 Hz
Order designation	▶ 10-A Current Shunt UDL 4-Z2 346.8065.02

Clamp-on Current Probes — UDL 4-Z3/UDL 4-Z4

In conjunction with the **UDL 3,** the **UDL 4** or the **UDS 5** (or with any other AC ammeter) the current probes permit AC measurements

up to 150 A with UDL 4-Z3 and
up to 1000 A with UDL 4-Z4.

The transformation ratio of 1000:1 yields a readout in A if the corresponding measurement range has been selected.

	UDL 4-Z3	**UDL 4-Z4**
Max. current measured	150 A	1000 A
Transformation ratio	1000:1	1000:1
Frequency range of measured current	30 to 1000 Hz	50 to 5000 Hz
Isolating voltage	3000 V	2000 V at 50 Hz
Error limits	±2% at 30 to 400 Hz	±2% at 50 and 60 Hz
Max. diameter of current-carrying wire	11.5 mm	54 mm
Order designation	▶ 150-A Clamp-on Current Probe UDL 4-Z3 346.8113.02	▶ 1000-A Clamp-on Current Probe UDL 4-Z4 346.8165.02

40-kV High-voltage Probe — UDL 4-Z7

The high-voltage probe for the **UDL 3, UDL 4, UDS 5** and **UDS 6** can be used for measurements up to max. 40 kV and is also suitable for use with all multimeters with 10 MΩ input impedance for DC voltage measurements. If the 100-V range is selected on the multimeter, it reads out the high voltage in kV.

Max. voltage measured	40 kV
Error limits	±2% at a voltage of 20 kV and t_{amb} = +25 °C
Voltage coefficient	max. -2×10^{-6}/V
Input impedance	1 GΩ
Temperature coefficient	max. 1×10^{-4}/°C
Order designation	▶ 40-kV High-voltage Probe UDL 4-Z7 346.8313.02

Temperature Probe — UDL 4-Z6

With the aid of the temperature probe the Digital Multimeters **UDL 3, UDL 4, UDS 5** and **UDS 6** or any other voltmeter can measure temperatures between −65 °C and +150 °C rapidly and easily.

Temperature measurement range	−65 to +150 °C
Output voltage	1 mV/°C
Error limits	±1 °C between −10 and +110 °C beyond this range linearly increasing error up to +2/+4 °C at −65 °C and 0/+3 °C at +150 °C
Permissible temperature for handle and cable	70 °C
Power supply	9 V (built-in battery IEC 6 F 22)
Order designation	▶ Temperature Probe UDL 4-Z6 346.8265.02

Rack Adapter — UDL 4-Z5

Up to two Digital Multimeters **UDL 4** can be installed in a 19″ rack with the aid of the rack adapter. A blank panel is supplied with the adapter.

Order designation	▶ 19″ Rack Adapter UDL 4-Z5 346.8213.02

UIG

DC Microvoltmeter UIG

- 0.2 µV to 320 V
  (up to 30 kV with probe)
  1 pA to 320 mA

- High sensitivity; floating circuitry
- Amplifier output −50 to +100 dB
- Independent of Ac supply, battery sufficient for 10,000 operating hours
- Use as input adapter, e.g. in conjunction with digital multimeters or with any low-sensitivity DC recorder

The **DC Microvoltmeter UIG** is a very accurate and sensitive measuring instrument with an amplifier output. The MOS-FETs in the chopper and the precision design of the amplifiers keep the power consumption so low that one battery is sufficient for 10,000 operating hours (battery voltage can be checked on meter). Since the circuit is isolated from the case, the UIG can be operated off earth.

Measurement ranges and input resistances. DC-voltage and DC-current ranges are set by means of two switches, one for numerical values and the other for units. The fullscale value is determined by the positions of the two switches.

Switch 2, numerical values: 0.01/0.03/0.1/0.3/1/3
10/30/100/300

Switch 1, units: mV/V (R_{in} = 10/50 MΩ)
nA/µA/mA (R_{in} = 1 MΩ/1 kΩ/1 Ω)

Switch 1 in position mV: the amplifier is directly connected to the voltage-test terminal; ranges 10 µV to 300 mV with **10-MΩ input resistance.** Position V: a 60-dB attenuator is connected ahead; range 10 mV to 300 V with **50-MΩ input resistance.** In the positions nA, µA and mA, the amplifier is shunted by the resistances 1 MΩ, 1 kΩ and 1 Ω and connected to the current-test terminals.

Reading. The measured value is indicated on a meter having a mirror scale of 105°; class of accuracy 0.5. Since the zero is in the middle of the scale, no polarity reversal is required. The electrical zero need only be adjusted in the most sensitive ranges.

Accuracy. In the temperature range +10 to +35°C the error is below 2.5% in all ranges, at room temperature 1.5% (without noise and drift). Typical values of voltage and current drifts: 50 nV/°C and 1 pA/°C; typical values of noise: 0.3 μV_{pp} and 0.8 pA_{pp}.

Amplifier output. Open-circuit voltage 1 V at full-scale deflection. Gain adjustable in 10-dB steps from −50 to +100 dB, error limit 0.5%.

Examples of application

Compared with a classical voltmeter, the UIG offers a far higher, sensitivity and complete off-earth operation at an input resistance of 50 MΩ in the range 1 mV to 320 V. The following examples are only some of the applications possible with the UIG.

Measurement of low resistances such as contact resistances, winding and printed-circuit conductor resistances (measured with the aid of a power source). Measurement range with a test current of 1 A: 1 µΩ to 320 mΩ; with 1 mA: 1 mΩ to 320 Ω; direct resistance readings.

Insulation-resistance measurements (by means of current measurement). Resistance up to 10 TΩ can be measured with a test voltage of 10 V.

Bridge measurements. Null detection and error measurements according to the deflection method can be carried out. With a bridge supply voltage of 10 V, a resolution of 0.2×10^{-6} can be achieved.

Measurement of rectified diode voltages. An RF voltage of 0.7 mV produces a rectified voltage of approximately 10 µV on an ideal diode. This corresponds to full-scale deflection in the most sensitive range of the UIG.

Semiconductor measurements, e.g. pinch-off voltage and gate current of field-effect transistors, offset voltage and offset current of operational amplifiers.

Specifications

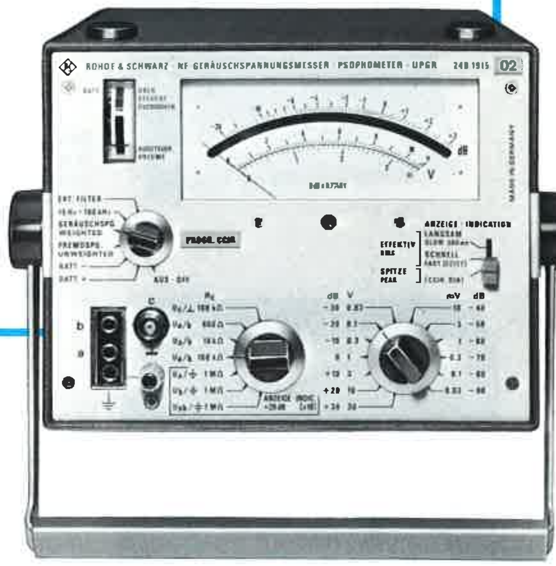
Measurement ranges and input resistances	see text on the left
Minimum readable voltage	0.2 µV
Maximum readable voltage	320 V
Minimum readable current	<1 pA
Maximum readable current	320 mA
Error limit	1.5%
Maximum values at test input	
Voltage, position V	500 V
position mV	300 V, short-time
Current, position mA	1 A } response
position µA	10 mA } threshold of fuse
position nA	5 mA (300 V, short-time)
Isolation resistance between common and earth	$>10^{10}$ Ω
Amplifier output	1 V; R_{out} = 1 kΩ
Power supply	6 single cells IEC-R 20
Dimensions, weight	162 mm×238 mm×302 mm, 4 kg
Order designation	▶ DC Microvoltmeter UIG 203.5111.02
Accessories supplied	1 set of batteries 1.5 V/IEC-R 20
Recommended extra	40-kV DC Probe (UDL 4-Z7) 346.8313.02

Psophometer UPGR

UPGR

◆ 15 Hz to 100 kHz
3 μV to 350 V/−110 to +53 dB

- Psophometer complying with CCIR (DIN 45405 and CCITT by means of accessory filter)
- Psophometer complying with CCITT (using telephone weighting filter)
- High-impedance balanced and unbalanced inputs
- Quasi-peak-responding detector complying with CCIR and DIN and true rms-responding detector with switch-selected time constant complying with CCITT

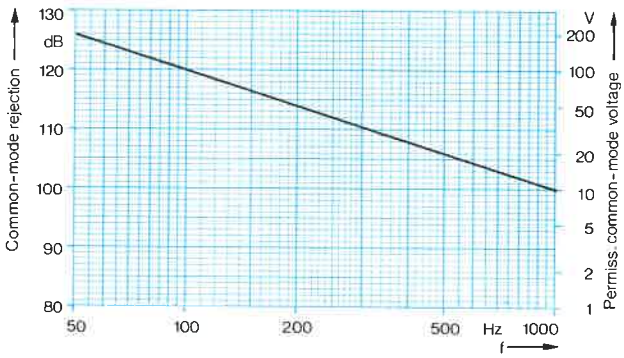


Combined with its two options the **Psophometer UPGR** complies with the relevant recommendations of CCIR, CCITT and DIN 45405. It is used for

wideband level and voltage measurements in the AF range from 15 Hz to 100 kHz, and for

measurement of weighted and unweighted noise voltages and levels in electroacoustic broadband and telephone transmission systems.

The UPGR has a high-impedance balanced input with excellent common-mode rejection (diagram below). It can be switched for balanced measurements with 600 Ω, 10 kΩ and 100 kΩ input impedance, high-impedance measurement of the voltage to earth of the a- and b-wires, direct measurement of common-mode voltage and – via an isolated BNC female connector – floating measurement of AF voltages.



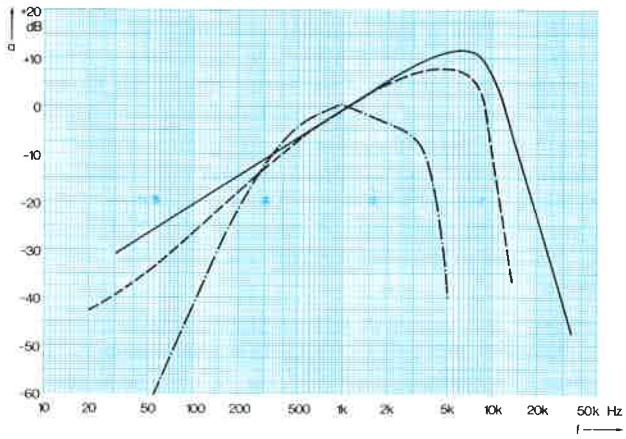
Common-mode rejection and common-mode voltage of UPGR versus frequency

Weighted noise measurements can be performed with the following filters:

broadcast weighting filter in line with CCIR (built-in)

broadcast weighting filter UPGR-Z2 in line with old standards of CCITT and DIN (option; can be readily substituted for the CCIR filter)

telephone weigthting filter UPGR-Z1 in line with CCITT (option; can be attached and connected at the rear of the set).



Standard characteristics of psophometric filters

Full line: program weighting filter complying with CCIR Rec. 468 (future DIN standard)
Dashed line: program weighting filter complying with DIN 45405 and CCITT Rec. P. 53 B (old)
Chain-dotted line: telephone weighting filter complying with CCITT Rec. P. 53 A

The following unweighted measurements can be made with the UPGR:

Unweighted noise measurements in the range 31.5 Hz to 16 kHz via the built-in CCIR filter

Unweighted noise measurements in the range 31.5 Hz to 20 kHz in line with DIN via the filter UPGR-Z2 (see above)

Accurate voltage and level measurements in the wideband range of 15 Hz to 100 kHz, e.g. in stereo channels and on control and pilot tones.

External filters can be connected at the rear for special measurement tasks. In conjunction with the Octave Filter PBO or Third-octave Filter PBT, for example, a rough spectral analysis of the test signal is possible. The Telephone Weighting Filter UPGR-Z1 can also be connected here.

UPGR

Filter UPGR-Z2 (option) in accessory case (broadcast weighting filter for old standard)

Rear of UPGR with Telephone Weighting Filter UPGR-Z1 attached

For indication of the test results, the meter of the UPGR can be switched for peak reading according to DIN and CCIR or rms reading to CCITT. When the instrument is driven to full-scale deflection, the crest factor should not be higher than 10 in rms measurements corresponding to an overdrive capacity of 17 dB relative to sinewave voltages. In the case of peak-responsive measurements the overdrive capacity is 20 dB; this is of special importance for weighting short individual pulses. A combined overdrive indication for the amplifier and the rms-responding detector prevents erroneous measurements.

Outputs. DC output: A voltage proportional to the rms or peak value is available for connection of a recorder or digital voltmeter. AC output: The UPGR can be used as a balanced preamplifier for oscilloscopes, headphones output, etc.

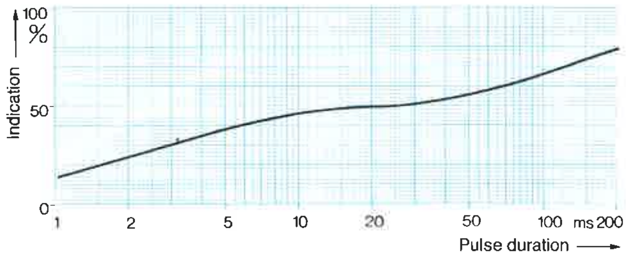
The UPGR can be powered from batteries (permitting floating operation and mobile use) or from the AC supply.

When the UPGR is operated in this position an additional error of 1% of fsd is to be taken into account

Meter rectifiers

CCIR and DIN 45 405 specify a peak-responding detector, the older CCITT standard only an rms-responding mode, for measuring the noise voltage. The UPGR therefore incorporates both rectifier types which, in conjunction with the meter, exhibit the dynamic behaviour required by the standard specifications.

The peak-responding detector measures the quasi-peak value, which depends on the duration of the signal pulse (see diagram). This value is determined such that when measuring a sinewave voltage the rms value is indicated and not the peak value, which is 3 dB higher. When measuring white noise with the quasi-peak-responding detector, the readout is about 4 dB higher than the rms value. With this kind of indication the annoyance of pulse-type noise voltages is weighted.



Peak indication as a function of pulse duration in measurements with single bursts of a 5000-Hz sinewave signal (amplitude corresponds to 100% indication with continuous signal)

The rms-responding detector is used to measure the true rms value of noise voltages as well as CCITT-weighted noise voltage. It recommends itself for **general voltage and level measurements,** including non-sinusoidal waveforms (distorted sinewaves, squarewaves, sinewave bursts). Small superimposed noise voltages cause only slight errors since the indicated value is the sum of the squares of test voltage and noise voltage. Such errors can be taken into account by calculation.

The high sensitivity of the UPGR (full-scale deflection in the most sensitive range 30 μV/−90 dB, approximate indication down to 10 μV/−100 dB) permits measuring very high S/N ratios as well as the S/N ratios of equipment handling low signal levels.

Overdrive capacity

The **high overdrive capacity** of the set (undistorted amplification of amplitudes up to 20 dB above fullscale value with sinewave voltages) guarantees correct weighting and indication of very short and high noise peaks. A **combined overdrive indication** for the amplifiers and detectors precludes erroneous measurements.

Specifications

Frequency range, wideband ...... 15 Hz to 100 kHz
3-dB cutoff frequencies .... 3 Hz/300 kHz
Weighted/unweighted measurements .... psophometric/flat filter in line with CCIR
Options .... psophometric filter (DIN/CCITT)
flat filter (DIN)
telephone weighting filter (CCITT)

Test inputs, measurement ranges

Balanced input (a and b) .... shielded two-pole socket to DIN 41 628
Unbalanced input (c) .... isolated BNC socket
Chassis connection .... 4-mm knurled terminal (grey)
Input impedance tolerance .... ±1%

Input capacitances .... 40 pF
Capacitance between common and chassis .... 260 pF

Footnotes

[1]) Reference for level measurement: 0 dB = 0.7746 V (1 mW into 600 Ω).
[2]) The differential input impedance is 10 kΩ for direct measurement of unbalanced voltage component (common mode).
[3]) **Warning!** When measuring dangerous voltages make sure that the cabinet is reliably connected to the earth conductor. The UPGR is not intended for use in heavy-current networks.
[4]) Multiply scale indication by 10 or add 20 dB (20-dB attenuator is switched in).
[5]) The balance conditions of CCITT and DIN 45 405 are fulfilled for measurements in positions 5 and 6 (in position 4: typical values).
[6]) Subrange 10 µV/−100 dB is provided for rough indication only (right-hand switch position without engraving).

Switch pos.	Input circuit	R_{in}	Coupling	Voltage total rge	Voltage subrange	Level[1]) total rge	Level[1]) subrange
1 V_{ab}/earth 2 V_b/earth 3 V_a/earth	unbal., common mode unbal., V_b to earth unbal., V_a to earth	1 MΩ[2]) 1 MΩ 1 MΩ	AC	30 µV to 350 V[3])	as below × 10[4])	−90 to + 53 dB[3])	as below + 20 dB[4])
4 $V_a/_b$[5]) 5 $V_a/_b$[5]) 6 $V_a/_b$[5]) 7 V_c/chassis	bal., high impedance bal., high impedance bal., low impedance unbal., floating	100 kΩ 10 kΩ 600 Ω 100 kΩ	AC DC DC AC	3 µV to 35 V	(10/)[6]) 30/ 100 µV/ to / 3/10/30 V	−110 to +33 dB	(−100/)[6]) −90/−80/ to / −10/0/+10/+20/ + 30 dB

For rough indication only .... 10 µV/−100 dB
Connectors, bal. input .... shielded two-pole female
unbal. input .... isolated BNC female
Input protection .... electronic circuit and fuse

Rms-responding detector .... max. peak factor = 10 (at fsd)
Detector time constant
FAST .... 30 ms for psophom. meas.
SLOW .... 500 ms

Peak-responding detector .... overdrive capacity 20 dB
Charge/discharge time constant ... 1 ms/250 ms

Indication .... moving-coil meter, mirror scale
Indication ranges .... −20 to +3 dB for level
0 to 11/0 to 3.5 V for voltage

Overdrive capacity ahead of filter .. 100 times or 40 dB (with sinewave referred to fsd at 1 kHz)
Overdrive indication .... red range of check meter

Error limits of indication with sinewave voltages and rms-responding detection; 15 Hz to 100 kHz, t_{amb} = +15 to +30 °C
Frequency-response error in % of rdg +1% of fsd

Switch positions 1 to 3	3/ to /30 mV	0.1/ to /300 V
15 to 30 Hz	±3	±2
30 Hz to 5 kHz	±2	±1
5 to 20 Hz	±5	±2
20 to 100 kHz	0/−30	±3

Below 3 mV well-defined measurement is not possible (inherent noise)

Switch positions 4 to 7	30 and 100 µV	300 µV/ to /30 V
15 to 30 Hz	±3	±2
30 Hz to 20 kHz	±2	±1
20 to 100 kHz	±4	±3

Indikator range 10 µV .... typically same as for 30-µV range
Additional error of detector .... ±3% (with peak factor between 3 and 5)
Peak-responding detector .... in line with CCIR and DIN
Effect of operating position .... add. error of ±1% if differing from a normal one

Inherent noise (depending on operating mode)

Switch position	1 to 3	4	5	6 and 7
Max. value in µV, rms	180	19	12	8
peak	300	30	17	10

Outputs

DC .... 1 V, 1 kΩ, knurled terminals
AC .... 100 mV, 600 Ω, isolated BNC, 70 dB max. gain
Phones (15 Hz to 20 kHz) .... max. 0 dB, adj.; 600 Ω

Connection of external filter ...... 2 isol. BNC female connectors, 600 Ω
Compensation of passband attenuation .... 0 to 3 dB

General data

Power supply battery .... 6 single cells 1.5 V; ≈3 mA approx. 2000 hours per set
AC supply .... 100 to 260 V, 47 to 420 Hz (1 VA)
Dimensions .... 210 mm×181 mm×281 mm
Weight w/o batt./w. power supply 4.2 kg/4.8 kg

Ordering information

Order designation .... ▶ Psophometer
UPGR for battery operation .... 248.1915.02 (incl. battery)
UPGR for AC supply operation 248.1915.03

Recommended extras

Telephone Weighting Filter UPGR-Z1 (CCITT) as external filter 248.3718.02
Broadcast Weighting Filter UPGR-Z2 (CCITT/DIN) 248.3601.02
19" rack adapter 085.5548.00 (for two UPGR units)
Blank panel for rack adapter: 085.5677.00 (if only one UPGR is incorp.)
Third-octave Filter PBT 235.3014.02
Octave Filter PBO 201.5520.02

URE

RMS Voltmeter URE ♦ DC, 10 Hz to 20 MHz
50 μV to 300 V

- True rms-value measurement of AC and AC + DC voltages
- Small basic error (0.5%) and high measurement rate (30 measurements/s)
- Readout of measured values selectable in: V, dBm, dBV, ΔV, ΔdB, Δ%
- Entry of reference value and reference impedance for dBm measurements
- Built-in lowpass filters, switch-selected: 4/20/100 kHz
- IEC-bus-compatible with option

Scale 1:2.5

IEC 625 Bus

The **RMS Voltmeter URE** uses an rms-responding rectifier circuit of new design and permits true rms-value measurement with wide bandwidth and both high measurement speed and accuracy. A microprocessor provides for error correction and converts the measured values for readout in different selectable units. The IEC-bus interface option permits the use of the URE in automatic test assemblies.

Measured quantities. The URE measures DC voltages and the rms value of AC and AC + DC voltages in the frequency range from 10 Hz to 20 MHz. For AC + DC voltage measurements the microprocessor measures alternately the DC and the AC voltage and determines the total rms value by square-law addition of the individual components.

Measurement speed. The URE provides three different measurement speeds: SLOW, FAST and SUPERFAST (1/3/30 measurements per second). The FAST button is for switchover between SLOW and FAST. SUPERFAST can be selected via the IEC us or with the aid of service function 3. The lower cutoff frequency of the URE is matched to the selected measurement rate by automatically selected high-pass filters in the AC measuring circuit. Hence, lowfrequency AC voltages can only be measured at a slow rate, and the suppression of the DC measuring circuit is greater, the lower the selected measurement rate.

Measuring functions. The AC, DC and AC + DC buttons permit selection of AC, DC or AC + DC measurement. The measured values are read out in V or mV and autoranging is enabled.

DC measurement. In this switch position the URE measures the DC voltage component up to a maximum of ±300 V with a resolution of 1 μV in the most sensitive measurement range. A higher-order lowpass filter automatically selected with the measurement speed suppresses superimposed AC voltages.

AC measurement. In this mode the RMS Voltmeter measures the rms value of AC voltages in the range from 50 μV to 300 V at crest factors of up to 5. The frequency range is 10 Hz to 10 MHz (typ. 20 MHz), the lower cutoff frequency as a function of the measurement rate is 10 Hz, 100 Hz or 1 kHz. For suppression of unwanted frequencies the upper cutoff frequency can be limited to 100 kHz, 20 kHz or 4 kHz with the aid of a built-in lowpass filter. The filter is switched in with the LOWPASS button, the cutoff frequency of the filter is selected with the SELECT button.

AC + DC measurement. For AC + DC measurements the URE carries out alternately an AC and a DC measurement and reads out the calculated rms value of the AC + DC voltage. Voltage components whose frequencies are less than the lower cutoff frequency of the AC measuring circuit are not fully considered. Measurement range and bandwidth are as described under DC and AC measurement.

Display of measured value. The display panel of the URE is subdivided into several sections (see photo on page 203). The measured value is read out on a **4½-digit 7-segment LED display** and the associated unit by luminous letters arranged next to it. If the numerical value is positive the sign is blanked. Blinking of the display shows that the result is invalid, e.g. because the range is exceeded. If the measured value is below the range, only the last digit blinks.

For quick detection of any changes in the measured value the URE has a **tendency indication** which also facilitates adjustments and maximum/minimum settings. It consists of LEDs arranged in a circle, the lighted LED corresponding to the momentary measured value. If the measured value becomes higher or lower this light dot follows quasianalogously clockwise or counterclockwise. The two **illuminated displays** on the right indicate the selected **cutoff frequency of the lowpass filter** for AC measurements and the current **remote control mode** of the URE.

Conversion of measured value. The microprocessor of the URE converts the measured values, if desired, at the push of a button for readout in different units.

Reference values may be entered from 1 µV to 19 999 V, reference impedances from 0.1 mΩ to 19 999 Ω. The measured value can also directly be used as reference value. The table on page 204 shows in detail the many ways of displaying the results in the RMS Voltmeter URE.

The following readouts can be selected:

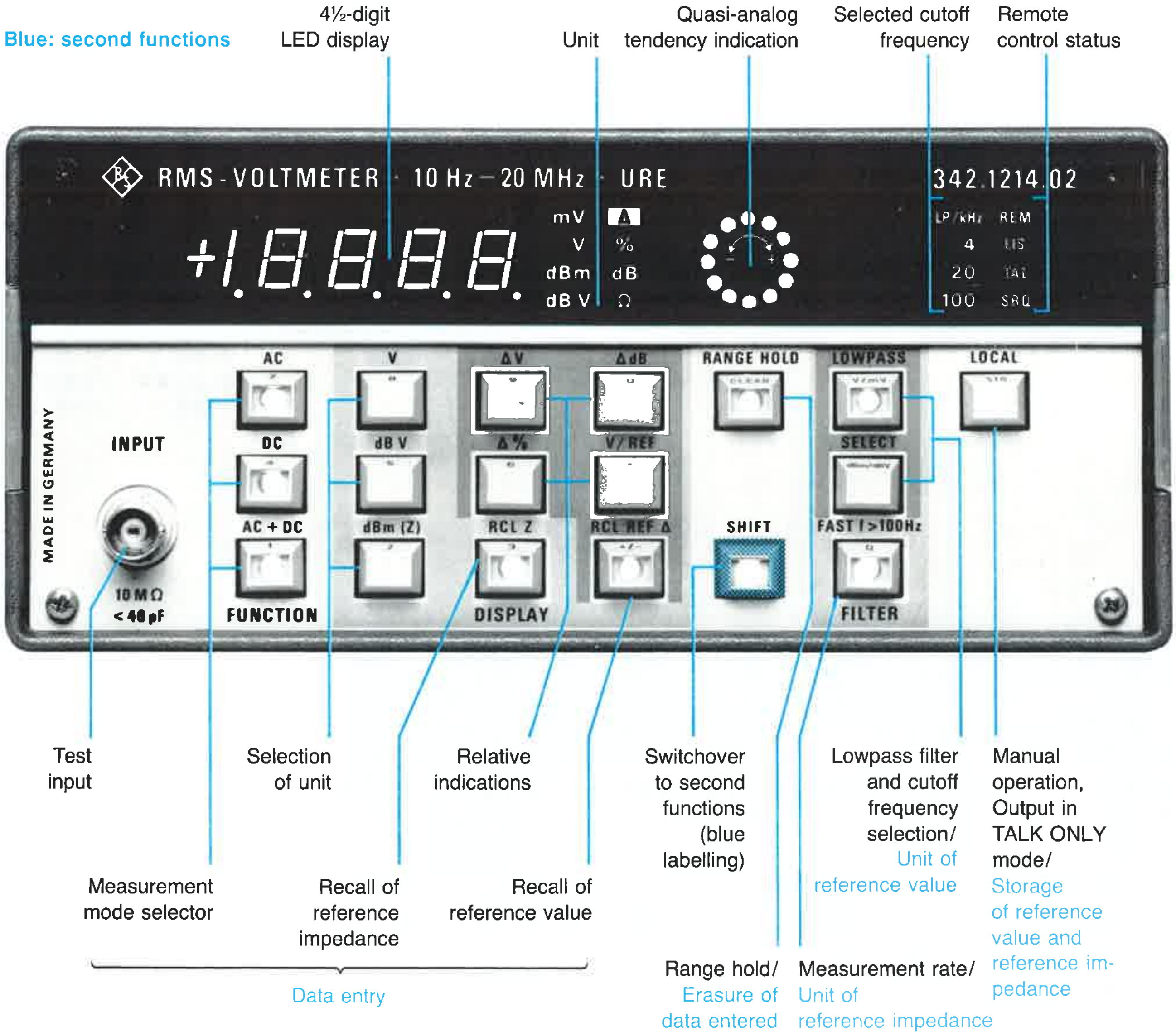
	Unit	Button
• Voltage	V or mV	V
• Level	dBV	dBV
• Power level (referred to reference impedance entered)	dBm	dBm(Z)
• Voltage deviation from reference value	V or mV	ΔV
• Relative voltage deviation from reference value in dB	dB	ΔdB
• Relative voltage deviation from reference value in %	%	Δ%
• Ratio of measured value to reference value	–	V/REF

Also indicated are:

• Stored reference value	V, mV, dBV, dBm	RCL REFΔ
• Stored reference impedance for power level measurement	Ω	RCL Z

Front panel details

Blue: second functions



URE – RMS Voltmeter

Example for flexible display of results

Measured values/conversion: Voltage, Button: V/mV	Level: dBV	Level: dBm (Z)	Reference values[1]: Impedance STO	Reference values[1]: V, dBV, dBm V/mV, dBV/dBm; STO	Deviations from reference value: absolute ΔV	relative ΔdB	relative Δ%	relative V/REF
10.000 V	20.00 dBV	33.01 dBm	50.00 Ω	1.0000 V	9.000 V	20.00 dB	900.0 %	10.000
1.0000 V	.00 dBV	13.01 dBm			0. V	0. dB	0. %	1.0000
0.125 mV	−78.06 dBV	−65.05 dBm			−0.999 V	−78.06 dB	−99.98 %	.0001
1.0000 V	.00 dBV	12.22 dBm	60.00 Ω	.1000 mV	.9999 V	80.00 dB	19999 %	10000
1.0000 V	.00 dBV	11.25 dBm	75.00 Ω		.9999 V	80.00 dB	19999 %	10000
1.0000 V	.00 dBV	6.20 dBm	240.0 Ω		.9999 V	80.00 dB	19999 %	10000
10.000 V	20.00 dBV	22.22 dBm	600.0 Ω	.0010 mV	10.000 V	140.00 dB[2]	19999 %	19999
2.400 V	7.60 dBV	9.81 dBm		.7750 V	1.625 V	9.81 dB	209.7 %	3.097
10.000 V	20.00 dBV	10.00 dBm	10000 Ω	1.0000 V	9.000 V	20.00 dB	900.0 %	10.00
12.57 V	21.99 dBV	35.00 dBm	50.00 Ω	20.00 dBV	2.570 V	1.99 dB	25.70 %	1.2570
2.236 V	6.99 dBV	20.00 dBm		20.00 dBm	0. V	0. dB	0. %	1.0000
25.00 V	27.96 dBV	40.96 dBm		10.00 dBm	24.29 V	30.96 dB	3.436 %	35.36

[1]) Entered value or measured value used; values remain stored until new value is entered.
[2]) dBμV.

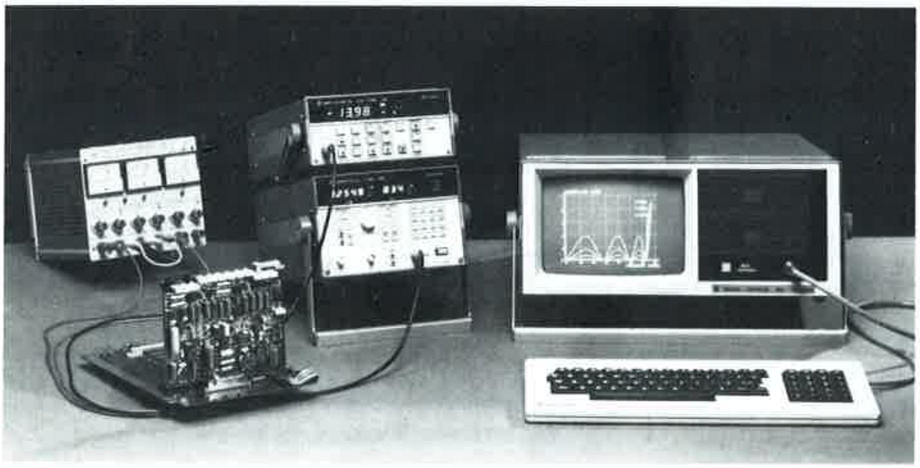
Service functions. The service functions of the URE are only rarely required and therefore no separate buttons are provided for them. These functions can be called up by pressing a certain combination of buttons. The functions display test, display of IEC-bus address or autocalibration, for instance, can easily be executed by entering a code number via the keyboard.

IEC-bus Option URE-B1. This option permit all functions of the voltmeter to be remotely controlled. The maximum measurement speed of 30 measurement per second makes the URE an ideal AF system voltmeteer.

DC Output Option URE-B2. This output supplies a DC voltage proportional to the indicated numerical value which permits logging of the measured values on a recorder. Thanks to the manifold conversion capabilities of the URE the scale can be linear or logarithmic. The output voltage range is −2 V to +2 V with least increments of 1 mV.

The relationship between the analog output voltage and the measured value is as follows:

Output voltage	=	Readout without decimal point	Example: Readout	V_{out}
V		10 000	11.500 V	+1.150 V
			−37.25 dBV	−0.372 V
			1.13%	+0.011 V



Automatic filter measurement with RMS Voltmeter URE, Process Controller PUC and Generator SPN

Specifications

Basic unit

Measured parameters .... DC voltage
AC voltage
AC + DC voltage

Frequency range

Measurement without lowpass filter .... 10 Hz to 20 MHz
Cutoff frequency (−3 dB) of switch-selected lowpass filters .... 4/20/100 kHz, 40 dB/decade

Measurement ranges

DC voltage .... 0 to +300 V
AC voltage .... 50 µV to 300 V
Range setting .... automatic or manual
automatic .... when applying the test voltage, with optimum switching speed
manual .... with RANGE HOLD button: prevents autoranging from switching to a lower range
or
selection of any range via service function

Input connector .... BNC female, floating
Input impedance .... 10 MΩ shunted by <40 pF
Loading capacity up to 20 kHz .... V_p = 600 V, V_{rms} = 300 V
up to 500 kHz .... V_p = 350 V, V_{rms} = 200 V
above 500 kHz .... $V_{rms} \times f$ = $<10^8$ V × Hz
Max. common-mode voltage .... <42 V (shock hazard)

Common-mode rejection .... >120 dB up to 100 Hz
>100 dB up to 10 kHz

Measurement rate
(measurements/second)

SLOW (f_l = 10 Hz) .... 0.8 (AC + DC: 0.4)
FAST (f_l = 100 Hz) .... 3 (AC + DC: 1.5)
SUPERFAST (f_l = 1 kHz) .... 30 (AC + DC: 15)

Settling times to 0.1% of fsd
(without changing the range)

SLOW .... 1.3 s
FAST .... 270 ms
SUPERFAST .... 25 ms

Weighting .... true rms-value rectification
Max. crest factor 5

Reference value .... entered via keyboard or directly as measured value
Entry of reference impedance (for dBm measurement) .... via keyboard, range 0.0001 to 19999 Ω

Readout of measured values

Units of measured parameters (see also text) .... V or mV
dBV
dBm
ΔV or ΔmV
ΔdB, Δ%
ratio (without unit)

Measured value, digital .... 4½-digit 7-segment LED display
Tendency indication .... quasi-analog indication by light dot travelling in a circle
Resolution in lowest subrange .... 1 µV
Digital steps 10,000

Error limits (at t_{amb} +15 to +30°C)

DC .... 0.1% of rdg +10 digits
AC (crest factor <3) .... see table below
AC + DC (crest factor <3) .... see table below, plus 10 digits
Additional error at crest factor 3 to 5 .... 3% of rdg

Temperature effect (at t_{amb} +5 to +15 and +30 to +45°C)

DC .... (0.01% of rdg + 1 digit)/°C
AC, up to 1 MHz .... 0.05% of rdg/°C
up to 10 MHz .... 0.15% of rdg/°C

Data of options

IEC-bus Option URE-B1

Interface to IEC 625-1 standard for control of all operating modes
Interface functions SH1, AH1, T5, L4, SR1, RL1, DC1, DT1
Connector .... 24-way, Amphenol

Analog-output Option URE-B2

Output impedance .... 100 Ω
Output voltage range .... −2 to +2 V
Resolution .... 1 mV/10 digits displayed
Error limits .... < ±2 mV

General data

Operating temperature range .... +5 to +45°C, safety class 1 to IEC 359 (no dew accumulation)
Storage temperature range .... −40 to +70°C
Power supply .... 100/120/220/240 V ±10%, 47 to 63 Hz (35 VA)
Radio interference .... complies with VDE 0871/0875 and MIL-STD 461 B
Dimensions, weight .... 220 mm × 109 mm × 340 mm, 4.4 kg

Ordering information

Order designation .... ▶ RMS Voltmeter URE
342.1214.02

Options

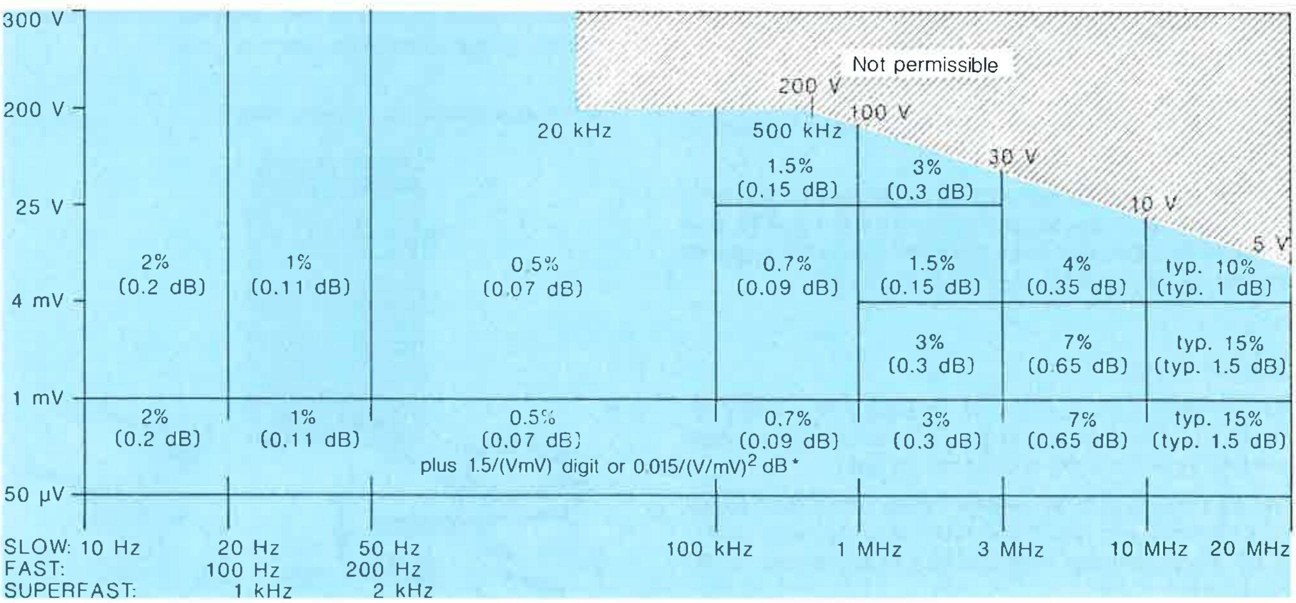
IEC-bus Option URE-B1 .... 342.2910.02
DC Output Option URE-B2 .... 342.2810.02

Recommended extras

19" Rack Adapter ZZA-22 .... 078.8222.00

Input-voltage-dependent frequency response error

* This additional error is almost negligible when the lowpass filter is switched into circuit or when considering the calculated inherent noise of the URE.



URV

RF-DC Millivoltmeter URV ♦ DC, 10 kHz to 2 GHz

- High sensitivity for DC and AC, lowest subrange 3 mV fsd
- Basic error 2.5% for RF measurement, 1% for DC measurement
- Two probe inputs facilitate two-port measurements
- RF voltage measurement in coaxial systems up to 350 V
- Battery operation: floating system

The **RF-DC Millivoltmeter URV** belongs to the time-proven URV series which is continuously being adapted to the state of the art.

The instrument features high sensitivity and accuracy, and a comprehensive range of accessories, such as probes, attenuators, insertion heads and adapters, make it suitable for many applications.

The URV has both V and dB scales (0 dB = 0.7746 V; 1 mW into 600 Ω).

Applications

Measurements on resonant circuits in oscillators, narrow-band amplifiers and filters, the extremely low loading causing only slight damping and detuning.

RF voltage measurements on broadband amplifiers. The slight load capacitance produces no phase shift, say, in feedback amplifiers.

Measurements on the outputs of low-power transmitters up to 200 W or of power stages.

Maximum, minimum, nominal-value adjustment of voltages. Measurement of the 3-dB points as a function of frequency.

Frequency-response measurements on two-port networks (gain, attenuation) are readily carried out with the URV, one probe being connected to the input and one to the output of the test item with switch selection on the URV.

Characteristics

Measurement ranges and input impedances. Measurements are possible direct at the DC input (4 mm knurled) terminals) from 50 µV to 1050 V into 10 MΩ.

Two equivalent inputs (three-pole female connectors) permit the simultaneous connection of two measuring heads for AC or RF measurements. They can be switch-selected on the instrument.

Combined with its various options (see specifications) the URV offers the following capabilities:

Use of
probe alone (0.5 mV to 10.5 V, C_{in} = 2.5 pF)

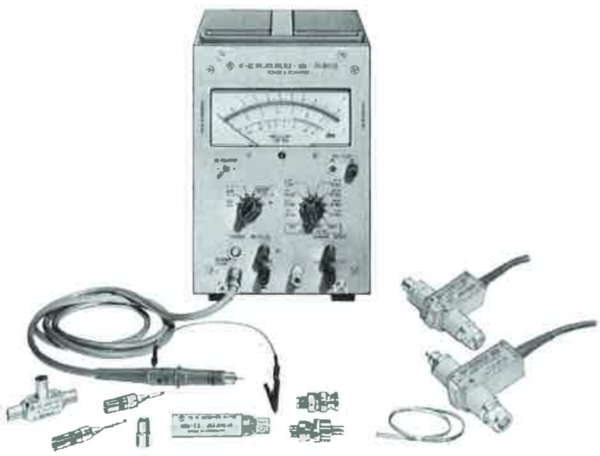
probe +20-dB divider (up to 100 V, C_{in} = 1 pF)
+40-dB divider (up to 1000 V, C_{in} = 0.5 pF)
+75-Ω adapter (makes up a termination for 75-Ω coaxial systems; 0.1 to 500 MHz, max. 2 W)
+coaxial BNC insertion adapter (with or without divider; for example up to 350 V with 40-dB divider)

Coaxial insertion heads with low reflection coefficients

10-V insertion head (500 µV to 10.5 V, 50 Ω: 10 kHz to 2 GHz; 75 Ω: up to 1.6 GHz)
100-V insertion head (5 mV to 105 V, 1 MHz to 2 GHz with 50 Ω)

Coaxial insertion heads and 75-Ω adapters are available for different connector systems; see specifications.

URV with accessories and recommended extras



Accuracy

The measuring heads are instrument-compatible; combined with any URV basic unit each probe and insertion head complies with the specified error limits without any adjustment.

At room temperatur the error limits of the URV are 0.5% of rdg +0.5% of fsd for DC voltage measurements, 1.5% of fsd plus frequency response of probe and insertion unit for AC measurements; see table below.

Frequency response error in % of reading

Measuring head	Range	10 kHz 2 5 100 kHz 2 5 1 MHz 2 10 MHz 100 MHz 2 5 1 GHz 1.6 2								
10-V insertion unit 50 Ω	0.1 to 10 V	Prozent v.M. 1	2	5	7	12	20			
	0.7 to 100 mV	2	3	7	10	12	20			
10-V insertion unit 75 Ω	0.1 to 10 V	1	2	5	7	15				
	0.7 to 100 mV	2	3	7	10	15				
100-V insertion unit 50 Ω	1 to 100 V	20	5	2	1	2	5	7	12	20
	7 to 1000 mV	30	10	3	2	3	7	10	12	20
RF probe *)	0.1 to 10 V	20	5	2	1	3	7	18		
	0.7 to 100 mV	20	5	3	5	10	15			
with 20-dB divider	1 to 100 V	20	11	13	16					
	7 to 1000 mV	20	13	15	20					
with 40-dB divider	10 to 1000 V	15	6	8	12					
	0.07 to 10 V	20	8	10	15					
with 75-Ω adapter	0.1 to 10 V	20	5	2	1	3	10			
	0.7 to 100 mV	20	5	3	5	12				

*) Probe alone or with 20-dB or 40-dB divider in BNC adapter (50-Ω coaxial system).

Reflection coefficients

Measuring head	Z_0	10 kHz 100 kHz 1 MHz 10 MHz 100 MHz 2 5 1 GHz 1.6 2				
10-V insertion unit	50 Ω	Reflection coefficient in % 1	2	5	10	15
	75 Ω	3	5	15	20	
100-V insertion unit	50 Ω	1	2			
75-Ω adapter	75 Ω	1.5	3	10		

Indication weighting

The URV has a 105° mirror scale which indicates the rms value for sinusoidal voltages. With non-sinusoidal voltages, the true rms value is indicated independently of the waveform in the ranges up to 30 mV (3 V with divider). For voltages of 1 V and higher, the test circuit operates as a full-wave peak-responding detector for all measuring heads.

Functional description

The RF probe and the insertion units both have two similarly designed detector circuits, one for the RF voltage to be measured and the other for the comparison voltage generated in the instrument. The difference of the two detected voltages is taken via an attenuator to a chopper amplifier followed by a filter and a control loop. The squarewave thus processed is converted to a sinewave and according to the measurement range drives the comparison detector circuit. Since matched diode pairs with identical characteristics are used in the detector circuits, the indicated voltage is proportional to the amplitude of a sinusoidal test voltage.

Specifications

DC voltage range ... 50 µV to 1050 V
Subranges ... 3/10/30/100/300 mV/ 1/3/10/30/100/300/1000 V

AC voltage range ... 0.5 mV to 10.5 (1050) V
Level, URV with dB scale ... −64 to +22.5 (62.5) dB
Subranges ... 3/10/30/100/300 mV/ 1/3/10 V −50/to/+20 dB

With
probe/10-V insertion unit ... 0.2 mV to 10.5 V
probe + divider
20 dB/100-V insertion unit ... 2 mV to 105 V
40 dB ... 20 mV to 1050 V

Frequency range
RF probe ... 100 kHz to 1 GHz (as indicator 2 GHz)
with 20-dB divider ... 2 to 500 MHz
with 40-dB divider ... 1 to 500 MHz
with 75-Ω adapter ... 100 kHz to 500 MHz
10-V insertion unit, 50 Ω ... 10 kHz to 2 GHz (3 GHz)
75 Ω ... 10 kHz to 1.6 GHz (3 GHz)
100-V insertion unit, 50 Ω ... 1 MHz to 2 GHz (3 GHz)

Input impedance
DC input ... 10 MΩ shunted by 10 pF
Probe ... >80 kΩ (up to 10 MHz), C_{in} ≈ 2.5 pF
with 20-dB divider ... >1 MΩ (up to 20 MHz), C_{in} = 1 pF
with 40-dB divider ... >10 MΩ (up to 20 MHz), C_{in} = 0.5 pF
Insertion units ... 50 Ω, 75 Ω, acc. to order; reflection coefficient up to 200 MHz: 1 (3)%, see also table on left

Loading capacity

	Max. values for V_{DC}	V_{rms} (sinewave)
DC input	1200 V	800 V
Probe	400 V	15 V
with 20-dB divider	1000 V	150 V
with 40-dB divider (100 MHz)	1000 V	1050 V
with 40-dB divider (500 MHz)	1000 V	210 V
10-V insertion unit	50 V	15 V
100-V insertion unit	1000 V	150 V
75-Ω adapter (up to 200 MHz)	12 V	12 V
Common line ref. to chassis	500 V	—

Error limits	V_{DC}	V_{rms} (sinewave)
at t_{amb} = +20 to +25°C	0.5% of rdg +0.5% of fsd	1.5% of fsd
at t_{amb} = +15 to +30°C	0.5% of rdg +1% of fsd	2% of fsd
plus frequency response error	see table on left	

DC output
Open-circuit voltage ... 1 V for indication of 10 or 3.16
Source impedance ... 1 kΩ
Settling time ... 500 ms

General data
Rated temperature range ... +5 to +40°C
Operating temperature range ... −20 to +60°C (w/o meas. head)
Storage temperature range ... −25 to +75°C (w/o meas. head and batt.)
Operating and storage temperature range for measuring heads ... 0 to +45°C
Dimensions, weight ... 162 mm×238 mm×275 mm, 4 kg

Ordering information

Order designation ... ▶ RF-DC Millivoltmeter URV 216.3612.02
URV with dBm scale ... 216.3612.03

Accessories supplied ... RF probe with earth cable and clip, earth sleeve, earth strip, hook tip, solder tip, 20-dB divider, 40-dB divider
6 batteries, R-20, IEC ... 017.0015.00

Recommended extras
Accessory Set URV-Z6 ... 292.5364.02 consisting of:
20-dB divider 241.1510.00,
40-dB divider 241.1710.00,
BNC Adapter URV-Z 241.1110.02
for RF probe (including matching sleeve for voltage divider

75-Ω Adapter URV-Z3
for RF probe ... 243.9118.70
including adapters from UNI-9 female
to 2.5/6 male 243.9260.00
1.6/5.6 male 243.9276.00
BNC male 243.9282.00

RF Insertion Units	50 Ω N connector	50 Ω Dezifix B	75 Ω Dezifix B
10-V Insertion Unit URV-Z2	288.8010.55	288.8010.54	288.8010.74
100-V Insertion Unit URV-Z4	283.7716.55	—	—

RF Probe URV-Z7 ... 292.5312.02 (additionally required for measurements using two RF probes)

URV 3

Millivoltmeter URV 3 ♦ 10 kHz to 2 GHz/0.7 mV to 1050 V

- Handy RF millivoltmeter for mobile and stationary use
- High-impedance voltage measurement with RF probe and dividers;
- Voltage and level measurement using insertion units with defined characteristic impedance of 50 or 75 Ω
- Basic error 2%
- Universal powering system – battery, accumulator, power supply unit or external source

Scale 1:2.5

The **Millivoltmeter URV 3,** the analog unit of the URV family, is a highly sensitive and accurate voltage and level meter for the frequency range from 10 kHz to 2 GHz (up to 3 GHz if only used as an indicator).

A broad range of accessories, such as probe, dividers, insertion units and adapters, and battery operation capability permit versatile mobile and stationary use of voltmeter.

Applications

RF voltage measurement. High-impedance measurements with RF probe in broadband amplifiers, on resonant circuits of oscillators, narrowband amplifiers and filters; measurements with impedance-matched RF insertion unit at the outputs of transmitters and other coaxial systems. True rms-value measurement possible up to 3 V and peakvalue measurement from 1 V RF voltage.

Adjustment to maximum, minimum or nominal value. Determination of the 3-dB points as a function of frequency.

Gain or attenuation measurement on passive or active four-terminal networks as a function of frequency (frequency response).

Level measurement in dBm referred to 0 dBm = 1 mW into Z = 50 Ω (0.2236 V), correction of level indication (according to relation $10 \log \frac{50}{Z}$): −1.76 dB at Z = 75 Ω.

Characteristics

The URV 3 affords extremely constant indication and zero setting as well as easy reading of measured values. Low capacitive and resistive loading by the RF probe minimize measuring errors introduced by detuning of resonant circuits, damping and unwanted phase shifts in feedback networks, etc. Mismatching is megligible thanks to the low reflection coefficient of the RF insertion units.

Measuring principle, measuring heads. In accordance with the well-proven control method used by the URV instruments (see page 207 under functional description), the RF voltage is converted into a proportional DC voltage with high linearity so that the accuracy is exclusively determined by the matching of the characteristics of the diodes incorporated in the measuring head. This makes the **measuring heads freely interchangeable** within the URV family without degrading the error limits.

Depending on the order number selected, the RF probe is supplied with the URV 3; the other accessories are recommended extras.

Connections and measuring possibilities:

Measurement using
probe alone (700 μV to 10.5 V, C_{in} = 2.5 pF)
probe +20-dB divider (up to 105 V, C_{in} = 1 pF)
+40-dB divider (up to 1050 V, C_{in} = 0.5 pF)
+coaxial BNC adapter (with or without divider; with 40-dB divider for instance up to 350 V)
+75-Ω adapter (RF voltage measurement in 75-Ω coaxial systems, 100 kHz to 500 MHz)

coaxial insertion units with low reflection coefficients
10-V insertion unit (700 μV to 10.5 V, 50 Ω: 10 kHz to 2 GHz, 75 Ω: 10 kHz to 1.6 GHz)
100-V insertion unit (7 mV to 105 V, 1 MHz to 2 GHz, 50 Ω)

Appropriately terminated, the 100-V insertion unit is suitable for measurements on power stages up to 200 W.

URV 3 with measuring heads and insertion units plus case accomodating small parts

Input Impedance of RF probe. The input impedance of the RF probe is given by the input capacitance C_{in} (see to the right) and the parallel input resistance R_p, which is dependent on the test voltage (100 kΩ to 1 MΩ between 1 mV and 10 V) and, above 3 MHz, also on the frequency.

Indication, waveform weighting. The RF voltage and level are indicated on a precision moving-coil meter on separate scales in eight subranges which can be manually selected. The level indication in dBm is valid for 50-Ω coaxial systems but can also be used to advantage for relative measurements in case of an undefined source impedance.

Rms-value measurement. The URV 3 measures and reads the rms value in the three most sensitive measurement ranges. At voltages above 1 V, it measures the peak-to-peak value (V_{pp}) but reads out the value $V_{pp}/2\sqrt{2}$ corresponding to the rms value for sinusoidal voltages.

Accuracy. The operational error consists of the basic error plus the frequency-response error. At room temperature the basic error is 2%; for the frequency-response error see the table below.

Frequency response error in % of reading

Measuring head	Range	10 kHz · 100 kHz · 1 MHz · 10 MHz · 100 MHz · 1 GHz · 2 GHz (Prozent v.M.)								
10-V insertion unit 50 Ω	0.1 to 10 V	1	2	5	7	12	20			
	0.7 to 100 mV	2	3	7	10	12	20			
10-V insertion unit 75 Ω	0.1 to 10 V	1	2	5	7	15				
	0.7 to 100 mV	2	3	7	10	15				
100-V insertion unit 50 Ω	1 to 100 V	20	5	2	1	2	5	7	12	20
	7 to 1000 mV	30	10	3	2	3	7	10	12	20
RF probe *)	0.1 to 10 V	20	5	2	1	3	7	18		
	0.7 to 100 mV	20	5	3	5	10	15			
with 20-dB divider	1 to 100 V	20	11	13	16					
	7 to 1000 mV	20	13	15	20					
with 40-dB divider	10 to 1000 V	15	6	8	12					
	0.07 to 10 V	20	8	10	15					
with 75-Ω adapter	0.1 to 10 V	20	5	2	1	3	10			
	0.7 to 100 mV	20	5	3	5	12				

*) Probe alone or with 20-dB or 40-dB divider in BNC adapter (50-Ω coaxial system).

Reflection coefficients

Measuring head	Z_0	Reflection coefficient in % (10 kHz · 100 kHz · 1 MHz · 10 MHz · 100 MHz · 1 GHz · 2 GHz)				
10-V insertion unit	50 Ω	1	2	5	10	15
	75 Ω	3	5	15	20	
100-V insertion unit	50 Ω	1	2			
75-Ω adapter	75 Ω	1.5	3	10		

Specifications

Instrument

Test input

Parameters measured	voltage (V, mV)/level (dBm)
Frequency range	10 kHz to 2 GHz
Voltage range	700 µV to 1050 V (with dividers)
Subranges	3/10/30/100 mV/0.3/1/3/10 V
Level range	−50 to +73 dBm
Subranges	−40/−30/−20/−10/0/+10/+20/+30 dBm
Level reference	0 dBm corresponding to 1 mW into 50 Ω (0.2236 V)
Range of indication	300 to 700 µV or −57 to −50 dBm

Connection of measuring head	three-pole socket (for URV meas. heads)

Recorder output (shortcircuit-proof)

Output voltage	1 V at final value 10, 3.3 V at final value 3.3, 10 V at final value 10 in range 10 V
Output impedance	1 kΩ
Polarity	positive, referred to ground
Connectors	two 4-mm sockets
Setting time	approx. 100 ms for test voltages >10 mV (increasing with decreasing volt.)

RF measuring heads

RF measuring heads	RF probe with 20-dB and 40-dB dividers as well as BNC adapter and 75-Ω adapter; 10-V insertion unit (50, 75 Ω); 100-V insertion unit (50 Ω)
Input impedance of RF probe	R_p >80 kΩ (up to 10 MHz), C_{in} = 2.5 pF
with 20-dB divider	R_p >1 MΩ (up to 20 MHz), C_{in} = 1 pF
with 40-dB divider	R_p >10 MΩ (up to 20 MHz), C_{in} = 0.5 pF

Voltage rating	V DC	V_{rms} (sinew.)	V_p
RF probe	400 V	15 V	22 V
with 20-dB divider	1000 V	150 V	220 V
with 40-dB divider			
up to 100 MHz	1000 V	1050 V	1500 V
up to 500 MHz	1000 V	210 V	1500 V
10-V insertion unit	50 V	15 V	22 V
100-V insertion unit	1000 V	150 V	220 V
75-Ω adapter (P_{max} = 2 W)	12 V	12 V	17 V

Frequency ranges

RF probe	100 kHz to 1 GHz (from 20 kHz to 2 GHz if only used as indicator)
with 20-dB/40-dB divider	1 to 500 MHz/0.5 to 500 MHz
10-V insertion unit, 50 Ω	10 kHz to 2 GHz (up to 3 GHz if only used as indicator)
10-V insertion unit, 75 Ω	10 kHz to 1.6 GHz
100-V insertion unit, 50 Ω	1 MHz to 2 GHz
75-Ω adapter	100 kHz to 500 MHz

Voltage ranges (level ranges Z = 50 Ω)

RF probe, 10-V insertion unit	700 µV to 10.5 V/−50 to +33 dBm
RF probe with 20-dB divider	7 mV to 105 V/−30 to +53 dBm
100-V insertion unit	7 mV to 105 V/−30 to +53 dBm
RF probe with 40-dB divider	70 mV to 1050 V/−10 to +73 dBm

Error limts (sinewave voltages)

Operational error = basic error + frequency response error (see left)

Basic error at t_{amb} +20 to +25 °C	2% of fsd
t_{amb} +15 to +30 °C	2.5% of fsd
t_{amb} + 5 to +40 °C	2.5% of fsd +2% of rdg

General data

		Measuring heads
Rated temperature range	+ 5 to +40 °C	
Operating temperature range	−20 to +60 °C	0 to +45 °C
Storage temperature range	−25 to +75 °C	−15 to +60 °C
Power supply	battery compartment for operation with: 4 single cells 1.5 V, R-20, DIN 40 866 and IEC, lead-acid accumulator or AC supply unit: external source 5 to 8 V/35 mA	
Service life		
Battery (alkali-manganese cells)	approx. 200 h	
Lead-acid accumulator	approx. 70 h	
Dimensions, weight	241 mm×110 mm×219 mm, 2.5 kg	

Ordering information

Order designation	▶ Millivoltmeter URV 3
URV 3 with probe	302.9014.02
URV 3 without probe	302.9014.12

Accessories supplied

RF Probe URV-Z7 (only with model 02)	comprising earth cable with clip, earth sleeve, earth strip, hook tip, solder tip, case
4 batteries, R-20, IEC	

Recommended extras

Accessories URV-Z6	292.5364.02 comprising 20-dB divider, 40-dB divider, BNC adapter URV-Z for RF probe, including reducing sleeve for dividers
75-Ω adapter URV-Z3	243.9118.70 comprising adapters from UNI-9 socket to 2.5/6 connector, to 1.6/5.6 connector and to BNC conn.

RF insertion units (other connectors on request)	50 Ω N connect.	50 Ω Dezifix B	75 Ω Dezifix B
10-V Insertion Unit URV-Z2	288.8010.55	288.8010.54	288.8010.74
100-V Insertion Unit URV-Z4	283.7716.55	—	—

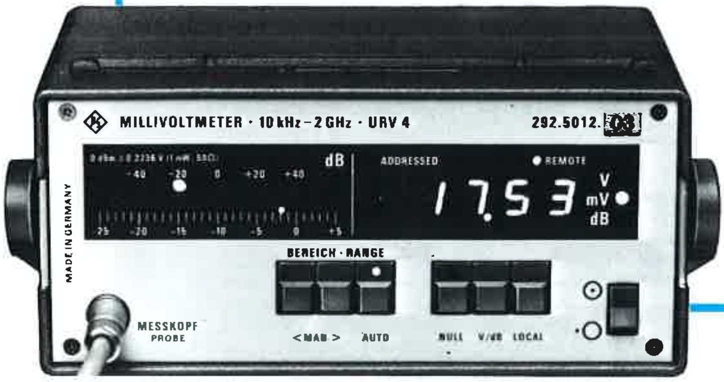
Power Supply (6 V) EGT-Z (220/115 V, 50/60 Hz), with connecting cable for buffer operation and charging	201.5414.00
Lead-acid Storage Battery (6 V) EGT-Z	201.5437.00

URV 4

Millivoltmeter URV 4

♦ 10 kHz to 2 GHz
700 μV to 1000 V/−50 to +73 dBm

- Model 02 for manual measurement
  Model 03 for manual measurement and remote controlled operation via IEC bus
- Digital readout of voltage and level, resolution 1 μV and 0.01 dB
- Additional analog level indication for trimming (rapid tendency indication), resolution 0.5 dB
- RF voltage measurement in coaxial systems up to 350 V



Scale 1:2.5

IEC 625 Bus

The **URV 4** – the first digital meter of the URV series – is a highly sensitive and accurate **millivoltmeter** measuring RF voltages and levels from 10 kHz to 2 GHz, up to 3 GHz if only used as indicator. Both high-impedance measurements using the probe of low capacitive loading and voltage measurements in any coaxial system (up to 350 V) or systems of standard characteristic impedance (50 and 75 Ω) are possible. To this end a comprehensive range of accessories such as probes and measuring heads is available.

System compatibility. The URV 4 is available with and without IEC-bus interface, the characteristics remaining the same. In addition to the conventional applications (see also URV and URV 3), the instrument fitted with the IEC-bus connector is especially, suitable for use in automatic test assemblies and systems.

The digital display gives a readout of the voltage or the level. Its high resolution and accuracy (4000 steps for measuring voltage; 10,000 steps without autoranging) is optimally matched to the overall accuracy of the measuring head and the meter. The measurement ranges can also be pushbutton-selected after switching off the autoranging. The levels are indicated directly in dB relative to 1 mW into 50 Ω in all subranges. When the unknown signal falls out of the selected subrange, the display of the URV 4 flashes.

Additional analog indication. To facilitate trimming (tendency indication) and for coarse measurements an additional analog indication is provided on the URV 4 in the form of a row of LEDs. The coverage is 30 dB in steps of 1 dB. Since two LEDs light between steps, level differences of 0.5 dB are discernible. The reference value for the analog scale can be taken from the five additional range indications.

Automatic zeroing. The URV 4 features automatic zeroing for voltage measurements in the most sensitive measurement range. It sets the electrical zero at the press of a button doing away with the tedious and error-prone zero setting by means of a zero adjustment potentiometer. Zero correction is not required in the higher measuring ranges.

A level-proportional DC voltage (100 mV/dB) is available at the **recorder output** provided on the rear panel of the URV 4. Thus with the aid of automatic ranging continuous recording is possible over a dynamic range of 83 dB.

The URV 4 can be powered from the **AC supply** or an external battery (automatic switchover depending on available AC supply voltage).

Measuring heads (probes, insertion units, adapters)

The measuring heads are freely interchangeable – also with those of the predecessor type URV. Depending on the order number selected, the RF probe is supplied with the URV 4, the other extras are recommended for use with the set.

RF probe alone:	700 μV to 10 V 100 kHz to 1 GHz (indicator up to 2 GHz)
RF probe + 20-dB divider:	7 mV to 100 V/2 to 500 MHz
+ 40-dB divider:	70 mV to 1000 V/1 to 500 MHz
+ BNC adapter	(with or without divider): measurement in any coaxial system up to 350 V (probe + 40 dB)
+ 75-Ω adapter:	700 μV to 10 V/100 kHz to 500 MHz
10-V insertion unit; 50 or 75 Ω:	700 μV to 10 V 10 kHz to 2 GHz (50 Ω)
100-V insertion unit; 50 Ω: (for powers up to 200 W)	7 mV to 100 V 1 MHz to 2 GHz

Case containing accessoires and recommended extras

Input impedance of RF probe. The input impedance of RF probe is given by the input capacitance C_{in} (see to the right) and the parallel input resistance R_p, which is dependent on the test voltage (100 kΩ to 1 MΩ between 1 mV and 10 V) and, above 3 MHz, also on the frequency.

Waveform weighting. The URV 4 measures and reads out the rms value in the three most sensitive measurement ranges. At voltages above 1 V, it measures the peak-to-peak value (V_{pp}), but reads out the value $V_{pp}/2\sqrt{2}$ corresponding to the rms value for sinusoidal voltages. The following table gives **permissible crest factors** for different test voltages with a weighting error of 2 and 5% (blue for peak-value measurement).

Probe +	10-V insertion unit	20-dB divider + 100-V insertion unit	40-dB divider
Error	2 / 5%	2 / 5%	2 / 5%
V_{meas}	crest factor	crest factor	crest factor
3 mV	10 / 13		
10 mV	3 / 4		
30 mV	1.7 / 2	10 / 13	
100 mV		3 / 4	
300 mV		1.7 / 2	10 / 13
1 V	2.2/3.8		3 / 4
3 V	4.1/7.2		1.7 / 2
10 V	8.0/ 15	2.2/3.8	
30 V		4.1/7.2	
100 V		8.0/ 15	2.2/3.8
300 V			4.1/7.2
1000 V			8.0/ 15

Accuracy. The operational error consists of the basic error plus the frequency-response error; see the corresponding tables.

Basic error in the indicating range 300 to 4000 or −20 to +5 dBm on the analog scale

	Voltage measurement *)		Level measurement *)		
	4 mV to 10 V	0.7 to 4 mV	-35 to+33 dBm	-45 to -35 dBm	-50 to-45 dBm
+20 to +25 °C	1% of rdg + 3 digits	1% of rdg + 30 digits	0.2 dB	0.4 dB	0.6 dB
+15 to +30 °C	2% of rdg + 3 digits	2% of rdg + 40 digits	0.3 dB	0.6 dB	0.8 dB
+ 5 to +40 °C	3% of rdg + 5 digits	5% of rdg + 50 digits	0.5 dB	1 dB	1.2 dB

*) Used only as indicator at voltages <0.7 mV or levels <−50 dBm.

Frequency-response error (reflection coefficients as for URV)

Prozent v.M.

Measuring head	Range	10–20 kHz	20–50 kHz	50–100 kHz	100–200 kHz	200–500 kHz	500 kHz–1 MHz	1–2 MHz	2–100 MHz	100–200 MHz	200–500 MHz	500 MHz–1 GHz	1–1.6 GHz	1.6–2 GHz
10-V insertion unit 50 Ω	0.1 to 10 V	1								2	5	7	12	20
	0.7 to 100 mV	2								3	7	10	12	20
10-V insertion unit 75 Ω	0.1 to 10 V	1								2	5	7	15	
	0.7 to 100 mV	2								3	7	10	15	
100-V insertion unit 50 Ω	1 to 100 V				20	5	2	1		2	5	7	12	20
	7 to 1000 mV				30	10	3	2		3	7	10	12	20
RF probe *)	0.1 to 10 V		20	5	2	1				3	7	18		
	0.7 to 100 mV		20	5	3					5	10	15		
with 20-dB divider	1 to 100 V							20	11	13	16			
	7 to 1000 mV							20	13	15	20			
with 40-dB divider	10 to 1000 V						15	6		8	12			
	0.07 to 10 V						20	8		10	15			
with 75-Ω adapter	0.1 to 10 V		20	5	2	1				3	10			
	0.7 to 100 mV		20	5	3					5	12			

*) Probe alone or with 20-dB or 40-dB divider in BNC adapter (50-Ω coaxial system).

Specifications

Instrument

Test input

Parameters measured .... voltage/level (dBm)
Frequency range .... 10 kHz to 2 GHz
Voltage range .... 700 µV to 1000 V
Subranges .... 4/40/400 mV/4/10 V

Level range .... −50 to +73 dBm
Subranges .... −40/−20/0/+20/+40 dB
Level reference .... 0 dBm corresponding to 0.2236 V (1 mW into 50 Ω)
Range of indication .... 300 to 700 µV
Range setting .... autoranging
pushbuttons for manual setting to next higher/lower subrange

Auto zeroing .... elektronic zeroing by pushbutton control for measuring RF voltages <4 mV

Readout of measured value
Range indication, analog .... 5 LEDs for subranges
digital .... decimal point and unit (mV/V/dB)
Digital display
Voltage .... 4 digits (4000 steps, 10,000 steps without autoranging), resolution 1 µV
Level .... 4 digits plus polarity sign, res. 0.01 dB
Analog level indication .... row of 31 LEDs
Indication range .... −25 to +5 dB, step size 1 dB, resolution 0.5 dB

Recorder output .... 1 kΩ, shortcircuit-proof
Output voltage .... positive or negative level-proportional DC voltage, 0 V at 0 dBm (223.6 mV), 100 mV per dB input level variation
Dynamic range .... 83 dB corres. to −5 to +3.3 V

IEC-bus connector (model 03) .. interface in accordance with IEC 625-1 for controlling the operating modes
Interface functions SH1, AH1, T5, L4, SR1, RL1, DC1
Setting time .... level-dependent, up to 30 meas./s

Connection of measuring head . three-pole female connector (for URV measuring head)

RF measuring heads

RF measuring heads ...... RF probe with 20-dB and 40-dB dividers as well as BNC adapter and 75-Ω adapter
10-V insertion unit (50, 75 Ω)
100-V insertion unit (50 Ω)

Input impedance of RF probe ... R_p >80 kΩ (up to 10 MHz), C_{in} = 2.5 pF
with 20-dB divider .... R_p >1 MΩ (up to 20 MHz), C_{in} = 1 pF
with 40-dB divider .... R_p >10 MΩ (up to 20 MHz), C_{in} = 0.5 pF

Voltage rating	V DC	V_{rms} (sinew.)	V_p
RF probe	400 V	15 V	22 V
with 20-dB divider	1000 V	150 V	220 V
with 40-dB divider			
up to 100 MHz	1000 V	1050 V	1500 V
up to 500 MHz	1000 V	210 V	1500 V
10-V insertion unit	50 V	15 V	22 V
100-V insertion unit	1000 V	150 V	220 V
75-Ω adapter (P_{max} = 2 W)	12 V	12 V	7 V

Frequency ranges
RF probe .... 100 kHz to 1 GHz (2 GHz)
with 20-dB/40-dB divider ...... 2 to 500 MHz/1 to 500 MHz
10-V insertion unit 50 Ω .... 10 kHz to 2 GHz (indicator: 3 GHz)
10-V insertion unit 75 Ω .... 10 kHz to 1.6 GHz
100-V insertion unit 50 Ω .... 1 MHz to 2 GHz
75-Ω adapter .... 100 kHz to 500 MHz

Voltage ranges (level ranges)
RF probe, 10-V insertion unit ..... 700 µV to 10 V/−50 to +33 dBm
RF probe with 20-dB divider, 100-V insertion unit .... 7 mV to 100 V/−30 to +53 dBm
RF probe with 40-dB divider ..... 70 mV to 1000 V/−10 to +73 dBm

Error limits

Error limits .... see lefthand column under accuracy

General data

Rated temperature range .... +5 to +40 °C
Operating temperature range .... −20 to +60 °C (measuring head: 0 to +45 °C)
Storage temperature range ...... −25 to +75 °C (measuring head: −15 to +60 °C)
Power supply, AC supply .... 115/220 V ±10%, 47 to 440 Hz (4 VA, model 03: 6 VA)
ext. battery .... 11 to 28 V, 300 (450) mA at 12 V
Dimensions, weight .... 241 mm×110 mm×219 mm, 2.6 kg (2.9 kg)

Ordering information

Order designation	▶ Millivoltmeter URV 4 with probe	without probe
URV 4 without IEC-bus connector .	292.5012.02	292.5012.12
with IEC-bus connector ...	292.5012.03	292.5012.13
(10 kHz to 1 GHz)	292.5012.04	—

Accessories supplied
RF probe URV-Z7, same as for URV 3 (only for models 02 and 03 of URV 4), RF probe 342.3600.04 (only for model 04 of URV 4), connector for battery; power cable

Recommended extras
Accessories URV-Z6, 75-Ω adapter and RF insertion units as for URV 3 on page 209
Adapter ZZA-1 for 19" racks 078.8016.00

Power measurement at high frequencies

Active power is defined in electrical engineering as the product of the magnitudes of current and voltage, taking account of the phase angle between them:

$$P_{active} = |\underline{V}_{rms}|\,|\underline{I}_{rms}|\,\cos\varphi.$$

This applies, of course, also for RF power.

The frequency range in which a power measurement according to this formula is practicable extends from a few Hz to about 10 kHz. A dynamometer inserted into the current and voltage paths accomplishes the multiplication with correct phase.

At **higher frequencies the dynamometer** can no longer be used to measure power. Two completely different methods are employed here represented by the output power meter (absorption type) and the directional power meter, which also differ in their fields of application.

Power meters and reflectometers

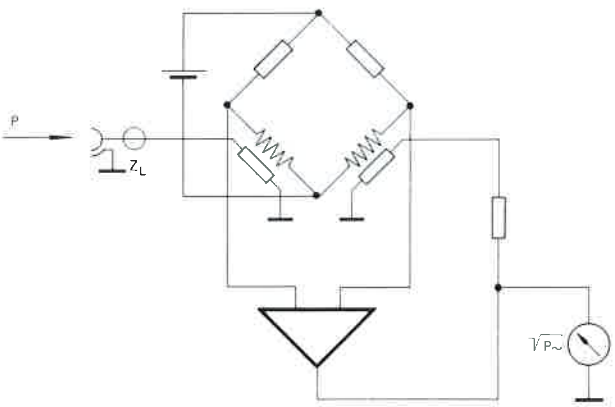
Output power meters

Output power meters practically have a resistive input impedance, the standard values being 50, 60 or 75 Ω (Z_0). They thus reflect only a small portion of the incident wave energy while the major part is converted into heat. The power indication of the output power meter is derived from the measurement of the heat produced (calorimeter).

The Microwave Power Meter NRS operates according to this principle.

The power consumed in matched probe is converted into heat and unbalances a very sensitive bridge. The power of a standard resistor required to compensate for the unbalance is a measure of the power applied to the probe.

The principle of the output power meter is shown in the following diagram.



Power measurement using temperature-dependent resistors in a bridge circuit

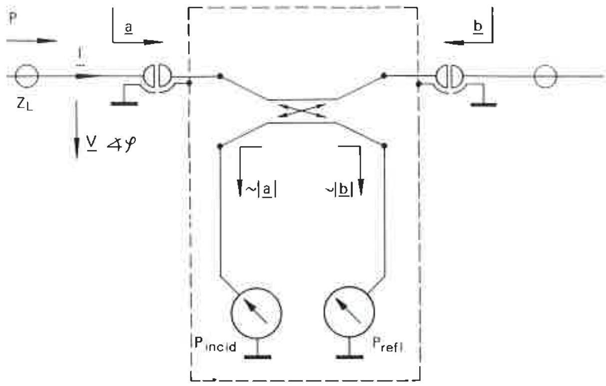
Directional power meters

Directional power meters are inserted into a transmission line and measure the incident and reflected powers according to a directional-coupler principle. Transmitter output power and antenna or load matching can be checked simultaneously with this type of power meter.

The reflection coefficient is obtained as

$$|\underline{r}| = \sqrt{\frac{P_{refl}}{P_{incid}}}$$

and
$$VSWR = \frac{1 + \sqrt{P_{refl}/P_{incid}}}{1 - \sqrt{P_{refl}/P_{incid}}}$$



Power measurement using directional coupler

Instruments operating on this principle are the Power Meters NAU and NAUS.

Overview

Several instruments with different power and frequency ranges are available for use in the frequency range of 1 to 1000 MHz; see table on next page.

Type NAN with its power range extending up to 1.2 kW is suitable for power measurement and matching indication in the **shortwave range.**

With a power range of 30 W NAUS 3 is ideal for **measurements on RT equipment** between 25 and 1000 MHz. All frequency bands and power classes of the radio sets are covered without exchanging any measuring heads or inserts. The AM Unit SMDU-Z1 and the Power Test Adapter SMDU-Z2 are destined for use in RT and air navigation test assemblies, but can also operate on their own.

For **higher-power applications,** e.g. measurement on transmitter systems, NAUS 4 (25 to 1000 MHz, 110 W) and NAUS 5 and 6 (25 to 1000 MHz, 340 W and 1100 W, resp.) are available.

Adjacent-channel **interference components** of radio equipment are measured and weighted by the **Adjacent-channel Power Meter NKS** in conjunction with the RT Test Assembly SMDU. The NKS is therefore described in section 3 page 115 among the test assemblies.

Frequency range	Designation	Type	Order No.*	Power range	Sub-ranges	Error of fsd	Indication of small refl. components	Text on page
1.5 to 30 MHz	HF-Wattmeter & Matching Indicator	NAN	100.2727...	0 to 1.2 kW	4	±8% incl. freq. resp.	—	213
25 to 1000 MHz	Directional Power Meter	NAUS 3 NAUS 4	288.8610... 289.9010...	20 mW to 34 W 50 mW to 110 W	5 5	page 215	20 mW to 34 W 50 mW to 110 W	214
25 to 1000 MHz	Directional Power Meter	NAUS 5 NAUS 6	349.8014.55 349.8314.54	0.2 to 340 W 0.5 to 1100 W	5 5	page 216	0.2 to 340 W 0.5 to 1100 W	215
1 to 1050 MHz	AM Unit	SMDU-Z1	242.2010...	50 mW to 30 W 0.1 to 60 W	5 5	± (8% of rdg +1.5% of fsd)	—	106
1 to 1050 MHz	Power Test Adapter	SMDU-Z2	242.4012.52	50 mW to 30 W	5	± (8% of rdg +1.5% of fsd)	—	106
0 to 15 GHz	Microwave Power Meter + Probe	NRS	100.2433.92 100.2440...	0.1 to 330 mW[1]	5	±1.5 (2.3) %	—	217

*** If seven-figure designation is given, see text for complete (nine-figure) order No.**

[1]) The measurement range can be extended with high-power attenuators (section 10).

HF Wattmeter & Matching Indicator NAN
♦ 1.5 to 30 MHz

- Reflection-coefficient range of 0 to 100%
- Power range up to 1200 W, direct reflection indication with 20 W incident power

The HF Wattmeter affords direct power and reflection-coefficient reading in the shortwave range. The instrument is suitable for measuring the power of HF transmitters and for matching antennas, therapeutic equipment and other loads.

The NAN consists of a measuring head and an indicator. The measuring head is connected into the transmission line. It accomodates two directional couplers and is connected to the indicator section with a cable. The indication of incident or reflected power as well as reflection can be switch-selected.

The measuring-head connector is an RF female connector 4/13, DIN 47284, that can be adapted to many other connector systems.

Specifications

Frequency range	1.5 to 30 MHz
Four subranges for incident and reflected power (fsd)	36/120/360/1200 W
Reflection coefficient range	0 to 100%
Minimum incident power required for direct reflection-coefficient reading	20 W
Maximum power	1200 W
Characteristic impedance	50 Ω
Reflection due to the coupling systems	<2%
Error limits of indication incl. frequency response error	±8% of fsd (with temperature correction curve)
Dimensions	measuring head: 76 mm×76 mm×100 mm indicator: 130 mm×180 mm×105 mm
Order designation	▶ HF-Wattmeter & Matching Indicator NAN 100.2727.50

NAUS 3 and 4

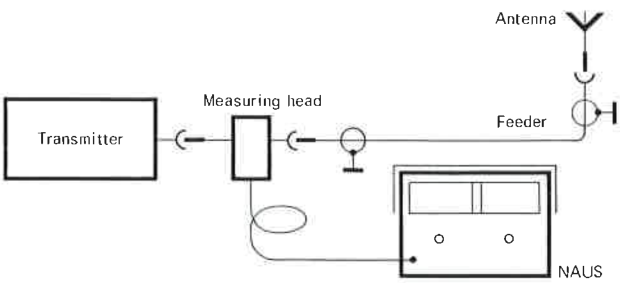
Directional Power Meter NAUS 3 ♦ 25 to 1000 MHz/34 W
NAUS 4 ♦ 25 to 1000 MHz/110 W

- For servicing radio sets and systems
- Separate measuring head – forward direction arbitrary
- Simultaneous indication of incident (forward) and reflected power – independent range setting
- Lowest power reading 20 mW (NAUS 4: 50 mW); indication of average power, high accuracy

For powers of 340 W/1100 W: see page 216

The **Directional Power Meters NAUS** are handy, easy to operate and designed for in-situ servicing of radiotelephone equipment, radio installations (up to 110 W with NAUS 4) and walkie-talkies of low output. Owing to their wide frequency and power ranges the NAUS power meters can be used over the entire radiotelephone bands for the output levels of most types of radiotelephone equipment.

The power meters of the NAUS series are similar in appearance and design; they differ mainly in their power handling capacities, see above. The instruments consist of an indicator (case with carrying handle, see photos) and a separate measuring head, which can be connected in either direction. The incident and the reflected power are indicated on separate meters so that – also due to the wide continuous frequency range – operating errors are precluded.



Power measurement on antenna feeder using NAUS

Measurement ranges. The power range of the NAUS power meters is divided into five subranges; it extends from 20 mW to 34 W, from 50 mW to 110 W, from 200 mW to 340 W or from 500 mW to 1100 W depending on the model; fsd is obtained with 0.3 W, 1 W, 3 W or 11 W in the most sensitive range. The range of the 30-W models can be extended to 68 W by inserting a High-power Attenuator RBU (3 dB, see section 10).

Indication and accuracy. The instruments deliver correct results under all conditions: the indication is highly stable and insensitive to temperature fluctuations. Since the rectifier diodes are very lightly driven, both meter scales are linearly calibrated and the indications can be easily read. True average power indication is also given of non-sinusoidal signals (modulated transmitter). The negligible internal losses do not impair the measurements.

Input and output. The measuring head is available in the following models depending on the order number:

NAUS 3 50 Ω Dezifix B or N female/male, all adaptable
NAUS 4 50 Ω N female/male, adaptable.

Suitable screw-in assemblies for conversion to other connector systems (e.g. UHF or BNC): please enquire.

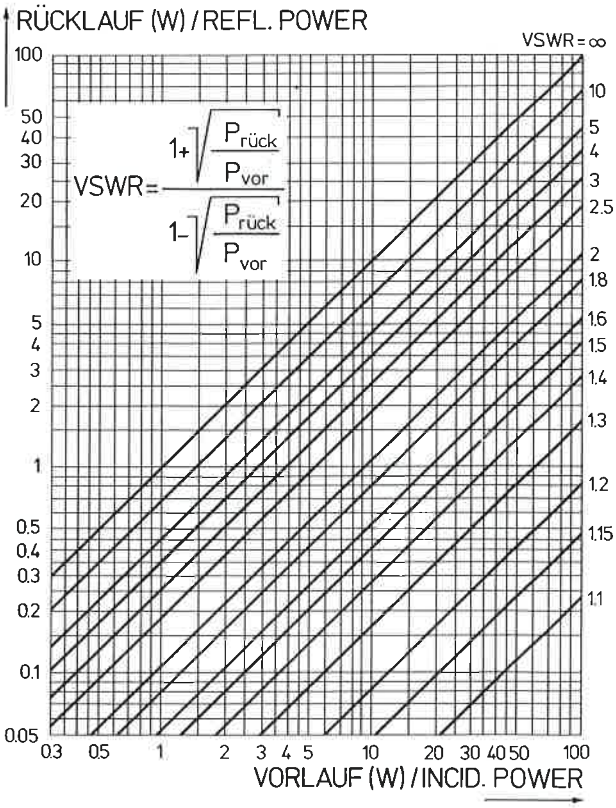
Since the two measuring channels are alike, the forward direction is arbitrary.

Design and power supply. The measuring head of the NAUS consists of a directional coupler. The input power is fed through to the load with almost no attenuation (electrical length of line 140 mm). The secondary line is matched at both ends. Voltages proportional to the incident and reflected power are coupled into this line and rectified. An RC section is used to compensate for the frequency response of the coupler. The rectified signal voltages are fed via the connecting cable to the instrument which includes shielded chopper amplifiers, and are then displayed separately.

The power supply uses five 1.5-V batteries (R20, acc. to DIN or IEC). These can be easily replaced after removing the cabinet cover (voltage check by pressing a pushbutton on the lefthand meter). Owing to the very low current drain, a set of commercially available, leakproof batteries has a lifetime of almost one year with continuous operation (>7000 operating hours).

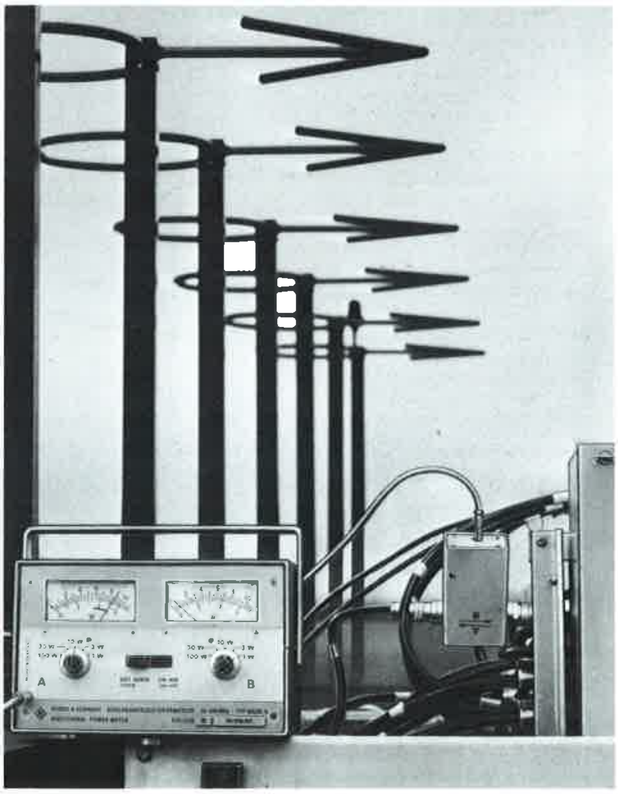
Directional Power Meter NAUS 4 (50 mW to 110 W)

A diagram (right) for determining the VSWR as a function of the incident andd reflected power is provided on the rear of the instrument.



Graph to derive VSWR from incident and reflected power (provided on the rear panel of each instrument)

Measurement of incident and reflected power in the feeder of an antenna for air-traffic control with the Directional Power Meter



Specifications

	NAUS 3	NAUS 4
Frequency range	25 to 1000 MHz	
Permissible incident and reflected power	34 W	110 W
Indication ranges	0.34/1.1/3.4/11/ 34 W	1.1/3.4/11/34/ 110 W
Lowest power reading	20 mW	50 mW
Indication error	≦3% of rdg ±2% of fsd	≦3% of rdg ±2% of fsd
Effect of temperature	≦0.25%/°C	≦0.25%/°C
Directivity		
at and above 30 MHz	≧30 dB	≧30 dB
up to 30 MHz	≧26 dB	≧26 dB
Characteristic impedance	50 Ω	50 Ω
VSWR	≦1.03	≦1.03
Transmission loss		
up to 300 MHz	≦0.1 dB	0.08 dB
up to 500 MHz	≦0.25 dB	0.15 dB
up to 1000 MHz	≦0.75 dB	0.35 dB
Electrical length of transmission channel	140 mm	140 mm

General data (all models)

Rated temperature range	−20 to +55 °C
Storage temperature range	−25 to +70 °C
Power supply	5 single cells 1.5 V, R 20 IEC
Battery life	>7000 hours
Dimensions indicator	230 mm×150 mm×130 mm
measuring head 50 Ω	125 mm×105 mm× 45 mm
60 Ω	125 mm×105 mm× 62 mm
Weight	4 kg

Ordering information

Order designations	▶ Directional Power Meter
NAUS 3 (50 Ω), Dezifix B	288.8610.54
N connector	288.8610.55
NAUS 4 (50 Ω), N connector	289.9010.55

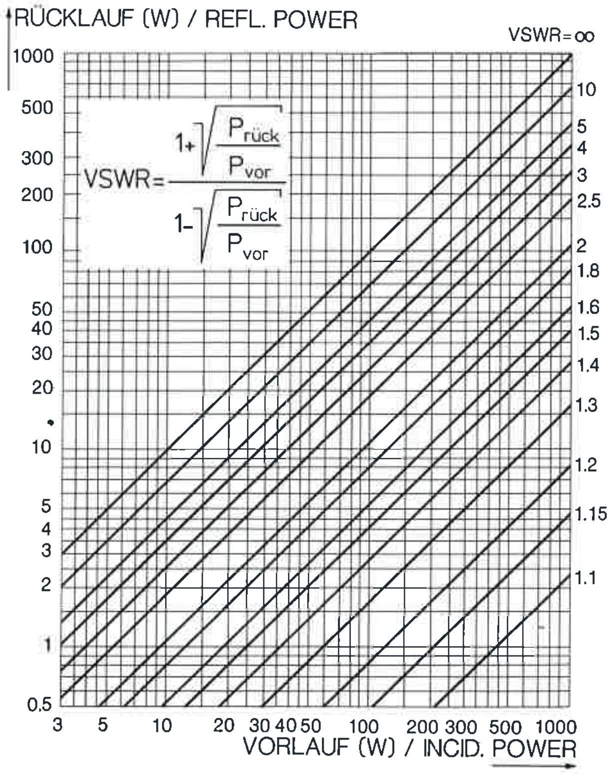
NAUS 5 and 6

Directional Power Meter NAUS 5 ♦ 25 to 1000 MHz/340 W
NAUS 6 ♦ 25 to 1000 MHz/1100 W

- Reflection-free power and VSWR measurement; VSWR ≦1.03
- Lowest power reading 0.2 or 0.5 W respectively; indication of average power
- Battery operation with more than 7000 hours service life

Apart from their higher power rating the **Directional Power Meters NAUS 5 and NAUS 6** are the same in design and performance as the NAUS 3 and NAUS 4 models described on pages 214, 215. Like these they consist of an **indicator** (case with carrying handle) and a separate **measuring head** which can be connected in either direction. The incident and the reflected power are indicated on separate meters in five subranges.

The power supply uses five 1.5-V cells which are easy to replace and last for more than 7000 operating hours on average.



Graph to derive VSWR from incident and reflected power (provided on the rear panel of each instrument)

Applications: Owing to their higher power-handling capacity the NAUS 5 and NAUS 6 can be used for power and VSWR measurements on modulated or unmodulated transmitter, radio equipment in general and power stages (amplifier alignment). Each unit is provided on its rear panel with a graph enabling the user to read the VSWR from the incident and the reflected power.

Specifications

	NAUS 5	NAUS 6
Frequency range	25 to 1000 MHz	25 to 1000 MHz
Indicator		
Meter calibration	in W, linear scale	
Subranges	3.4/11/34 110/340	11/34/110/ 340/1100
Lowest power reading	0.2 W	0.5 W
Maximum indicent and reflected power	340 W	1100 W
Indication error	≦4% of rdg ±2% of fsd	
Temperature effect	≦0.25%/°C	
Directivity at and above 30 MHz	≧30 dB	
up to 30 MHz	≧26 dB	
Measuring head		
Characteristic impedance	50 Ω	
VSWR	≦1.03	
Transmission loss		
up to 300 MHz	≦0.08 dB	≦0.05 dB
up to 500 MHz	≦0.15 dB	≦0.1 dB
Electrical length	140 mm	140 mm
Connectors (adaptable)¹)	N female/ N male	Dezifix B²)
General data (both types)		
Nominal temperature range	−20 to +55°C	
Storage temperature range	−40 to +70°C	
Power supply	5 single cells 1.5 V, R20	
Battery life	>7000 hours	
Battery check	indication on lefthand meter	
Dimensions of indicator	230 mm×150 mm×130 mm	
measuring head	125 mm×105 mm×45 mm	
Weight	4 kg	

Ordering information

Order designation	▶ Directional Power Meter
NAUS 5 (340 W)	349.8014.55
NAUS 6 (1100 W)	349.8314.54

¹) Suitable screw-in assemblies for conversion to UHF connector: male 017.7384.00, female 017.5217.00; Dezifix B: 018.2486.00; please order separately.

²) When using N connectors for NAUS 6, it should be noted that the max. power of 1.1 kW can only be measured up to 650 MHz due to the size of the connectors.

Microwave Power Meter NRS

NRS

◆ 0.1 to 330 mW

- Wide frequency range 0 to 15 GHz
- Exchangeable probes for 50 Ω, 60 Ω and 75 Ω
- Automatic zero adjustment

The **NRS** makes high-accuracy power measurements on test items to be terminated with 50 Ω (coaxial lines). Its wide frequency range ensures a large field of application, especially in the RF range.

Power range. The power range of 0.1 to 330 mW is divided into five subranges 3/10/30/100/300 mW, corresponding to 5-dB steps. Continuous range extension up to 60 kW is possible by means of attenuators of high powerhandling capacity or load resistors with an output for an accurately known insertion loss (see section 10).

Indication and accuracy. Only active power is measured and indicated. AC signals of any waveform, even very short pulses, are correctly measured. As the NRS has a flat frequency response from DC to 15 GHz it also provides a true power indication of frequency spectra. The error limits are ±2% of the reading of the mW scale. The accuracy can be greatly improved through the use of an external indicator. The rear output of the NRS delivers a DC voltage V_0 which equals to within ±0.2% the original rms voltage V_s of the source. The power is calculated from the voltage V_0 read on a digital voltmeter

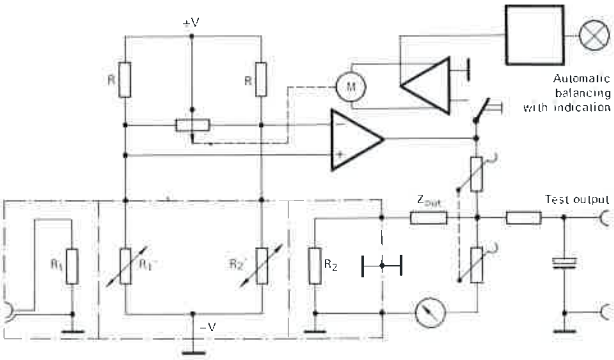
$$P = \frac{1}{Z_0}\left(\frac{V_0}{2}\right)^2 = \frac{V_0^2}{4Z_0}$$

The error of power measurement is in this case <±0.4% of reading.

The settling time of the NRS is short relative to other calorimetric power meters. It is less than 10 s at power values >1 mW.

Connection (probe). The unknown is picked up by a probe. Probes for the NRS are available with 50 Ω input impedance (to be ordered separately). They can be used with any basic unit and are interchangeable. The probes are equipped with coaxial connectors which can readily be adapted to the Dezifix A or Dezifix B system (screw-in assembly supplied with the probe). Adaptations to other systems, e.g. to N or APC 7 systems, are possible.

Test output. A test output for the connection of a DC recorder or analog/digital converter is provided at the rear of the NRS. (For output voltage see "Indication and accuracy"; Z_{out} = 2 kΩ ±10%). Moreover, the NRS has an input for triggering the automatic balancing facility, which makes it suitable for incorporation into automatic test assemblies.



Simplified diagram of Power Meter NRS

Specifications

Basic unit

Power ranges (fsd)	3/10/30/100/300 mW
Calibration	in mW and dBm
Indication error	≦ ±1.5% at fsd ≦ ±2.3% at 31.6% of fsd
Frequency range	0 to 15 GHz max.
Input impedance	50 Ω
Recorder output	Z_{out} = 2 kΩ, V_{out} proportional to RF input voltage
Temperature effect	≦ ±0.03%/°C
Settling time for powers ≧1 mW	≦10 s for 100% ±2.0% of rdg
Probes	50 Ω 0 to 15 GHz
Reflection coefficient	
0 to 4.5 GHz	<1% +2%/GHz
up to 11 GHz	<10%
above	<20%
Connector	Dezifix A[1])
Dimensions, weight	484 mm×150 mm×336 mm, 12 kg

Ordering information

Order designations

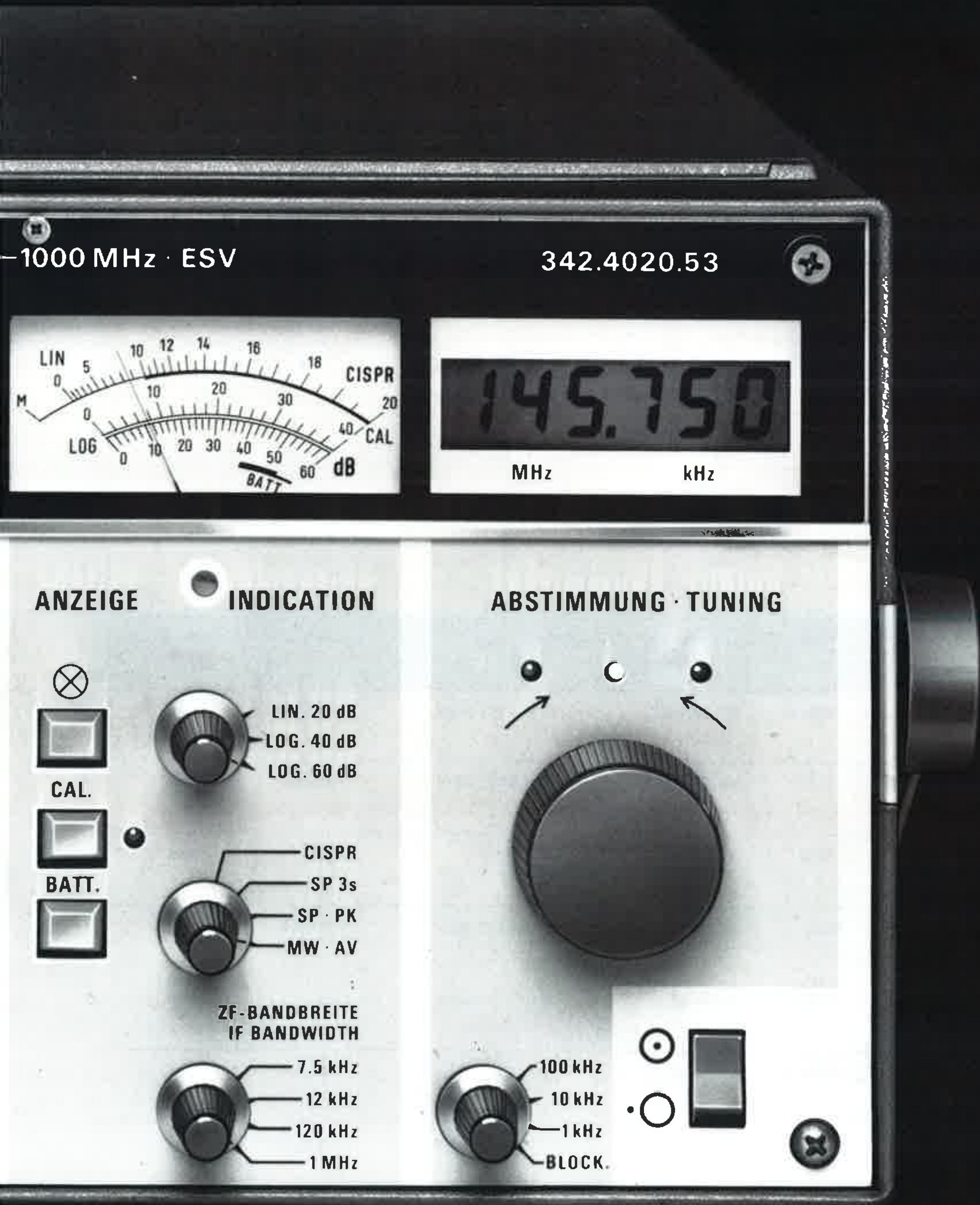
Basic unit	▶ Microwave Power Meter NRS 100.2433.92
Probes 50 Ω, 0 to 15 GHz	▶ Probe for NRS, 100.2440.50
Accessories supplied	
for basic unit	power cable, connecting cable (2 m, basic unit-probe)
for 50-Ω probe	1 adapter from Dezifix A to B

[1]) Adapter from Dezifix A to B is delivered with the probe. Coupling mechanism II (400.0133.00) permits connection to APC 7.

Test Receiver ESV;
combined with test antennas
it forms the Field-strength Meter HUF
for 20 MHz to 1 GHz;
details on pages 234 and 254

7

test receivers · field-strength meters wave analyzers · modulation analyzers



Test receivers

Fields of application

Test receivers are used for **frequency-selective** measurements of voltage and – combined with suitable antennas – of electrical and magnetic **field strength.** They have applications in laboratories and test departments wherever signal levels, non-linearities, noise and modulation characteristics of signal generators and amplifiers are to be measured. Organisations using radiocommunications (postal, broadcasting, military, commercial security, civil) employ test receivers and field-strength meters for **propagation measurements** in planning and determining the coverage of communications networks. In this context the measurement of horizontal and vertical antenna radiation patterns is an important application.

Radiomonitoring services use test receivers to check the transmissions from the individual stations for compliance with the technical specifications – an essential condition for simultaneous operation of the different communications networks without mutual interference. These checks involve measurements of level, spurious signals, centre frequency and bandwidth.

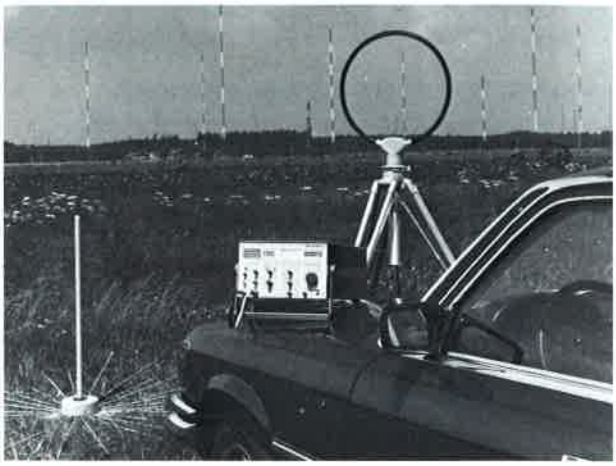
Radio-interference measurements open another important field of application for test receivers. In the civilian sector the aim is to secure undisturbed broadcast reception, whereas in the industrial and military fields electromagnetic compatibility (EMC) plays a more and more important role because of the increasing complexity of electronic systems. Here test receivers measure the interference in terms of current, voltage or field strength, depending on the type of transducer (antenna) connected to the receiver. Weighting curves for the readings are specified for civilian applications in VDE 0876; EMC is indicated as peak voltage or as spectral voltage density.

	Frequency range	Designation	Type	Order No. (complete No.: see text)	Voltage range	Fs of lowest subrange	Error of voltage indication
	9 kHz to 30 MHz	Test Receiver	ESH 2	303.2020.52	−30 to +137 dBμV	−10 dBμV	<1 dB
	9 kHz to 30 MHz	Programmable Test Receiver	ESH 3	335.8017.52	−30 to +137 dBμV	−10 dBμV	<1 dB
	25 to 300 MHz	VHF Field-strength Meter and Test Receiver	HFV	203.6018...	1 μV to 0.1 V	10 μV	<2 dB
new	20 to 1000 MHz	Test Receiver	ESV	342.4020...	−10 to +137 dBμV	+10 dBμV	<1.2 dB
new	20 to 1300 MHz	Test Receiver	ESVP	354.3000...	−18 to +137 dBμV	0 dBμV	<1 dB
	25 to 1000 MHz	VHF-UHF Test Receiver	ESU 2	252.0010...	−10 to +120 dBμV	10 dBμV	<1 dB
	25 to 1000 MHz	VHF-UHF Selective Test Equipment	MSU	253.2016.55	−10 to +120 dBμV	10 dBμV	<1 dB
		Progr. VHF-UHF Test Equipment	MSUP	253.3512.55	Data same as MSU; IEC-bus compatible, software available		
	9 kHz to 1000 MHz	Automatic Test Equipment	MSUP + ESH 3 + PUC	see p. 248	−30 (−10) to +137 dBμV	−10/+10 dBμV	<1 dB

Instrument features

Test receivers always use superhet circuitry with multiple conversion. They have **filters preceding the first mixer,** providing the wide dynamic range required for radio interference measurements. State-of-the-art models produce all the internal conversion frequencies by **frequency synthesis.** The receive frequency which has been set is displayed digitally. Automatic voltage calibration can be triggered on command.

Field-strength measurements are usually made with mobile stations (vehicles, helicopters), especially when propagation and coverage are to be determined. Portability and **battery operation** are thus important criteria in the choice of the test receiver. On the other hand, computer control is demanded for radio-interference measurements, radio-monitoring and test systems. With the present state of technology, it is not efficient to combine both features in one instrument type. R&S therefore offers two series of test receivers for the frequency range 9 kHz to 1 GHz: the ESH 2, HFV, ESV and ESU 2 have built-in batteries for mobile use while the ESH 3, ESVP and MSUP are equipped with an **IEC 625 interface** for computer controlled operation.



Field-strength Meter HFH 2 for 9 kHz to 30 MHz

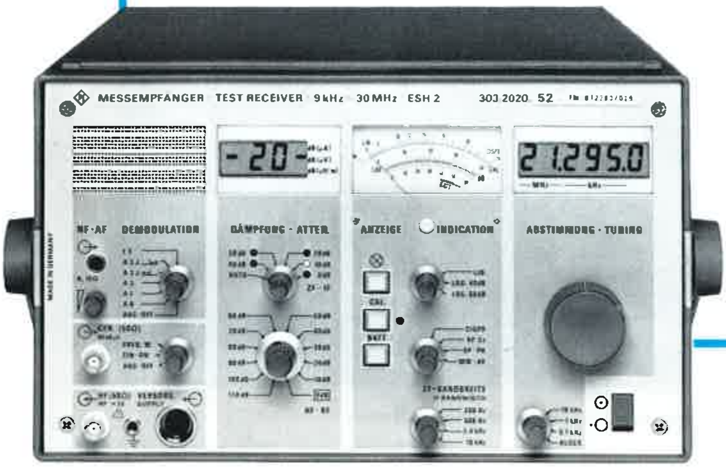
Frequency response dB	Noise voltage	Input impedance	Intermediate frequency MHz 1st IF	2nd IF	3rd IF	IF band width kHz	Image frequency rejection	Dimensions in mm (W×H×D)	Text on page
automatic calibration by pushbutton	<−30 dBµV	50 Ω	75	9	0.03	10/2.4/ 0.5/0.2	>100 dB	347× 206× 484	222
automatic calibration	<−30 dBµV	50 Ω	75	9	0.03	10/2.4/ 0.5/0.2	>100 dB	492× 205× 514	226
calib. possible at any frequency	<0.7 µV	50 Ω	400	10.7		120	>80 dB	326× 96× 290	252
automatic calibration by pushbutton	<−10 dBµV	50 Ω	810.7 310.7	10.7		7.5/12/ 120/1 MHz	>80 dB	347× 206× 484	234
	< −18 dBµV	50 Ω	810.7 310.7	10.7		7.5/12/ 120/1 MHz	>80 dB	492× 205× 514	238
calib. possible at any frequency	≦−13 dBµV	50/60/75 Ω	199.3/ 339.3	10.7	0.45	15/120/300	>70 dB	492× 195× 556	242
calib. possible at any frequency	≦−13 dBµV	50 Ω	199.3/ 339.3	10.7	0.45	15/120/300	>70 dB	520× 400× 535	244
MSUP: data same as MSU								520× 534× 635	248
calib. possible at any frequency	<−30/<−10 dBµV	50 Ω	up to 30 MHz 75 at higher freq.: same as MSU	9	0.030	0.2/0.5/2.4/ 10	>100 dB >70 dB	520× 710× 635	248, 249

ESH 2

Test Receiver ESH 2

◆ 9 kHz to 30 MHz/−30 to +137 dBµV

- Synthesizer-based test receiver offering crystal-referenced frequency display, 100 Hz resolution
- Level range >165 dB
- Automatic voltage calibration at the push of a button
- Interference measurements in line with CISPR, VDE, MIL and VG
- AC supply and battery operation



The **ESH 2** is a manually operated, sensitive and overload-protected test receiver offering a very wide dynamic range and maximum ease of operation. Compact construction, the wide range of power supplies that can be used, and low power consumption make the receiver suitable for use in fixed stations as well as for mobile and portable applications.

Thanks to its excellent characteristics and the availability of a wide range of accessories, the applications of the ESH 2 include **interference measurements** and **field-strength measurements;** for use of ESH 2 as the Field-strength Meter HFH 2 see page 251.

Covering the frequency range from 9 kHz to 30 MHz, the ESH 2 can tune to any signal from LF to the upper shortwave range, where it overlaps with the ESV (page 234).

Characteristics, uses (ESH 2 alone)

The ESH 2 needs no accessories to operate as a selective voltmeter (test receiver) with a level range from −30 to +137 dBµV, for example, for measurements, in 50-Ω coaxial systems. The Active Probe ESH 2-Z2 is available for measuring high-impedance test items. Relative and absolute selective voltage measurements are possible even in the presence of a multitude of signals.

Automatic calibration at the push of a button and excellent receiver selectivity permit accurate measurements of closely spaced signals with very different levels, for example: SSB two-tone measurements, spurious-content and sideband-noise measurements on signal generators, intermodulation and distortion measurements, noise figure measurements.

The calibration-generator output can be used for twoport measurements over an attenuation range of more than 100 dB and a gain range of more than 50 dB; see diagram on the right.

Signal ealuation. Four switch-selected IF bandwidths and numerous test outputs make it easy to carry out a wide range of measurements:

wideband IF output, 75 MHz,, for the connection of a panoramic display or a wave analyzer,

narrowband IF output, 30 kHz, for an oscilloscope,

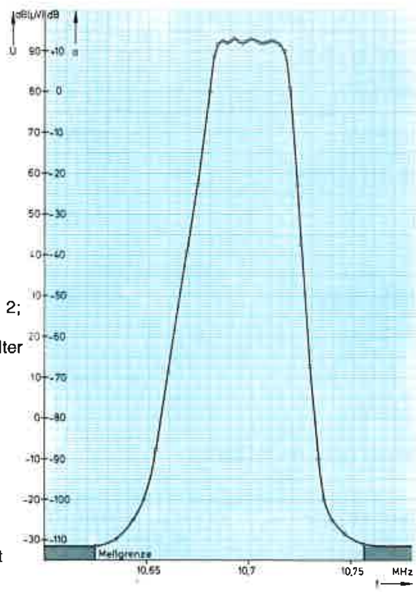
AM/FM demodulator outputs,

recorder output for level and frequency offset,

output for the connection of a frequency counter.

Overload of the input or of other important circuits is recognized by the test receiver and automatically signalled.

Example of twoport measurement using Test Receiver ESH 2; Test item: IF amplifier with crystal filter



Test limit

Auxiliary instruments for additional applications

Interference measurement. Interference voltage and interference current can be measured in accordance with the relevant standards (CISPR, FCC, MIL, VG, VDE). The following accessories are available for this purpose (see specifications on page 225 and page 230):

Active Probe	ESH 2-Z2
Passive Probe	ESH 2-Z3
Current Probe	ESH 2-Z1
Artificial Mains Network	ESH 2-Z5 and
Pulse Limiter	ESH 3-Z2

In addition to the overload indication and automatic calibration which have already been mentioned, the ESH 2 has other features which are particularly important in interference measurements:

level indication taking into consideration the conversion factor of the sensor, e.g. directly in dBμA,

frequency-dependent automatic switchover of weighting and of calibration pulse for CISPR 1 or 3,

peak indication with selectable hold time,

IF bandwidths of 200 Hz and 9 kHz in line with CISPR,

IF bandwidth of 10 kHz in line with MIL.

In interference measurements the Loop Antenna HFH 2-Z2 is used to measure the magnetic component and the Rod Antenna HFH 2-Z1 the electric component.

Radiomonitoring, remote frequency measurement. In conjunction with a receiving antenna and a frequency counter the test receiver can be used in radiomonitoring, since it features excellent frequency accuracy and stability and is capable of demodulating A1A, A3E, J3E (formerly A1, A3, A3J) and FM transmissions. With a frequency counter connected to the ESH 2 generator output, high-accuracy remote frequency measurements can be performed. The test receiver then functions as an active filter of high selectivity.

Field-strength measurements. Completed by the following antennas the test receiver can be used for field-strength measurements (see also Field-strength Meter HFH 2 on page 251):

Active Rod Antenna	HFH 2-Z1 (9 kHz to 30 MHz)
Active Loop Antenna	HFH 2-Z2 (9 kHz to 30 MHz
Inductive Probe	HFH 2-Z4 (100 kHz to 30 MHz)

Another Loop Antenna, HFH 2-Z3, is available as an accessory for measurements on very weak signals in the frequency range of 9 to 150 kHz. The Roof-mounting Kit HFH 2-Z5 permits the HFH 2-Z2 to be operated on top of test vehicles.

Propagation measurements and measurements of coverage in the radio-monitoring field can also be carried out; with an YT recorder connected to the corresponding output, field-strength observation is possible over extended periods of time.

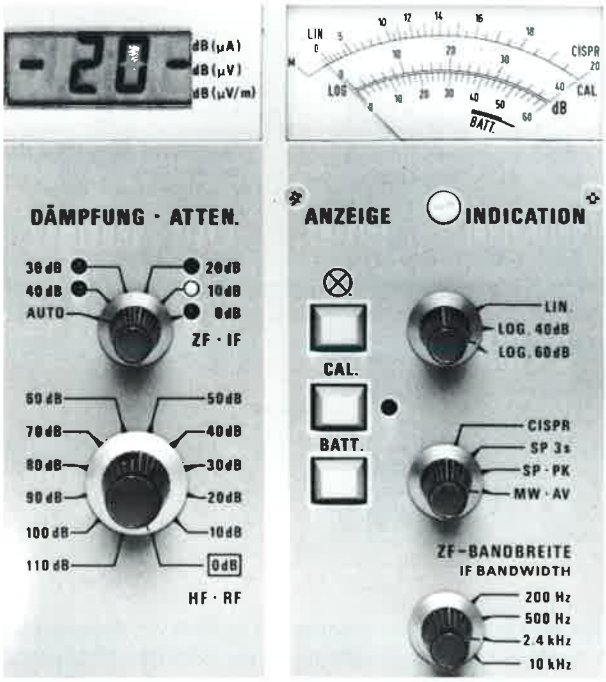
The digital readout of the reference level in dBμV/m, which takes into consideration the conversion factor of the antenna used, is an important asset in field-strength measurements.

Ease of operation, setting functions

The correction of the level indication taking into account antenna factors and conversion factor of sensors, the automatic level calibration and many more features affording ease of operation make it possible to make do with a minimum of operating controls. Thanks to the clear arrangement of the front panel, even unskilled staff can soon learn to operate the instrument.

Frequency setting. The whole range from 9 kHz to 30 MHz is covered without band switching, in 100-Hz/1-kHz or 10-kHz steps. The 6-digit LCD frequency display in crystal-controlled. The frequency setting is retained in a memory even while the instrument is switched off.

Sensitivity, level switching. The measurement range for sinewave signals of −30 dBμV to +137 dBμV is determined at the lower limit by the inherent noise at 200 Hz IF bandwidth and at the upper limit by the maximum dissipation in the RF attenuator. Sensitivity is set for the RF and IF sections using attenuators with 10-dB steps, see front panel section.



Front panel section with controls for level, bandwidth, weighting and display

In the AUTO position of the IF attenuator, the IF gain is automatically controlled as a function of bandwidth and display mode in such a way that the receiver's internal noise is always below 0 dB on the display.

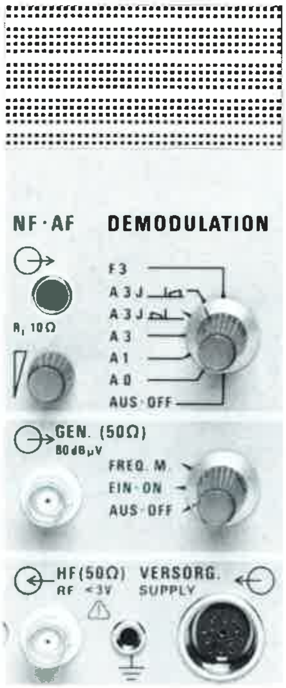
Bandwidths, signal weighting. IF bandwidth is switch-selected at 10 kHz, 2.4 kHz, 500 Hz or 200 Hz. The signal weighting mode can be switched to average or peak with different hold times (e.g. 3 s) or noise weighting in line with CISPR.

ESH 2 – Test receiver

Level indication. The meter has a linear range of 20 dB and two logarithmic ranges of 40 and 60 dB. The measured level is obtained from the meter indication and the digital reference value displayed in the same line, e.g. −20 dBμV in the photo on page 223.

Overload indication. If one of the stages in the metering path of the receiver is overloaded the reference-value display flashes. This indication operates with sinewave noise as well as with pulses.

Internal calibration, battery check. Automatic calibration, initiated at the push of button or when the bandwidth is changed, guarantees reproducibility of the measurements and ease of operation. In the case of battery operation the state of charge of the batteries can also be checked at the push of a button.



Front-panel section: demodulation and AF settings; output for calibration signal and frequency measurement; RF input and power supply connection

Signal demodulation, outputs. The ESH 2 is designed for a multitude of signal waveforms including SSB and frequency modulation: it can be switched to N0N, A1A, A1B, A3E, J3E, formerly A0, A1, A3, A3J (upper or lower sideband) and F3E as well as G3E. Numerous outputs are provided for signal evaluation, recording or plotting:

- wideband output at 1st IF (75 MHz) for the connection of a panoramic display
- narrowband output at 30-kHz IF for the connection of an oscilloscope
- AM and FM demodulator outputs
- outputs for the connection of recorders for level and frequency offset

The power supply is either direct from a 12-V source, from the 12-V battery pack (delivered without batteries), from a 24-V supply (additional adapter required) or from the local AC supply via the power supply unit (safety class II; see photo on the right), which can at the same time recharge or trickle-charge the 12-V battery.

Description

The Test Receiver ESH 2 is a triple heterodyne receiver covering the receiving range from 9 kHz to 30 MHz by means of 16 RF filters, the first 14 of which are fixed-tuned and the upper two tracking with the receive frequency via varicaps. The intermediate frequencies are 75 MHz, 9 MHz and 30 kHz. The signal to be measured passes from the RF attenuator, which is adjustable in steps of 10 dB and through which the calibration signal is fed in during calibration, via the filter group to the first mixer, where it is converted to the first IF of 75 MHz by a synthesizer.

After passing through a crystal filter of 10 kHz bandwidth the signal is converted from 75 MHz to 9 MHz. Two further crystal filters, which can be switch-selected, provide bandwidths of 2.4 kHz and 500 Hz. The following 9-MHz amplifier contains the control element for the nominal gain of the receiver with automatic calibration. After conversion to the last intermediate frequency of 30 kHz the signal is amplified in a 40-dB amplifier, this range being adjustable in 10-dB steps. The IF bandwidth can be decreased to 200 Hz using a mechanical filter. The signal passes through a logarithmic or a linear amplifier with an active demodulator or undergoes interference weighting according to CISPR Publicatoin 1 or 3, depending on the selected indicating mode. A second, independent 30-kHz IF amplifier with AGC operates in parallel with the indicating branch into a demodulator for AM, SSB and FM.

Construction

Even though heavy shielding is provided, this compact receiver weighs only 20 kg. The modern cassette design, using primarily plug-in PC boards on a motherboard, makes the ESH 2 very easy to service, whilst at the same time the interior space of the receiver is optimally utilized. The use of high-grade components and the low self-heating as a result of the moderate power drain (approx. 12 W in battery operation) further cut down the failure expectancy of the receiver. A plastic cover may be put on the front or rear panel to protect the receiver during transport or when it is being operated outdoors.

Rear view of Test Receiver ESH 2 with battery pack incorporated and power supply connected

Specifications of ESH 2

Frequency range	9 kHz to 29.9999 MHz
Frequency setting	quasicontinuous with knob
Resolution (step width)	100 Hz, 1 kHz or 10 kHz, switch-selected
Indication	6-digit LCD, switchable back-lighting
Setting error at 9 to 150 kHz	100 Hz
at 150 kHz to 30 MHz	<500 Hz[1]

RF input .... Z_{in} = 50 Ω, BNC female
VSWR with RF attenuation ≧10 dB . <1.2
with RF attenuation 0 dB .... <2
Maximum input level
with RF attenuation 0 dB .... 130 dBμV
with RF attenuation ≧10 dB ..... 137 dBμV
Maximum pulse energy (τ = 10 μs)
with RF attenuation ≧20 dB .... 1 mW s
Oscillator reradiation .... <0 dBμV
Internal input filters
9 to <150 kHz .... bandpass filters
150 kHz to <10 MHz .... 13 suboctave filters
10 to <20 MHz .... tracking filter
20 to <30 MHz .... tracking filter

Interference immunity, nonlinearities

Image-frequency rejection (1st IF) .. >100 dB, typ. 120 dB
IF rejection .... >100 dB, typ. 110 dB
Nonlinearities: a) frequency range 10 to 150 kHz
(signal spacing ≧40 kHz)
b) Frequency range 150 kHz to 30 MHz

Type		Signal level dBμV	S/N ratio dB	Intercept point (guaranteed) dBm	typical dBm
a)	k_2	100	>55	+47	+60
	d_2	100	>50	+43	+55
	d_3	90	>65	+15	+20
b)	k_2	100	>80	+73	+100
	d_2	100	>60	+53	+75
	d_3	100	>53	+20	+25

Crossmodulation
An interfering signal with m = 30% and f = 1 kHz spaced >100 kHz away produces 3% modulation of a 20-dBμV signal
at a level of .... >100 dBμV
RF leakage
Variation of indication at a field strength of 10 V/m (with f ≠ f_o) ... <1 dB

Intermediate frequencies

1st IF .... 75 MHz
2nd IF .... 9 MHz
3rd IF .... 30 kHz

IF bandwidths (for average and peak)

Nominal bandwidth	3-dB bandw.	6-dB bandw. (±10%)	6:60-dB ratio
200 Hz[2]	160 Hz[3]	200 Hz	≈1:5
500 Hz	550 Hz[3]	630 Hz	≈1:5
2.4 kHz	2.4 kHz	2.6 kHz	≈1:1.8
10 kHz	8 kHz[3]	9.5 kHz	≈1:2.4

IF bandwidth (−6 dB) for measurements acc. to CISPR (Publ. 1 & 3) and VDE 0875 .... 0.2 kHz/9 kHz (automatic switchover)

Internal noise a (f_{in} >50 kHz)

Average B = 200 Hz .... typ. −30 dBμV
Peak B = 200 Hz .... typ. −22 dBμV
CISPR 1 B = 9 kHz .... typ. −6 dBμV
CISPR 3 B = 200 Hz .... typ. −28 dBμV

Increase in noise indication .... see diagram
(with f <50 kHz, B = 200 Hz)

Voltage range

Lower limit
(3 dB above internal noise level) .... see internal noise
Upper limit .... 137 dB
Inherent spurious responses ...... equivalent to <−6 dBμV
Voltage indication .... moving-coil meter, switchable back-lighting
Scale ranges, linear .... 20 dB
logarithmic .... 40 dB/60 dB
battery check ..... tolerance marker
Types of indication .... average
peak
peak with 3 s hold time
CISPR (Publ. 1 & 3)

Voltage indication error
average lin. 20 dB
V_{in} >16 dB above internal noise <1 dB
Additional error of log. conversion
due to temperature effect .... <2 dB

[1] An input for an external reference frequency of 5 MHz or 10 MHz is provided to improve the setting accuracy.
[2] Reduced accuracy when measuring sinewaves at 200 Hz bandwidth (additional measuring error 1.5 dB) due to receiver tuning in steps of 100 Hz.
[3] ±20%.

Calibration generator
Average/Peak .... sinewave generator
CISPR .... pulse generator

Types of demodulation N0N, A1A, A1B, A3E, J3E, F3E, G3E;
Former designations .... A0, A1, A3, A3J (LSB, USB), F3

Outputs

Sig. generator EMF (ref. voltage, can be switched off) .... 86 dBμV ±0.5 dB; 50 Ω, BNC female connector
Connector for antenna supply and antenna coding .... 12-pole Tuchel female
AF signal, adjustable .... up to 3.5 V; 10 Ω; jack JK 34
IF 75 MHz .... 50 Ω; BNC female connector
Gain (input at 0 dB) .... <12 ±3 dB, bandwidth corresponds to RF bandwidth
IF 30 kHz .... 1 kΩ; BNC female connector
EMF at fs .... 2 V, bandwidth corresponds to IF bandwidth
AM demodulator .... 10 kΩ; BNC female connector
EMF, peak to peak .... 1 V at 100% mod.
FM demodulator .... 10 kΩ; BNC female connector
EMF .... ±0.5 V for 5 kHz deviation
Recorder outputs .... 50-pole Amphenol female connector
Frequency offset .... ±5 V for ±5 kHz offset; 10 kΩ
Level 1 in average, peak modes .. +5 V for fs
in CISPR .... +2 V for fs
10 kΩ output impedance in all modes
Level 2 .... lowpass filter simulating meter response acc. to CISPR (1, 3); EMF and output impedance as for level 1

Reference frequency input ...... 5/10 MHz, switch-selected; EMF 1 V across 50 Ω, sinewave (BNC female connector)

General data

Rated temperature range .... −10 to +45°C
Storage temperature range .... −25 to +70°C (without batteries)
−10 to +60°C (with batteries)
Power supply .... either via power supply unit or from battery pack, see photo on the left
AC power supply unit .... 110/125/220/235 V +10/−15%, 47 to 420 Hz (60 VA); VDE 0411 safety class II (DIN 47411)
Battery pack .... +12 V, 8.5 to 9.5 Ah, operating life ≈4 h per charge
Battery input .... 4-pole special socket
supply: +10.8 to +14.5 V/≈1 A
Charging input .... 4-pole special socket
Dimensions, weight .... 347 mm×206 mm×484 mm, 19 kg with power supply unit
21 kg with battery pack

Ordering information

Order designation .... ▶ Test Receiver ESH 2 303.2020.52

Accessories supplied .... Battery pack (without batteries)
battery connector:
LEMO F.c 2304 6.7
50-pin Amphenol male connector

Recommended extras

For interference measurements:

RF Current Probe .... ESH 2-Z1 .. 338.3516.52
(100 kHz to 30 MHz)
Aktive Probe .... ESH 2-Z2 .. 299.7210.52
(9 kHz to 30 MHz, high impedance)
Passive Probe .... ESH 2-Z3 .. 299.7810.52
(9 kHz to 30 MHz, VDE 0876)
Artificial Mains Network .... ESH 2-Z5 .. 338.5219.52
(9 kHz to 150 kHz/30 MHz, VDE 0876)
Pulse Limiter .... ESH 3-Z2 .. 357.8810.52

For field-strength measurements (details under HFH 2, page 251):

Rod Antenna .... HFH 2-Z1 .. 335.3215.52
Loop Antenna .... HFH 2-Z2 .. 335.4711.52
Loop Antenna .... HFH 2-Z3 .. 335.6214.52
Tripod .... HFU-Z 100.1114.02
Inductive Probe .... HFH 2-Z4 .. 338.3016.52
Roof-mounting Kit
(for Loop Antenna HFH 2-Z2) ...... HFH 2-Z5 .. 335.5718.02

General:
Headphones 110.2959.00
24-V Adapter .... ESH 2-Z4 .. 338.4512.02
6-V Lead-acid Storage Battery
9.5 Ah (2 required) 338.4012.00
19″ Adapter .... ESH 2-Z6 .. 338.4312.02
Service Kit .... ESH 2-Z7 .. 338.4112.00
Protective Cover for front or
rear panel (2 recommended) ...... ESH 2-Z8 .. 303.2065.00

Recorders, frequency counters:
XYT Recorder ZSKT 301.9010.02

Frequency counter for remote frequency measurement, sensitivity <10 mV into 50 Ω, e.g. PM 6676/04 from Philips

For operation with other type of artificial mains network
Attenuator .... ESH 2-Z11 .. 349.7580.52

ESH 3

Test Receiver ♦ 9 kHz to 30 MHz
−30 to +137 dBμV

- Frequency setting quasi-continuous in steps of 100 Hz or 10 kHz, or by keyboard entry – steps of any size
- Measurement of voltage, field strength, RF current, wideband noise and twoport attenuation
- Automatic correction after calibration
- Storage of device settings
- IEC-bus compatible

IEC 625 Bus

The automatic **Test Receiver ESH 3** which measures and demodulates AM double-sideband, single-sideband, pulse-modulated and FM signals as well as interference in the range of 9 kHz to 30 MHz is suitable for manual and programmed use as a

- selective RF voltmeter
  (in conjunction with a current probe, it can also measure RF currents in the range 0.1 to 30 MHz)
- field-strength meter in conjunction with the test antennas of the HFH 2
- building block in automatic test systems.

The ESH 3 has the same RF, IF and demodulator circuits as the ESH 2 (pages 222 to 225); it thus features the same excellent characteristics and covers the same fields of application. In addition, the ESH 3 is equipped with microcomputer circuitry and an evaluation unit, which make it a versatile, intelligent test receiver with a maximum of **operating convenience.**

Extended signal evaluation capabilities and **extra features and functions** characterize the ESH 3:

- Digital level indication in selectable units
- Measurement of frequency offset, frequency deviation and modulation depth
- Automatic ranging (for low noise or low distortion) or presetting of RF and IF attenuation
- Tuning in programmed steps, e.g. 9-kHz channel pattern or for harmonic measurements
- Automatic scanning with data output to printers or recorders (XY, YT or radiomonitoring recorder)
- Storage of last and nine additional device settings even when the unit is switched off or the supply interrupted
- Automatic correction after calibration, ensuring full measurement accuracy at all frequencies, IF bandwidths, display modes and types of demodulation
- IEC-bus interface for computer control

Further characteristics, uses

The ESH 2 is ideal when only manual operation is required and portability and battery-power capability are wanted; the ESH 3 comes into its own when automation is needed to improve efficiency, when **computer** control is required and the maximum versatility in terms of measurement functions is important.

In conjunction with the Programmable VHF-UHF Test Equipment MSUP (page 249) and the new Test Receiver ESVP (page 238), signals and interference can be measured automatically in the range 9 kHz to 1 or 1.3 GHz in accordance with the relevant international regulations.

The antennas, the RF current probe, the probes and the artificial mains network available for the ESH 2 can also be used with the ESH 3.

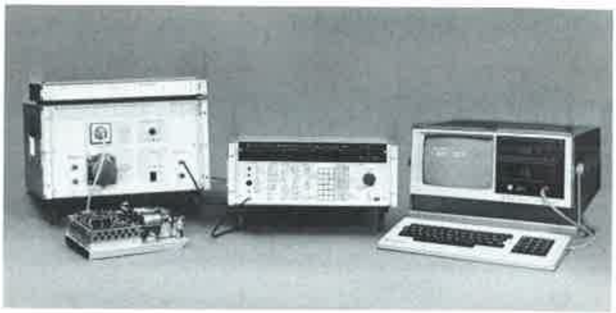
Selective voltage measurement. For use in the laboratory and test department for measurements on signal generators (level of fundamental, harmonics and non-harmonic spurious signals, sideband noise, frequency deviation and modulation depth); twoport measurements (filter attenuation up to >100 dB, gain up to 57 dB) with automatic recording of frequency response with an XY recorder; amplifier measurements (frequency response, noise figure, overdrive capacity, intermodulation and crossmodulation characteristics).

Field-strength measurement. Propagation and coverage measurements are possible in conjunction with the rod, loop and probe antennas of the HFH 2 (page 251).

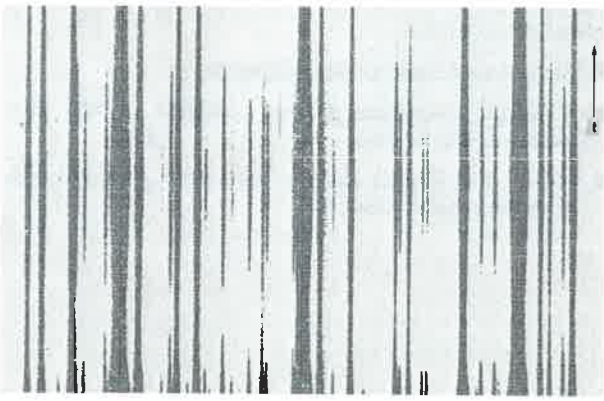
In **radiomonitoring** the ESH 3 can be used to measure: field strength and range of fluctuation of field strength with max./min. indication, frequency (remote measurement with add-on frequency counter), frequency offset, frequency deviation and modulation depth.

Data-logging capabilities in radiomonitoring

1. Output of all measured data to a printer via the IEC-bus interface with the ESH 3 in the talk-only mode.
2. Recording of amplitude spectrum on a XY recorder. The values entered for start and stop frequencies and minimum and maximum levels determine the end values of the scales.
3. Long-term recording of frequency-band occupancy using the R&S Radiomonitoring Recorder ZSG 3. One ESH 3 permits up to five different frequency bands with different recording thresholds to be constantly observed and their occupancy to be recorded on five ZSG 3 recorders; see recording below.



Automatic interference-voltage measurement with programmed phase-switching: Test Receiver ESH 3, Artificial Mains Network ESH 2-Z5, Process Controller PUC and Code Converter PCW



Recording of frequency-band occupancy using Test Receiver ESH 3 and Radiomonitoring Recorder ZSG 3

Use in computer-controlled test systems. Computer control proves the optimum solution when, for example, extended data-logging capabilities or special methods of evaluation are required or when irregularly distributed test frequencies call for different IF bandwidths, classes of demodulation, display modes, etc.

Operation, functions

The front-panel **controls** of the ESH 3 are arranged in an easy-to-understand way in spite of the multitude of functions, and logically organized according to frequency, display mode, IF bandwidth, attenuation (sensitivity) and demodulation.

A 13-digit alphanumeric display facilitates data entry (frequencies, measuring times, limit levels) and reads out the measured results. In addition, the analog value of the input voltage is indicated within the limits of the demodulator operating range by a row of LEDs. Another LED row indicates the frequency offset, see detail photo below.

Radio-interference measurements in line with CISPR Publ. 1 and 3 and VDE 0875 and interference measurements complying with MIL standards and VG regulations are possible with the following special weighting modes:

CISPR: The weighting complies with CISPR 3 in the frequency range 9 to 149.9 kHz and with CISPR 1 in the range 150 kHz to 30 MHz.

Combining the receiver with the Artificial Mains Network ESH 2-Z5 forms a test assembly for **radio interference voltage measurements** in line with CISPR.

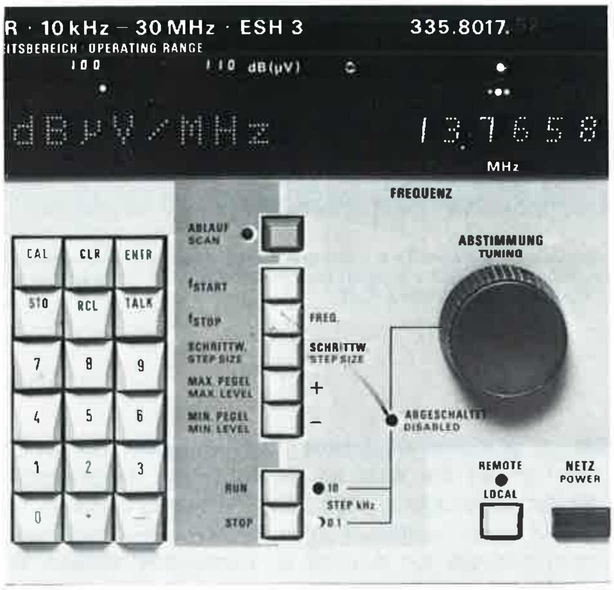
MIL: For the measurement of wideband noise according to MIL standards and VG regulations the MIL mode applies. The bandwidth correction values are automatically taken into account and the results are indicated in dBµV/MHz or dBµV/m MHz for field strength and dBµA/MHz for current.

When using the (four-wire) Artificial Mains Network ESH 2-Z5 the Code Converter PCW can be employed for computer-controlled phase switching.

Front-panel section with frequency display and alphanumeric display, e.g. for results of measurements

All active functions are indicated by LEDs. If serious operating errors are made, or when a fault occurs in the main modules, an error message is issued with an error code. The end of long-term tests is indicated by a buzzer.

ESH 3 – Test Receiver



Front panel section with controls for frequency entry and recall

Output of results. The measured value is converted into a level with or without logarithmic conversion; RF and IF attenuation, all correction values and transducer conversion factors – if applicable – are added and conveyed together with their physical unit to the alphanumeric display and the IEC-bus interface.

A 24-pole output permits the **connection of recorders** of three types of XY, YT and radiomonitoring recorders. The ESH 3 automatically adjusts to the recorder type connected by selecting the required drive to the A/D converter.

The **IEC-bus interface** is provided with all the listener and talker capabilities covered in the standard: the limited capabilities of the widely commercial available controllers have, however, also been taken into consideration. For example, it is also possible to use computers without serial- and parallel-poll capability.

Computer control of the ESH 3 via the IEC bus provides the following capabilities:

- Execution of complex test programs
- Automatic evaluation of large quantities of data from various points of view
- Use of the ESH 3 together with other programmable measuring instruments.

Frequency setting or frequency entry can be carried out in different ways:

1. with tuning knob in steps of 100 Hz or 10 kHz (quasi-continuous)
2. at a keystroke in steps of any preset size, e.g. in 9-kHz steps, or in steps of the width of the fundamental frequency to measure harmonics
3. by keyboard entry
4. by automatic frequency scanning over up to five subranges, with any desired preset start and stop frequencies and step sizes.

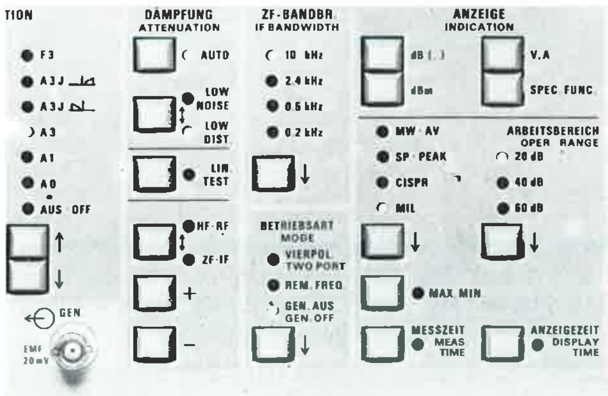
Tuning is facilitated by a calibrated offset indication. The last, and nine further complete device settings can be stored.

Sensitivity, measurement ranges. The voltage range in the average mode extends from −30 to +137 dBµV. Frequency offset is indicated – depending on IF bandwidth – from −5 to +5 kHz, frequency deviation from 0 to 5 kHz; modulation depth can be measured from 0 to 100% and gain from −110 to +57 dB.

Calibration. Two different calibration processes are initiated depending on whether the calibration button is pressed for a shorter or longer period:

1. Check and, if necessary, correction of level and frequency-offset calibration
2. Measurement of all the calibration correction values that do not vary with time, for frequency response, IF bandwidth, logarithmic amplifier and detector – and storage in a non-volatile memory.

Front-panel section with operating controls for display, IF bandwidth, mode, attenuation and demodulation



Specifications of ESH 3

Frequency range	9 kHz to 29.9999 MHz
Frequency setting	1. quasicontinuous with knob in steps of 100 Hz or 10 kHz 2. keyboard entry 3. in steps of any preset size 4. automatic scanning
Indication	6 digit LED display
Resolution	100 Hz
Setting error¹)	1.5 × 10^{-5} +50 Hz
RF input	Z_{in} = 50 Ω, BNC female connector
VSWR	<1.2 with RF attenuation ≧10 dB <2 with RF attenuation 0 dB

Oscillator reradiation .... <1 µV
Maximum input voltage
with RF attenuation 0 dB .... 3 V = 130 dBµV
with RF attenuation ≧10 dB ..... 7 V = 137 dBµV

Interference immunity, nonlinearities

Image-frequency rejection .... >100 dB, typ. 120 dB
IF rejection .... >100 dB, typ. 110 dB
Nonlinearities: a) Frequency range 10 to 150 kHz (≧40 kHz off carrier)
b) Frequency range 150 kHz to 30 MHz

Type		Signal level dBµV	S/N ratio dB	Intercept point guaranteed dBm	typical dBm
a)	k_2	100	>55	+30	+45
	d_2	100	>50	+25	+40
	d_3	90	>65	+15	+20
b)	k_2	100	>80	+75	+100
	d_2	100	>60	+55	+75
	d_3	100	>52	+20	+25

Crossmodulation
An interference signal of m = 30% and f_m = 1 kHz spaced >100 kHz away produces 3% modulation of a 20-dBµV signal at a level of .... >100 dBµV

Intermediate frequencies

1st IF .... 75 MHz
2nd IF .... 9 MHz
3rd IF .... 30 kHz

IF bandwidths (for average and peak)

Nominal bandwidth	3-dB bandw. (±10%)	6-dB bandw. (±10%)	6:60-dB ratio
200 Hz[2]	160 Hz[3]	200 Hz	≈ 1 : 5
500 Hz	550 Hz[3]	630 Hz	≈ 1 : 5
2.4 kHz	2.4 kHz	2.6 kHz	≈ 1 : 1.8
10 kHz	8 kHz[3]	9,5 kHz	≈ 1 : 2.4

IF bandwidth (−6 dB) for measurements acc. to CISPR (Publ. 1 & 3) and VDE 0875 .... 0.2 kHz / 9 kHz (automatic switchover)

Internal noise a (f_{in} >50 kHz)

Average	B = 200 Hz	typ. −30 dBµV
Peak	B = 200 Hz	typ. −22 dBµV
CISPR 1	B = 9 kHz	typ. −6 dBµV
CISPR 2	B = 200 Hz	typ. −28 dBµV

Increase in noise indication .... see diagram (with f <50 kHz, B = 200 Hz)

Measurement ranges

Voltage
Lower limit (3 dB above noise level) .... see internal noise
upper limit .... +137 dBµV; for pulse spectra: 146 dBµV/10 kHz
Measurement error
average, 20 dB .... <1 dB with V_{in} ≧16 dB above internal noise
Frequency offset .... −5 to +5 kHz, depending on IF bandwidth
Frequency deviation .... 0 to 5 kHz, depending on IF bandwidth
AM modulation depth .... 0 to 100%
Gain .... −110 to +57 dB

Indication of measured value .... 13-digit alphanumeric display of numerical value and unit of measurement for level, frequency offset, deviation, modulation depth or gain

Level
digital in dBµV etc. .... 4 digits, resolution 0.1 dB
in µV, mV etc. .... 3 digits, resolution 1 LSD
analog .... row of 31 LEDs within operating range of IF detector, with digital indication of range boundaries

---

[1]) An input for an external reference frequency of 5 or 10 MHz is provided to improve the setting accuracy.
[2]) Reduced accuracy when measuring sinewaves at 200 Hz bandwidth (additional measuring error 1.5 dB) due to receiver tuning in steps of 100 Hz.
[3]) ±20%.

Operating range of IF detector ... 20, 40, 60 dB
Indicating modes .... average, peak
CISPR (Publ. 1 & 3)
broadband noise acc. to MIL stand.
max./min. levels over preset period of observation
Frequency offset
digital in kHz .... 3 digits, resolution 10 Hz
analog .... row of 16 LEDs
Frequency deviation in kHz .... 3 digits, resolution 10 Hz
Modulation depth in % .... 2 digits, resolution 1%
Gain in dB .... 4 digits, resolution 0.1 dB

Classes of demodulation N0N, A1A, A1B, A3E, J3E, F3E, G3E
Former designations .... FM, A0, A1, A3, A3J (USB, LSB), F3

Outputs

Generator (ref. voltage, can be switched off) .... 86 dBµV ±0.5 dB; 50 Ω, BNC female connector
Connector for antenna supply and antenna coding .... 12-pole Tuchel female
AF signal, adjustable .... up to 3.5 V, 10 Ω; jack JK 34
IF 75 MHz .... 50 Ω, BNC female connector
Gain (input at 0 dB) .... 12 ±3 dB, bandwidth corresponds to RF bandwidth
IF 30 kHz .... 1 kΩ, BNC female connector
EMF at max. analog indication .... 2 V, bandwidth corresponds to IF bandwidth
AM demodulator .... 10 kΩ, BNC female connector
EMF .... 1 V at 100% modulation
FM demodulator .... 10 kΩ, BNC female connector
EMF .... ±0.5 V for 5 kHz deviation
Frequency offset .... ±5 V for 5 kHz offset
Z_{out} = 10 kΩ, BNC female connector
Analog level output 1 .... 0 to +5 V between boundaries
(average, peak, MIL) of analog indication
CISPR .... 0 to +2 V
Analog level output 2 .... 0 to +2 V, Z_{out} = 10 kΩ,
(CISPR) BNC female connector, includes lowpass network acc. to CISPR for simulation of meter resp.
Recorder output .... 24-pole Amphenol female connector for coding lines to identify recorder type, analog X and Y outputs, penlift control, paper advance for ZSKT, connection of 5 ZSG 3s

Reference frequency input ...... 5/10 MHz, switch-selected; required EMF: 1 V across 50 Ω

Remote control .... interface according to IEC 625-1, 24-pole Amphenol connector; functions: AH1, L4, SH1, T5, RL1, SR1, PP1, DC1, DT1, C0

General data

Rated temperature range .... +5 to +45°C
Storage temperature range .... −25 to +70°C
Power supply .... 115/125/220/235 V ±10% 47 to 440 Hz (70 VA)
Dimensions, weight .... 492 mm×205 mm×514 mm, 25 kg

Ordering information

Order designation .... ▶ Test Receiver ESH 3 335.8017.52

Accessories supplied .... Power cable

Recommended extras

For interference measurements

RF Current Probe (100 kHz to 30 MHz)	ESH 2-Z1	338.3516.52
Active Probe (9 kHz to 30 MHz, high impedance)	ESH 2-Z2	299.7210.52
Passive Probe (9 kHz to 30 MHz, VDE 0876)	ESH 2-Z3	299.7810.52
Artificial Mains Network (9 kHz to 150 kHz/30 MHz, VDE 0876)	ESH 2-Z5	338.5219.52
Pulse Limiter	ESH 3-Z2	357.8810.52

For field-strength measurements (details on pages 230 to 233):

Rod Antenna	HFH 2-Z1	335.3215.52
Loop Antenna	HFH 2-Z2	335.4711.52
Loop Antenna	HFH 2-Z3	335.6214.52
Tripod	HFU-Z	100.1114.02
Inductive Probe	HFH 2-Z4	338.3016.52

General:
Headphones 110.2959.00

Recorders:

XY Recorder ZSK 2	290.2016.02	(page 268)
XYT Recorder ZSKT	301.9010.02	(page 266)
Radiomonitoring Recorder ZSG 3	242.6015.92	(page 265)

Accessories for the Test Receivers
ESH 2 and ESH 3
for field-strength and radio-interference measurements

Overview

Designation		Page	Measurements (application)				
			Current	Voltage high-imp.	Field strength electric	Field strength magnetic	Radio interference
Measuring aids for ESH 2 and ESH 3							
Rod Antenna	HFH 2-Z1	231			●		●
Loop Antenna	HFH 2-Z2	231				●	●
Loop Antenna	HFH 2-Z3	232				●	●
Inductive Probe	HFH 2-Z4	232				●	●
Clamp-on RF Current Probe	ESH 2-Z1	230	●				●
Active Probe	ESH 2-Z2	231		●			●
Passive Probe	ESH 2-Z3	231		●			●
Artificial Mains Network	ESH 2-Z5	233					●
Attenuator	ESH 2-Z11	233					●
Pulse Limiter	ESH 3-Z2	233					●
Tripod	HFU-Z	233				●	●
Other accessories			**for use with**				
24-V Adapter	ESH 2-Z4	233	ESH 2 and ESV				
Roof-mounting Kit (for Loop Antenna HFH 2-Z2)	HFH 2-Z5						

Current measurements

Clamp-on RF Current Probe ESH 2-Z1

Selective or broadband measurements of both very small and very large RF currents on conductors are easy to perform with the aid of the ESH 2-Z1. It is shielded against electrostatic effects and built to VDE standard.

ESH 2-Z1

Specifications

Frequency range	0.1 to 30 MHz (above 9 kHz with frequency-dependent conversion factor)
Measurement range using ESH 2/ESH 3 (IF bandwidth 200 Hz, average-value indication)	
Lower limit (frequency-dependent)	−30 dBμA, approx.
Upper limit	137 dBμA
Transfer admittance	1 S
Conversion factor[1]) (I→V)	0 dB referred to 1 S
Error of conversion factor	<1 dB
Max. permissible current with f >10 kHz	10 A
f <500 Hz	50 A
Max. diameter of conductor under test	13.5 mm

General data

Rated temperature range	−10 to +55 °C
Storage temperature range	−25 to +70 °C
RF connector	BNC male
Termination	50 Ω
Length of connecting cable	1 m
Coding plug (conversion factor)	12-pole Tuchel-type
Dimensions (diameter/height)	55 mm/20 mm
Weight	0.4 kg

Order designation ▶ Clamp-on RF Current Probe ESH 2-Z1 338.3516.52

[1]) Conversion factor = logarithm of the ratio between the output voltage and the input current; automatically taken into account in the readout on the ESH 2 and ESH 3.

High-impedance voltage measurements

ESH 2-Z2
ESH 2-Z3

Active Probe ESH 2-Z2/Passive Probe ESH 2-Z3

For high-impedance measurements of, say, narrow-band wanted signals on lines or narrow-band or broadband interference signals at the receiver input or antenna cabling, use of shielded probes is recommended. They contain internal high-pass filter sections to reject supply voltages.

The **Active Probe ESH 2-Z2** is designed for measuring AC voltages over the frequency range 9 kHz to 30 MHz on lines that do **not** carry AC supply voltage.

Active Probe ESH 2-Z2 with accessories; the Passive Probe ESH 2-Z3 includes an additional probe tip with hand guard

The **Passive Probe ESH 2-Z3** (to VDE 0876 standards) is particularly suitable for measuring radio interference voltages on, for example, AC-supply-voltage-carrying lines.

Specifications

	ESH 2-Z2	ESH 2-Z3
Frequency range	9 kHz to 30 MHz	9 kHz to 30 MHz
Attenuation[1]	10 dB	40 dB
Attenuation error (Z_{source} = 50 Ω)	<1 dB	<1 dB for f = 30 kHz to 30 MHz <+1/−2 dB for f = 9 kHz to 30 MHz
Measurement range using ESH 2/ESH 3 (IF bandwidth 200 Hz, average value indication)		
Lower limit (frequency-dependent)	−20 dBμV, approx.	+10 dBμV, approx.
Upper limit	120 dBμV	154 dBμV
Input impedance	118 kΩ ±5% shunted by 8 pF	2425 Ω ±5% shunted by 6 pF (with 50-Ω termination)
Max. input voltage		
for f <500 Hz	3 V	250 V
for f = 9 kHz to 30 MHz	3 V	50 V
Order designation	▶ Active Probe ESH 2-Z2 299.7210.52	▶ Passive Probe ESH 2-Z3 299.7810.52

Accessories supplied
Accessories kit
Probe tip

Recommended extras

BNC Adapter URV-Z 241.1110.02

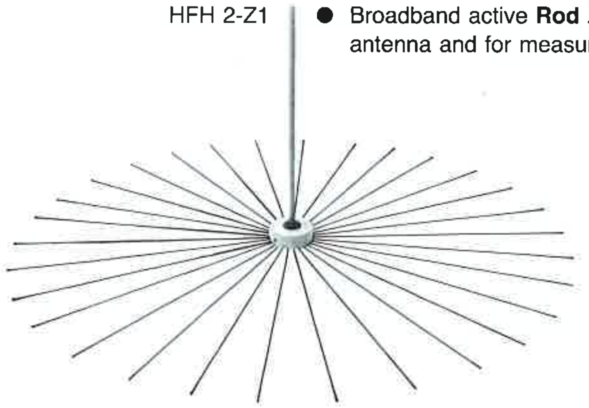
[1]) Automatically taken into account in the readout on the ESH 2 and ESH 3.

Field-strength measurements

HFH 2-Z1
HFH 2-Z2

Rod Antenna HFH 2-Z1, Loop Antenna HFH 2-Z2

HFH 2-Z1



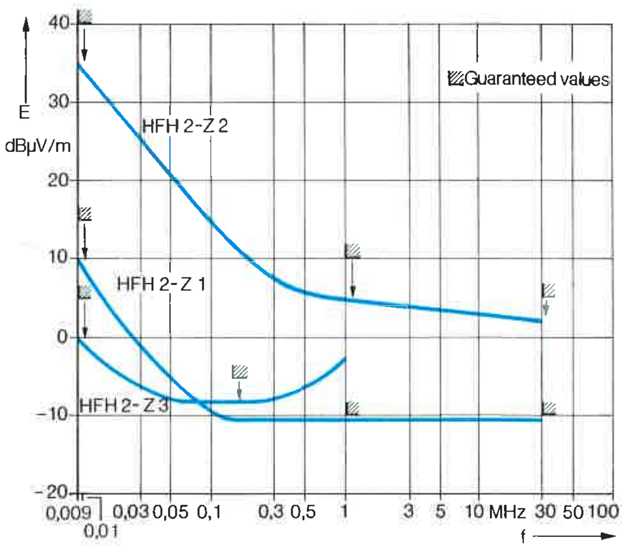
- Broadband active **Rod Antenna HFH 2-Z1** for use as a general-purpose receiving antenna and for measuring the electrical field-strength component

Data on page 232

HFH 2-Z2

- Active **Loop Antenna HFH 2-Z2** for measuring the magnetic field-strength component

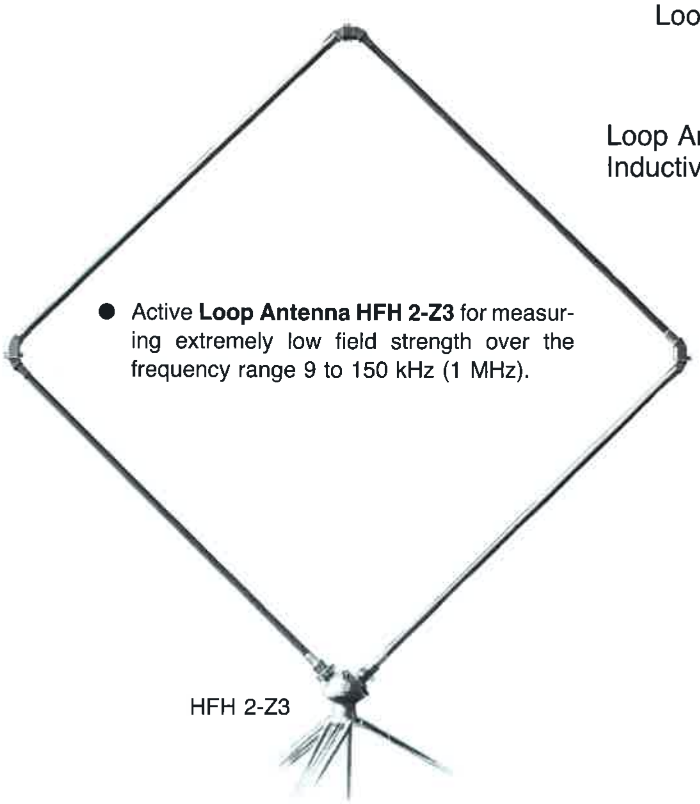
Minimum measurable field-strength level (for S/N = 1) of the antennas HFH 2-Z1, -Z2 and -Z3 as a function of the frequency (average-value indication and 200 Hz IF bandwidth). In the CISPR indicating mode the minimum measurable field-strength goes up by about 6 dB over the range, 9 kHz to 149.9 kHz (CISPR 3) and about 23 dB over the range 150 kHz to 30 MHz (CISPR 1)



Field-strength measurements

(see also page 231: Rod Antenna HFH 2-Z1
Loop Antenna HFH 2-Z2)

Loop Antenna HFH 2-Z3, Inductive Probe HFH 2-Z4



- Active **Loop Antenna HFH 2-Z3** for measuring extremely low field strength over the frequency range 9 to 150 kHz (1 MHz).

HFH 2-Z3

- **Inductive Probe HFH 2-Z4** for simple approximate measurements of the magnetic field-strength component.

HFH 2-Z4

Specifications

	Rod Antenna HFH 2-Z1 (page 231)	Loop Antenna HFH 2-Z2 (page 231)	Loop Antenna HFH 2-Z3	Inductive Probe HFH 2-Z4
Frequency range	9 kHz to 30 MHz	9 kHz to 30 MHz	9 to 150 kHz (1 MHz)²)	100 kHz to 30 MHz
Conversion factor k¹) (E→V)	20 dB, referred to 1/m	20 dB, referred to 1/m	10 dB, referred to 1/m	80 dB, referred to 1/m
Error	<1 dB	<1 dB	<1 dB	<6 dB
Measurement range (IF bandwidth 200 Hz, average-value indication)				
Lower limit (frequency-dependent, see diagram on page 231)	+15 to −10 dBµV/m	9 kHz to 1 MHz: +40 to +10 dBµV/m; 1 MHz to 30 MHz: +10 to +5 dBµV/m	+5 to −5 dBµV/m	50 dBµV/m
Upper limit	140 dBµV/m	140 dBµV/m	140 dBµV/m	>140 dBµV/m
Source impedance	50 Ω	50 Ω	50 Ω	50 Ω
Max. output voltage into 50 Ω	1 V	1 V	3 V	—
General data				
Rated temperature range	−10 to +55°C	−10 to +55°C	−10 to +55°C	−10 to +55°C
Storage temperature range	−25 to +70°C	−25 to +70°C	−25 to +70°C	−25 to +70°C
Inputs				
RF	BNC female	BNC female	BNC female	BNC male
Supply and coding (antenna factor)	12-pole Tuchel-type female connector	12-pole Tuchel-type female connector	12-pole Tuchel-type female connector	12-pole Tuchel-type male connector
Length of connecting cable	10 m	10 m	10 m	1 m
Current consumption (±10 V, varies with output level)	<40 mA	<40 mA	<50 mA	—
Weight	In transport case, without cables: 8 kg	In transport bag, without cables: 6 kg	Without cables, with (without) transport case: 43 (17) kg	With cables: 0.3 kg
Order designation	▶ Rod Antenna HFH 2-Z1 335.3215.52	▶ Loop Antenna HFH 2-Z2 335.4711.52	▶ Loop Antenna HFH 2-Z3 335.6214.52	▶ Inductive Probe HFH 2-Z4 338.3016.52
Accessories supplied	Coaxial cable (10 m), Supply/coding cable (10 m), 12-pole Tuchel-type female connector	Same as HFH 2-Z1	Same as HFH 2-Z1	
Recommended extras	—	Tripod HFU-Z (in transport bag): 100.1114.02	Same as HFH 2-Z2	—

¹) Conversion factor = logarithm of the ratio between the output voltage and the input field strength; automatically taken into account in the readout on the ESH 2 and ESH 3.

²) The antenna can be used up to 1 MHz without any derating of performance data.

Interference measurements

Artificial Mains Network ESH 2-Z5

For interference measurements on AC-supply-dependent loads a circuit must be provided to ensure that the AC supply voltage is supplied to the test item, on the one hand, and, on the other hand, that the AC supply represents a defined source impedance for the test item, that interference from the AC supply does not reach the test circuit, and that the defined interference voltage produced by the test item can be connected to a test receiver suitable for radio interference measurements, such as the ESH 2 or ESH 3.

The **Artificial Mains Network ESH 2-Z5** meets the requirements laid down in VDE 0876 and CISPR 3. It uses aircored coils and contains an artificial hand and a choke to suppress interference on the ground line. A built-in blower with a separate AC supply provides automatically controlled cooling or continuous cooling, as required.

ESH 2-Z5

For integration in an IEC-bus system the Artificial Mains Network ESH 2-Z5 can also be remote controlled using a code converter, such as the PCW from Rohde & Schwarz.

ESH 2-Z5
ESH 2-Z11/ESH 3-Z2

Other accessoires for use in radio-interference measurements are listed in the table on page 230, for example

Attenuator ESH 2-Z11 and
Pulse Limiter ESH 3-Z2.

They are recommended to protect the receiver's internal attenuator from excessive AC supply interference when working with the Artificial Mains Network (see specifications).

Specifications

Frequency range	10 to 150 kHz (30 MHz)
Equivalent circuit (to VDE 0876)	(50 µH +5 Ω) shunted by 50 Ω
Error limits (to VDE 0876)	±20%
Continuous-rated output current	4×25 A
Max. instantaneous output current	4×50 A
Cooling	built-in blower
Connectors	
AC supply inputs	
4×32 A	Cekon male
Blower connector	male European standard
AC supply outputs for test item	
2×16 A	female with earthing contact
4×32 A	Cekon female
RF output	BNC female
Remote control input	50-way Amphenol female
Artificial hand	telephone jacks

General data

Rated temperature range	−10 to +45 °C
Storage temperature range	−25 to +70 °C
AC supply (blower)	220 V, 20 VA
Overall dimensions (W×H×D)	492 mm×294 mm×603 mm
Weight	25 kg
Order designation	▶ Artificial Mains Network ESH 2-Z5 338.5219.52

Accessories supplied
Power cord, RF connecting cable,
50-way Amphenol male connector

Recommended extras (for automatic measurements)

Code Converter PCW	244.8015.92
Process Controller PUC	see Page 14
Attenuator ESH 2Z11, 20 dB, 10 W	349.7518.52
Pulse Limiter ESH 3-Z2	357.8810.52

Other accessories

24-V Adapter ESH 2-Z4

The ESH 2 as well as the ESV can be powered from a 24-V DC mains supply via the **24-V Adapter ESH 2-Z4** which may be mounted at the rear of the receiver in the place of the power supply or battery pack.

Specifications

Input voltage range (protected against reversal of polarity)	+18 to +32 V
Input connector (mating connector is supplied with the ESH 2-Z4)	6-way male standard
Output voltage range	+12.5 V ±0.5 V
Output connector	4-way female special
Maximum output current (short-circuit-proof)	1.8 A
Rated temperature range	−10 to +45 °C
Storage temperature range	−25 to +70 °C
Dimensions (W×H×D)	205 mm×172×50 mm
Weight	1 kg
Order designation	▶ 24-V Adapter ESH 2-Z4 338.4512.02

Accessories supplied

Mating connector, female	018.6946.00

ESH 2-Z4
HFU-Z

Tripod HFU-Z

is recommended for supporting the Loop Antennas HFH 2-Z2 and -Z3 (pages 231/232).

Order designation ..... ▶ Tripod HFU-Z 110.1114.02

ESH 2-Z4

ESV

Test Receiver ESV

♦ 20 MHz to 1 GHz/ −10 to +137 dBµV

- Synthesizer-based test receiver offering crystal-referenced frequency display
- High overload capacity
- High dynamic selectivity
- Automatic level calibration at the push of a button
- Automatic overload detection
- General-purpose unit for:
  Wanted-signal measurements
  Field-strength measurement with test antennas
  Interference measurements to CISPR, VDE, FCC, MIL and VG
- AC supply and battery operation

new

The **ESV** is a manually operated, sensitive and overload-protected test receiver offering a very wide dynamic range and maximum ease of operation. Compact construction, wide range of power supplies and low power consumption make the receiver suitable for use in fixed stations as well as for mobile and portable applications. The Test Receiver is available as model 52 (20 to 520 MHz) or as model 53 (20 to 1000 MHz).

Thanks to its excellent characteristics and the availability of a wide range of accessories, the applications of the ESV include **interference measurements** and **field-strength measurements.**

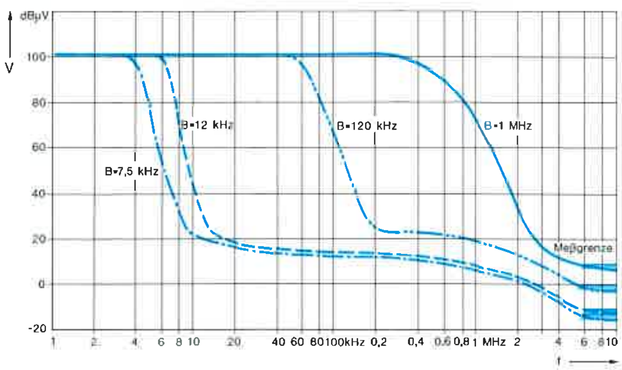
Characteristics, uses (ESV alone)

The ESV needs no accessories to operate as a **selective voltmeter** (test receiver) with a level range from −10 to +137 dBµV, for example, for measurements in 50-Ω coaxial systems. Relative and absolute selective voltage measurements are possible even in the presence of a multitude of signals.

Automatic calibration at the push of a button and excellent receiver selectivity permit accurate measurements of closely spaced signals with very different levels, for example: adjacent-channel measurements, spurious-content and sideband-noise measurements on signal generators, intermodulation and distortion measurements, noise figure measurements.

Signal evaluation. Four switch-selected IF bandwidths and numerous test outputs make it easy to carry out a wide range of measurements:

- wideband IF output of 10.7 MHz for the connection of a panoramic display or a wave analyzer
- narrowband IF output of 10.7 MHz for connecting an oscilloscope
- AM/FM demodulator outputs
- recorder output for level and frequency offset



Typical IF selectivity of the ESV

Auxiliary instruments for additional applications

Interference measurement. Interference voltage, interference current and interference power can be measured in accordance with the relevant standards (CISPR, VDE, FCC, MIL, VG). The following accessories are available for this purpose:

VHF Current Probe ESV-Z1 (20 to 300 MHz)
Absorbing Clamp MDS-21 (30 to 1000 MHz; see p. 255).

In addition to the overload indication and automatic calibration, which have already been mentioned, the ESV has other features which are particularly important in interference measurements:

level indication taking into consideration frequency-independent conversion factors of the sensor, e.g. directly in dBμA,
peak indication with selectable hold time,
IF bandwidth of 120 kHz in line with CISPR,
scale range for measurements to CISPR: 10 dB, linear,
IF bandwidths of 12 kHz, 120 kHz and 1 MHz in line with MIL.

Radiomonitoring. In conjunction with a receiving antenna the test receiver can be used in radiomonitoring, since it features excellent frequency accuracy and stability. It is capable of measuring and demodulating A0 (N0N), A3 (A3E) and F3 (F3E) transmissions and comprises a squelch and a switchable AF filter.

Field-strength measurements. Completed by the following antennas the Test Receiver ESV becomes the Field-strength Meter HUF:

Broadband Dipole HUF-Z1 (20 to 80 MHz)

Log-periodic Antenna HL 023 A1 (80 to 1300 MHz), with **mast, tripod** and **cable set**

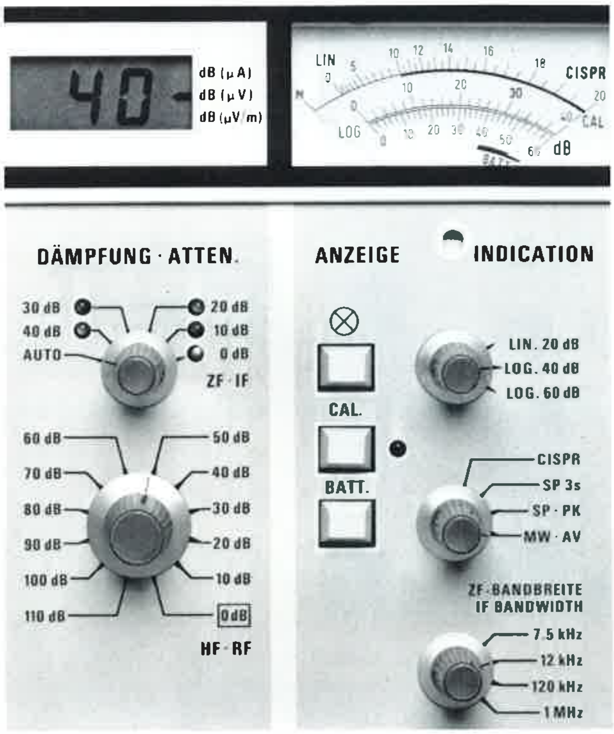
For radiomonitoring applications the HUF can be used to measure antennas, propagation and coverage. It features a field-strength measurement error of <3 dB complying thus with the CCIR Recommendation 378-1. Long-term field-strength variations can be recorded if a YT recorder is connected to the recorder output.

Ease of operation, setting functions

The correction of the level indication taking into account conversion factors of sensors, the automatic level calibration and many more logic functions make it possible to make do with a minimum of operating controls. Thanks to the clear arrangement of the front panel, even unskilled staff can learn to operate the instrument.

Frequency setting. The whole range from 20 to 1000 MHz is covered without band switching, in 1-kHz, 10-kHz or 100-kHz steps. The 6-digit LCD display is crystal-referenced. The frequency setting is retained in a memory even while the instrument is switched off.

Sensitivity setting. The measurement range for sinewave signals of −10 to +137 dBμV is determined at the lower limit by the inherent noise at 7.5-kHz IF bandwidth and at the upper limit by the maximum dissipation in the RF attenuator. Sensitivity is set for the RF and IF sections using attenuators with 10-dB steps, see front-panel section.



Front-panel section with controls for sensitivity, bandwidth, weighting and display

In the AUTO position of the IF attenuator, the IF attenuation is automatically controlled as a function of bandwidth and display mode in such a way that the receiver's internal noise is always below 0 dB on the display.

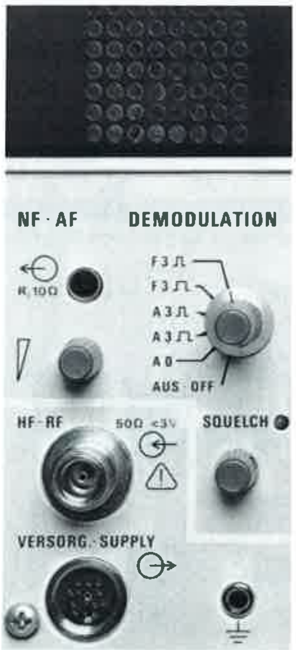
Bandwidths, signal weighting. If bandwidth is switch-selected at 7.5 kHz, 12 kHz, 120 kHz and 1 MHz. The signal weitghting mode can be switched to average or peak with different hold times (1 s, 3 s) or noise weighting in line with CISPR.

ESV – Test Receiver

Level indication. The meter has a linear range of 20 dB and two logarithmic ranges of 40 and 60 dB. The measured level is obtained from the meter indication and the digital reference value displayed in the same line, e.g. 40 dBμV in the photo on page 235.

Overload indicator. If one of the stages in the metering path of the receiver is overloaded the reference-value display flashes. This indication operates with sinewave voltages as well as with pulses.

Internal calibration, battery check. Automatic calibration, initiated at the push of a button or when the bandwidth is changed, guarantees reproducibility of the measurements and ease of operation. In the case of battery operation the state of charge of the batteries can also be checked at the push of a button.



Front-panel section:
demodulation and AF setting;
RF input,
squelch and power supply
for Current Probe

Signal demodulation, outputs. The ESV is designed for a multitude of modulation types: it can be switched to A0, A3 (AF wide or narrow) and F3 (AF wide or narrow). Numerous outputs are provided for signal evaluation, recording and plotting:

- wideband IF output of 10.7 MHz for the connection of a panoramic display or a wave analyzer
- narrowband output of 10.7 MHz for the connection of an oscilloscope
- AM and FM demodulator outputs
- output for the connection of recorders for level and frequency offset

The **power supply** is either direct from a 12-V source, from the 12-V battery pack (delivered without batteries), from a 24-V supply (24-V Adapter ESH 2-Z4 required) or from the local Ac supply via the power supply unit (safety class II; see photo below), which can at the same time recharge or trickle-charge the 12-V battery.

Description

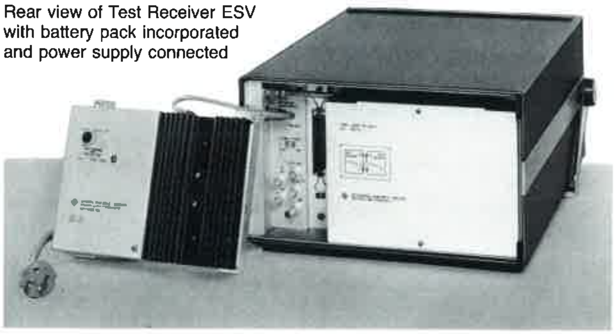
The ESV is a double heterodyne receiver with a phase-synchronized tuning oscillator. The input signal passes via an RF attenuator to one of nine bandpass filters (depending on input frequency) and then to a high-power ring mixer where it is converted to the 1st IF of 810.7 MHz (20 to <520 MHz) or of 310.7 MHz (up to <1000 MHz). The signal is then amplified and filtered in multi-section filter circuits. Another mixer stage produces the second IF of 10.7 MHz.

Further signal path: After filtering (crystal filters of 7.5, 12 and 120 kHz and LC filter of 1-MHz bandwidth), IF amplification (switchable in 10-dB steps) and rectification, the signal passes through circuits producing peak and average values and undergoes weighting to CISPR before it reaches the display.

An amplifier for monitoring AM signals and a limiter amplifier for FM signals are operative in parallel to this measurement and display section. Four demodulators permit reception of AM and FM signals with four different IF bandwidths.

Construction

Even though heavy shielding is provided, this compact receiver weighs only 20 kg. The modern cassette design, using primarily plug-in PC boards on a motherboard, makes the ESV very easy to service, whilst at the same time the interior space of the receiver is optimally utilized. The use of high-grade components and the low self-heating as a result of the low power drain (approx. 20 W in battery operation) further cut down the failure expectancy of the receiver. A plastic cover may be put on the front or rear panel to protect the receiver during transport or when it is being operated outdoors.



Rear view of Test Receiver ESV
with battery pack incorporated
and power supply connected

Specifications

	Models 52 and 53	Model 53
Frequency range	20 to 519.999 MHz	520 to 999.999 MHz
Frequency setting	quasicontinuous with knob (tuning speed increases with speed of rotation)	
Resolution (step width)	1, 10 or 100 kHz, switch-selected	
Indication	6-digit LCD, switchable back-lighting	
Setting error	1×10^{-5}	
Max. setting error (at 520 or 1000 MHz)	<5 kHz	<10 kHz

	Models 52 and 53	Model 53
RF input	Z_{in} = 50 Ω, N female connector	
VSWR with RF attenuation ≧10 dB	<1.2	
0 dB	<2	
Oscillator reradiation	<10 dBµV	<20 dBµV
Internal input filters	5 tracking filters	4 tracking filters
Interference immunity, non-linearities		
Image-frequency rejection (1st IF)	>80 dB typ. 100 dB	>80 dB typ. 90 dB
IF rejection	>80 dB typ. 100 dB	>80 dB typ. 90 dB
d_3 intercept point	>+13 dBm typ. +20 dBm	>+13 dBm typ. +20 dBm
k_2 intercept point	>+40 dBm typ. +50 dBm	>+40 dBm typ. +50 dBm

Blocking
(typical, frequency-dependent)
An interfering signal spaced >2 MHz from the receive frequency influences the display of a signal to be measured by <1 dB (RF attenuation 0 dB) at a level of >110 dBµV
Shielding effectiveness
Indication at a field strength of 10 V/m (with f ≠ 1st IF) .... <−5 dBµV
(adjust f = $f_{interf.}$ for calibration)

Intermediate frequencies		
1st IF	810.7 MHz	310.7 MHz
2nd IF	10.7 MHz	10.7 MHz

IF bandwidths (for average and peak)

Nominal bandwidth	−3 dB (±20%)	−6 dB (±10%)	6:60-dB ratio
7.5 kHz	7.5 kHz	8.3 kHz	≈1:2
12 kHz	12 kHz	13.4 kHz	≈1:2
120 kHz	110 kHz	120 kHz	≈1:3
1 MHz	0.8 MHz	1 MHz	≈1:4

IF bandwidth (−6 dB) for measurements to CISPR (Publ. 2 and 4) and VDE 0875	120 kHz (automatically switched on with measurements to CISPR)	
AF bandwidth (−3 dB)		
narrow	300 Hz to 3.3 kHz	
wide	<50 Hz to >15 kHz	
Internal noise (automatic on)		
Average B = 7.5 kHz	<−10 dBµV typ. −14 dBµV	<−8 dBµV typ. −12 dBµV
Peak B = 7.5 kHz	typ. −4 dBµV	typ. −2 dBµV
CISPR	typ. +5 dBµV	typ. +7 dBµV
Voltage range		
Lower limit (3 dB above internal noise level)	−10 dBµV	−8 dBµV
Upper limit (RF attenuation ≧10 dB)	137 dBµV	
Inherent spurious responses	equivalent to <−5 dBµV	
Voltage indication	moving-coil meter, switchable back-lighting	
Scale ranges		
CISPR	10 dB	
linear	20 dB	
logarithmic	40/60 dB	
battery check	tolerance range	
Types of indication	average peak peak with 3 s hold time CISPR (Publ. 2 and 4)	
Maximum permissible input level		
RF attenuation 0 dB		
DC voltage	7 V	
Sinusoidal AC voltage	120 dBµV	
Pulses (spectral density)	96 dBµV/MHz	
RF attenuation ≧10 dB (no DC separation)		
DC voltage	7 V	
Sinusoidal AC voltage (at 10 dB/≧10 dB)	130 dBµV/137 dBµV	
Max. permissible pulse voltage	100 V	
Max. permissible pulse energy	1 mWs	
Voltage indication error		
average, linear, 20 dB, for an unmodulated sinewave signal, 16 dB above noise indication		
B = 120 kHz, 1 MHz	<1.2 dB	
B = 7.5 kHz, 12 kHz	<1.5 dB	
peak, linear, 20 dB	same as average, additional tolerance for wideband interference measurements	

	Models 52 and 53	Model 53
CISPR, linear, 10 dB (for impulsive interference)	<1.5 dB	
Additional error due to temperature effect at log 40 dB/log 60 dB	<1 dB	
Types of demodulation	N0N (A0) A3E (A3) (AF wide or narrow) F3E (F3) (AF wide or narrow) with and without carrier squelch	
Outputs		
Connector for supply and coding of accessories	12-pole Tuchel female connector	
AF signal, EMF adjustable	up to 3.5 V, 10 Ω, jack JK 34	
IF 10.7 MHz		
wide (approx. 2 MHz)	50 Ω, BNC female connector	
Gain (RF attenuation 0 dB)	7.5 dB	
narrow	50 Ω, BNC female connector	
EMF at fsd, lin.	100 mV	
AM demodulator	330 Ω, BNC female connector	
EMF	1 V_{pp} at 50% modulation	
3-dB bandwidth >0.3 MHz (depending on IF bandwidth)		
FM demodulator	330 Ω, BNC female connector	
EMF at IF bandwidths		
7.5 kHz and 12 kHz	±1 V_{pp} for ±1 kHz offset	
120 kHz and 1 MHz	±1 V_{pp} for ±100 kHz offset	
Recorder outputs	50-pole Amphenol female connector	
Frequency offset at IF bandwidths		
7.5 kHz and 12 kHz	±1 V for ±1 kHz offset, Z_{out} = 10 kΩ	
120 kHz and 1 MHz	±1 V for ±100 kHz offset, Z_{out} = 10 kΩ	
Level 1 in average, peak modes, in CISPR	+4 V for fsd, R_s = 10 kΩ	
Level 2 in CISPR	output with lowpass filter simulating meter response, to CISPR (2 and 4); +2 V for fsd R_s = 10 kΩ	
Input for ext. reference frequency	5/10 MHz, switchable, EMF 1 V across 50 Ω, sinewave, BNC female connector	
General data		
Rated temperature range	−10 to +45 °C	
Storage temperature range	−25 to +70 °C (without batteries) −10 to +60 °C (with batteries)	
Power supply	either via power supply unit or from battery pack (see photo on the left)	
AC power supply unit	115/125/220/235 V +10/−15%, 47 to 420 Hz (70 VA) VDE 0411, safety class II (DIN 57411)	
Battery pack	+12 V, 8.5 to 9.5 Ah operating life >3 h per charge	
Battery input	4-pole special socket (Lemosa) ext. battery +10.8 to 15 V, typ. 1.8 A	
Dimensions	347 mm×206 mm×484 mm	
Weight with power supply unit	18 kg	19 kg
with batteries	20 kg	21 kg

Ordering information

Order designation	▶ Test Receiver ESV	
Test Receiver ESV, 20 to 520 MHz	342.4020.52	
Test Receiver ESV, 20 to 1000 MHz	342.4020.53	
Accessories supplied	Battery pack (without batteries) battery connector LEMO F.c 23046.7 50-pin Amphenol male connector	

Recommended extras

Options:		
Option 0.5 to 1 GHz (for model 52)	ESV-B2	353.6012.02
For interference measurements:		
VHF Current Probe (20 to 300 MHz)	ESV-Z1	353.7019.02
Absorbing Clamp (30 to 1000 MHz)	MDS-21	194.0100.50
Adapter (BNC female to N male)		118.2812.00
For field-strength measurements:		
Broadband Dipole (22 to 80 MHz)	HUF-Z1	358.0512.52
Log.-periodic Antenna (80 to 1300 MHz)	HL 023 A1	577.8017.02
Tripod	HFU-Z	100.1114.02
Mast (for tripod)	HFU-Z	100.1120.02
RF cable (7 m)	HFU2-Z5	252.0055.55
General:		
Headphones		110.2959.00
24-V Adapter	ESH2-Z4	338.4512.02
6-V Lead-acid Storage Battery 9.5 Ah (2 required)		338.4012.00
19" Adapter	ESH2-Z6	338.4312.02
Service Kit	ESV-Z2	353.7319.02
Protective Cover for front or rear panel (2 recommended)	ESH2-Z8	303.2065.00
Recorders:		
XYT Recorder	ZSKT	301.9010.02

ESVP

Test Receiver ESVP

♦ 20 to 1300 MHz
−10 to +137 dBμV

- Programmable test receiver for selective voltage measurements and twoport measurements in laboratories and test departments
- Field-strength measurements with test antennas
- RFI measurements to CISPR, VDE and FCC
- Interference measurements to MIL and VG standards
- Radiomonitoring
- AC supply and battery operation

IEC 625 Bus

new

The **Test Receiver ESVP** measures and demodulates AM double-sideband, single-sideband, pulse-modulated and FM signals as well as narrowband and wideband interference. High overload capacity, a wide dynamic range and manifold evaluation capabilities make the ESVP suitable for

selective voltage and twoport measurements – in automatic test systems too –

and all applications in the field of radiomonitoring and EMC measurements.

In its frequency-related characteristics and application capabilities the ESVP is very similar to the ESV (page 234), in measurement convenience, intelligence and system compatibility to the ESH 3 (page 226); its frequency range overlaps and extends that of the ESH 3.

Special features of ESVP

- Synthesizer; frequency resolution 1 kHz, with SSB 100 Hz
- High measurement accuracy – error <1 dB
- Wide dynamic range: noise figure typical 8 dB (preamplifier on) 3rd-order IP typical +20 dBm (preamplifier off)
- Automatic gain correction in the whole frequency range after calibration
- Measurement of voltage, field strength, current, spectral density and attenuation constant with display of physical unit; conversion and bandwidth correction factors are automatically taken into account.
- Additional evaluation capabilities for radio-monitoring: modulation-depth and frequency-deviation measurements, remote frequency and frequency-offset measurements thanks to internal IF counter, connection of radiomonitoring recorders (maximum of 5 ZSG 3), SSB demodulator, AF filter, squelch with programmable threshold, indication of date and time of day.
- Storage of 10 complete device settings and of 5 data sets for automatic frequency scanning

Further characteristics, uses

Selective voltage measurement. With its measurement range −15 to +137 dBμV the ESVP on its own is an automatic high-precision selective voltmeter for laboratory, testing and servicing applications. RF currents in the frequency range 20 to 300 MHz can be measured in conjunction with the VHF Current Probe ESV-Z1. Excellent receiver selectivity permits the measurement of adjacent-channel power and of nonharmonic spurious signals of generators. Other important applications are the measurement of intermodulation, crossmodulation and distortion and the determination of noise figures.

Frequency-response/attenuation measurement with calibration generator. The calibration generator output of 90 dBμV across 50 Ω is ideally suited for frequency-response measurements on amplifiers and filters; attenuation can be measured up to 105 dB and gain up to 47 dB. The VHF Current Probe ESV-Z1 facilitates the measurement of shielding effectiveness on cables and a VSWR bridge can be used for return-loss measurements on two-terminal networks (e.g. antennas) and twoports.

Signal evaluation capabilities

Four switch-selected IF bandwidths: 7.5/12/120 kHz/1 MHz

Average and peak indication, pulse weighting to CISPR 2 and 4 with programmable measurement times

Demodulation of commonly used FM and AM modes, SSB (USB, LSB) included

Wideband IF output of 10.7 MHz for panoramic display and spectrum analyzer

Narrowband IF output for oscilloscope

AM and FM demodulator outputs

Recorder outputs for level and frequency offset

Digital readout of modulation depth, frequency offset and frequency deviation

Trigger input for level and frequency measurement of short signals.

Recording. Harmonic, nonharmonic and sideband noise spectra, gain and attenuation curves can be readily plotted on an XY recorder. The start and stop frequencies and the maximum and minimum levels set on the ESVP define the recorder writing area. The frequency scale can be linear or logarithmic. Chart paper complying with VDE/FTZ/MIL can be used.

Remote control. The IEC-bus interface possesses all standard listener and talker capabilities. Commercial controllers without parallel poll capability can be used.

Special applications of ESVP

EMI measurements. Programmable automatic frequency scanning with direct printer/recorder control gives the ESVP a considerrable advantage over earlier test receivers. Accessories, such as current probes and broadband antennas, are available for measurements of interference voltages, currents and field strengths in line with the relevant standards (CISPR, VDE, MIL, VG); see specifications on page 241.

Further advantages of ESVP in interference measurements:

- Conversion factors are automatically taken into account
- Bandwidth factors are taken into account in measurements of spectral density to MIL and VG
- Peak indication with programmable hold time for narrowband and wideband interference measurements to MIL and VG
- Average indication with programmable integration time for narrowband interference measurements
- Indication to CISPR with determination of maximum within the programmed measurement time

Radiomonitoring, propagation and coverage measurements. Thanks to its outstanding RF characteristics, switch-selected IF bandwidths and types of demodulation, the wide range of available test antennas and its programmability, the ESVP is idal for use in radiomonitoring with remote frequency measurement, determination of frequency-band occupation and for propagation and coverage measurements. It offers the following possibilities:

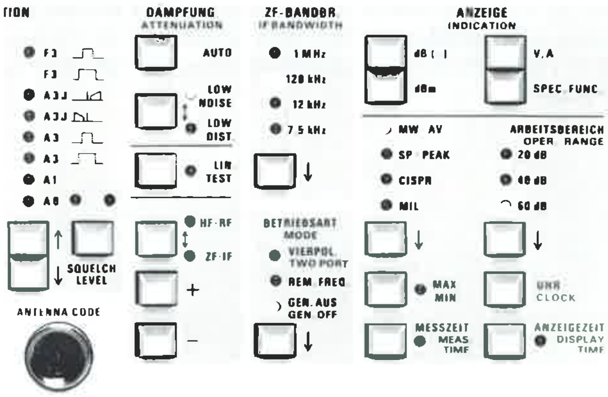
- Graphical representation of field strength in particular frequency bands, in the form of line spectra or segmented curves, on an XY recorder, with additional output of field-strength levels and, say, frequency offset on a printer
- Measurement of the variation range of field-strength level within a preset time (1 to 1000 s)
- Recording of field strength as a function of time for plotting antenna radiation patterns, for example in helicopters, and for measurement of channel occupation
- Recording of frequency-band occupation as a function of time, using the Radiomonitoring Recorder ZSG 3
- Reduction of data volume in automatic scanning mode: only signal levels above the preset threshold are taken to the computer.

Where highest operating speed is important and controller capacity must be saved, the IEC-bus interface of the ESVP offers the following possibilities:

The controller instructs each ESVP (and ESH 3) to permanently scan a particular frequency range and to issue SR when the programmed level is exceeded – whereupon the controller identifies the calling receiver by a serial poll and accepts the measured data – or to answer a parallel poll of the controller.

Operation

The operating controls are logically organized in functional groups on the front panel; all settings are indicated by LEDs.



Front-panel section with operating controls for demodulation, attenuation, IF bandwidth and display

The operating philosophy of the ESVP is basically the same as that of the Test Receiver ESH 3, which covers the lower frequency range from 9 kHz to 30 MHz. **Operator errors are signalled** by the ESVP: when a logically inhibited key is pressed, the LED of the inhibiting function blinks; when the demodulator operating range is exceeded or essential stages are overloaded (even with pulses), the display blinks; when illegal data is input or an essential module fails, a coded error message appears together with a sound signal.

The 15-digit **alphanumeric display** of the ESVP outputs the measured data with physical unit and is used for checking the formatted input of setting data.

Frequency setting is possible in different ways (quasi-continuous, via keyboard, etc.; see specifications).

The **level measurement range** is selected either manually by separate setting of RF and IF attenuation or by automatic setting of RF attenuation with the IF attenuation setting being determined by the selected IF bandwidth and indicating mode.

Storage. A battery-buffered memory in the ESVP can store the last and nine more complete device settings. It also stores all the correction values obtained from an automatic calibration process for frequency response, IF bandwidths and demodulator characterististic.

ESVP – Test receiver

Measuring convenience

The physical unit is selected automatically and **conversion factors** are **taken into account,** so the user need not do any additional work to perform measurements. Reading errors are virtually excluded.

The frequency-dependent **antenna factors** of passive R&S antennas are also automatically taken into account when a special function is selected. Conversion factors of other probes can be permanently stored in the ESVP using a process controller via the IEC-bus interface.

One of three demodulator operating ranges can be selected to suit the measurement task: 20/40/60 dB. Accordingly, the automatic attenuation setting is in steps of 10, 20 or 30 dB. The operating range also determines the range of the analog level indication, which consists of a row of 31 LEDs. The range limits and RF attenuation are digitally displayed.

Calibration. By a short or long push of the calibration button, function 1 or 2 is initiated:

1 Adjustment of IF gain and frequency offset to the rated value at 100 MHz, followed by a check of the level measurement at the set frequency.

2 Measurement and storage of all calibration correction values that are constant over a long time: frequency response, gain differences between IF bandwidths and demodulator linearity.

During operation the IF gain is adjusted each time a new frequency and IF bandwidth is set, so the rated levels are obtained at the IF and recorder outputs.

Thanks to this method, calibration of individual functions is very seldom necessary and automatic measurements take much less time than would be required if a calibration were performed at each new frequency.

Construction

Modular design, signature-analysis capability and selftest routines afford easy serviceability. All modules are independently exchangeable; the RF and µP modules are of state-of-the-art cassette design.

Specifications

Frequency range	20 to (1000) 1300 MHz	
Frequency setting	1. in 1 kHz/100 kHz steps with knob; least increment in SSB mode: 100 Hz 2. keyboard entry 3. in steps of any preset size 4. automatic scanning	
Indication	8-digit LED display	
Resolution	1 kHz/100 Hz (SSB)	
Setting error (freq. prop.)	$<5\times10^{-6}$; max. 5 kHz at 1 GHz, ref.-freq. input 5/10 MHz for accuracy improvement	
RF input	Z_{in} = 50 Ω, N female connector	
VSWR	<1.2 with RF attenuation ≧10 dB <2 with RF attenuation 0 dB	
Oscillator reradiation at RF input without pre-amplifier and with RF attenuation 0 dB (with pre-amplifier 15 dB less)	<10 dBµV for f_{in} = 20 to <520 MHz <20 dBµV for f_{in} = 520 to <1020 MHz typ. 35 to 45 dBµV (f_{o1}) } for f_{in} = 1.02 to 1.3 GHz typ. 65 to 15 dBµV ($2\times f_{o1}$) } for f_{in} = 1.02 to 1.3 GHz	
Pre-amplifier	switch-selected between RF attenuator and input filter: ≈+10 dB	
Input filters	10 tracking filters	
Maximum input level	RF atten.	
	0 dB	≧10 dB
DC voltage	7 V	7 V
Sinewave AC voltage	130 dBµV	137 dBµV (at ≧10 dB)
Max. pulse voltage		150 V
energy (10 µs)		1 mWs
Interference immunity, non-linearities	pre-amplifier without	with
Image frequency rejection		
20 to <520 MHz	>80 dB } typ. 100 dB	>80 dB } typ. 100 dB
520 to <1020 MHz	>80 dB } typ. 100 dB	>80 dB } typ. 100 dB
1.02 to 1.3 GHz	75 to 60 dB, typ.	75 to 60 dB, typ.
Spurious responses in range 1.02 to 1.3 GHz for $2\times f_{in}$ −932.1 MHz	down 40 to 80 dB, typ.	
IF rejection	>80 dB, typ. 100 dB	>80 dB, typ. 100 dB
d_3 intercept point	>+13 dBm, typ. +20 dBm	>+3 dBm, typ. +8 dBm
k_2 intercept point	>+45 dBm, typ. +55 dBm	>+35 dBm

Desensitization (typical, frequency-dependent): An interfering signal spaced >2 MHz from the receive frequency influences the display of the measured signal by <1 dB (RF attenuation 0 dB) at a level of	110 dBµV		100 dBµV
Shielding effectiveness Voltage indication at a field strength of 3 V/m	<0 dBµV		0 dBµV
Radio interference from internal microcomputer, etc.	below VDE 0876 and MIL-Std. 461 A and B tolerance limits		
Intermediate frequencies			
1st IF f_{in} <520 MHz	810.7 MHz		
f_{in} ≧520 MHz	310.7 MHz		
2nd IF	10.7 MHz		
IF bandwidths (for average and peak values)			
Nominal bandwidth	−3 dB (±20%)	−6 dB (±10%)	6:60 dB ratio, typ.
7.5 kHz	7.5 kHz	8.3 kHz	1:1.8
12 kHz	12 kHz	13.4 kHz	1:1.8
120 kHz	110 kHz	120 kHz	1:2.5
1 MHz	0.8 MHz	1 MHz	1:3.5
IF bandwidth (−6 dB) for ratio interference measurements to CISPR (Publ. 2 and 4) and VDE 0876	120 kHz		
IF bandwidth (−3 dB) for SSB demodulation (only aural monitoring path)	2.4 kHz		
Internal noise indication	without pre-amplifier		with
Average B = 7.5 kHz			
20 to <520 MHz	<−10 dBµV, typ. −14 dBµV		<−16 dBµV, typ. −20 dBµV
520 to 1300 MHz	<−8 dBµV, typ. −12 dBµV		<−14 dBµV, typ. −18 dBµV
Peak	average +10 dB, typ.		
CISPR 20 to <520 MHz	typ. +5 dBµV		typ. −1 dBµV
520 to 1000 MHz	typ. +7 dBµV		typ. +1 dBµV
MIL (B_{IF} = 1 MHz)	typ. +20 dBµV/MHz		typ. 14 dBµV/MHz

Voltage range (with pre-amplifier)	
Lower limit	3 dB above noise level (see internal noise)
Upper limit	137 dBμV (RF attenuation ≧20 dB)
Inherent spurious responses	<−5 dBμV (equivalent input voltage)
Voltage indication	
digital in dBμV, dBm	4 digits, max.: resolution 0.1 dB
in μV, mV, V	3 digits
analog	LED row over operating range of IF rectifier with digital display of range limits
Operating ranges of IF detector	20, 40, 60 dB
Indicating modes	average value (progr. averaging time) peak value (progr. hold time) spectral density measurements to MIL, CISPR (Publ. 2 and 4); programmable averaging, hold and measuring times: 5 ms to 100 s
Measurement of maximum and minimum levels	the maximum and minimum levels are determined from individual measurements of 0.1 s duration each; programmable measuring time: 1 to 1000 s
Measuring error (level indication)	
Average indication for unmodulated sinewave signal ≧16 dB above internal noise	<1 dB
Additional error in operating ranges 40 und 60 dB	typ. <0.5 dB
Level calibration facility	
Average/peak	tracking generator (sinewave)
CISPR, MIL in addition	pulse generator
Error of analog level indication	
Operating range 20 dB	typ. <2 dB
40, 60 dB	typ. <4 dB
Frequency offset	indication: digital in kHz, resolution 0.1 to 100 Hz, analog with LED row
Measuring times	100 ms to 10 s
Frequency deviation (+/−, peak)	indication in kHz, 4 digits, resolution 0.1/0.01 kHz
Measurement range	1 to 500 kHz
Measuring error for S/N ≧30 dB	<5% typ.
Modulation depth	indication in %, 3 digits, resolution 1%
Measurement range	≈1 to 99% (150% pos. peak)
Measuring error for S/N ≧40 dB	<3 counts, typ.
Gain measurement	indication in dB, 4 digits, resolution 0.1 dB
Measurement range	−105 to +47 dB
Error	<1 dB, <0.5 dB typ.
Demodulation modes	A3E, J3E, F3E (former designations A3, A3J, F3); in addition: N0N (A0) for zero beat adj. A1A (A1) 1-kHz beat note
Squelch	carrier squelch, threshold adjustable −20 to +137 dBμV
Date, time of day	internal clock module, permanently in operation from internal battery
Remote control	interface to IEC 625-1 (IEEE 488), 24-pole Amphenol connector; functions: AH1, L4, SH1, T5, SR1, PP1, DC1, DT1, RL1, C0
Max. data rate	
Talker mode	approx. 5 kbyte/s
Listener mode	approx. 2 kbyte/s
Setting times	
Internal frequency, e.g. scan mode in steps <100 MHz	typ. 10 to 20 ms
exceeding a 100-MHz digit	typ. 70 ms
Internal RF level switch	25 ms/step
Max. measuring rate with PUC, measuring time 5 ms	50 ms/measured value
Front-panel outputs	
Generator output (switch-selected)	Z_{out} = 50 Ω, N female connector
EMF	96 dBμV ±0.3 dB
Connector for supply and coding of test antennas, etc.	12-pole Tuchel female connector
AF output	Z_{out} = 10 Ω, telephone jack JK34
EMF	adjustable up to 3.5 V

Rear-panel outputs	
IF 10.7 MHz	
wide (B ≈2 MHz)	Z_{out} = 50 Ω, BNC female connector
gain ref. to RF input (RF attenuation 0 dB)	typ. 7.5 dB (without pre-amplifier) typ. 17.5 dB (with pre-amplifier)
narrow (B = IF bandwidth)	Z_{out} = 50 Ω, BNC female connector
EMF in analog level indication range	
operating range 20 dB	7 to 70 mV
40 dB	7 to 700 mV
60 dB	0.7 to 700 mV
AM demodulator	Z_{out} = 330 Ω, BNC female connector
EMF	1 V with m = 50%
FM demodulator	Z_{out} = 330 Ω, BNC female connector
EMF at IF bandwidth 7.5/12 kHz	1 V/1 kHz deviation
0.12/1 MHz	1 V/100 kHz deviation
Analog outputs for recording	
Frequency offset	Z_{out} = 10 kΩ, BNC female connector
EMF at IF bandw. 7.5/12 kHz	1 V/1 kHz offset
0.12/1 MHz	1 V/100 kHz offset
Level 1 in AV, PEAK, CISPR, MIL modes	+4 V for max. analog indication
Level 2 in CISPR mode	+2 V for max. analog indication (includes LP filter simulating meter response, to CISPR 2 and 4)
Recorder output	24-pole Amphenol female connector; includes X and Y analog outputs for D/A-converted signal for recording of scanning process X = 0 V: start frequency 10 V: stop frequency Y = 0 V: MIN. level 10 V: MAX. level; pen lift control: (L = pen up); formatted paper feed for ZSKT (H pulse, duration 10 ms); connecting of five Radiomonitoring Recorders ZSG 3
Rear-panel inputs	
Ext. trigger	Z_{in} ≧3 kΩ, BNC female connector
Trigger threshold	TTL (H ≧2 V, L ≦0.8 V hysteresis), switch-selected positive or negative slope
Ext. reference frequency	Z_{in} = 50 Ω, BNC female connector
Required level	EMF = 1 V from 50 Ω, sinewave
Frequency	5/10 MHz (switch-selected)

General data

Rated temperature range	+5 to +45°C
Storage temperature range[1]	−25 to +70°C
Power supply/AC supply	100/120/220/240 V ±10%, 47 to 440 Hz (90 VA)
Battery	22 to 32 V, 3 A at 24 V
Dimensions, weight	492 mm×205 mm×514 mm, 27 kg

Ordering information

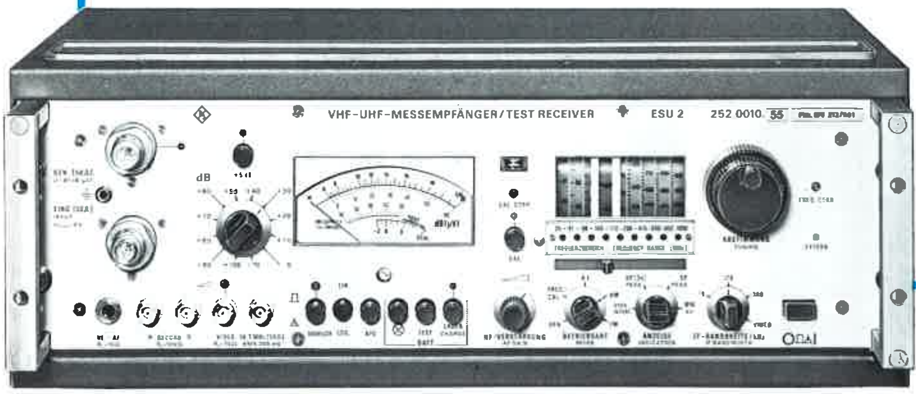
Order designation		▶ Test Receiver ESVP
ESVP 20 to 1300 MHz		354.3000.52
ESVP 20 to 1000 MHz		354.3000.54
Accessories supplied		Power cord, battery cable
Recommended extras		
VHF Current Probe (20 to 300 MHz)	ESV-Z1	353.7019.02
Absorbing Clamp (30 to 1000 MHz)	MDS-21	194.0100.50
Adapter BNC/N		118.2812.00
Broadband Dipole (20 to 80 MHz)	HUF-Z1	358.0512.52
Log-periodic Broadband Antenna (80 to 1300 MHz)	HL 023 A1	577.8017.02
Tripod	HFU-Z	100.1114.02
Mast (for tripod)	HFU-Z	100.1120.02
RF connecting cable (7 m)	HFU 2-Z5	252.0055.55
Headphones		110.2059.00
Service Kit	ESVP-Z1	358.1019.02

Other accessories
XYT Recorder ZSKT, Radiomonitoring Recorder ZSG 3, Universal Printer PUD 2 (in this catalog).

[1]) The ESVP contains a Li battery for buffering the CMOS-RAMs. Storage at high temperatures over extended periods curtails the life of this battery.

ESU 2

VHF-UHF Test Receiver ESU 2 ♦ 25 to 1000 MHz -10 to $+120$ dBμV



- Manually and remotely controllable test receiver for field-strength measurements, CISPR and MIL interference measurements, selective voltage measurements in laboratories and test departments, and for radiomonitoring.
- Error ≦1 dB – automatic voltage calibration
- Indication modes: average, peak, VDE and CISPR weighting

The manually and remotely controllable **VHF-UHF Test Receiver ESU 2** is designed for the measurement and demodulation of AM and FM signals, and for the measurement of TV, pulse-modulated and interference signals in the range 25 to 1000 MHz. It is of very versatile use.

By itself, the ESU 2 is a top-class **RF voltmeter** – add the 25-to-300-MHz clamp-on probe and it can also measure RF current from -30 to $+100$ dBμA.

The **VHF-UHF Field-strength Meter HFU 2** is a combination of the ESU 2, a 25-to-80-MHz broadband dipole, an 80-to-1300-MHz log-periodic antenna, mast and tripod. The overall measurement band is 25 to 1000 MHz; see page 254.

As a **system component** the ESU 2 can easily be used with a frequency controller, a panoramic adapter, recorders and test assemblies; see pages 244 and 248.

High RF-input sensitivity and linearity, together with an internal calibration standard, make for unambiguous and precise measurements. A close-tolerance attenuator extends the linear 20-dB meter range to give a **measurement range of -10 to $+120$ dBμV.**

Test receiver applications

Laboratories and test departments Versatile selective voltmeter, offering many ways of evaluating each input; measurement of RF current from -30 to $+100$ dBμA using current probe for 25 to 300 MHz.

The reference voltage output of the ESU 2 permits field-strength calibration and **measurements on twoports** with an overall range (attenuation, gain) of 130 dB; swept measurements over frequency subranges are possible using the Panoramic Adapter EZP for display.

Television measurements. The peak-responding indication permits direct measurement of the sync-peak rms vision-carrier level independently of the picture content. Using the average-value indication, the sound carrier and the noise level can be measured to obtain the signal-to-noise ratio. The two direct-coupled AM-demodulator outputs are particularly useful for measuring hum- and cross-modulation on the pilot carriers in cable TV networks.

Interference measurements. The ESU 2 incorporates a weighting filter as required for radio interference measurement according to the procedures laid down in VDE 0875 and by CISPR. Interference field-strength measurements can be made with the help of antennas. Radio noise power measurements are also possible using the Absorbing Clamp MDS-21. Wideband interference can be measured according to MIL standards (electromagnetic compatibility measurements) on a separate calibrated scale. Measurements of single pulses or pulse trains with low repetition rates are possible thanks to a peak response with a hold time of 3 s.

Remote frequency measurement. The test receiver can be switched over to remote frequency measurement via the rear remote-control inputs, the RF input signal being stabilized to 20 mV EMF and brought out at the generator output without frequency shift. The signal is filtered in accordance with the selected IF bandwidth. The signal frequency can be displayed on a frequency counter connected to the ESU 2.

Auxiliary instruments for diversified applications

Frequency Controller EZK displays the reception frequency with a resolution of 1 kHz. With digital frequency control (DFC) the set frequency is held to within 100 Hz, meaning that the ESU 2 is always ready for operation even when handling intermittent signals.

Panoramic Adapter EZP displays the spectrum of the received signal with different resolution bandwidths. The sweep width can either be set to cover up to a full receiver subrange (RF analysis) or up ±1 MHz from the receive frequency (IF analysis). The receiver plus adapter forms an analyzer with tuned preselection in the subrange for the RF analysis mode.

An XY recorder, e.g. ZSK 2, can be directly driven from the X and Y recorder outputs of the ESU 2 to record voltage or field strength.

Battery Unit. This mounts on the rear panel and renders the receiver independent of an AC supply, for example, in field-strength measurements.

Programmability. All settings of ESU 2 can be programmed via two rear-panel inputs, including frequency selection if the Frequency Controller EZK is used. It is also possible to use both manual and programmed operation simultaneously, as well as to connect several ESU 2s for master-slave operation.

Specifications

Frequency range	(20)[1]) 25 to 1000 MHz
Subranges	24 to 42 MHz; 40 to 70 MHz; 67 to 110 MHz; 100 to 175 MHz; 170 to 270 MHz; 265 to 420 MHz; 410 to 605 MHz; 595 to 805 MHz; 800 to 1000 MHz
Frequency setting	range selection: slide switch tuning: coarse/fine drive for drum dial (2 m long)
Resolution	100 kHz/mm (1 MHz/mm)
Setting error	$<\pm(1\times10^{-3}\,f_{in}+100$ kHz) (after calibration)
AFC	switch-selected
RF Input	$Z_{in}=50\ \Omega$[2]), N female connector, adaptable
VSWR	<2 for switch positions <+20 dB <1.5 for switch positions ≧+20 dB
Noise figure (typical)	8 dB up to 400 MHz, 10 dB up to 1000 MHz
Maximum input voltage	1 V_{rms} for switch positions ≦+10 dB 3 V_{rms} for switch position +20 dB 5 V_{rms} for switch positions ≧+30 dB
Intermodulation attenuation for two signals in RF passband	70 dB typical, referred to 1 µV (0.3 µV in level switch position −10 dB)
Oscillator reradiation at RF input with 50-Ω termination	<10 µV, <1 µV typical
RF screening (cabinet model with battery unit) in battery operation and with 10 V/m at reception frequency	indication <10 dBµV with level switch position ≦+10 dB (RF input terminated)

Suppression of spurious responses within RF passband

Level switch at −10 dB	>70 dB referred to 0.3 µV
≧0 dB	>70 dB referred to 1 µV
Image-frequency rejection	>70 dB
IF rejection	>80 dB

Intermediate frequencies

1st IF	199.3 MHz for subranges 1, 2 and 6 339.3 MHz for other subranges
2nd IF/6-dB bandwidths	10.7 MHz/15/120/300 kHz
3rd IF	450 kHz (6-dB bandwidth 120 kHz)

Measurement range	−10 to +120 dBµV for linear average-value indication; 10-dB steps
Measurement error (after calibration)	≦±1 dB for V_{in} ≧1 µV
Indicated noise (15 kHz bandwidth)	≦−13 dBµV, typical −16 dBµV
Indication	analog, illuminated scale
Indication range	
Lin	20 dB
Log	60 dB; 40 dB log peak value in dBµV/MHz at 300 kHz bandwidth
For interference measurement	7 dB
Indication modes	average value, lin and log; peak value, lin and log and lin with 3 s hold time weighted according to VDE 0876 and CISPR Publ. 2 and 4
Types of demodulation	AM and FM or A1A, A3E and F3E (A1, A3 and F3)

Outputs

Reference voltage	EMF = 86 dBµV, Z_s = 50 Ω; N female connector, adaptable
10.7-MHz IF	EMF ≈ 200 mV, 50 Ω; BNC
450-kHz IF	EMF ≈ 15 mV (unmod.), 120 kHz bandwidth, 50 Ω; BNC
AF	≦1.2 W (adjustable) into 8 to 16 Ω, JK-34 jack
Squelch	switch-selected, threshold adjustable
Video 0 to 500 kHz	EMF = 2 V, adjustable over 70 dB, 75 Ω; BNC
Demodulator outputs	
AM	EMF ≈ 1 V, 75 Ω; BNC
FM	EMF ≈ ±1 V for Δf = ±125 kHz, 75 Ω; BNC
Recorder outputs	BNC
X for frequency	0 to 10 V, 10 kΩ
Y for signal level	0 to 5 V proportional to meter reading; 10 kΩ
Connectors for Panoramic Adapter EZP, Frequency Controller EZK and for remote control	multiway female connector strips

Specifications of recommended extras

for interference measurements:

RF Clamp-on Current Probe ESU-Z

Frequency range	25 to 300 MHz
Measurement range with ESU and HFV	0.1 µA to 0.1 A
Max. diameter of line measured	13.5 mm
Permissible DC or AC component	<50 A
Characteristic impedance of cable	60 Ω (Dezifix B)

for field-strength measurements:

Broadband Dipole HFU 2-Z1

Frequency range	25 to 80 MHz
Antenna impedance	50 Ω, VSWR <2
Antenna factor k	7.2 to 12.2 dB (frequency dependent – curve supplied)
Connector	N female, adaptable
Dimensions, weight	3 m long (0.8 m demounted), 2.5 kg

Log-periodic Broadband Antenna HL 023

Frequency range	80 to 1300 MHz
Antenna impedance	50 Ω, VSWR <2 from 80 to 1000 MHz
Antenna factor k	2.5 to 24 dB (frequency dependent – curve supplied)
Dimensions, weight	1.7 m long, 2 m wide (1.7 m × 0.5 m demounted), 6 kg

General data

Rated temperature range	0 to +40 °C
Storage temperature range	−25 to +70 °C
AC supply	115/125/220/235 V +10/−15% (65 VA)
Battery operation	
with battery unit (bench model only)	holds 20 NiCd cells IEC KR 33/61, approx. 3.5 hours operating time
from external battery	21 to 28 V, negative earth
Charging	internal charger; charging time for battery unit 14 hours; charging current for external battery 400 mA
Dimensions, weight	
Cabinet model (with battery unit empty)	492 mm × 195 mm × 556 mm; 27 kg
19" rackmount	483 mm × 133 mm × 507 mm; 22 kg

Ordering information

Order designations ▶ VHF-UHF Test Receiver ESU 2

	19" rackmount	19" bench model
50-Ω model with N-type connector (standard version)	252.0010.54	252.0010.55
Model 20 to 1000 MHz	252.0010.58	252.0010.59
50-Ω model (Dezifix B, adaptable)	252.0010.51	252.0010.52
60-Ω model (Dezifix B, adaptable)	252.0010.61	252.0010.62
75-Ω model (Dezifix B, adaptable)	252.0010.71	252.0010.72

Accessories supplied

Power cable, battery cable, battery unit (with bench model)

Recommended extras

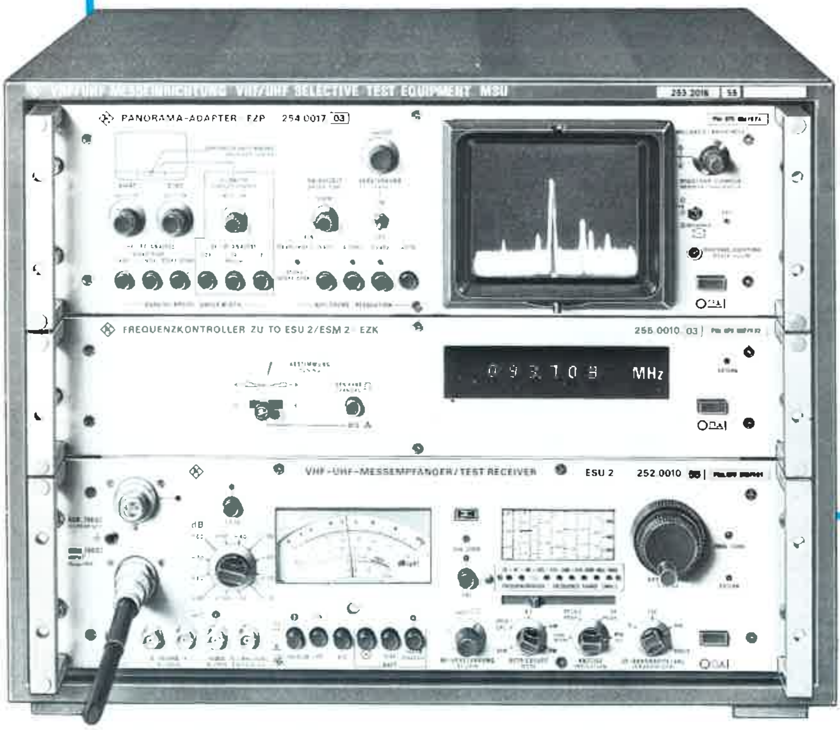
For bench model: 20 NiCd cells RS 4 as per IEC KR 33/61, order designation per cell		252.6001.00
Headphones (with Plug PL-55)		110.2959.00
RF Clamp-on Current Probe (25 to 300 MHz)	ESU-Z	100.1137.02
RF Cable		204.1090.02
Absorbing Clamp	MDS-21	194.0100.50
BNC female – N male adapter		118.2812.00
Antennas for field-strength measurements (see above)		
Broadband Dipole	HFU 2-Z1	253.0113.55
Log-periodic Broadband Antenna	HL 023	465.8716.55

[1]) A model with slightly restricted specifications is available for 20 to 1000 MHz.

[2]) 60- and 75-Ω models are also available with modified specifications.

MSU VHF-UHF Selective Test Equipment MSU

◆ 25 to 1000 MHz
−10 to +120 dBμV



- Programmable test assembly for field-strength measurements (with calibrated antennas), CISPR and MIL interference measurements, selective voltage measurements in laboratories and test departments, and radiomonitoring
- Digital display of receiver frequency with 100-Hz resolution
- Analog voltage indication (average, peak and CISPR weighting)
- Spectral display – RF and IF analysis with high resolution

Automatic test assembly (Programmable VHF-UHF Test Equipment MSUP with desktop computer) on page 248

The **VHF-UHF Selective Test Equipment MSU** is designed for the measurement and demodulation of AM and FM signals, and for the measurement of TV, pulse-modulated and interference signals. It is composed of the following instruments:

VHF-UHF Test Receiver ESU 2	(see page 242)
Frequency Controller EZK	(see page 245)
Panoramic Adapter EZP	(see page 246)

Great **ease of operation** of the equipment makes for precise and efficient measurements: internal reference for automatic voltage calibration, seven-digit display of receiver frequency, high sensitivity (typical noise figure 8 dB up to 400 MHz, 10 dB up to 1000 MHz), wide dynamic range and good image-frequency and IF rejection (precluding measurement ambiguities), panoramic display covering up to an ESU 2 subrange, recorder outputs, TTL logic for remote control and connection facilities for slave equipment.

Frequency setting and accuracy. The reception range of 25 to 1000 MHz is covered in nine subranges selected by a slide switch. Frequency can be adjusted continuously by a coarse/fine drive on the ESU 2 drum dial, no change of the direction of rotation being necessary at the range end (resolution 100 kHz to 1 MHz/mm). The Frequency Controller displays the set frequency in seven digits with 1 kHz resolution. Switch-selected AFC and an A1 demodulator further facilitate the tuning procedure.

With digital frequency control (DFC) of the EZK, the set frequency remains locked to the crystal frequency (resolution of display 100 Hz). Quasi-continuous frequency variation in three speeds is simultaneously possible by means of a Kellog switch.

Sensitivity, voltage calibration, display. As the noise figure it typically 10 dB up to 1000 MHz, voltages of 0.3 μV can be measured with the smallest bandwidth. Voltage calibration of the Test Receiver is possible within one second by the press of a button. The input and calibration signals pass through a level switch with motor-controlled 10-dB steps, extending the linear indication range of 20 dB (Test Receiver) to a measurement range covering −10 to +120 dBμV, and correspondingly the logarithmic ranges of 60 dB (Test Receiver) and 70 dB (Panoramic Adapter). Display modes: average, peak, VDE and CISPR weighting.

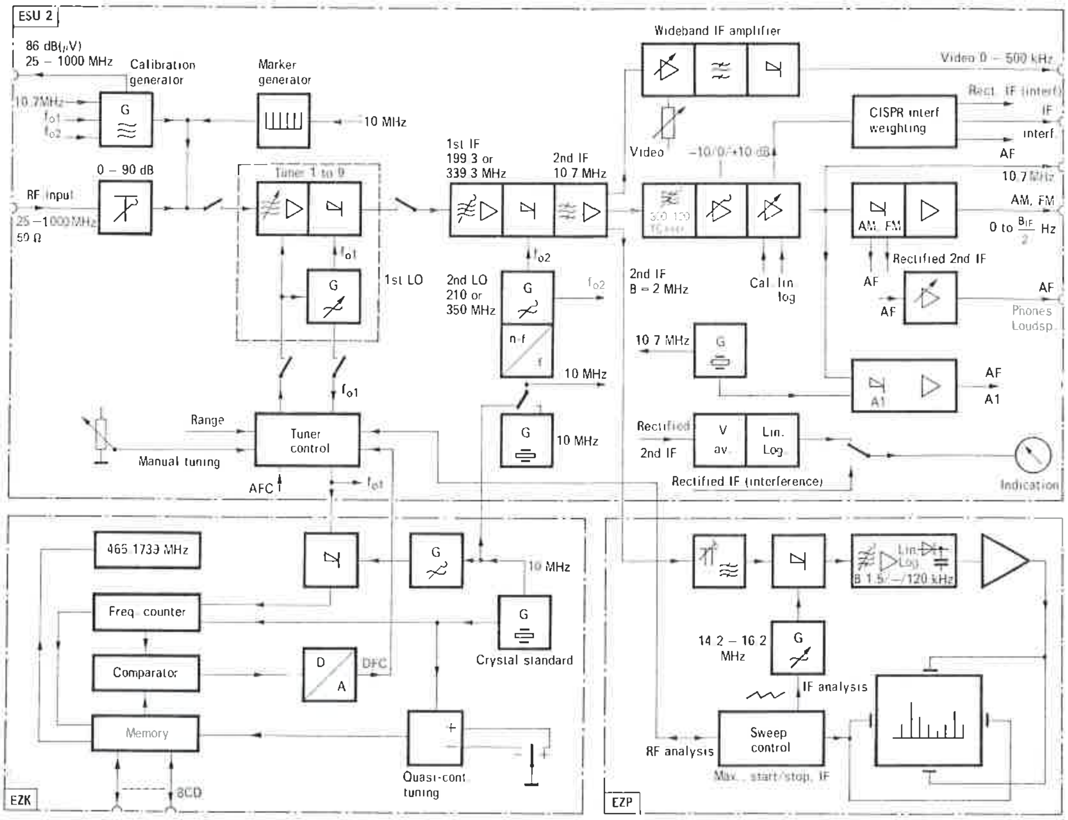
Bandwidth. The bandwidths are fixed for the IF wideband amplifier (1 MHz) and the Panoramic Adapter (2 MHz) and can be switch-selected (300, 120 or 15 kHz) for the 10.7-MHz signal via the 2nd-IF amplifier as required for further evaluation.

Panoramic display The EZP displays the spectrum of the RF input signal across a maximum of an ESU 2 subrange. Band occupancy, level, frequency (spacing) and modulation can thereby be assessed. The tuning of the Test Receiver is facilitated by a position marker produced in the EZP.

The following display modes and widths are possible:

a) RF analysis covering full subrange (max. 200 MHz with ESU 2).

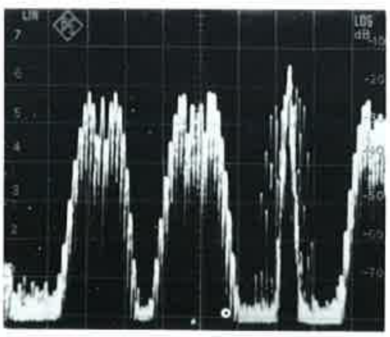
b) IF analysis with a maximum display width of 2 MHz. More information under EZK on page 245.



Block diagramm of VHF-UHF Selective Test Equipment MSU

Demodulation, outputs. The Test Receiver is designed for AM, FM and pulse modulation and has a video output for 0 to 500 kHz. The audio section delivers the demodulated and amplified signal to the loudspeaker or phones outpu. It contains a switch-selected squelch. The various outputs (IF, demodulator, AF and recorder outputs) afford great versatility.

Operation, programming, slave equipment. All functions of the receiver front-panel controls can be remotely controlled via rear connectors. Frequency setting is programmable in BCD code. It is also possible to use both manual and programmed operation simultaneously. Slave units ESU 2 + EZK can be connected to the Test Equipment.



IF analysis: Modulation spectrum of one occupied and three free public-land-mobile-service channels; display width 200 kHz, resolution 1.5 kHz

EZK

The **Frequency Controller EZK** in conjunction with the Receiver ESU 2 and the Panoramic Adapter EZP performs the following functions:

1. Measurement of a manually set receive frequency between 25 and 1000 MHz, which is displayed as a frequency marker on the Panoramic Adapter
2. Crystal-controlled locking to set receive frequency
3. Quasi-continuous digital tuning
4. Digital setting of receiver (range selection and tuning) to a BCD-programmed frequency
5. Master-slave operation.

To perform function 1, the EZK measures the oscillator frequency of the receiver and, taking into account the intermediate frequency of the receiver range selected, indicates the receive frequency (data output available after each measurement).

For performing functions 2 to 5, the EZK contains, in addition to the frequency meter, an adjustable up/down counter, which serves as a nominal-value store, and a comparator which controls the receiver (range selection and tuning voltage).

MSU/EZK+EZP

EZK

Modes. Three modes of operation are possible: manual, digital frequency control (DFC) and external (remote control).

After manual operation of the range switch and the tuning knob, the Frequency Controller gives a 6-digit readout of the set frequency and outputs the frequency information in BCD.

In the DFC mode, the EZK keeps the receive frequency constant with crystal accuracy. With external control, the frequency information is applied in TTL to the BCD inputs and entered upon an external command. In both cases, the frequency is displayed in seven digits.

Slave operation, e. g. in DF systems. For this purpose, the EZK control input and data output are wired such that the output of the master unit simply has to be connected to the input of the slave unit. Slave units can be operated in series or in parallel and set to different modes. In unattended operation, the receivers of the slave units can deliver the information content via CORs to magnetic tape recorders.

EZP

The **Panoramic Adapter EZP** in conjunction with a suitable receiver, such as the ESU 2 or ESM 2, permits spectral display within a particular frequency range. The screen display supplies information on band occupancy, and on the level, modulation and frequency spacing of the individual signals.

The panoramic display covers a wider band than the receiver and thus considerably facilitates receiver tuning, the exakt tuning frequency being marked on the screen by a light spot.

Display modes and sweep widths

a) Broadband display – RF analysis – over the full subrange width (max. 200 MHz for ESU 2 and ESM 2). By setting start/stop markers, a particular section of this range can be displayed either alone or together with the latter in the two-line mode, the receiver tuning frequency remaining marked.

b) IF analysis with a maximum sweep width of 2 MHz and automatic setting of optimal sweep time or resolution bandwidth.

In both cases, lin or log amplitude display can be selected. The gain is continuously adjustable in the linear mode.

Recording of screen displays. The EZP delivers output signals with TTL and analog levels for driving auxiliary units, such as recorders and recording systems. In addition to semi-automatic recording of screen displays by means of an XY or a YT recorder, it is possible to perform long-term recordings of the frequency band occupancy, using for instance the Radiomonitoring Recorder ZSG 3. Reference lines for frequency calibration can be set easily and accurately on the EZP. The adjustable recorder threshold can be inserted on the screen display as a level reference line.

External control. The essential switching functions, e. g. all pushbutton functions, lin-log switchover, free selection of sweep times, stopping and triggering the internal sawtooth generator, can be remote-controlled. It is also possible to blank the CRT or to insert additional frequency markers.

The internal graticule of the CRT can be illuminated. The frame in front of the screen can be folded up to accept a camera.

Specifications of EZK

Frequency range	approx. 0 to 1000 MHz
Range with Receivers ESU 2, ESM 2	24 (20) to 1000 MHz, subranges see under ESU 2, page 243
Crystal aging after 30 days of operation	$\leq 2 \times 10^{-9}$/day
Modes	
Local operation	
Receive frequency measurement	front-panel switch set to MANUAL
Receiver tuning	by crank-type knob on receiver
Measurement rate	10 measurements/s
Display	6-digit LED display; resolution 1 kHz
Receive frequency hold mode	front-panel switch set to DFC (digital frequency control)
Quasi-continuous receiver tuning (DFC int.)	relative to instantaneous frequency: freely selectable by means of Kellog switch on EZK front panel; tuning rate in pos. and neg. direction: 1 kHz/s, 10 kHz/s, 100 kHz/s (others: please enquire)
Measurement rate	10 measurements/s
Display	7-digit LED display, resolution 100 Hz (blanked during broadband sweeping of receiver)
Remote control (DFC)	programmable via control line
Nominal frequency entry	BCD parallel, by store command, setting time with Receivers ESU 2 and ESM 2: typical 0.5 s
Display	7 digits
Quasi-continuous tuning	same as for local operation
Master-slave operation	by connecting data output of master EZK to control input of slave EZK
Data output	after each measurement; output released by print command
Inputs, outputs	
Control input/data output	50-pole female connector (Amphenol), 7 decades BCD-coded, TTL pos. (adaptation to negative logic possible)
General data	
Rated temperature range	0 to 40 °C
Storage temperature range	−40 to +70 °C
AC supply	115/125/220/235 V +10/−15%, 47 to 440 Hz (50 VA)
Dimensions, weight	
19" bench model	492 mm×116 mm×514 mm, 13.3 kg
19" rackmount	483 mm×88 mm×508 mm, 12.3 kg

Ordering information

Order designations	▶ Frequency Controller EZK
19" bench model	255.0010.02
19" rackmount	255.0010.03
Accessories supplied	cable for connection of EZK to receiver; power cable

Specifications of EZP

Frequency	10.7 MHz ±1 MHz
Dynamic range (interference-free)	≧70 dB
Range of indication log	70 dB (10 dB/cm)
lin	gain manually adjustable over 70 dB
Required signal level for full output	9 to 40 mV, adjustable
Limit sensitivity with 1.5-kHz resolution	≦2 μV (S + N)/N = 2

RF analysis (Receiver ESU 2 or ESM 2)

Sweep width	
Maximum	range or subrange of receiver (200 MHz with ESU 2, 500 MHz with ESM 500)
Start/stop	any section of full sweep width
Max. + start/stop	simultaneous (two-line) display of range or subrange and section
Resolution (corresponding to 3-dB bandwidth)	
for maximum sweep width	120 kHz (according to CISPR Rec.)
for start/stop mode	50 kHz
Shape factor of filter	≈1/15
Frequency marking	by shiftable markers, frequency indication on receiver
Sweep time	40 to 200 ms, adjustable

IF analysis

Sweep width	2 MHz	200 kHz	20 kHz
corresponding to	200 kHz/cm	20 kHz/cm	2 kHz/cm
Resolution (corresponding to 3-dB bandwidth)	15/4.5/1.5 kHz; shape factor ≈1/6		
Automatic mode	sweep width ganged with resolution (minimum sweep time automatically selected)		
Sweep time	40 ms		
Centre-frequency marking	by crystal-controlled frequency marker		

Remote control	digital programming of all functions, TTL neg., adaptable to pos. logic
Control inputs for	sweep width, resolution, lin/log, time control, local oscillator "off", trace blanking, external marker, stopping and triggering of sawtooth
Outputs	control sawtooth return sweep, trigger ready, RF analysis
Recorder outputs	
Digital	Z (intensity) control, paper feed
Analog	sawtooth voltage, X and Y control for recorder, general Y control, recorder drive control
Operating voltage for external units	+5 V (100 mA), ±15 V (50 mA)
Display	rectangular CRT with GL (P2) screen; internal graticule 10 cm × 8 cm, 0 to −70 dB

General data

Rated temperature range	0 to +40 °C
Storage temperature range	−40 to +70 °C
AC supply	115/125/220/235 V +10/−15%, 47 to 440 Hz (35 VA)
Dimensions, weight	
19" bench model	492 mm×161 mm×514 mm, 14 kg
19" rackmount	483 mm×132 mm×508 mm, 12 kg

Ordering information for EZP

Order designations	▶ Panoramic Adapter EZP	
	Normal version	IF analysis only (no remote control)
19" bench model	254.0017.02	254.0017.04
19" rackmount	254.0017.03	254.0017.05
with converter for	ESP	EK 070
19" bench model	254.0017.08	254.0017.10
19" rackmount	254.0017.09	254.0017.11

Accessories supplied	power cable 025.2365.00, connecting cable 251.9494.00 for receiver, filter 254.2149.00

Recommended extras

Siemens Polaroid Camera	Rel. 3B952a (please order direct from Siemens)
Camera adapter	110.2571.02
Intermediate tube	110.2588.02
or Steinheil Camera with Adapter for OKF	please order direct from Steinheil

Specifications of Selective Test Equipment MSU

(Specifications of ESU 2, page 243)

Frequency range	25 to 1000 MHz, 9 subranges
Frequency setting	a) continuous with subrange slide switch and coarse/fine drive; drum dial 2 m in length, resolution 100 kHz in lowest subrange b) quasi-continuous on EZK in three speeds with digital display; steps and resolution 100 Hz c) external in BCD, setting time typ. 0.5 s including automatic range selection
Frequency display	6 digits with manual tuning (ESU 2) 7 digits with tuning through EZK
Noise figure up to 400 MHz	8 dB (typ.)
up to 1000 MHz	10 dB (typ.)
RF input	50 Ω, N female connector, adaptable

Immunity to interference

Suppression of spurious responses within RF passband with level switch at −10/≧0 dB	>70 dB referred to 0.3/1 μV
Image-frequency rejection	>70 dB
IF rejection	>80 dB

Intermediate frequency/bandwidths

2nd IF	10.7 MHz
6-dB bandwidth	15/120/300 kHz
3rd IF	450 kHz } only for CISPR interference measurements
6-dB bandwidth	120 kHz }
Measurement range	−10 to +120 dBμV for linear average-value indication; 10-dB steps
Measurement error	≦±1 dB for inputs ≧1 μV
Voltage indication lin.	20 dB
log.	60 dB, 40 dB log peak value for MIL measurement of wideband interference in dBμV/Hz
log.	7 dB for CISPR interference measurement
Indication modes	average value, lin and log; peak value, lin and log, weighted according to VDE 0876 and CISPR Publ. 2 and 4
Demodulation	AM and FM or A1A, A3E and F3E (A1, A3 and F3)
Panoramic display	
wideband (subrange) display	max. 1 subrange with 120 kHz resolution or any detail with 50 kHz resolution
Narrowband display (IF analysis)	20 kHz to 2 MHz display width with resolution bandwidths 1.5/4.5/15 kHz
Level display	>70 dB log or 20 dB lin
Screen size	10 cm × 8 cm (calibrated graticule 10 dB/cm)

General data

Rated temperature range	0 to +40 °C
AC supply	115/125/220/235 V +10/−15%, 47 to 420 Hz (140 VA)
Dimensions, weight	520 mm×400 mm×535 mm, 60 kg

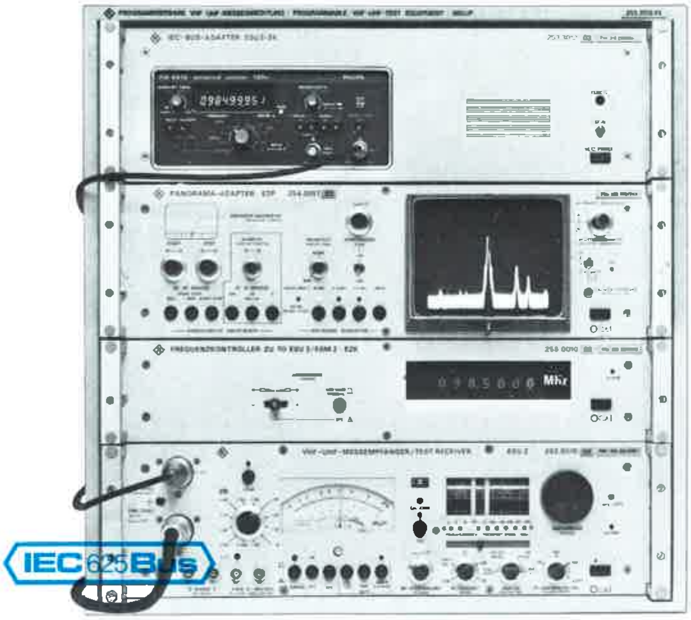
Ordering information for MSU

Order designation	▶ VHF-UHF Selective Test Equipment MSU
(complete system)	253.2016.55
MSU without RF analysis	253.2216.99
Accessories supplied	power cable, 2 connecting cables, battery cable for connection to ESU 2

Recommended extras

Radio Monitoring Recorder ZSG 3	242.6015.92
Connecting cable (EZP-ZSG 3)	251.9488.00
XY Recorder ZSK 2	247.4010.04
Headphones (with plug PL 55)	110.2959.00
RF Clamp-on Current Probe ESU-Z (25 to 300 MHz)	100.1137.02
RF cable for connection of RF Current Probe	204.1090.02
Absorbing Clamp MDS-21	194.0100.50
BNC-female to N-male adapters (for RF Current Probe and MDS-21)	118.2812.00
Antennas for field-strength measurements see HFU 2 (page 252)	
Recorder Adapter ESU 2-Z1	290.6011.92
Code Converter PCW	244.8015.92

ESU 2, computer-controlled



Automatic VHF-UHF Test Equipment
♦ 25 to 1000 MHz/ – 10 to + 120 dBμV

consisting of

Programmable VHF-UHF Test Equipment MSUP and Process Controller PUC

- Dialog programs available for various applications
- Control complying with IEC standards; therefore simple extension with further measuring instruments

The **Programmable VHF-UHF Test Equipment MSUP** is composed of the VHF-UHF Selective Test Equipment MSU described on page 244 and the IEC-bus Adapter ESU 2-Z4. It constitutes a compact IEC-bus-compatible test system for selective measurements of voltage and twoport parameters. In conjunction with clamp-on RF current probes and calibrated antennas, current and field-strength measurements are possible. A frequency counter can be inserted into the IEC-bus Adapter for remote frequency measurement with the MSUP (photo: top; not supplied). The loudspeaker incorporated in the ESU 2-Z4 facilitates aural monitoring of the modulation content for radiomonitoring and acoustic assessment of radio interference measured according to CISPR and VDE 0875. A button on the ESU 2-Z4 permits rapid transition to manual operation.

Control, characteristics. The MSUP Test Equipment is controlled by the Process Controller PUC. This desktop computing system gives numerical and graphic display of the results.

The software available with the test assembly consists of a basic program containing complete control, self-check, test and calculating routines, with which the user can compile individual programs without difficulties, and of **prepared dialog programs** for various applications.

The **advantage of computer control** lies in
- shorter test time,
- automatic preparation of test reports which are easy to interpret,
- elimination of operating erros.

The dialog programs are so written that even untrained operators may use the system.

Uses

The system is intended for all situations where a great number of measurements must be carried out, logged and evaluated with constant high accuracy and reliability. This especially applies to measurements of spectral characteristics of useful and unwanted signals.

A search program for **radiomonitoring** is used to measure within a specified frequency range the input voltages exceeding a certain value. With the aid of an IEC-bus-compatible frequency counter in the ESU 2-Z4, the respective frequencies are determined. Another dialog program permits level and fequency measurements for radiomonitoring on fixed frequencies which are stored in the computer.

When **measuring e-m interference** according to MIL specifications and VG regulations the test system permits separate detection of sinewave and wideband interference sources.

In the case of **radio-interference measurements** according to CISPR and VDE 0875 this test system is the first to offer the possibility of automatically recording the test results over a large dynamic range.

When **measuring the harmonics** of a signal or the absolute value of the transfer constant of twoport networks the possibility to obtain derived quantities (voltage ratios) by processing measured values (voltages) offered by the computing system is profitably used; during **field-strength measurements** the computing system automatically considers the (frequency-dependent) antenna factor (k).

Specifications of MSUP

Frequency range	25 to 1000 MHz

(For data of individual instruments see in this catalog: ESU 2: p. 243, EZK and EZP: pp. 245, 246)

RF input	N female connector
IEC-bus connector	24-way, female (Amphenol)
Operating temperature range	0 to +40 °C
AC supply	115/125/220/235 V (180 VA)
Dimensions, weight	520 mm×534 mm×635 mm, 70 kg
Order designation	▶ Programmable VHF-UHF Test Equipment MSUP 253.3512.55

Recommended extras

Desktop computing system PUC	Process Controller see page 14
Basic Software ESU 2-K4	253.3112.02
IEC-bus Cable PCK	292.2013.20
Frequency Counter	Philips PM 6615/04 with PM 9676

IEC-bus Adapter as individual unit

IEC-bus connector	24-way, female
Connectors for ESU 2 and EZK	three 50-way, female
AC supply	115/125/220/235 V (30 VA)
Dimensions, weight	
19" bench model (design 80)	492 mm×161 mm×514 mm, 11 kg
19" rackmount	483 mm×133 mm×506 mm, 10 kg
Order designation	▶ IEC-bus Adapter ESU2-Z4
19" cabinet model	253.3012.02
19" rackmount	253.3012.03

Automatic Test Equipment

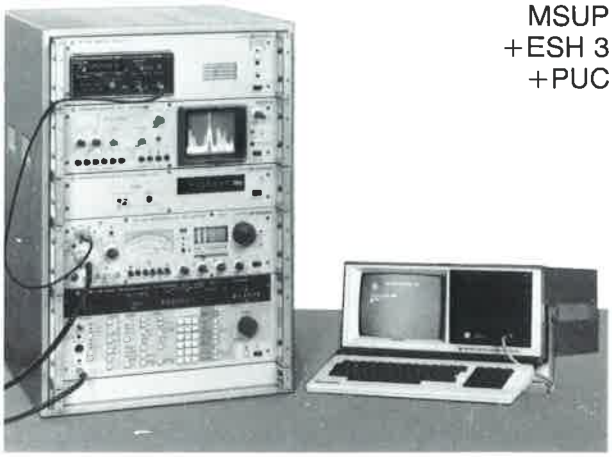
♦ 9 kHz to 1000 MHz
−30 (−10) to +137 dBμV

consisting of

Test Receiver ESH 3	9 kHz to 30 MHz
VHF-UHF Test Eqpt MSUP	25 to 1000 MHz
Process Controller PUC	

- Ready-made programs available for various applications
- Can be controlled via IEC bus, thus easy to expand if required

For basic configuration see Specifications.



MSUP
+ESH 3
+PUC

The **Automatic Test Equipment** is used for selective measurements and demodulation of signal and interference voltages; built-in signal outputs make it suitable for twoport measurements, and in conjunction with current probes and calibrated antennas RF current and field-strength can be measured. In the remote-frequency-measurement mode, both the ESH 3 and the ESU 2 perform as active filters between the RF inputs and the generator output. A frequency counter can be inserted in the ESU 2-Z4 to measure the frequency at the generator output. Loudspeakers in the ESH 3 and the ESU 2-Z4 (for ESU 2) make it possible to monitor the modulation aurally. Further IEC-bus compatible instruments can be added: Relay Matrix PSU for the connection of antennas or other transducers to the RF inputs or for switchover of the ESH 3 and ESU 2 generator outputs to the frequency-counter inputs; Control Unit RB 014 with Code Converter PCW for the control of an antenna rotator to adjust the azimuth in field-strength measurements; Signal Generator SMS for measurements on tuners and for generation of higher field strengths than those obtainable at the generator outputs of the receivers.

Control, Characteristics

The MSUP includes an IEC-bus interface in the ESU 2-Z4 for driving the ESU 2 and EZK, as well as for the digital voltmeter in the ESU 2-Z4 and for an optional frequency counter. The Software ESH 3-K1 offers applications in radiomonitoring, radio-interference measurements according to CISPR, EMI measurements according to MIL specifications and VG regulations as well as laboratory measurements (twoport and harmonics) in the frequency range from 9 kHz to 1000 MHz. Thanks to the internal control function of the ESH 3, the computer can load this receiver with measurement tasks, which are then performed automatically.

Uses

The frequency range from 9 kHz to 1000 MHz covers all the broadcasting bands and the most important of the other radio services. The Test Equipment can be used for determining frequency-band occupation, for propagation and coverage measurements and remote frequency measurements for **radiomonitoring** purposes. Programs for the measurement of the relevant field-strength data in a preset frequency range or for remote level and frequency measurements at fixed frequencies can easily be prepared. Even without a computer, the occupation of up to six frequency bands can be determined as the ESH 3 on its own is capable of driving five Radiomonitoring Recorders ZSG 3.

When **measuring EMI** according to MIL specifications and VG regulations, separate detection of sinewave and wideband interference is possible. The conversion factors of the antennas and current probes specified in the MIL standards are included in the computer software.

In the case of **radio-interference measurements** according to CISPR and VDE 0875, computer control is possible in the frequency range up to 30 MHz in conjunction with the Artificial Mains Network ESH 2-Z5. A Code Converter PCW is used for programmed phase switching. Radiointerference power can be measured with the aid of the Absorbing Clamps MDS (page 255) and radio-interference field strength with the calibrated antennas of the VHF-UHF Field-strength Meter HUF.

In **laboratories and test departments** the Test Equipment is ideal for the automatic measurement of twoport gain and attenuation, reflection coefficient, harmonics and spuria of transmitters and oscillators and, with add-on signal sources, for measuring overdrive capacity.

Specifications of the Automatic Test Equipment

For data on individual instruments see in this catalog:
ESH 3 page 226 EZK page 245 PUC page 14
ESU 2 page 242 EZP page 246

Frequency range	9 kHz to 1000 MHz
Frequency setting	quasi-continuous, resolution 100 Hz
RF inputs	Z_{in} = 50 Ω
9 kHz to 30 MHz	BNC female connector
25 to 1000 MHz	N female connector
Measurement ranges	
9 kHz to 30 MHz	−30 to +137 dBμV
25 to 1000 MHz	−10 to +137 dBμV
Remote control inputs	2 IEC-bus connectors, 24-pole Amphenol
General data	
Operating temperature range	0 to +40°C
Power supply	115/125/220/235 V (250 VA)
Dimensions, weight	520 mm×710 mm×635 mm, 90 kg
Order designation	choice of component units by R&S or by customer as required; for designations of individual instruments, see elsewhere in this catalog
Recommended extras	
Software for PUC:	
ESH3-K1	336.1097.02
Software for other computing systems: please enquire.	
IEC-bus cable PCK (2 m long)	292.2013.20
Frequency counter (Philips)	PM 6615/04 with PM 9676

7 FIELD-STRENGTH METERS

Field-strength meters and receivers

Magnetic field strength (A/m) and electric field strength (V/m) are measured in practice in V/m or µV/m or in dBµV/m. The electric and magnetic fields are related according to $E = HZ_0$, where $Z_0 = \sqrt{\mu_0/\varepsilon_0} = 120\pi\Omega$ is the field characteristic impedance of free space.

The measurement of electric or magnetic field strength is reduced to a voltage or power measurement by means of a calibrated antenna. The calibrated test receivers[1]) employed here can also be used for other measuring and monitoring purposes.

VHF-UHF Field-strength Meter HUF for propagation measurements, measurement of radiation patterns and interference field strength

The **antennas** used at frequencies below 30 MHz are broadband. The dimensions are small compared to the wavelength. The electric field strength is measured with rod antennas of constant length and the magnetic component with loop antennas. At higher frequencies (above 25 MHz) tuned antennas with broadband characteristics (dipoles or log-periodic antennas) are used. Probes of small dimensions are suitable for determining field configurations.

The **test receivers** are selective heterodyne receivers with switch-selected bandwidth. The built-in standardizing oscillator allows a voltage calibration of the receiver at any frequency. Switch-selected attenuators in the IF section and at the receiver input extend the meter range, which is calibrated in dB. Linear indication covering 20 dB or logarithmic indication over 40 or 60 dB can be switch-selected. Test receivers meet stringent requirements in regard to ultimate selectivity, rejection of spurious responses and stray fields. In addition to a recorder output, AF and IF outputs are provided for the connection of interpreting equipment, such as analyzers, panoramic units or oscilloscopes.

In conjuntion with a radio interference indicator, **interference field measurements** complying with VDE 0876 or CISPR recommendations can be carried out.

The **Absorbing Clamp MDS** (see page 255) in conjunction with a radio-interference measuring receiver permits radio interference power issued from the power cable of an interference source to be measured in the frequency range 30 to 300 (1000) MHz according to VDE 0875.

Monitoring receivers (Part of the Rohde & Schwarz line of communications equipment; see separate data sheets) need not provide for accurate measurement of input voltage or power. The switchable attenuators and the standardizing oscillator are omitted. On the other hand, the monitoring receivers feature high setting accuracy for the reception frequency and excellent stabilization of the AF output voltage at different input levels. Adequate selectivity and heavy rejection of spurious responses and intermodulation preclude errors in observation. IF and AF outputs allow the connection of accessories for the evaluation of the received signal.

[1]) Special-purpose receivers (HF, VHF and UHF ATC, VHF and TV relay reception) are described in separate data sheets.

	Frequency range	Designation	Type	Order No.	Voltage range	Field-strength range	Antennas	See also page
	0.009 to 30 MHz	Field-strength Meter Clamp-on RF Current Probe	HFH 2 —	335.3015.52 338.3516.52	−30 to +137 dBµV 0.1 µA to 0.1 A	−3 to +140 dBµV/m —	2 loop antennas 1 rod antenna —	251
	0.009 to 30 MHz	Test Receiver	ESH 3	335.8017.92	−30 to +137 dBµV	−3 to +140 dBµV/m	same as HFH 2, but to separate order	226
	25 to 300 MHz	VHF Field-strength Meter	HFV	203.6018.02	0 to 100 dBµV (1 µV to 0.1 V)	3 to 121 dBµV/m	<60 MHz sh. dipole >60 MHz tun. dipole	252
new	20 to 1000 MHz	Field-strength Meter	HUF	354.1520.53	−10 to +137 dBµV	−7.5 to +140 dBµV/m	broadband dipole, log-per. antenna	254
new	20 to 1300 MHz	Test Receiver	ESVP	354.3000.52	−15 to +137 dBµV	−12.5 to +140 dBµV/m	same as HUF, but to separate order	238
	25 to 1000 MHz	VHF-UHF Field-strength Meter	HFU 2	253.0013.55	−10 to +120 dBµV	−7.5 to +143 dBµV/m	broadband dipole log-periodic antenna	—

Field-strength Meter HFH 2
♦ 9 kHz to 30 MHz

- Uses: propagation measurements, radiomonitoring, testing RF shielding, selective measurement of very small voltages, measurements of interfering fields in line with VDE, CISPR, MIL and VG specifications
- Wide measurement range: 140 dB
- Accuracy complying with CCIR recommendations
- Direct indication of field strength in dBμV/m, RF current in dBμA and voltage in dBμV

The **Field-strength Meter HFH 2** is used to measure wanted-signal fields – propagation, coverage, antenna patterns, monitoring – as well as interfering fields in accordance with MIL, CISPR, VDE and VG specifications in the frequency range 9 kHz to 30 MHz.

The HFH 2 consists of
Test Receiver ESH 2
Rod Antenna HFH 2-Z1
Loop Antenna HFH 2-Z2
Tripod and accessories (see specifications).

The Test Receiver ESH 2 is a synthesizer design (detailed description on pages 222 to 225) and is tuned quasicontinuously in steps of 100 Hz, or of 10 kHz for rapid search operations. Frequency is indicated on a 6-digit LCD using a crystal reference.

Switch-selection of four bandwidths (200 Hz, 500 Hz, 2.4 kHz, 10 kHz), linear or logarithmic average or peak indication and calibration at the press of a button, among other features, ensure that accurate and reproducible results are obtained rapidly:

- The conversion factors of the antennas and the current probe are automatically taken into account so that a corrected display of the measured value and unit of measurement is obtained directly.
- Overloading of the main receiver stages is immediately recognized and signalled.
- Control of the IF gain as a function of bandwidth and indication mode ensures that the minimum S/N ratio required is maintained.
- Pulse calibration with CISPR indication, sinewave calibration with average and peak-value indication; automatic changeover when the bandwidth is switched.

The AC power supply of the receiver is readily replaced by the rechargeable battery unit which is provided with the HFH 2. Direct powering from a 12-V or 24-V vehicle supply is also possible.

Since all receiver settings are maintained during "off" periods, the receiver can be switched off during measurement intervals in order not to waste the capacity of the battery.

Antennas. The Field-strength Meter is delivered with an inductive probe as well as a rod antenna and a loop antenna for 9 kHz to 30 MHz. A special loop antenna for sensitive measurements in the range 9 kHz to 1 MHz is available to separate order; its conversion factor is automatically taken into account.

Specifications of HFH 2

Measurement range	9 kHz to 1 MHz	1 to 30 MHz
Using Rod Antenna HFH 2-Z1		
Lower limit	15 to −10 dBμV/m	−10 dBμV/m
Upper limit	140 dBμV/m	140 dBμV/m
Using Loop Antenna HFH 2-Z2		
Lower limit	40 to 10 dBμV/m	10 to −5 dBμV/m
Upper limit	140 dBμV/m	140 dBμV/m
Using Loop Antenna HFH 2-Z3		
Lower limit	5 to −5 dBμV/m	
Upper limit	140 dBμV/m	
Using Inductive Probe HFH 2-Z4 (100 kHz to 30 MHz)		
Lower limit	50 dBμV/m	
Upper limit	>140 dBμV/m	
Measurement error (incl. antennas)	<2 dB (within 10 dB of lower limit, the inherent noise must be taken into account)	

Test Receiver ESH 2	more information on page 225
Frequency range	9 kHz to 29.999 MHz
Antenna input	Z_{in} = 50 Ω; BNC female connector; VSWR <1.2 (<2)
Measurement range, average reading	−30 to +137 dBμV
Indication ranges	lin 20 dB, log 40/60 dB
Measurement error	<1 dB

Antennas

Rod Antenna HFH 2-Z1	9 kHz to 30 MHz
Connector	BNC male, Z_s = 50 Ω
Conversion factor k	20 dB, length = 1 m
Loop Antenna HFH 2-Z2	9 kHz to 30 MHz
Connector	BNC male, Z_s = 50 Ω
Conversion factor k	20 dB
Loop diameter	60 cm
Loop Antenna HFH 2-Z3 (to be ordered separately)	
Frequency range	9 kHz to 1 MHz
Connector	BNC male, Z_s = 50 Ω
Conversion factor k	10 dB
Measurement range with ESH 2	5 (−5) to 140 dBμV/m
Side length of loop, weight	240 cm, 17 kg (with transport case 43 kg)

General data

ESH 2: temperature range, power supply, dimensions, weight .. see page 225

Ordering information

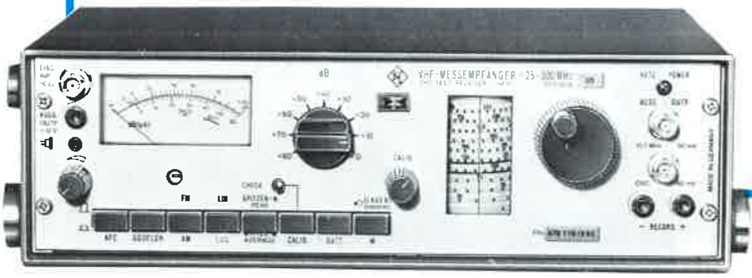
Order designation	▶ Field-strength Meter HFH 2 335.3015.52
System components (items can also be obtained individually)	
Test Receiver ESH 2 (incl. battery unit without battery)	303.2020.52
Rod Antenna HFH 2-Z1, 9 kHz to 30 MHz	335.3215.52
Loop Antenna HFH 2-Z2, 9 kHz to 30 MHz	335.4711.52
Tripod HFU-Z (in transport bag)	100.1114.02
Inductive Probe HFH 2-Z4	338.3016.52
Recommended extras	see overview on page 230
Roof-mounting Kit HFH 2-Z5 (for Loop Antenna HFH 2-Z2)	335.5718.02

HFV

VHF-Field-strength Meter and Test Receiver HFV

♦ 25 to 300 MHz

- Frequency range covered in one band
- Measurement range 0 to 100 dBμV; indication range log 60 dB, lin 20 dB; peak- and average-value modes
- Interference measurement according to VDE and CISPR (with Pulse Weighting Unit)



The selective instrument HFV for 25 to 300 MHz is available in three models to suit different applications (models 02/03 and 05; see ordering information):

Field-strength meter with rotatable and tiltable dipole, with optional Pulse Weighting Unit

Test receiver for radiomonitoring and selective laboratory measurements, 50 Ω input, IF bandwidth 36 kHz, squelch

The main characteristics such as frequency range, voltage range, demodulation, etc. are the same for the two models, only the application-oriented data for bandwidth and interference weighting and the equipment configuration differ.

The **VHF Field-strength Meter HFV** (models 02 and 03) with dipole antenna is used for measurements of radiosignal propagation and of interfering fields existing in the particular service area. Its high performance makes it also suitable for laboratory use as a selective microvoltmeter for absolute and relative measurements. Input impedance 50 Ω.

HFV with dipole antenna

A dipole which may be tilted and rotated, with a coaxial feeder, is used as **antenna** for field-strength measurements. It operates as a shortened dipole between 25 and 60 MHz and as a tunable halfwave dipole from 60 to 300 MHz. Field strength is determined from the indicated voltage with the aid of an antenna-factor curve.

The **test receiver** – a heterodyne receiver with high IF – is tunable through the whole range without band switching. Adequate ultimate selectivity is ensured by the selective input and by a bandpass filter. A crystal filter with a 6-dB bandwidth of 120 kHz (36 kHz for model 05) is provided in the second IF stage of 10.7 MHz. A substantially low-distortion reproduction of FM broadcasts is thus also possible. A built-in pulse generator supplies pulses of 100 Hz repetition frequency with constant amplitude up to 300 MHz, permitting voltage calibration at any frequency.

Measurement ranges and signal evaluation. The instrument indicates the average and peak values of the IF signal over a linear range of 20 dB or a logarithmic range of 60 dB. With the 8×10 dB attenuator, the linear indication covers an overall range of 100 dB. Average-value indication is used to measure AM and FM signals. Peak-value measurement allows, for example, the sync-peak rms value of the picture carrier in TV signals to be indicated independent of the picture information. Furthermore, signals from pulse-modulated transmitters and interfering signals can be measured. The 10.7-MHz IF output allows observation on an oscilloscope. The AF and recorder outputs provide further possibilities for the evaluation of AM and FM signals.

Pulse Weighting Unit. The Field-strength Meter is available with or without Pulse Weighting Unit. In conjunction with this accessory, the HFV presents the overdriving capacity required according to VDE 0876 and CISPR Publ. 2 and complies with the tolerances admitted for bandwidth and weighting (attenuation adjustable in 5-dB steps). Weighted measurements of interference field strength and – with the Absorbing Clamb MDS (see page 255) – **measurements of radio interference power** complying with VDE 0875 are possible.

RF current measurements from 0.1 μA to 0.1 A can be carried out in conjunction with the Clamp-on RF Current Probe at frequencies from 25 to 300 MHz.

Measurement of signal and interference fields near the highway

Specifications

Frequency range	25 to 300 MHz
Setting error (temperature range +10 to +30°C)	$<\pm5 \times 10^{-3} \times f_{in}$ ±500 kHz
Scale resolution	300 kHz/mm
AFC	switch-selected
Antenna	
25 to 60 MHz	shortened halfwave dipole
60 to 300 MHz	tuned halfwave dipole
Input impedance	
Models 02, 03	50 Ω
05	50 Ω
VSWR	
Level switch position <20 dB	2 (typical)
≧20 dB	<1.25
IF/bandwidths/interference rejection	
1st IF	400 MHz
2nd IF	10.7 MHz
6-dB bandwidth models 02, 03	120 kHz ±10%
05	36 kHz ±2 kHz
IF rejection	>80 dB
Image rejection	>80 dB
RF leakage with battery op.	indication <3 μV
Oscillator reradiation at RF input with match-termination	<30 μV
Measurement range, indication	
Measurement range, linear	
Voltage	0 to 100 dBμV
Field strength, min. 50-Ω model	3 to 23 dBμV/m
max. 50-Ω model	103 to 123 dBμV/m
Measurement range, logarithmic	0 to 130 dBμV
Measurement error	
Voltage measurement	<±2 dB
Field-strength measurement	<±4 dB
Indication	average/peak, switch-selected
Range lin.	20 dB
log.	60 dB
Demodulation	AM/FM, switch-selected
Squelch	only in model 05, switch-selected
Outputs	
IF	10.7 MHz, Z_{out} = 50 Ω
Video (only model 05)	0 to 16 kHz, Z_{out} ≈100 kΩ
Phones	Z_{out} = 15 Ω
Loudspeaker	built-in, switch-selected
General data	
Power supply AC supply	110/115/125/220/235 V +10/−15% 47 to 63 Hz (10 VA)
Battery	10 NiCd cells RS 1.8 (IEC KR 26/50)
Charging	built-in charging circuit, charging time 14 hrs
Dimensions	
without leather case	367 mm×113 mm×270 mm
with leather case	428 mm×135 mm×294 mm
Weight (with antenna, battery, leather case)	9.5 kg

Ordering information

Order designations	
Field-strength Meter	▶ VHF Field-strength Meter HFV
without Pulse-weighting Unit	203.6018.02
with Pulse-weighting Unit	203.6018.03
Test Receiver for radiomonitoring	▶ VHF Test Receiver HFV 203.6018.05
Accessories supplied	dipole antenna, tape measure, antenna-factor curve, leather case, power cable
Recommended extras	
Headphones HFV-Z	204.0220.00
DEAC cell (10 required)	020.3805.00
Clamp-on RF Current Probe ESU-Z	100.1137.02
Cable for current probe	204.1090.02
Probe HFV-Z	204.1010.02
Recorder output (not floating)	8.5 V at fsd, required recorder input impedance ≧100 kΩ

Test receiver for radiomonitoring. HFV model 05 is used for reception of AM and FM signals. With an IF bandwidth of 36 kHz it is particularly suitable for operation in particular channels. Logarithmic indication over 60 dB, a switch-selected squelch and AFC are ideal features for radiomonitoring. A built-in calibration oscillator together with linear indication facilitates the accurate measurement of received signals. A halfwave dipole is supplied with the set for accurate determination of field strength.

Laboratory use (applies to all models). In the laboratory the HFV is suitable as a selective microvoltmeter. The circuitry is designed to ensure good suppression of spuria and intermodulation. RF currents can be measured with the aid of the RF Current Probe ESU-Z (see recommended extras).

The **power supply** of the HFV is either from a local AC supply or from the built-in battery (about 7 hours of operation, charging time about 14 hours).

Field-strength Meter HUF
♦ 20 to 1000 MHz

- Test assembly for measurements of propagation characteristics and coverage, antenna patterns and radio interference with CISPR and VDE weighting, radiomonitoring
- Two broadband antennas covering the whole frequency range
- Wide measurement range: -7.5 ($+13$) to 140 dBμV/m

The **Field-strength Meter HUF** is equally suitable for signal- and interfering-field-strength measurements in the range 20 to 1000 MHz and for radiomonitoring.

The HUF consists of

Test Receiver ESV 20 to 1000 MHz (page 234),
Broadband Dipole HUF-Z1 20 to 80 MHz,
antenna mast and accessories.

The Test Receiver ESV (for description see page 234) constituting the heart of the system is ideal for portable use and manual operation. It features

- synthesizer technique affording crystal-referenced frequency indication
- high overload capacity and high overall selectivity
- AC-supply and battery operation

Four switch-selected IF bandwidths (7.5/12/120 kHz/1 MHz), AM and FM demodulators with switch-selected AF filter and adjustable squelch, four weighting modes (CISPR, peak with 3 s or 1 s hold time, and average) and three ranges of indication (20/40/60 dB) facilitate a great number of applications for useful-signal and interference measurements.

A built-in loudspeaker, a phone outpu, two IF outputs (one for connection of an IF analyzer), DC-coupled AM and FM demodulator outputs and recorder outputs for frequency deviation and level permit signal evaluation.

Antennas. Broadband dipole of constant length for the range 20 to 80 MHz with compensated antenna impedance and approximately constant antenna factor in the range 25 to 80 MHz. For measurements above 80 MHz: log-periodic broadband antenna with a gain of 6.5 dB.

The antenna height on the mast can be adjusted from 1 to 5 m. The azimuth and polarization plane are freely adjustable; the elevation angle can be varied by ±30°.

Field-strength measurement. Field strength in dBμV/m is obtained by adding the antenna factor k (in dB) and the measured voltage (in dBμV). The antenna factor of the broadband dipole is taken into account via the coding input of the ESV, so field strength can be read in dBμV/m on the ESV in the range 25 to 80 MHz.

Programmed field-strength measurements are possible using the Test Receiver ESVP (20 to 1300 MHz, page 238.

Interference field measurement. The HUF is a standard instrument for radio interference measurements in line with national and international (CISPR) specifications.

Accessory units, see under ESV, page 234.

Specifications

Frequency range	20 to 1000 MHz
Measurement range	
lower limit	-7.5 to $+13$ dBμV/m
upper limit	140 dBμV/m[1])
Measurement error	<3 dB including antenna
Test receiver	Test Receiver ESV 20 to 1000 MHz
Antenna input	50 Ω; N female connector
Measurement range	-10 to $+137$ dBμV
Measurement error	<1.5 dB
Antennas	
Broadband Dipole HUF-Z1	20 to 80 MHz
Antenna connector	50 Ω, N female
VSWR	<2
Antenna factor k	22.5 to 14 dB (frequency-dependent)[2])
Dimensions, weight	length 1.77 m; in transport bag: 0.9 m long, 0.13 m dia.; 2.5 kg
Log-periodic Broadband Antenna HL 023 AL	80 to 1300 MHz
Connector	50 Ω; N female
VSWR	<2 (up to 1000 MHz)
Antenna factor k	2.5 to 23 dB in range 80 to 1000 MHz, frequency-dependent
Dimensions, weight	length 1.7 m, width 2 m, knocked down 1.7 m×0.5 m; 5 kg
Antenna mast (epoxy glass)	
Adjustment ranges	
Antenna height	1 to 5 m
Polarization	any
Azimuth	any
Elevation	±30°
Dimensions, weight	length 1.65 m (knocked down); 36 kg (incl. accessories)
Tripod HFU-Z	length 0.9 m, dia. 0.22 m (knocked down), 9 kg
Order designation	▶ Field-strength Meter HUF 354.1520.53

System breakdown (delivery of individual items possible)

Test Receiver ESV	342.4020.53
Broadband Dipole HUF-Z1	358.0512.52
LP Broadband Antenna HL 023 AL	577.8017.02
Tripod HFU-Z	100.1114.02
Mast with swivel arm and antenna bracket, HFU-Z	100.1120.02
Connecting Cable HFU-Z5, 7 m long	252.0055.55
Headphones	110.2959.00

[1]) Theoretically, the upper limit is also frequency dependent. The ESV shielding is guaranteed up to 140 dBμV/m (see page 234); the power-handling capacity of the internal attenuators of the Broadband Dipole HUF-Z1 is also 140 dBμV/m.

[2]) On delivery, the HUF-Z1 has an antenna factor higher by 5 dB for coding on the ESV. The antenna factor here specified can be obtained by changing two soldered links.

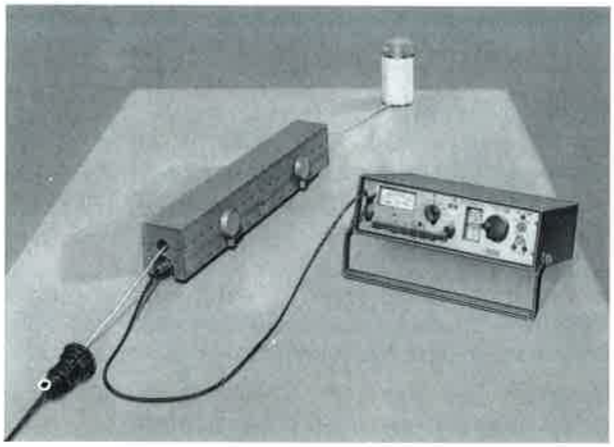
Absorbing Clamp
MDS-21 ♦ 30 to 1000 MHz

MDS

- Direct measurement of RF interference power on power cords and connecting cables of electrical appliances
- Meter reading in dBμV on interference measuring receiver corresponds to RF interference power in dBpW

Measurement of interference power in the VHF range

For perfect reception of radio and television signals, interference from electrical appliances must be kept within certain limits. The amount of interference from an interference source is expressed in terms of voltage, power, current or field strength. On account of direct radiation, the interference in the metric-wave range has up to now been defined as the field strength prevailing at a certain distance. The reliability of this rather inconvenient measurement depends on numerous parameters. The absorbing clamp*) considerably simplifies measurements on interference sources whose dimensions are small compared to the wavelength.



Test setup consisting of VHF Field-strength Meter HFV and Absorbing Clamp for the measurement of interference power

The **Absorbing Clamp** MDS-21 in conjunction with an interference measuring receiver according to CISPR, Publ. 2, e.g. ESV, permits the interference to be measured directly as the noise power introduced by the interference source in the power cord. Measurements with the MDS Absorbing Clamp are easier and more reliable than field-strength measurements. Moreover, the Absorbing Clamp is insensitive to external radiation.

*) after Meyer de Stadelhofen (Switzerland)

Operating priciple and functioning. Interference is mainly radiated from the power cord of the interference source. For this reason, a ferrite absorber is provided inside the MDS Absorbing Clamp, which encircles the power cord and acts as a resistance to the RF interference power. A calibrated interference-measuring receiver, connected to the input, measures the RF current flowing through the absorber via a current converter. Because, with this arrangement, there is no matching between the interference source, the power cable and the absorber, the Absorbing Clamp must be slid along the power cord to adjust for maximum interference power. By suitable design of the absorber and choice of the conversion ratio of the current converter, the reading obtained on the calibrated interference-measuring receiver in dBμV corresponds to a power indication in dBpW.

Construction The units consist of a plastic case of two parts hinged together, each containing a set of ferrite ring halves. These are fixed in plastic spring holders, thus forming a duct for the power cord of the interfering appliance. Eccentric catches provide the required contact pressure. Rollers are provided to facilitate moving the Absorbing Clamp when searching for interference maxima.

MDS-21 version up to 1000 MHz. Effective shielding and use of a correction curve make radio-interference measurements on lines and cables possible up to 1000 MHz.

Specifications

Diameter of appliance power cable	up to 20 mm
Dimensions, weight	610 mm×115 mm×80 mm, 6.3 kg
Order designation	▶ Absorbing Clamp MDS-21 (50 Ω) 194.0100.50
Accessories supplied	1 coaxial cable (MDS → interference receiver), 5 m long, with BNC male connectors

FAM

Modulation Analyzer FAM

◆ 55 kHz to 120 (1360) MHz

- Microprocessor-controlled unit for analyses of modulated RF signal, with simultaneous frequency measurement
- Modulation measurement with AM, FM and φM
- Switch-selected highpass and lowpass filters for various test bandwidths; CCITT and CCIR weighting filters
- Modulating-signal measurement using weighting filters (AF voltmeter or psophometer function)
- IEC-bus-compatible

IEC 625 Bus

Characteristics, Uses

The Modulation Analyzer FAM offers a maximum of convenience for modulation measurements on AM, FM and phase-modulated signals. All functions being microprocessor-controlled, manual operation is reduced to a minimum. Modulation measurements over a range of carrier frequencies from 55 kHz to 1360 MHz are performed more precisely and more easily with the FAM than with previously available equipment. The IEC-bus interface makes the instrument system-compatible and suitable for use in automated test assemblies.

Types of measurements. The Modulation Analyzer can be used for measurements otherwise calling for up to five different instruments. It features the following capabilities:

- Measurement of modulation depth, frequency deviation and phase deviation
- Simultaneous carrier-frequency measurement with 1 Hz or 10 Hz resolution
- Measurement of modulation frequency with 1 Hz resolution
- Distortion measurement down to <0.1%, also SINAD indication in dB
- AF voltage measurement with weighting filters (psophometer function)
- Evaluation of external AF signals

Unwanted modulation can be measured and weighted accurately on account of switch-selected test bandwidths and standard weighting filters.

Field of application. The basic model covers a carrier-frequency range of 55 kHz to 120 MHz and offers a very economical and high-performance solution for measuring tasks in FM and AM broadcasting and certain radiotelephony and other radio services.

The **Frequency-range Extension Option** – which can be fitted when the main unit is originally produced, or added later – extends the frequency range up to 1360 MHz, thus covering practically all radio services.

Special features. The FAM exhibits negligible inherent noise and excellent linearity.

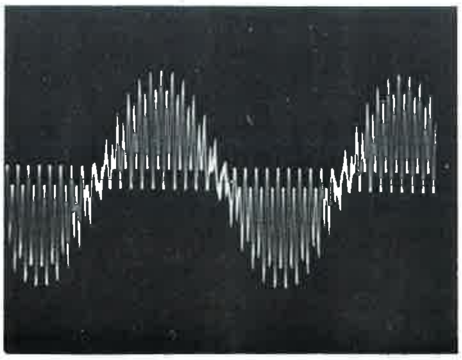
Residual FM being less than 1 Hz in the basic frequency range (proportionally increasing above) with CCITT weighting and 5 Hz with 20 kHz weighting bandwidth, whilst residual AM is as low as 0.01%, the FAM permits unwanted modulation to be measured precisely.

The FM stereo noise of FAM model 54, being −72 dB referred to 40 kHz deviation, CCIR weighting, permits precise S/N-ratio measurements, say, on FM broadcast transmitters.

The **transmission linearity** of the FAM fulfils the exacting demands involved in wideband modulation methods used, for example, in FM broadcasting. Excellent amplitude and phase linearity make distortion-free demodulation of multiplex signals possible; see application example on page 258.

Distortion of less than 0.1% and crosstalk attenuation of 50 dB guarantee accurate results of measurement.

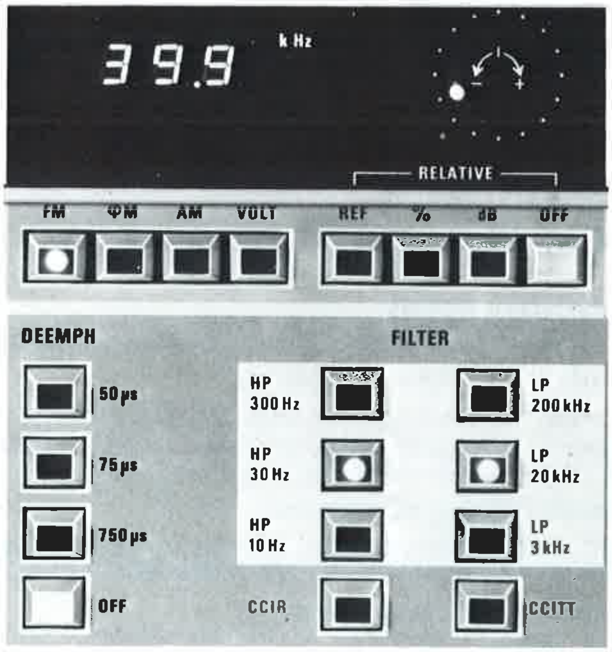
Demodulated stereo signal available at FM output of Modulation Analyzer FAM



Setting, Measurement, Display

The front panel of the FAM is divided into three functional sections for easy operation and clear presentation of the results, several parameters being displayed simultaneously:

Left-hand section	**Carrier-frequency** display and entry (with manual tuning)
Middle section	**Result** display and setting of operating modes
Right-hand section	**Modulating-signal** display measuring section for modulating frequency, distortion, SINAD



Front panel section; display of modulation measurement results and setting of operating modes

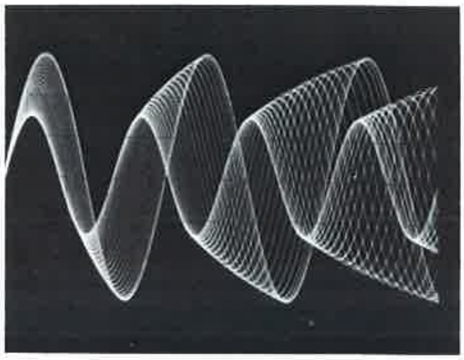
Frequency setting. Setting is performed **fully automatically** under microprocessor control; see description on next page. When a signal is applied, the FAM tunes automatically to the input frequency within 3 s and displays this frequency in the l. h. section with a resolution of 10 Hz.

If automatic tuning is not desired in specific cases, the frequency can be **set via the keyboard** (this is important for instance when measuring selective calling equipment, with data transmission and other techniques where no continuous signal is available).

For such specific measurements, the other automatic functions can also be suppressed. RF atenuator or AF range can be held at or brought to a particular setting.

Modulation measurement, display. The middle section is used for setting the type of modulation and time constant, selecting the filter and displaying the modulation measurement result. An additional, analog display in the form of a light spot moving around a circle greatly facilitates adjustments by providing trend indication. The user simply selects the type of modulation – AM, FM or φM – and, with FM, one of three deemphasis time constants. The Modulation Analyzer demodulates signals of any mode of modulation including simultaneous FM and AM; see photo below.

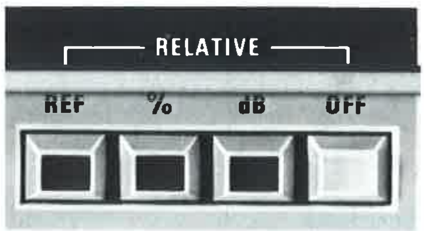
Modulation signal analysis using FAM: display of an RF signal with simultaneous FM and AM



Weigthing. Three HP and three LP filters provide a great variety of weighting bandwidths and suppress unwanted signals. CCITT and CCIR standard filters (perceived loudness) can be inserted or retrofitted as options for standard S/N measurements.

Display of results (absolute or relative). The measured modulation can be desplayed as an absolute value or relative to a key-entered reference value. This is very convenient if modulation is to be determined as a function of modulation frequency or carrier frequency.

Keyboard and display for relative measurements

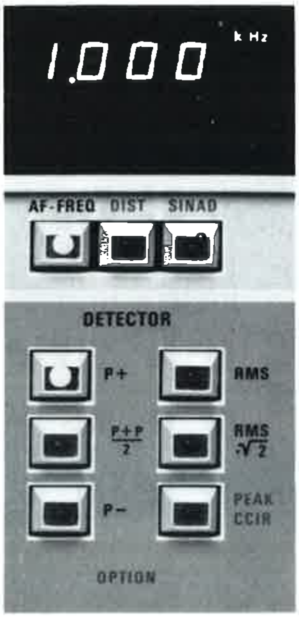


The high resolution (≤0.25%) and the high accuracy of the modulation depth indication (1.5%) permit precise measurements without needing recalibration.

Type of detection. The measurement of the AF modulating-signal amplitude can be performed either with peak responding detection (most frequently employed for measuring wanted modulation) or with rms responding detection (for example for measuring unwanted modulation). The CCIR weighting filter option includes the prescribed quasi-peak responding detector.

Modulation Analyzer FAM, continued

Modulation-frequency/distortion measurement. The **frequency of the modulating signal** is displayed in the r. h. section of the front panel. The 0.1-Hz resolution is required for measuring frequencies of calling signals or code signals for squelch switching.



Front-panel section: display and keyboard for modulating-frequency and distortion measurement

Option FAM-B8 is available for **measuring the distortion** of the modulating signal. Measurements can be made at 30 fixed frequencies from 30 Hz to 20 kHz. The measurement is automatically initiated by the microprocessor when the frequency of the modulating signal lies within the measurement range. The FAM displays either distortion in % or SINAD in dB.

Evaluation of external AF signals. The AF section, comprising the weighting filter, frequency counter, detector and distortion meter, can be used for the evaluation of an external AF signal via a separate input socket. The Modulation Analyzer can thus be used as an automatic AF voltmeter and as a psophometer.

IEC-bus interface. The Modulation Analyzer has an IEC-bus interface so it can be controlled by an external computer, e.g. the R&S Process Controller PUC. The FAM can receive setting and trigger instructions and can output measured data to the computer, meaning that it can function as both listener and talker. Thus it is suitable for use in automatic measuring systems for testing transmitters and transceivers in development, production and quality control.

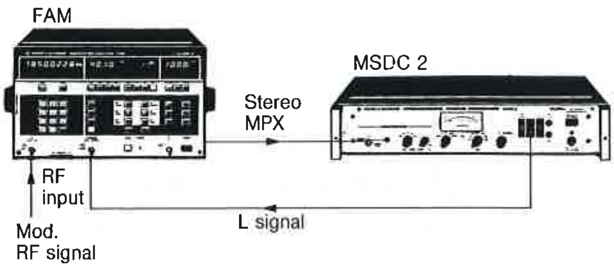
Description

The FAM is made up of RF, IF and AF sections and the microcomputer circuitry. The RF section contains a counter for measuring the frequency of the input signal, an AGC stage and a mixer. The IF section comprises AM and FM demodulators and the AF section evaluates the demodulated signal. The microprocessor handles the settings, data acquisition, and I/O operations of keyboard and display.

Sepcial features of the RF section. The input frequency range of the FAM basic unit is 55 kHz to 120 MHz divided into two bands: frequencies up to 3.5 MHz are processed directly in the IF section, those between 3.5 and 120 MHz undergo a single frequency conversion. A frequency-range-extension option adds a third band above 120 MHz with double frequency conversion.

The microprocessor detects the presence of an input signal by a search process using level detectors in the RF and IF sections and a frequency counter. From this information it derives the setting of the first local oscillator and performs the RF level adjustment.

Input signals above 120 MHz are converted to the range below 120 MHz by the second local oscillator when the 1.36-MHz Frequency-range Extension option is used. The microprocessor calculates the input frequency from the frequency of the second local oscillator. The input frequency is displayed.



Measurement of stereo multiplex signals using Modulation Analyzer FAM

Extensions (options)

The FAM can be delivered or retrofitted with a number of options to suit different requirements:

1-GHz/1.36-GHz Frequency-range Extensions FAM-B2
extend the frequency range of the FAM up to 1000 or 1360 MHz (two models with otherwise equal characteristics).

CCITT Weighting Filter FAM-B6
for weighted measurement of unwanted modulation using standard perceived-loudness-characteristic filter.

CCIR Weighting Filter FAM-B7
for weighted measurement of unwanted modulation using standard perceived-loudness-characteristic filter. The required quasi-peak-responding detector is built in.

DIST and SINAD Meter FAM-B8
for automatic measurement of modulation distortion, including external signals at 30 fixed frequencies from 30 Hz to 20 kHz.

Reference Oscillator SMS-B1
temperature controlled, improves the frequency stability (temperature coefficient 1×10^{-7} in the operating temperature range; crystal aging 5×10^{-8}/month).

Specifications

Frequency range	55 kHz to 120 MHz	
With option FAM-B2 1.36 GHz	55 kHz to 1360 MHz	
With option FAM-B2 1 GHz	55 kHz to 1000 MHz	
Frequency setting	automatic[1]) or manual	
Display	8 digits	
Resolution, $f < 1000$ MHz	10 Hz or 1 Hz	
$f \geqq 1000$ MHz	100 Hz or 10 Hz	
Frequency error and drift	±1 digit + error of reference freq.	
Reference oscillator	standard	option SMS-B1
Crystal aging	$<\pm1\times10^{-6}$/month	$<\pm5\times10^{-8}$/month
Temperature coefficient	$<\pm1\times10^{-6}$/°C	$<\pm1\times10^{-7}$ over total op. range

[1]) Frequency measurement and automatic tuning for AM $\leqq$80%; for $f_{in} \geqq$550 MHz up to 60%.

RF input .... Z_{in} = 50 Ω, BNC female connector
Input level range
55 kHz to 550 MHz .... 10 mV to 3 V (−27 to +22.5 dBm)
550 to 1050 MHz .... 20 mV to 3 V (−21 to +22.5 dBm)
1050 to 1360 MHz .... 30 mV to 3 V (−17 to +22.5 dBm)
RF attenuator programmable

Amplitude modulation measurement
Modulation frequency range .... 10 Hz to 200 kHz
10 Hz to 20 kHz for f_{in} <3.5 MHz
Max. measurable modulation depth 100%
Display .... 4 digits + analog indication
Units .... absolute: %; relative: % or dB
Resolution .... 0.25% (of reading), max.: 0.005% (AM)

Error (peak-resp. detector) (plus peak residual AM)	mod. ≦80%	mod. >80%
f_{mod} 30 Hz to 60 kHz	≦±2%	≦±5%
60 to 100 kHz	≦±4%	≦±10%
Residual AM[2]) weighted with CCITT filters (rms.-resp. detector)	≦550 MHz: ≦0.01%	>550 MHz: ≦0.02%
Weighting bandwidth 30 Hz to 20 kHz	≦0.05%	≦0.05%
CCIR weighting	≦0.05%	≦0.1%

Incidental AM with FM[3]) (f_{mod} 1 kHz, 50 kHz deviation, meas. bandwidth 30 Hz to 3 kHz) 0.1%

AF distortion (at AF output; f_{mod} 30 Hz to 20 kHz)	≦120 MHz	>120 MHz
40% mod.	≦0.2%	≦0.4%
40 to 80% mod.	≦0.4%	≦0.6%

AM modulation range programmable

Frequency modulation measurement (with input frequ. ≧4.25 MHz)
Modulation frequency range .... 10 Hz to 200 kHz
Max. measurable frequency deviation .... 500 kHz
Display .... 4 digits + analog indication
Units .... absolute: Hz, kHz; relative: %, dB
Resolution .... 0.25%, max.: 0.1 Hz

Error	deviation ≦100 kHz	dev. >100 kHz
with peak.-resp. detector (plus peak residual FM)		
f_{mod} 30 Hz to 60 kHz	≦±1.5%	≦±3%
60 to 100 kHz	≦±3%	≦±6%
with rms.-resp. detector (plus peak residual FM)		
f_{mod} 30 Hz to 60 kHz	≦±3%	≦±3%
60 to 100 kHz	≦±6%	≦±6%

Residual FM at f	≦120 MHz	120 to 550 MHz	550 to 1050 MHz	1050 to 1360 MHz
With CCITT weighting and rms.-resp. detector	≦1 Hz	≦3 Hz	≦6 Hz	≦12 Hz
Weighting bandwidth 30 Hz to 20 kHz, with rms.-resp. detector	≦5 Hz	≦14 Hz	≦25 Hz	≦50 Hz
With CCIR weighting and deemphasis and squelch	≦6 Hz	—	—	—

Stereo S/N ratio (CCIR) ref. to 40 kHz deviation (f_{in} ≦120 MHz, V_{in} ≧20 mV) .... 72 dB, typical
Incidental FM with AM (f_{mod} 1 kHz, m = 50%; test bandwidth 30 Hz to 3 kHz) .... ≦20 Hz
AF distortion (at AF output; f_{mod} 30 Hz to 20 kHz)
75 kHz deviation .... ≦0.1%
500 kHz deviation .... ≦0.5% (input freq. >10 MHz)
Stereo separation
at f_{mod} 30 Hz to 15 kHz .... ≧46 (typ. 50) dB at stereo output
f_{mod} 1 kHz .... ≧50 dB
Deemphasis .... 50/75/750 µs, switch-selected
FM modulation range programmable

Phase modulation measurement (with input frequency ≧4.25 MHz)
Modulation frequency range .... 300 Hz to 20 kHz
Maximum measurable phase deviation .... 500 rad (up to 1 kHz mod.-freq.)
Display .... 4 digits + analog indication
Units .... absolute: rad; relative: %, dB
Resolution .... 0.25%, max.: 0.001 rad
Error with peak-resp. detector .... ≦±3.5% + peak residual φM
with rms.-resp. detector .... ≦+5% +residual φM

Residual φM at f	≦120 MHz	120 to 550 MHz	550 to 1050 MHz	1050 to 1360 MHz
Weighted with CCITT filter: rad	≦0.002	≦0.003	≦0.006	≦0.012
bandwidth 30 Hz to 20 kHz: rad	≦0.005	≦0.01	≦0.02	≦0.04

AF distortion (at AF output), deviation 4 rad .... ≦0.1%
φM modulation range programmable

[2]) With input level 6 dB above minimum; >250 mV for f_{in} <3.6 MHz.
[3]) In frequency range specified for FM measurement.
[4]) Only for retrofitting in earlier FAM models.

AF detector
Peak-responding detector .... positive or negative peak of AF or their arithmetic mean
Rms-responding detector .... true rms response, indication as rms or for sinewave converted to peak; crest factor 10

Weighting filters
High pass (1-dB cutoff frequency) .... 10 Hz (2 Hz at 3 dB by changing connection), 30 Hz and 300 Hz (12 dB/octave),
Low pass (3-dB cutoff frequency) .... 3/20/200 kHz(24 dB/octave min.)
CCITT filter (option FAM-B6) .... weighting network acc. to CCITT Rec. P53
CCIR filter (option FAM-B7) .... weighting network acc. to CCIR Rec. 468-2 (Rev. 78) combined with quasi-peak detector

AF frequency display
Frequency range .... 10 Hz to 200 kHz
Display .... 4 digits
Resolution .... 0.1 Hz up to 1 kHz
Error at f >100 Hz .... ±1% at S/N >40 dB
f <100 Hz .... ±0.1 Hz at S/N >60 dB

Distortion measurement .... with option FAM-B8
Test frequencies (total of 30) .... 30/40 to 100 Hz, 200/300 to 1000 Hz, 2/3 to 10 kHz, 12.5/15/17.5/20 kHz
Automatic tuning (S/N >30 dB) .... tuning range ±3%; automatic switchoff when frequency is outside of measurable range
Display .... 4 digits, THD in % or SINAD in dB
Display range .... 0.1 to 50%, 6 to 60 dB (SINAD)
Error (THD ≦10%) .... ≦ ±10% of rdg or ≦±1 dB
Test frequency programmable

AF voltmeter
Frequency range .... 10 Hz to >200 kHz
Measurement range .... 0.1 mV to 3 V (max. 5 V peak)
Display .... 4 digits
Units .... absolute: mV; relative: %, dB
Resolution .... 0.1 mV
Error with LP 3/20 kHz .... ≦ ±1.5% ±0.1 mV
without LP .... ≦ ±1.5% ±0.4 mV (30 Hz to 60 kHz)
≦ ±3% ±0.4 mV (60 to 100 kHz)
Weighting .... all AF measuring facilities in the FAM (detectors, weighting networks, frequency counter, distortion meter) can also be used in voltage measurements (except LP 200 kHz)
Input .... Z_{in} ≧400 kΩ ||300 pF, floating; BNC female connector
Voltage range programmable

Outputs
AM signal output (V_{rms}) .... max. 1 V across 2 kΩ at 100% mod
FM stereo signal output (V_{rms}) .... 1.5 V at 40 kHz dev. corresp. to + 6 dBm across 600 Ω (for crosstalk see FM)
AF output (V_{rms}) .... 350 mV to 1 V depending on modulation of AF voltage

IEC-bus interface .... in accordance with IEC 625-1 (IEEE 488); 24-pin Amphenol connector
Listener and talker functions AH1, T4, L2, RL1, DC1

Measurement time (frequency, RF and AF ranges programmed)

For triggered RF and modulation measurement	with frequency resolution 10 Hz/100 Hz	1 kHz
FM, φM	≦250 ms	≦2050 ms
AM	≦420 ms	≦2300 ms

General Data
Operating temperature range .... + 5 to +45°C
Storage temperature range .... −40 to +70°C
Power supply .... 115/125/220/235 V ±10%
47 to 440 Hz (80 VA), safety class I
Dimensions, weight .... 347 mm × 206 mm × 370 mm, 12 kg

Ordering information

Order designation .... ▶ Modulation Analyzer FAM
FAM 55 kHz to 120 MHz 334.2015.54
Accessories supplied .... power cable, adapter (for PC boards)

Options
Reference Oscillator .... SMS-B1 ... 302.8918.02
1.36-GHz Frequency-range Extension .... FAM-B2 ... 334.4918.02
1-GHz Frequency-range Extension .... FAM-B2 ... 334.4918.04
IEC-625-1 Interface[4]) .... FAM-B4 ... 334.5914.02
CCITT Filter .... FAM-B6 ... 334.5614.02
CCIR Filter .... FAM-B7 ... 334.5514.02
DIST/SINAD Meter .... FAM-B8 ... 334.5714.02
19" Adapter .... FAM-Z9 ... 349.7318.02

XYT Recorder ZSKT,
a general-purpose two-axis recorder;
details on page 264

8

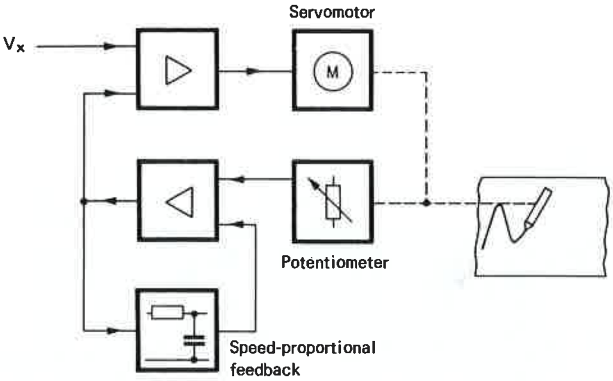
recorders

Introduction

A quantity recorded as a function of time or of another variable can be readily interpreted and precisely evaluated.

Principle of potentiometer-type recorders

The self-balancing potentiometer principle is illustrated in the following diagram:

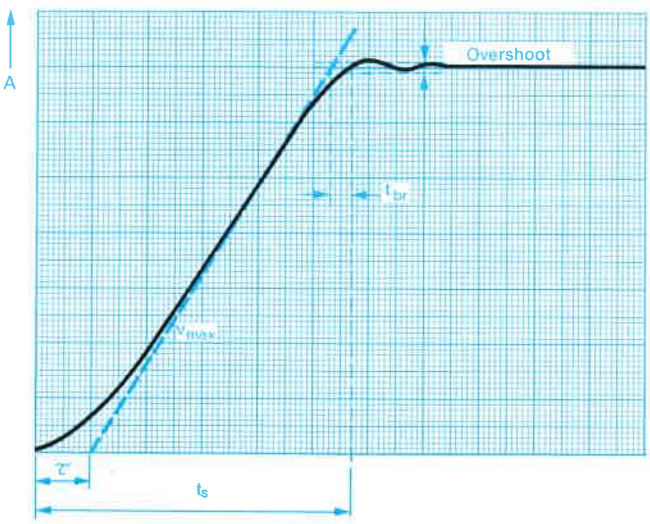


Simplified diagram of potentiometer-type recorder

The input voltage V_x is compared with the output voltage of the balance potentiometer, which is fed from a reference voltage source. If there is a difference, the motor acts on the potentiometer and thereby on the stylus until balance is restored. The speed-proportional feedback affords optimal damping of the system.

Dynamic behaviour of the potentiometer-type recorder

Whether a quickly varying quantity is represented faithfully depends on the dynamic characteristics of the recorder. The step function is most commonly used to test a recorder for maximum writing speed, time constant of recording system and overshoot or damping. The typical step function is shown below:



Step function of a recorder and definition of terms

The servomotor has reached its final speed v_{max} after about 3 τ. The asymptote to the slewing function with the slope v_{max} intersects with the time axis at the point τ.

The braking force of the servomotor is greater than the starting force, since the polarity is reversed at full rpm; therefore an optimally damped system has a shorter braking time than starting time, typically about 0.5 τ.

The settling time is the sum of starting time τ, running time at constant speed v_{max} and braking time $t_{br} \approx 0.5\ \tau$ (see diagram). For a step of amplitude A the settling time is obtained as

$$t_s \approx 1.5\tau + \frac{A}{v_{max}}.$$

The time constant of the servosystem can also be determined from the starting acceleration "a", which is specified by many manufacturers, and the final speed v_{max}

$$\tau = \frac{v_{max}}{a}.$$

Here it is to be noted that "a" is the starting acceleration from standstill and not equal to the maximum acceleration a_{max} during braking, which is in practice about 1.5 a to 1.8 a.

Some basic concepts

Linearity. The departure of indication from linear response is stated in percent of the calibrated width of the chart as a function of the input level.

Reproducibility (hysteresis, deadband). Coincidence obtained with repeated plotting of the same pairs of values or time functions. (Hysteresis or deadband designates the departure occuring with repeated plotting of the same value, referred to the higher or lower values; the departure is stated in percent of the calibrated width of the chart.)

Maximum writing speed v_{max}. Final speed of the recording carriage produced by the servomotor in response to a step function on one coordinate axis.

Time constant τ. Characteristic quantity of the servo system, indicating the time required by the recording carriage to reach 63% of the maximum writing speed.

Settling time t_s. Time the stylus takes with a step function from the start until it reaches the full amplitude to within ±1 mm without exceeding this tolerance again.

Radiomonitoring Recorder ZSG 3

ZSG 3

- Electro-sensitive recording of radio signals with automatic time-of-day printout
- Five individually selected frequency markers
- Visible and audible end-of-paper signals

Characteristics and uses

The **Radiomonitoring Recorder ZSG 3** records the radio signals picked up within a selected frequency band by a receiving system, thus constituting a valuable supplement for radiomonitoring stations.

The signals are traced on electrosensitive paper in the form of horizontal lines. The sawtooth voltage which tunes the receiver is also used to control the stylus over a chart width of 200 mm. The deflection of the recording electrode is thus a measure of the instantaneous reception frequency. The recorded trace length depends upon the adjusted threshold, the receiver bandwidth and the field strength. Recording by means of the voltage-controlled electrode is only effected during the forward sweep. A constant paper feed gives an accurate time scale, which is 30 or 60 s/line when the ZSG 3 is used in conjunction with the Radiomonitoring/Recording System MFBR.

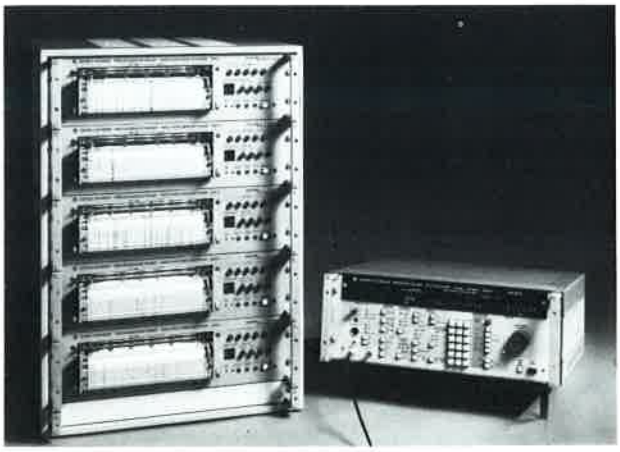
Orientation and evaluation are facilitated by additionally recording up to five frequency markers. The ZSG 3 also records every full hour on the righthand margin.

Description

The Radiomonitoring Recorder ZSG 3 operates on the principle of the self-balancing potentiometer. The input V_x must be a sawtooth voltage which also tunes the receiver of the radiomonitoring/recording system. Recording is electrosensitive, producing a black trace at the point where the recording electrode touches the paper when the electrode voltage is applied. This so-called Z control is accomplished by the processed signal of the receiver output.

An additional recording device, controlled by the paper feed and the hours pulse derived from a clock system, records every full hour on the righthand margin by way of seven-segment figures.

Up to five frequency bands (with adjustable thresholds) can be recorded simultaneously in conjunction with a single Test Receiver ESH 3 (see also "Data-logging capabilities" on page 227)



Specifications

Recording principle	voltage-controlled recording head
Recording voltage	<42 V_{rms}
Intensitiy control	by potentiometer on front panel
Recording paper	electrosensitive, blanck paper
Size of paper roll	width 230 mm, diameter 50 mm, length 20 m
Paper feed	by stepping motor, forward only
Advance	0.41 mm/step
Free running	by pushbutton (approx. 5 mm/s)
Paper-advance control	by return pulse of sawtooth (TTL)
Paper output	flowing out or rolled up
End-of-paper signal	pilot lamp and buzzer
Time-of-day recording	by 7-segment digits (1 to 24) on righthand margin
Control	by hour pulse from a clock system (TTL or contact)
Time setting at beginning of recording	by pushbutton and 7-segment readout on front panel
Frequency markers	by 5 manually adjustable electrodes, individually selected by pushbuttons
Z control	digital or analog
Digital	with TTL signal
Analog (adj. threshold)	0 to +10 V, R_{in} = 250 kΩ
Output	TTL signal

Servo circuit

Deflection factor	0.5 V/cm (+10 V for 20 cm)
Input	differential input, floating; R_{in} = 40 KΩ
Nonlinearity	±0.1% of fsd (±0.2 mm)
Calibrated chart width	200 mm
Overlow	2 mm to the right and to the left
Position of zero	left, setting range ±2 cm
Maximum recording speed	20 cm/s

General data

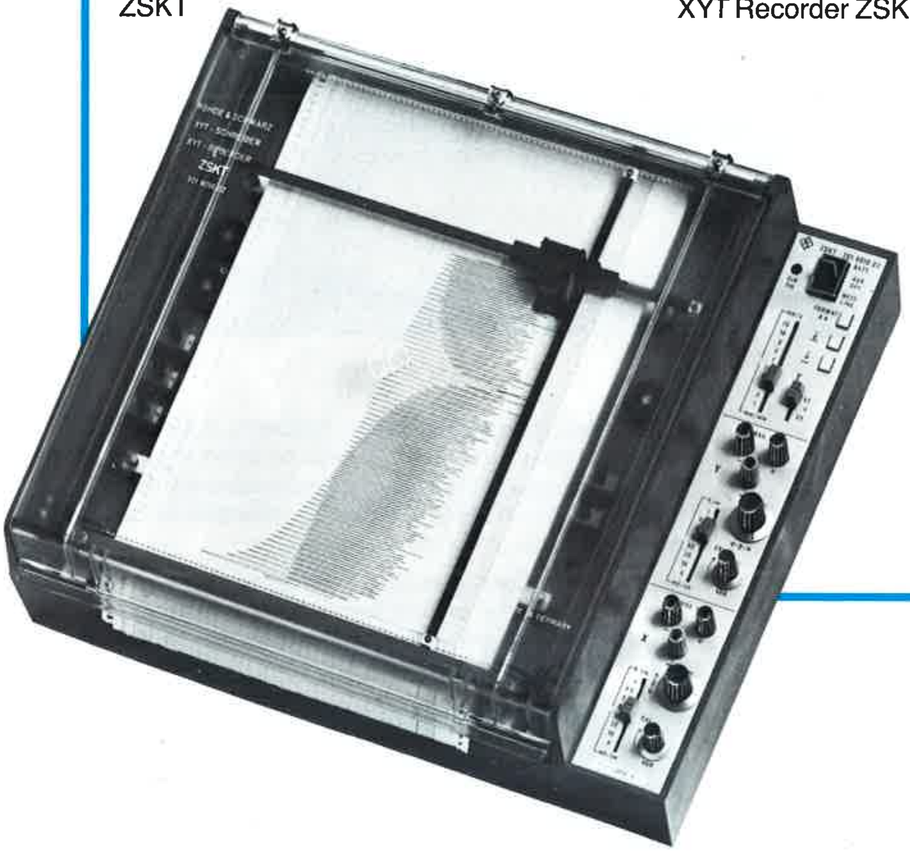
Connectors	36-pole female at the rear
Rated temperature range	+10 to +35 °C
AC supply	115/125/220/235 V ±10%, 100 VA (3 A)
Dimensions	484 mm×150 mm×436 mm
Weight, cabinet included	12.6 kg
not included	11.6 kg

Ordering information

Order designation	▶ Radiomonitoring Recorder ZSG 3
19" cabinet model	242.6015.92
19" rackmount	242.6015.91

Accessories supplied
1 power cord 025.2365.00; 3 rolls of recording paper 088.3117.00; 10 electrode wires 242.7786.00; 2 frequency-marker electrodes 242.7863.00.

ZSKT



XYT Recorder ZSKT ♦ 5 mV/cm to 3 V/cm

- XY and YT recording
- Excellent dynamic characteristics
- DIN-A4-format paper advance in XY operation
- Differential-amplifier inputs for X and Y signals
- Remote-controllable functions: paper feed, DIN-A4-format advance and pen lift

Characteristics and uses

The **ZSKT** is an extremely fast and accurate two-axis recorder with outstanding dynamic characteristics. It permits **XY and YT recording** and can be battery-powered and remotely controlled.

With these and many other features the ZSKT can be **universally used,** for example for mobile operation, for acoustic applications thanks to its high writing speed, or for automatic recording thanks to DIN-A4-format paper advance in the XY mode.

The **dynamic characteristics** of the recorder are virtually the same on both axes because of the identical construction. Events changing simultaneously in both directions at a fast rate can therefore be recorded practically free of distortion.

With a maximum writing speed of more than 120 cm/s and a maximum acceleration of more than 6 g, the ZSKT sets new standards in its price category. Nonlinearity is less than 0.2% referred to the calibrated writing width; the reproducibility error is less than 0.5 mm. Overshoot is very small at ±1 mm.

The useful **writing area** of the ZSKT is 180 mm×240 mm in XY operation. YT recording is possible with 180 mm width for more than 250 hours without interruption using the minimum chart speed of 1 mm/min and a paper roll that is 15 m long. For details on paper advance and recording see under description.

Remote control is possible for pen lift, paper advance in YT operation. DIN-A4-format advance in XY operation and start/stop. The stepping motor for paper advance can be controlled via a separate input, any paper speed up to 20 mm/s being adjustable. The remote-control capability makes the ZSKT ideal for use in automatic systems.

Description

Operating principle. The ZSKT operates on the principle of a self-balancing potentiometer. A new design of the recording system allows reduced driving forces. The lower current drain makes battery operation possible.

Input amplifiers. Differential amplifiers are used in the input stage, which makes connecting the signal sources very easy. The common-mode voltage may be as high as 100 V (common-mode rejection 60 dB).

Deflection sensitivity. The deflection factor can be set in eight calibrated steps from 5 mV/cm to 1 V/cm. Uncalibrated variation is also possible giving scale factors of ×1 to ×3, i.e. to a maximum of 3 V/cm.

Zero. The zero can be shifted over the whole writing width and suppressed by up to one full writing width; setting by means of ten-turn potentiometer.

Electronic limiting of writing area prevents the recording system from bouncing against a mechanical stop when the input amplifier is overdriven. This reduces wear of the mechanical parts, considerably enhancing the life expectancy and reliability of the recorder.

Recording. Fibre-tipped pens – available in different colours – are used for recording. The pen snaps into the penholder clip. The recording is made on paper rolls at least 15 m long and preprinted with a millimeter grid, or on individual sheets. Different modes of paper feed are used in XY operation and YT operation:

XY operation. At the push of a button the paper is advanced by 300 mm. The advance is controlled by a stepping motor so that the pen shifts to a horizontal grid line at a distance of exactly 300 mm.

YT operation. The X input amplifier is cut off. Instead of X deflection the paper is advanced by the stepping motor. True YT recording is thus possible without time limitation. The paper speed can be set in ten steps from 20 mm/s to 1 mm/min.

Power supply. The ZSKT is normally powered from the local AC supply, but it can also be used with external DC-voltage sources (+15 to +20 V and −15 to −20 V) or batteries; see photo below. The operating time with battery supply is at least 20 hours and even longer if the dynamic characteristics of the recorder are not fully utilized.

XYT Recorder ZSKT
on top of battery pack

Mechanical design. The case of the ZSKT is a one-piece fibreglass-reinforced moulding. The writing area with the driving mechanism is protected by a transparent cover. When the cover is opened the servomotors are switched off.

The **battery pack** can be fastened with two screws to the base of the recorder. Recorder and battery pack thus form a unit that is easy to transport and can be used anywhere.

A **rack adapter** available as an extra permits easy mounting of the ZSKT in a standard 19″ rack.

Specifications

Recording system

Writing area in XY operation	180 mm×240 mm
Writing width in YT operation	180 mm
Recording paper	rolls, width 220 mm or individual DIN-A4-format sheets
Recording pen	fibre-tipped pens
Max. writing speed	not less than 120 cm/s in both directions
Acceleration	>60 m/s²
Mechanical time constant of servosystem	≈20 ms
6-dB cutoff frequency for ±1 cm deflection	≈15 Hz
Settling time for full-scale deflection in Y direction	≈150 ms
X direction	≈190 ms
Nonlinearity	0.2%
Reproducibility error	0.5 mm
Overshoot	±1 mm
Pen control	by pushbutton or remote control

XY inputs

Test inputs	3 knurled terminals for X and Y directions, designated +/−/⊥
Input circuits	differential amplifiers for X and Y deflection
Deflection factor, calibrated	5 mV/cm to 1 V/cm in 8 steps, max. error 0.2%
uncalibrated	×1 to ×3
Input resistance	1 MΩ
Zero offset	± one full writing width, using ten-turn potentiometer
Common-mode rejection	>60 dB
Max. permissible common-mode voltage	100 V (between input and ⊥)

Paper feed

Drive	stepping motor
Start/stop	by switch (continuous advance), by pushbutton (advance in DIN-A-4-format steps) or by remote control (continuous or in steps)
Paper advance XY operation	DIN-A4-format advance (exactly 300 mm) or smaller steps, max. duration of advance 15 s
YT operation, internal	switch-selected speeds 1, 2, 5, 10, 20 mm/s 1, 2, 5, 10, 20 mm/min
YT operation, external Required drive voltage	3.5 to 10 V
Pulse repetition frequency f_p	0 to 420 Hz
Chart speed	v_p (mm/s) $= 300/6272 \cdot f_p$ (Hz)

General data

Operating temperature range	+5 to +45°C
Storage temperature range	−20 to +70°C
Power supply	AC supply, battery or external source (+15 to +20 V and −15 to −20 V)
AC supply operation	115/220 V ±10%, 47 to 63 Hz (10 VA)
Battery operation	from battery pack (with meter), 28 single cells IEC R-20; 20 hours of operation using battery pack with alkaline-manganese cells
Dimensions, weight	380 mm×110 mm×320 mm, 5 kg
with battery pack	380 mm×150 mm×320 mm, 7.5 kg

Ordering information

Order designation	▶ XYT Recorder ZSKT 301.9010.02
Accessories supplied	1 roll of recording chart, 1 set of fibre-tipped pens, power cable

Recommended extras

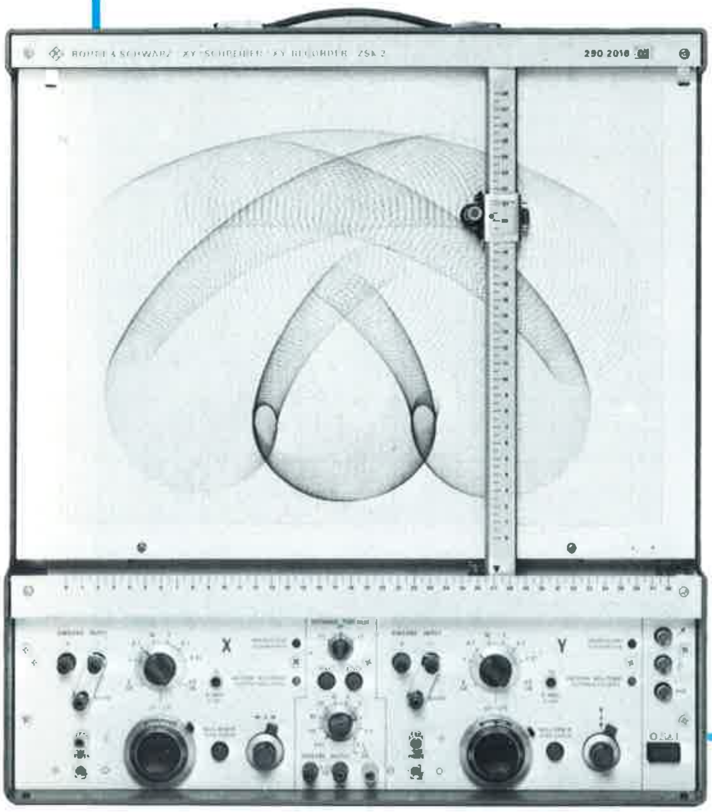
Battery Pack ZSKT-Z2	302.2010.02
Recording chart (roll of 15 m)	301.9291.00
Log. Recording Chart ZSKT-Z9 (for Impulse Sound-level Meter EGT)	302.1713.02
Fibre-tipped pens (set of 4 pens) red	301.9456.00
blue	301.9479.00
green	301.9491.00
black	301.9433.00
Set of fibre-tipped pens (on of each of above colours)	301.9510.00
19″ Rack Adapter ZSKT-Z1	302.1813.02

ZSK 2

XY Recorder System ZSK 2

♦ 10 μV/cm to 11 V/cm

- Choice of four models; the right recorder for every application
- Electrostatic paper holddown and electronic limiting of writing area for DIN A3 and DIN A4 sizes
- Floating inputs up to 500 V DC
- Common-mode rejection up to 200 dB
- Writing speed >110 cm/s on both axes
- Timebase; recording times up to 76 minutes



Front views of models 04, 06 and 08, which differ from the universal model 02 only with regard to the input circuits


04


06


08

Type familiy, characteristics, uses

The ZSK 2 family is a range of high-quality XY and YT recorders featuring high writing speed, precision and reliability.

Models of the ZSK-2 recorder system

The **ZSK 2 family** offers a user-oriented selection of four models. They differ mainly in the characteristics of the input section; see data on next page.

List of models:

02 Universal model
04 Standard model
06 Lab model with timebase
08 Lab model

The wide deflection-factor range of 10 μV/cm to 11 V/cm, the timebase generator and an internal DC voltage source for offset compensation (depending on model) offer a great variety of applications.

The electrostatic paper holddown grips charts of DIN A3 size (297 mm×420 mm) or smaller. Switch-selected limiting of the writing range to DIN A3 or DIN A4 ensures that the stylus remains within the selected useful area. Overdriving is indicated.

Plotting with ballpoint or fibre pen in four selectable collours; see recommended extras.

The input amplifiers of models 02, 06 and 08 are floating and isolated from ground for both the X and Y axes. Therefore the connection of test signals that are referred to different common points for the X and Y axes does not cause any problem.

A timebase generator incorporated in models 02 and 06 permits plotting of quantities varying in time. Model 06 includes in addition an isolated DC voltage source for offset compensation in the range 1 mV to 10 V.

Remote control is possible for lowering/lifting the recording stylus, forward and return sweep of the timebase and zero offset.

Outputs. The connections for remote control and the outputs for the deflection-proportional voltage and the timebase generator are combined in a multiway connector at the rear of the set.

Description

The ZSK 2 operates on the principle of the self-balancing potentiometer. This affords excellent linearity and accuracy. The potentiometer circuit is isolated from the test circuit by buffer amplifiers.

The X and Y amplifiers of the **universal model 02** are floating, guarded differential amplifiers and feature exceptionally high common-mode rejection.

The differential amplifiers of the **standard model 04** are referred to ground potential.

The **laboratory models 06 and 08** are equipped with floating differential amplifiers without guard. Both models offer the possibility of selecting normal or inverted operation.

The ZSK 2 can be mounted in racks with the aid of a 19″ rack adapter (see recommended extras).

Specification

Specifications of input section	**Universal model 02**		**Standard model 04**	**Lab model with timebase 06**		**Lab model 08**	
Deflection factor	10 μV/cm to 11 V/cm		5 mV/cm to 3 V/cm	100 μV/cm to 11 V/cm		100 μV/cm to 11 V/cm	
Steps	6		8	5		5	
Continuous adjustment	cal. × 1 to × 11		× 1 to × 3	cal. × 1 to × 11		cal. × 1 to × 11	
Error	0.2% ±0.5 div.		0.3%	0.2% ±2.5 div.		0.2% ±2.5 div.	
Input circuit	floating diff. ampl., guard; X, Y isol. from ground		diff ampl., for X and Y	floating impl., X, Y isol. from ground		floating ampl., X, Y isol. from ground	
Input resistance	10 MΩ (1 MΩ)		1 MΩ	1 MΩ		1 MΩ	
Max. input voltage	500 V (≦1 V/cm) 150 V		100 V	100 V (≦1 V/cm) 400 V		100 V (≦1 V/cm) 400 V	
Max. common-mode voltage	500 V		100 V	200 V		200 V	
Common-mode rejection DC	>160 dB		>60 dB	>160 dB		>160 dB	
AC (50 Hz); range:	w. filter	w/o filter		w. filter	w/o filter	w. filter	w/o filter
≦1 mV/cm	>200 dB	>140 dB		>170 dB	>110 dB	>170 dB	>110 dB
10 mV/cm	>160 dB	>100 dB		>130 dB	>70 dB	>130 dB	>70 dB
0.1 and 1 V/cm	>140 dB	>80 dB		>120 dB	>60 dB	>120 dB	>60 dB
Zero offset	±1 full scale		±1 full scale	±1 full scale		±1 full scale	
Timebase generator	X, Y: 0.2 to 120 s/cm		—	X: 0.1 to 20 s/cm		—	
Steps	9		—	8		—	
Error limits	±1%		—	±1%		—	
Output	0.1 V/cm		—	0.1 V/cm		—	
Offset voltage source	—		—	1 mV to 10 V		—	
Steps	—		—	8		—	
Continuous adjustment	—		—	×0.1 to×1		—	
Max. voltage to chassis	—		—	200 V		—	
Temperature cofficient	—		—	$\leqq 5\times10^{-5}$/°C		—	

System specifications

Calibrated chart area	280 mm×380 mm (DIN A3)
Electronic limiting	a) 280 mm×180 mm (DIN A4), b) 380 mm×280 mm (DIN A3), switch-selected
Paper holddown	electrostatic
Stylus	ballpoint pen or fibre-tipped pen (see extras)
Lowering of stylus	by pushbutton or ext. control
Max. writing speed	>110 cm/s on X and Y axes
Mechanical time constant of servosystem	25 ms
Max. settling time for fsd	
on X axis (380 mm)	400 ms
on Y axis (280 mm)	310 ms
Overshoot	≦1 mm
Linearity	0.1% of fsd
Reproducibility	0.2 mm
DC voltage output	retransmitting potentiometer, <1 Ω, shortcircuit-proof
Zero setting, ext.	0.1 V/cm, max. 10 V
Ratio recording	by external reference voltage
Rated value of nominal voltage	1.000 V
Operating voltage range	0.5 to 1.5 V ($V_{in\ max}$: 50 V)
Input resistance	1 MΩ (≦2 μA)

General data

Rated temperature range	+5 to +40 °C
Operating temperature range	−10 to +45 °C
Storage temperature range	−20 to +70 °C
Power supply	115/125/220/235 V +10/−15%, 47 to 420 Hz (50 to 150 VA, depending on recording mode)
Dimensions	440 mm×490 mm×160 mm

Ordering information

Order designations	▶ XY Recorder ZSK 2	
02 Universal Model	290.2016.02	
04 Standard Model	290.2016.04	
06 Lab Model with timebase	290.2016.06	
08 Lab Model	290.2016.08	

Accessories supplied

Set of Ballpoint Pens using fountain pen ink (FPI) ZSK 2-Z5 (2× black, 1× red, 1× green, 1× blue)	290.4860.00

2 shorting links 19 mm
2 shorting links 25 mm
1 pad of paper, with mm grid. DIN A3
power cable, service kit, dust cover

Recommended extras

19″ Rack Adapter ZSK 2-Z	290.2097.00	
Transport Cover (aluminium) ZSK 2-Z	290.2100.00	
Adapter for Fibre-tipped Pen ZSK 2-Z3	290.4919.02	
Set of Fibre-tipped Pens ZSK 2-Z4 (2× black, 1× red, 1× green, 1× blue)	247.7855.00	
Disposable pens (sets of five)	fibre-tipped ZSK 2-Z4	FPI ballpoint ZSK 2-Z5
black	247.7755.00	290.4783.00
red	247.7790.00	290.4825.00
blue	247.7778.00	290.4802.00
green	247.7832.00	290.4848.00
36-way male connector	247.7055.00	

Motor-vehicle Sound-level Meter ELMOT for rpm-dependent measurements; details on page 278

9

acoustic test equipment
sound-level meters · noise meters

Why sound-level measurement?

The most frequent objective of sound-level measurement is **noise abatement:** the advance of civilization and industrialization is accompanied by an increasing noise exposure suffered by man, which has reached such a level that countermeasures are urgently called for. Noise surrounds us by day and night, where we dwell, where we work, where we travel.

Noise **at the place of work** is of particular concern, considering that loss of hearing induced by noise is the No. 1 occupational illness in industrialized nations. Prolonged exposure to noise levels exceeding 85 dB is injurious to hearing. Even much lower levels – depending on the physical and mental condition and the activities of the people concerned – may cause them considerable annoyance, reduce their productivity and have adverse effects ont their nervous systems eventually leading to damage to their health. To counteract these risks, legislative bodies and unions have worked out regulations defining appropriate noise limits.

Such differentiated noise-limit regulations exist already in some countries or are under preparation, the regulations being partly enforced by law and partly laid down in management-union agreements. For example, the regulations concerning noise at the place of work issued by the government of the Federal Republic of Germany in May 1976 give the following noise level limits averaged over 8 hours **(rating sound level,** see page 272),

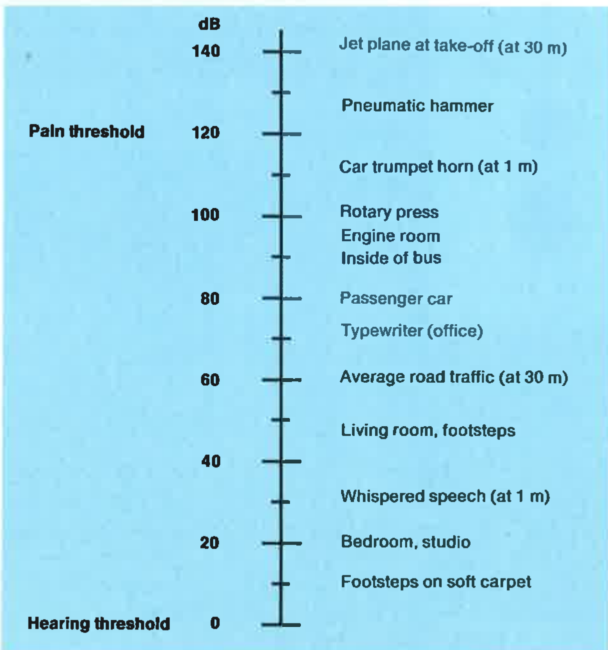
55 dB (A) for primarily brainwork

70 dB (A) for simple or to a great extent mechanized office work or comparable activities

85 dB (A) for any other activities; under certain circumstances, which mus be justified, up to 90 dB (A).

Sound-level measurement in residential area

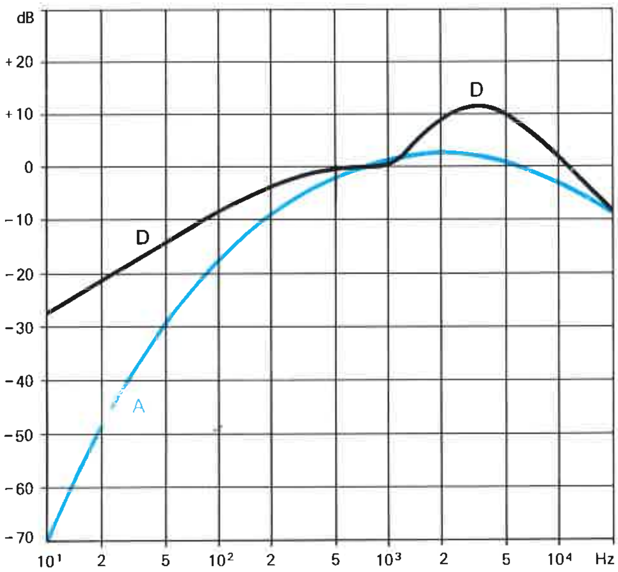
Environmental noise and average sound levels



Some concepts in sound measurements

The physical measure of sound intensity is the rms value of the (alternating) **sound pressure p** measured in pascals (Pa) with 1 Pa = 10 μbar or 1 N/m^2. Considering the very wide dynamic range of human sound perception, extending over six decades, the logarithmic measure, i.e. **sound-pressure level L,** is more convenient, giving easier-to-follow figures. L is 20 times the logarithm of sound pressure referrred to the hearing threshold of 2×10^{-5} Pa and is **measured in dB.** The human ear responds to sound-pressure levels from 0 to 130 dB (see dB scale on preceding page). A level increase of 10 dB corresponds approximately to a doubling of the loudness sensation as registered by the ear.

To take account of the strong frequency dependence of loudness sensation, sound-level meters must be provided with **frequency weighting** networks. Four weighting curves, A, B, C and D are internationally standardized. The present tendency toward unification and simplification has led to curve A now being prescribed for the large majority of measurements. Aircraft noise is measured using curve D, see diagram below.



Relative attenuation of weighting networks referred to 1 kHz

The measured quantity is denoted weighted sound level – or simply **sound level** – if a weighting filter is used for the measurement (without filter, sound-pressure level is measured). The weighting curve used is indicated as an index to the symbol L, for instance L_A, L_D. When specifying results, the index letter is often added in parentheses to the unit, e.g. 70 dB (A).

Noise measurements, in particular, call for a distinction to be made between the

instantaneous sound level L and the
equivalent sound level L_{eq} averaged over a predetermined period of time.

A measurement of **instantaneous values** permits observation or recording of sound-level variations with time. Applications are most diversified, e.g. checking noise-abating measures on machines or determining sound propagation in rooms, building or residential areas.

Time weighting. Almost all instantaneous-value sound-level meters have analog meter indication since this is best suited to the visualization of varying levels. Depending on the complexity and price class of the instrument, the time weightings
fast,
slow,
impulse,
peak and
maximum hold
can be switch-selected.

In the fast mode the indication follows the varying level as quickly as permitted by the meter response (τ=125 ms); with slow, very unsteady pointer movements are electrically damped. With impulse weighting a circuit whose time constant is τ=3 s holds impulse sound events such that their rms value can be read. The peak mode measures the peak value (not rms) of even shorter sound pulses, e.g. shots.

The time weighting is indicated by a second index to the quantity symbol: F meaning fast, S slow and I impulse. With frequency weighting A, for example, there are three level designations: L_{AF}, L_{AS} and L_{AI}.

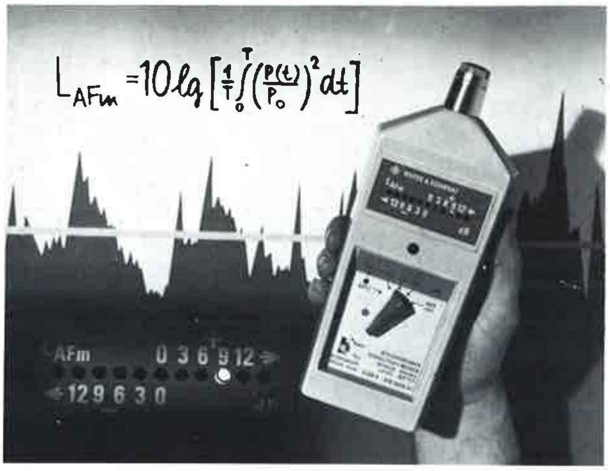
Below: Instantaneous-value measurement using Impulse Sound-level Meter EGT on large building site

Characteristics of sound-level meters. The requirements are laid down in IEC and DIN standards. Precision instruments must comply with DIN standard IEC 651. This standard distinguishes between four classes numbered from 0 to 3 each with its own set of specifications defined. Class 1 (Type 1) is identical with the requirements of DIN 45 633, 1 and 2, and class 2 (Type 2) is in line with DIN 45 634. The qualification in line with these standards can be certified in Germany by type-approval through PTB (Federal-German Office of Standards). Thereby the instruments are admitted for official calibration, which is required in many cases. The user of a type-approved instrument is always sure that it complies with the relevant standard specifications.

Integrating sound-level meters have gained special importance in the last few years. They evaluate the varying sound level accurring over a predetermined time, e.g. a work shift, and form the mean sound level whose annoyance effect is assumed to be equal to the actual sound effect. The mean level is used for comparsion of the different noise levels.

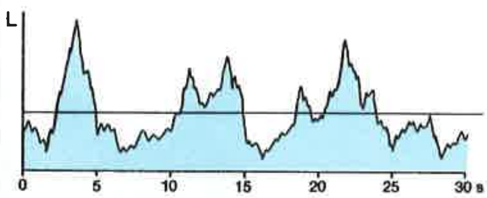
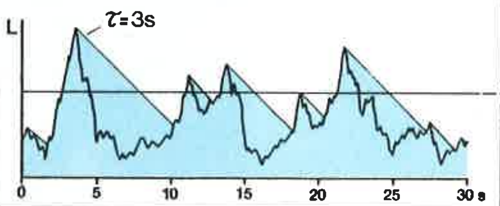
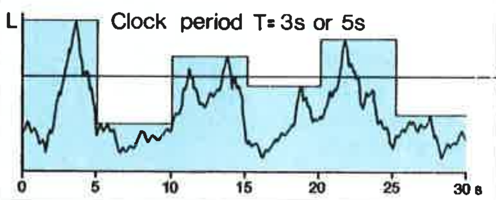
DIN 45 641 and 45 645 specify two variants of mean level L_m, namely the equivalent continuous sound level L_{eq} and the rating level L_r. The latter rates impulse sound higher than L_{eq} because of the higher annoyance it causes to man. In the Federal Republic of Germany L_r is commonly referred to for noise at places of work, whereas traffic noise, which contains few impulse components, is generally assessed by L_{eq}. The present international standards ISO R 1996 and ISO R 1999 refer to L_{eq} only.

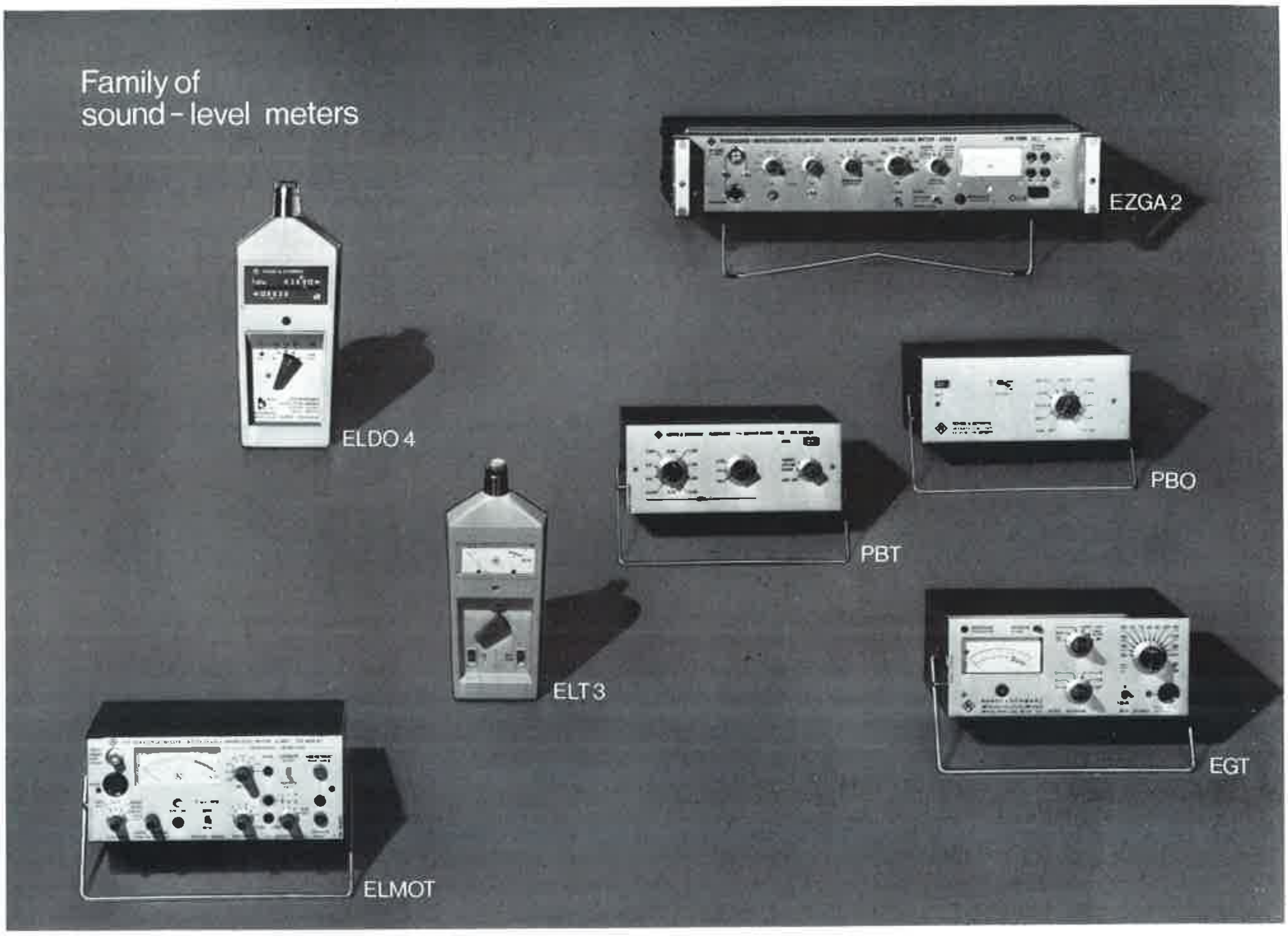
The rating level can be obtained by two different methods leading practically to the same result. Graphs of the different weighting modes and associated designations are compiled in the table below, as many users may not yet be familiar with these distinctions.



The Integrating Sound-level Meter ELDO 4 gives a direct indication of the mean sound level for the selected measurement duration

Below: Relationship between time-weigthing modes and mean levels

Mean levels L_m with different time weightings acc. to DIN 45645 $L_m = 10 \log_{10}\left[\frac{1}{T}\int_0^T 10^{0.1L(t)} dt\right]$			
Time weighting	Measured quantity before averaging	Sound-level integration (example: impulsive sound)	Designation of mean level
FAST or SLOW $L_{AFm} = L_{ASm} = L_{eq}$	L_{AF}		equivalent continuous level L_{eq} — mean level L_m
IMPULSE	L_{AI}		L_{AIm} — rating sound level L_r
FAST with clocked max. hold	L_{AFT}		L_{AFTm}
Index A stands for frequency weighting according to curve A			L_r weighting of impulsive sound gives higher value than L_{eq}



All instantaneous-value reading R&S sound-level meters are type-approved, i.e. they are admitted for calibration by PTB (Federal-German Office of Standards).

Overview of sound-level meter data

Frequency range	Designation	Type	Order No.	Measurement range	Time weighting, meas. quantity	Error limits	Standard	Dimensions (W×H×D) in mm	Text on page
Instantaneous-value sound-level meters									
16 Hz to 16 kHz	Sound-level Meter	ELT 3	215.8510.02	25 to 120 dB	F / S	1 dB	DIN 45634 IEC 123 IEC 651 Typ 2	104 × 233 × 43	274
10 Hz to 20 kHz	Portable Impulse Sound-level Meter	EGT	220.5174.02	24 to 160 dB	F / S / I max.-value store	1 dB	DIN 45633, sheets 1 & 2 IEC 179, 651 Typ 1	212 × 88 × 158	275
10 Hz to 20 kHz	Precision Impulse Sound-level Meter	EZGA 2	220.7660.02	20 to 160 dB	F / S / I / Peak max.-value store	1 dB	DIN 45633, sheets 1 & 2 IEC 179, 651 Typ 1	484 × 105 × 336	276
10 Hz to 20 kHz	Motor-vehicle Sound-level Meter	ELMOT	235.4010.02	55 to 130 dB	F / S max.-value store	1 dB	DIN 45633 IEC 179 IEC 651, Typ 1	218 × 88 × 158	278
Integrating sound-level meters									
16 Hz to 16 kHz	Integrating Sound-level Meter	ELDO 4	219.4026.02	43 to 100 dB	L_{AFm} (= L_{eq})	1 dB response tolerance of LEDs		104 × 233 × 43	280

ELT 3

Sound-level Meter ELT 3

◆ 16 Hz to 16 kHz/25 to 120 dB

- High-performance and inexpensive sound-level meter with measuring range starting at 25 dB, thus also suitable for measuring night-time noise
- Type-approved by PTB; admitted for official calibration and for measurements good in law
- Measuring characteristics in line with DIN 45634 and IEC 651 Type 2
- With capacitor microphone; insensitive to structureborne vibrations
- AC output: for connection of Sound-level Integrator ELDO 1
- Minimal current drain: >200 h per battery

Scale 1:3

The **Sound-level Meter ELT 3** is a new and very inexpensive instrument with measuring characteristics in line with DIN 45634 and IEC 651 Type 2. Several features, such as pickup pattern and sound-volume range, also comply with DIN 45633, IEC 179.

The ELT 3 comes in a flat and compact format at low weight.

Due to the good performance and handiness, the Sound-level Meter ELT 3 is suitable for a wide variety of applications, e.g. for noise measurements in industry or traffic, in residential areas or for investigations made by health service. The wide level range permits measurements of sound events ranging from the loudest noise to levels that lie below the values permissible in residential areas at night.

Simple operation renders the ELT 3 suitable for use even by non-technical personnel.

Microphone. The capacitor microphone that is used makes the instrument largely insensitive to structureborne vibrations, e.g. in applications in vehicles. Pressure compensation in the microphone eliminates the effects of fluctuating air pressure.

Indication, weighting. The ELT 3 indicates the rms value of sound level with A weighting in dB, and can be switched to fast or slow response.

Calibration. Absolute calibration of the sound-level meter is possible with the Sound-level Calibrator ELEB, see page 283.

Output. An AC output (0.8 V_{rms} at fsd) enables connection of a sound-level integrator for example. This combination is an extremely favourably priced, portable measuring setup for determining equivalent continuous sound level L_{eq} or mean level of varying noise, for example.

The 9-V battery of the power supply suffices for over 200 hours of operation.

Specifications

(Characteristics comply with DIN 45634 and IEC 651 Type 2)

Measuring range	25 to 120 dB(A) over p_o ($p_o = 2\times10^{-5}$ Pa = 0 dB)
Range switching	in 10-dB steps
Error limits	±1 dB
Frequency range	16 Hz to 16 kHz
Indication	built-in meter with rms-responding rectification
Meter speeds	fast/slow
Scale	−5 to 0 to +10 dB, battery check
Precision microphone	capacitor microphone, omnidirectional characteristic
Main direction of sound incidence	from front along longitudinal axis of set
Operating temperature range	−10 to +50 °C
Temperature dependence, referred to 20 °C	<0.5 dB
AC output	0.8 V_{rms} at fsd
Power supply	9-V battery (IEC 6 F 22); battery check on meter
Average battery life	>200 h
Dimensions, weight	104 mm × 233 mm × 43 mm, 0.55 kg

Ordering information

Order designation	▶ Sound-level Meter ELT3 215.8510.02
Accessories supplied*)	battery, carrying case
Recommended extras	Wind Screen MKPM-Z 100.5810.02 Tripod Bracket ELT-Z3 215.8940.02 Tripod MKPM-Z2 154.5899.02
For measurements near ground level	Tripod Mount ELT-Z 215.9469.02
Sound-level Calibrator ELEB	201.5443.90

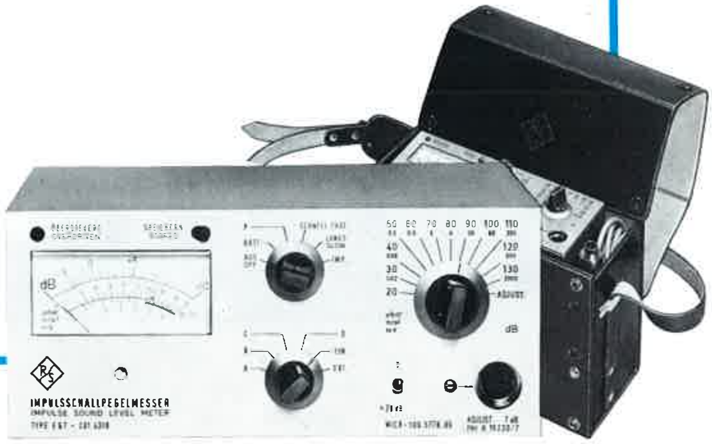
*) If a calibration certificate is required, the instrument will be forwarded to the respective authority for calibration and delivery.

Impulse Sound-level Meter EGT

EGT

♦ 10 Hz to 20 kHz/24 to 160 dB

- Type-approved by PTB; admitted for official calibration and for measurements good in law; precision data in line with DIN 45633, IEC 651 Type 1, IEC 179
- Noise measurement with weighting curves A, B, C and D, with linear response or via external filters
- Recording outputs, AC or battery power supply



The portable **Impulse Sound-level Meter EGT** covers the wide test range of 24 to 160 dB and fulfils the requirements of the German Standard DIN 45633, sheet 1, for presicion sound-level meters, and sheet 2 for impulse sound-level meters, and of IEC 651 Type 1.

Microphone. The Standard Microphone MKPM is used as an electro-acoustic transducer (capacitor-type microphone with two-stage impedance transformer), receiving its polarizing and supply voltage from the EGT. Its low-impedance output makes the use of long connecting cables possible (up to 100 m). The microphone capsule can be replaced by the Adapter 100.5803.02 for connection of the Acceleration Pickup EBVB. Acceleration measurements can then be performed.

Test range (sensitivity). The total range of 24 to 160 dB is covered as follows: Switchable in 10-dB steps from 24 to 130 dB, +10 dB fsd on panel meter, +20 dB by reducing the polarizing voltage of the microphone.

Weighting. A, B, C, D and linear can be selected as required. In addition, external filters can be connected via BNC sockets, the 3-dB insertion loss being compensated in the EGT.

Indication. The test result is shown on a moving-coil meter with rms rectification. Scale calibration −5 to +10 dB with resolution of 1 dB. Overdriving (e.g. extreme peak factors) is signalled by a warning lamp. By means of a push/slide switch it is possible to hold the maximum meter indication of a transient event.

Calibration check is provided by feeding an internal calibration voltage to the microphone capsule.

Outputs. The weighted AC signal voltage is available at the AF output, e.g. for recording on tape or for an AC-voltage recorder.

Power supply. Instead of the usual 1.5-V single cells an accumulator or a power supply/charger can be employed.

Carrying case. This is supplied with the instrument and can also hold the microphone and spare batteries. A double case accommodating the EGT plus an octave or third-octave filter (see page 282) is available as an extra.

Specifications

Frequency	10 Hz to 20 kHz
Ranges	
for weighted sound level	24 to 160 dB
with external filters	15 to 160 dB
for sound-pressure measurement	0.01 to 20,000 µbar
for acceleration measurement	0.01 to 2000 m/s²
for voltage measurement	0.01 to 2000 mV
Equivalent noise level (with microphone)	weighting A B C D lin; dB 18 18 21 24 27
External filter connection	BNC, Z = 600 Ω
Indication	rms/fast/slow/impulse; stored: discharge <0.5 dB/min
Scala	−5 to 0 to +10 dB
Error limits (normal)	±1 dB
Outputs, AC	2 V, 100 Ω
DC	2 V fsd, 200 kΩ
Dimensions, weight	212 mm × 88 mm × 158 mm, 2.7 kg

Ordering information

Order designation ▶ Impulse Sound-level Meter EGT

EGT incl. carrying case and batteries, plus Microphone MKPM, 1.2-m cable and wind screen 220.5174.02

Recommended accessories for the EGT*)

	Order Nos.	Page
For airborne-sound measurements		
Standard Microphone MKPM (second microphone with 1.2-m cable)	220.5180.02	283
Microphone cable		
1.2 m	100.5784.05	
5 m	100.5784.02	
10 m	100.5784.03	
20 m	100.5784.04	
50 m	100.5784.06	
Tripod MKPM-Z2	154.5899.02	
For vibration measurements		
Acceleration Pickup EBVB		
sensitive to acceleration	100.5890.02	283
sensitive to force and accel.	100.5884.02	283
EBVB Adapter	100.5803.02	
Impedance transformer	110.0410.02	
For selective measurements		
Octave Filter PBO	201.5520.02	282
Third-octave Filter PBT	235.3014.02	
Connecting Cable EGT-Z (PBO/PBT)	205.3016.02	
For voltage measurements		
Voltage Adapter EGT-Z	201.5489.02	
Power supply		
Lead Storage Battery EGT-Z	201.5437.00	
Power Supply/Charger EGT-Z	201.5414.00	
Calibration equipment		
Sound-level Calibrator ELEB	201.5443.90	283
Recording equipment		
YT recorder	please enquire	
Connecting cable for tape recorder	201.5514.02	
Carrying Case EGT-Z	201.5508.02	
Double case (leather)	201.5337.00	

*) If a calibration certificate is required, the instrument will be forwarded to the respective authority for calibration and delivery.

EZGA 2

Precision Impulse Sound-level Meter EZGA 2

- 10 Hz to 20 kHz/ 20 to 160 dB
- Type-approved by PTB; admitted for official calibration and for measurements good in law
- Precision data in line with DIN 45633 and IEC 651 Type 1
- Weighted (A, B, C, D) and linear response

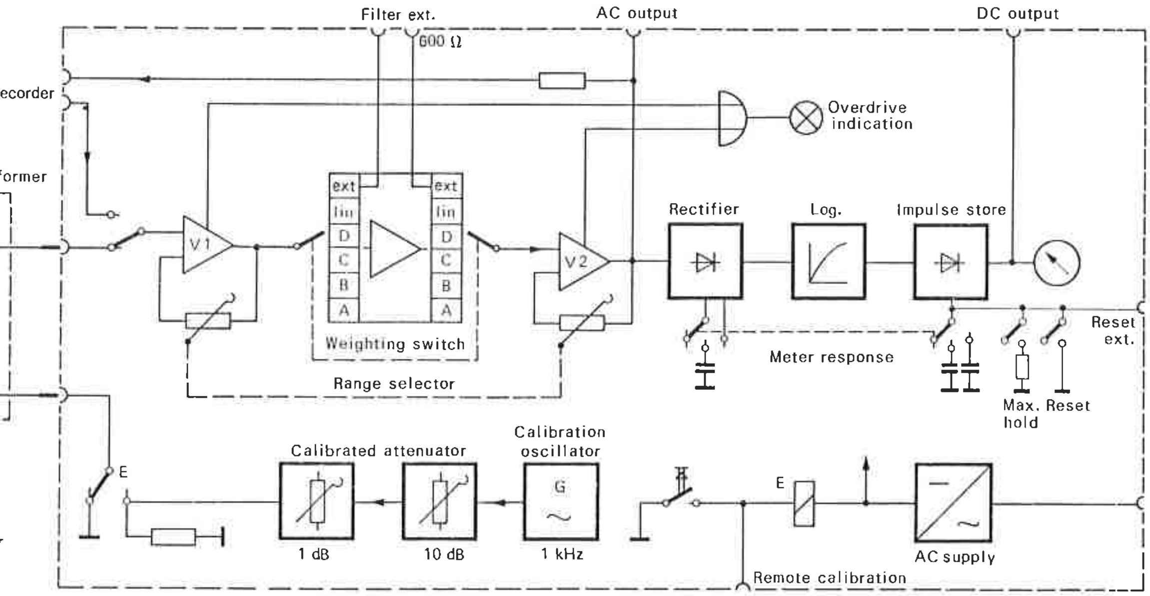
The **Impulse Sound-level Meter EZGA 2** is ideal for use in test setups or systems for acoustic measurements. it is particularly suitable for long-term noise monitoring and recording, for the determination of the noise-exposure index, and for sound analyses in conjunction with external filters. The EZGA 2 complies with DIN 45 633, sheets 1+2, and IEC 651 Type 1. The wide dynamic range of the logarithmic DC output and the remote-control capability render the EZGA 2 particularly suitable for use in automated test systems incorporating data-processing equipment.

Indication and dynamic range. The extremely wide logarithmic indicating range of 50 dB and the 75-dB dynamic range of the rms-responding rectifier enable long-term measurements to be made without range switching.

Modes of indication. Any of the four modes, i.e. FAST, SLOW, PULSE and PEAK, can be switched so that either the instantaneous signal level or the maximum level is indicated. The maximum level is stored and can be erased with a switch on the front panel or by remote control, an important prerequisite for use in automated systems.

Level calibration. The built-in calibration generator can be adjusted in 1-dB steps between 50 and 130 dB by local or remote control. Any calibration level can thus be applied as a reference during long-term noise recording.

Recording outputs. The EZGA 2 is provided with AC and DC and DC outputs and with a socket for the connection of a tape recorder. AC and DC recording outputs with a dynamic range of about 60 dB (crest factor+15 dB) are provided; of particular importance is the logarithmic DC output which permits wideband level recording on DC recorders without great demands on the speed of the recorder.



Block diagram of Impulse Sound-level Meter EZGA 2 with microphone

Microphone. The capacitor-type Standard Microphone MKPM (page 283) can be electrically heated from the EZGA 2 and is thus optimally protected against environmental influences. For fixed outdoor use, the microphone can also be supplied with a weather shield. The low output impedance of the MKPM permits the use of connecting cables up to 100 m long.

Acceleration measurements between 0.003 and 3000 m/s^2 can be made in conjunction with an acceleration pickup and adapter, see under MKPM. Connection is made via the impedance transformer of the microphone after unscrewing the microphone capsule.

Description

The signal voltage delivered by the microphone first passes through the impedance converter V0 and the amplifiers V1 and V2 with weighting filters connected in between; see block diagram on the preceding page. The feedback networks are coupled to the range selector and determine the sensitivity of the instrument, which may be between 40 and 110 dB for a 0-dB reading on the meter (fsd = +30 dB). In addition, the polarizing voltage (150 V) of the microphone can be reduced by 20 dB thereby increasing the upper sound-pressure limit to 160 dB.

The output signal of amplifier V2 is then applied to an rms-responding rectifier, which can also be switched to peak-responsive rectification; this is followed by a logarithmic-function generator. The output of the subsequent holding circuit for impulse operation or storage is connected to the panel meter with parallel DC measuring or recording ouput.

The AC amplifiers can be overdriven by 14 dB (crest factor 5). An overdrive indicator with a response time of <1 ms monitors the amplifiers V1 and V2, which would otherwise be endangered in the case of excessive overdriving. To check the calibration, a reference voltage can be applied to the low end of the microphone[1]). This voltage can also be used for checking the voltage divider of the range selector and the accuracy of the scale.

[1]) The calibration signal is taken via the capacitance of the microphone so that the effects of the impedance transformer and microphone cable are also taken into account.

Specifications

Frequency range .... 10 Hz to 20 kHz

Frequency response (linear mode)
- without microphone .... <0.5 dB (20 Hz to 16 kHz)
- with Microphone MKPM .... <1.0 dB (20 Hz to 16 kHz); <3.0 dB (10 Hz to 20 kHz)

Frequency weighting .... A, B, C, D, LINEAR and FILTER EXT.

Sound-level range .... 20 to 160 dB

Equivalent sound level and lower response threshold (with Microphone MKPM)

	equivalent sound level (max.) dB	lower response threshold (max.) dB
with weighting curve A	22	27
B	24	29
C	27	32
D	30	35
LIN	30	35
FILTER EXT.		20

Indication .... by panel meter with logarithmic 50-dB scale; 0-dB point shiftable in 10-dB steps

Scale engraving .... −20 to 0 to +30 dB, measuring range: 0 to +30 dB range overlap: −20 to 0 dB

Rectifier .... rms-responding (calibrated at max. output with test-signal crest factor of 5)

Time weighting .... FAST, SLOW, PULSE, PEAK (rise time <200 µs, fall-off ≈1 dB/s) MAX. HOLD for any of the above four modes (fall-off <0.2 dB/ min)

Overdrive indication .... by signal lamp; response time 200 µs, minimum on-time ≈500 ms

Error limits

Under normal conditions (acc. to DIN 45633), including microphone .... <1 dB

Additional error caused by temperature variations
- between −10 and +50°C .... <0.5 dB
- variation of relative humidity between 10 and 90% .... <0.3 dB
- variation of barometric pressure by ±10% .... <0.2 dB

Effect of non-audio interference

Mechanical vibrations of 1 m/s^2 (rms) in the frequency range from 20 to 1000 Hz .... max. 90 dB equivalent sound level

Electromagnetic field of 80 A/m (rms) at 50 Hz .... max. 80 dB equivalent sound level

With the indication-mode selector set to PEAK, the error limits specified only apply to the scale range from −10 to +30 dB.

Calibration .... by built-in 1-kHz oscillator; calibration signal is applied via microphone capacitor

Attenuator .... for adjustment of calibration level in 1-dB steps between 50 and 130 dB

Standards complied with .... DIN 45633, sheets 1 and 2, IEC 179 and 179 A, IEC Draft Type 1, ANSI Type 1

Connections

Microphone .... 6-pole socket for Standard Microphone MKPM

Tape recorder .... 3-pole socket for 200-mV AC output and for input (input voltage adjustable between 0 and 10 V)

AC output .... 2.5 V_{rms} at fsd, 600 Ω, 4-mm-connector strip on rear panel

DC output .... +2.5 V at fsd (50 mV/dB), 600 Ω, 4-mm-connector strip on rear panel

Remote control .... a) switchover to calibration signal b) erasure of MAX. HOLD store

External filter .... via rear BNC sockets, 600 Ω

General data

Storage temperature range .... −40 to +60°C

AC supply .... 110 to 125/220 to 235 V +10/−15%, 47 to 63 Hz (5 VA)

Dimensions with cabinet .... 484 mm × 105 mm × 336 mm

Weight 19" cabinet model/ rackmount .... 7.1 kg/4.75 kg

Ordering information

Order designation .... ▶ Precision Impulse Sound-level Meter EZGA 2
- 19" cabinet model 220.7660.02
- 19" rackmount .... 220.7660.03 (one mating multipoint connector for rear inputs is supplied)

Accessories supplied .... 1 power cable

Recommended extras*)

Standard Microphone MKPM 220.5180.02
Sound-level Calibrator ELEB 201.5443.90
Wind Screen for MKPM 220.9005.03

*) If a calibration certificate is required, the instrument will be forwarded to the respective authority for calibration and delivery.

ELMOT Motor-vehicle Sound-level Meter ELMOT

♦ 10 Hz to 20 kHz/55 to 130 dB (A)

- Sound-level meter and rpm counter in one instrument, combined indication
- Characteristics comply with ISO standard, ISO/DIS 5130 and EC guidelines for measurement of noise in immendiate vicinity of stationary vehicles
- Sound-level measurement according to DIN 45 633 and IEC 179; type-approved by PTB; admitted for official calibration and for measurements good in law
- Logic-circuit enables one-man operation in combined sound-level/rpm measurement
- Rapid readiness for use with contactless rpm probe

General remarks on motor-vehicle noise measurement

Noise measurements on motor vehicles according to the earlier valid standard ISO R 362 were practically impossible on a large scale and in vehicle maintenance and traffic checks because of the test conditions laid down, for instance the large distance of 7 meters at which the measurement was to be made.

The **measurement of noise in the immediate vicinity of stationary vehicles** offers a better solution. Relevant standards – ISO/DIS 5130 and EC guidelines – have already been introduced. The measuring distance will be reduced to 0.5 meters and the disturbance caused by ambient noises and reflections thus largely eliminated.

The **measuring method** provides for the testing of a stationary motor vehicle under certain conditions and with the microphone located very near: to one side of the exhaust outlet at a distance of 0.5 meters, and at an angle of 45° to the vertical plane of the direction of the exhaust emissions with the engine running at 75% of the speed at which maximum horsepower is developed.

To enable efficient measurements under these conditions (one-man operation) and with optimum setting accuracy, Rohde & Schwarz developed the

Motor-vehicle Sound-level Meter ELMOT

The combination in this instrument of rpm and sound-level measurement, plus a logic circuit, simplifies and automates the measurement of vehicle noise. The measurement becomes devoid of problems and can be performed by a single person with no worries about errors in setting or readout. Rpm is measured by means of a contactless inductive rpm probe clamped on a spark-plug cable. Apart from two-stroke and four-stroke engines no further distinction need be made between engine types as in the case of capacitive probes. The ELMOT is battery-powered, compact and complies in precision with DIN 45 633; it is type-approved by PTB and admitted for official calibration.

Uses

The features of the ELMOT were selected so that it can be employed by automobile manufacturers in development and testing, by vehicle-inspection authorities, motor workshops and, primarily, by the police. In addition to its mode of operation with automatic coupling of rpm and sound-level measurement, this instrument can also be used as an independent sound-level meter or revolution counter. With an XY recorder connected to the DC outputs it is also possible to display logarithmic sound-level characteristics over 40 dB as a function of rpm.

Operation

Setting, reference value. The reference value for the operating conditions of an engine is the engine speed S at which it produces its maximum horsepower. The standard gives three versions:

I Stabilization to ¾ S (or ½ S for motorcycles with S >5000 rpm).

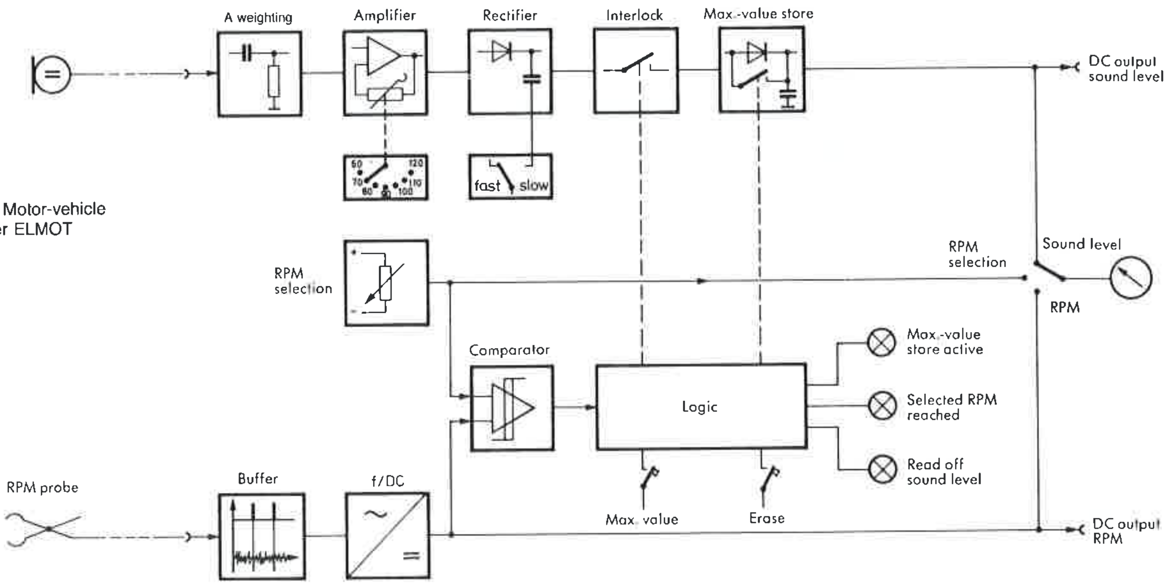
II As under I and then sudden release of the throttle; only the highest sound level that occurs is noted.

III Sudden increase of rpm (or by pumping) to ¾ S (½ S), and again only the highest sound level is noted.

Measuring procedure. The complete process is as follows:

1) Set up microphone next to exhaust.
2) Lift engine bonnet and clamp rpm probe to spark-plug cable.
3) Sit in driver's seat with ELMOT and start engine. Turn ELMOT rotary switch "automatic" to setting 1 (¾ S), for example, and select rpm.

When the throttle is operated, the ELMOT meter indicates the rpm and a red LED signals when the preselected rpm (±2%) is reached. At the same time the measured sound level is electronically stored. If the rpm figure remains within the tolerance for at least 1 s, a yellow LED ("level") signals that the held sound-level value can be read off.



Block diagram of Motor-vehicle Sound-level Meter ELMOT

Features

With diesel engines the rpm cannot be electrically determined. This is possible using an optical probe which is available as an accessory.

Indication of maximum sound level. This device enables reliable measurement of the noise of moving vehicles. From the side of the road, for example, it is possible to ascertain immediately whether a conspicuously noisy vehicle is louder than prescribed limits and should be stopped for a noise measurement which could then, if necessary, be used as legal evidence.

Shortened measurement time. The measurement time can be factory-adjusted to 0.2 s instead of 1 s on customer's request. This is preferable, for example, for measuring racing motorcycles of very high rpm, which by present rules have to be tested before every contest.

DC output for logarithmic sound-level characteristics. In many special investigations it is desirable to plot sound level versus rpm using an XY recorder. Here logarithmic level representation offers better evaluation.

Robust and handy tripod and microphone holder. These parts are designed to withstand the rough handling encountered in practice, for example, in motor car repair shops. The holder is provided with a device for setting distance and angle.

Specifications

Sound-level meter
(all characteristics comply with DIN 45633 and IEC 651 Type 1, IEC 179)

Frequency range	10 Hz to 20 kHz
Measurement range	55 to 130 dB (A)
Range selection	in 10-dB steps
Indication	moving-coil meter with rms-responding rectification
Scale range	−5 to 0 to +10 dB
Time weighting	fast, slow, max. hold
Frequency weighting	curve A
Error limits	±1 dB
Precision microphone	Type MKPM (DIN 45633)
Internal calibration	by stabilized voltage, f = 1 kHz
DC output	log 50 mV/dB lin 2 V at fsd
AC output	2 V_{rms} at fsd

All outputs shortcircuit-proof

Rpm counter

Measurement ranges	2000/4000/8000/16000 rpm
Error	±3%
Rpm measurement	via spark-plug cables by means of inductive rpm probe
DC output	+2 V
Automatic evalution circuit	holds sound level when preset rpm are reached
Engine conditions	I for n = ¾ S II for n ≦ ¾ S downwards III for n ≦ ¾ S upwards

General data

Rated temperature range	−10 to +50°C
Power supply	4 single cells IEC R 20 or storage battery or power supply
Duration of battery-powered operation	≈100 h
Dimensions, weight	218 mm×88 mm×158 mm, 2.6 kg

Ordering information

Order designations .... ▶ Motor-vehicle Sound-level Meter ELMOT 235.4010.02

Accessories supplied[1]: .... Standard Microphone MKPM with 5 m microphone cable, tripod with carrying case and setting-up plate, rpm probe, cable, set of single cells and carrying cases for ELMOT and for accessories

Recommended extras

Lead Storage Battery EGT-Z	201.5437.00
Power Supply/Charger EGT-Z	201.5414.00
Optical RPM Probe ELMOT-Z for diesel engines	235.5900.02
Sound-level Calibrator ELEB	201.5443.90

[1]) If a calibration certificate is required, the instrument will be forwarded to the respective authority for calibration and delivery.

ELDO 4

Scale: 1:3

Integrating Sound-level Meter ELDO 4

♦ 16 Hz to 16 kHz/43 to 100 dB

- For quick noise measurements at places of work and residential areas – handheld or on tripod
- Direct indication of equivalent continuous sound level L_{eq} in line with DIN 45641 and 45645
- Choice of six meassurement durations from 15 s to 8 h
- Inexpensive

Measuring and averaging sound levels

Noise exposure caused by sound events varying in time can only be determined by averaging the sound level over the period in question: **Mean sound levels** cannot be measured with conventional instantaneous-value soundlevel meters. The integrating sound-level meters required for this purpose need more elaborate circuitry and are consequently more expensive.

The **Integrating Sound-level Meter ELDO 4** from Rohde & Schwarz, based on a new circuit concept, indicates the equivalent continuous sound level directly in dB. It is offered at an expectionally low price.

To take a measurement with ELDO 4 simply

- select measurement duration
- select level range
- wait until measurement duration has elapsed and
- take reading

Characteristics and uses

Three measurement ranges adapted to the German regulations concerning noise at places of work:

Signalling by LEDs in 3-dB steps:

red if level is above limit,

green if level is below limit.

Hand-held for quick rough measurements,
mounted on tripod for long-term measurements.

The Integrating Sound-level Meter makes noise control as laid down by national and international regulations easy. Thanks to its light construction intended for mobile use it is equally suitable for measuring noise at the place of work or traffic noise and for noise evaluation in residential areas.

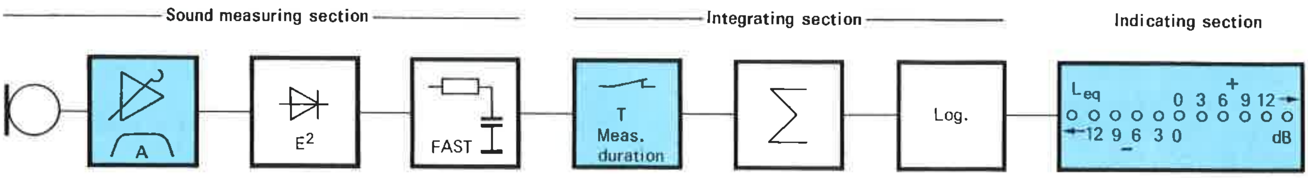
Operation is simple: there are only two switches, one for measurement duration and one for measurement range.

Measurement duration is selected by means of a sliding switch. It is factory-adjusted to 15 s and 4 min. Any desired combination of two of the available times – 15 s, 1 min, 4 min, 15 min, 1 h, 8 h – can be taken to the switch by resoldering, say 15 s and 8 h. A duration of 8 hours (full work shift) is required for measurements at places of work with greatly varying noise levels, while by random measurements of short duration it is possible to get a rough idea of the noise environment.

The measurement range extends from 43 to 100 dB and is divided into three switch-selected, generously overlapping subranges. The subranges are based on the Federal-German regulations for places of work stipulating noise limits for different types of work:

55 dB(A)	for primarily brainwork
70 dB(A)	for simple or to a great extent mechanized office work or comparable activities
85 dB(A)	for any other activities; under certain circumstances, which must be justified up to 90 dB(A).

Block diagram of ELDO 4



These limits are the centre values of the ELDO 4 subranges. A symmetrically arranged LED scale (red for + and green for −) directly indicates the amount by which the measured value is above or below the selected noise limit. The measured value is always to the right of the indicated figure. If, for example, +6 dB is indicated and the range selected is 70 dB, the measured value is above 76 dB, more precisely between 76 and 79 dB.

The 3-dB resolution is adequate for coarse measurements. The response tolerance of the LEDs is ±1 dB.

Although not used for traffic-noise measurements, a **rating sound level** L_r is encountered in the regulations governing noise at work. This quantity accounts for the higher annoyance effect of **impulsive noise** and can be computed from the equivalent noise level L_{eq} by adding 3 or 6 dB as given in DIN 45645. Some examples:

Add 0 dB for constant or slowly varying noise levels such as from motors and textile machinery;

Add 3 dB for moderately impulsive noise such as in offices, workshops and assembly areas;

Add 6 dB for markedly impulsive noise such as encountered in press shops and forges.

Quick rough measurement with hand-held ELDO 4

Description

The Integrating Sound-level Meter ELDO 4 consists of an analog sound measuring section (similar to that of the Sound-level Meter ELT 3), a digital integrating section and an indicating section (see block diagram at the bottom of preceding page).

The sound measuring section is made up of a capacitor microphone, a switchable amplifier with frequency weighting filter according to curve A and a square-law rectifier with FAST time weighting.

The DC signal is applied to the integrator by means of the measurement duration selector. After several logic functions have been performed in the integrator the logarithmized integration value is passed on to the indicating section in 3-dB steps.

The three measurement ranges are switched over in the analog section. The eleven indicating LEDs are symmetrically arranged about the reference level values 55/70/85 dB, i.e. each range covers 27 dB, namely −12 to 0 to +15 dB. Moreover, another two LEDs are provided to indicate when the range is exceeded or not reached.

Still another LED is provided beside the measurement range selector (position BATT./CAL.) for checking the battery voltage and for calibration. Use of CMOS integrated circuits ensures that very little current is required by the circuit, which is fed from a commercially available 9-V battery.

The plastic case is very handy and robust. Its shape takes into consideration the omnidirectional pickup pattern of the microphone, allowing for any direction of incidence of the noise. For long-time measurements the meter can be mounted on a tripod by means of a bracket. A carrying case is supplied with the meter for protection during transportation.

Specifications

Frequency range .... 16 Hz to 16 kHz
Indication .... equivalent continuous sound level L_{eq} according to DIN 45641 and 45645
Measurement ranges (A weighting) .... 55 dB −12/+15 dB
70 dB −12/+15 dB
85 dB −12/+15 dB
Display of test value .... by LEDs

Reference level		Colour	Indication in dB	Test value step in dB
	Not reached	green	←	below −12
			−12	−12 to −9
			−9	−9 to −6
			−6	−6 to −3
			−3	−3 to 0
	Exceeded	red	0	0 to +3
			+3	+3 to +6
			+6	+6 to +9
			+9	+9 to +12
			+12	+12 to +15
			→	above +15

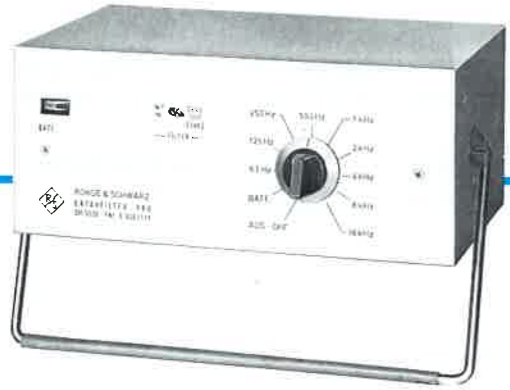
Error of LED response .... <1 dB
Error of range switching .... <0.5 dB max.
Inherent noise .... 10 dB below lower range limit
Type of rectifier .... rms-responding square-law rectifier
Crest factor .... 14 dB above +12-dB indication
Exchange rate .... 3 dB
Frequency weighting .... A-weighting curve
Time weighting .... FAST
Measurement duration,
switch-selected .... 15 s/4 min (factory-adjusted),
adjustable .... to any combination of two out of 15 s, 1 min, 4 min, 15 min, 1 h, 8 h by resoldering
Precision microphone .... capacitor microphone with omnidirectional pickup pattern
Power supply .... 9-V battery IEC 6 F 22
Battery life .... >50 h
Dimensions .... 104 mm×233 mm×43 mm
Order designation .... ▶ Integrating Sound-level Meter ELDO 4 219.4026.02

Accessories supplied:
9-V battery IEC 6 F 22
Adhesive labels for other measurement durations (in the meter)
Carrying case

Recommended extras
Wind Screen MKPM-Z 100.5810.02
Tripod Bracket ELT-Z3 .... 215.8940.02
Tripod MKPM-Z2 (with folding legs) 154.5899.02
Tripod MKPM-Z5 (with screw-in legs) 155.0303.02
Sound-level Calibrator ELEB 201.5443.90

PBT

PBO



Third-octave Filter PBT

♦ 22.4 to 22 400 Hz (f_m=25 to 20 000 Hz)

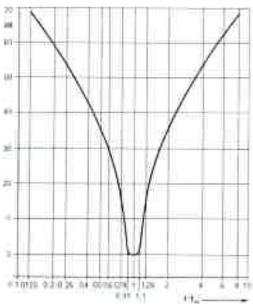
- Auxiliary instrument for acoustic and vibration tests
- High skirt selectivity, passband attenuation 3 dB; performance complying with DIN 45 652
- AC supply or battery operation

Third octave filters are required, for example, in sound-level and vibration analyses or measurements in the field of architectural acoustics to select particular frequencies trom wide spectra or to separate harmonics from fundamentals.

The active **Third-octave Filter PBT** consists of 30 bandpass filters which are switch-selected in ⅓-octave steps. Each is made up of two filter sections which together yield an attenuation characteristic complying with DIN 45 652.

Selection of the bandpass filter (midband frequency) with rotary switches. A DIRECT position is provided to bypass the filter via an internal 3-dB section.

The active section is fed from four 1.5-V single cells (or a power supply or a 6-V storage battery; to be ordered separately).



Typical filter response of a PBT

The plastic cabinet is metallized on the inside. It can be accommodated together with the EGT (Impulse Sound-level Meter) in a double case.

Specifications

Frequency range	22.4 to 22 400 Hz (30 steps)
Midband-frequency intervals	⅓ octave
Passband attenuation	3 dB
Max. input voltage	4.25 V_{rms} on sinewave
Characteristics impedance	600 Ω
Connectors	BNC and 1/3.9 mm coaxial
Dimensions	212 mm×88 mm×158 mm
Weight	2.1 kg (with single cells)

Order designation ▶ Third-octave Filter PBT 235.3014.02
(incl. four single cells)

Recommended extras

2 RF patch cords (100 cm, 75 Ω) 100.6980.10
1 Connecting Cable EGT-Z 205.3016.02 (PBT – EGT)
1 Storage Battery EGT-Z (6 V) 201.5437.00
1 Power Supply EGT-Z (6 V, weight 0.5 kg) 201.5414.00
1 Carrying case 235.5869.00
1 Double case (leather) 201.5337.00

Octave Filter PBO

♦ 45 to 22 400 Hz (f_m=63 to 16 000 Hz)

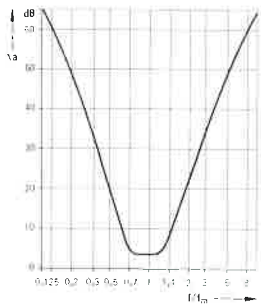
- Auxiliary equipment for acoustic and vibration tests
- Chebishev filter complying with DIN 45651; high skirt selectivity, passband attenuation 3 dB
- AC supply or battery operation

Octave filters are used for the measurement and analysis of the sound level or structure-borne sound in architectural acoustics to separate certain frequency regions from a larger spectrum or harmonics from the fundamental frequency.

The active **Octave Filter PBO** contains nine filters electable in octave steps. The three filter circuits of each octave filter provide an attenuation characteristic according to DIN 45 651.

Selection of the filter (midband frequency) by means of a rotary switch. The selected filter can be bypassed by an internal 3-dB attenuator with the help of a toggle switch.

The active section can be fed either from four 1.5-V dry batteries, a 6-V storage battery or a power supply unit, which must be ordered separately.



Typical filter characteristic of a PBO

The PBO is in a plastic box, metallized on the inside and can be accommodated together with the EGT (Impulse Sound-level Meter) in a double case.

Specifications

Frequency range	45 to 22 400 Hz (9 steps)
Midband-frequency intervalls	1 octave
Passband attenuation	3 dB
Max. input voltage	3.5 V_{rms} on sinewave
Characteristic impedance	600 Ω
Connectors	BNC and 1/3.9 mm coaxial
Dimensions	212 mm×88 mm×158 mm
Weight	2.1 kg (with single cells)

Order designation ▶ Octave Filter PBO 201.5520.02
(incl. four single cells)

Recommended extras

2 RF patch cords (100 cm, 75 Ω) 100.6980.10
1 Connecting Cable EGT-Z 205.3016.02 (PBO – EGT)
1 Storage Battery EGT-Z (6 V) 201.5437.00
1 Power Supply EGT-Z (6 V, weight 0.5 kg) 201.5414.00
1 Carrying case 235.5869.00
1 Double case (leather) 201.5337.00

MKPM

Standard Microphone MKPM ⧫ 8 Hz to 20 kHz

- Sound-pressure measurement range 28 to 150 (166) dB rms on a sinewave; 12 to 150 (166) dB with A-weighting curve
- Precision measurements in line with IEC 651 Type 0, and noise analyses with suitable test equipment
- Weather protection for diaphragm and electrical heater for outdoor use fitted as standard

The capacitor-type **Standard Microphone MKPM** is a multipurpose, electro-acoustic transducer. On account of its excellent characteristics it is mainly used for noise measurements requiring the highest accuracy. It has a low-impedance output so that long connecting cables (up to 100 m) can be used. Precision measurements according to DIN 45633 Bl. 1 and 2, and IEC 651 can be made in conjunction with the Impulse Sound-level Meters EGT and EZGA 2. Accurate noise analyses can be carried out with an analyzer. The MKPM can be electrically heated.

The 150-V polarizing voltage and the supply voltage for the two-stage impedance transformer (30 V; 1 mA) are derived from the test equipment connected, or from batteries. With the polarizing voltage of 150 V it is possible to measure a peak sound pressure of 150 dB, and with 15 V a pressure of 166 dB.

When used together with the Weather Shield MKPM-Z the microphone is ideally suited for long-time measurements in outdoor stations, e.g. for measuring air-traffic noise. This combination is also in line with the requirements of DIN 45643 and of ISO R 3891, R 1761 and R 507.

For acceleration measurements it is merely necessary to exchange the microphone capsule for the Adapter EBVB-Z 100.5803.02 in order to connect the Acceleration Pickup EBVB (right).

Specifications

Frequency range	16 Hz to 16 kHz (within ±1 dB) 8 Hz to 20 kHz (3 dB down)
Free-field voltage response (ref. to 1 kHz, 150 V polarizing voltage)	typ. 18 ±3 mV/Pa (accurate value shown on calibration certificate)
Output impedance	<150 Ω
Inherent noise voltage	≈9 μV_{rms} (Δf 10 Hz to 20 kHz)
Rated temperature range	−30 to +60°C

Ordering information

▶ Order designations

Standard Microphone MKPM (incl. case, calibration certificate, wind screen and microphone attachment)						220.5180.02
Weather Shield MKPM-Z (wind and rain protection)						220.9005.03
Connecting Cable MKPM-Z	1.2 m	5 m	10 m	20 m	50 m	
	100.5784.05	.02	.03	.04	.06	
Tripod MKPM-Z2 (with folding legs)						154.5899.02
Boom MKPM-Z3						154.5901.02
Tripod MKPM-Z5 (with screw-in legs)						155.0303.02

ELEB

(shown on larger scale)

Sound-level Calibrator ELEB ⧫ 1000 Hz

- Acoustic calibrator for sound-level meters
- Sound-pressure level 93.6 dB (94 dB = 1 N/m² = 10 μbar)
- Calibration check independent of weighting

The small, battery-powered **Sound-level Calibrator ELEB** is used for accurate calibration of sound-level meters (e.g. ELT 3, EGT, EZGA 2 and ELMOT from R&S). A 1000-Hz calibration frequency with a sound level of 93.6 dB (±0.25 dB) is generated independently of the weighting filters. The effect of static air pressure is ±0.05 dB/100 mbar between 500 and 1100 mbar.

Calibration. The microphone of the sound-level meter is inserted into the coupler opening of the Sound-level Calibrator, and by pressing a button the 1000-Hz calibration signal of 93.6 dB is switched on. The duration of the signal – approx. 1 min if the 9-V battery is fully charged – indicates the condition of the battery. The sound pressure is independent of the microphone's equivalent volume.

The Sound-level Calibrator is supplied in a leather case. Dimensions of ELEB: dia. 44 mm, length 110 mm; weight 260 g. ▶ Order No. 201.5443.90.

EBVB

Left: EBVB 100.5884.02, sensitive to force and acceleration; right: EBVB 100.5890.02, sensitive to acceleration

Acceleration Pickup EBVB ⧫ 1 Hz to 20 Hz

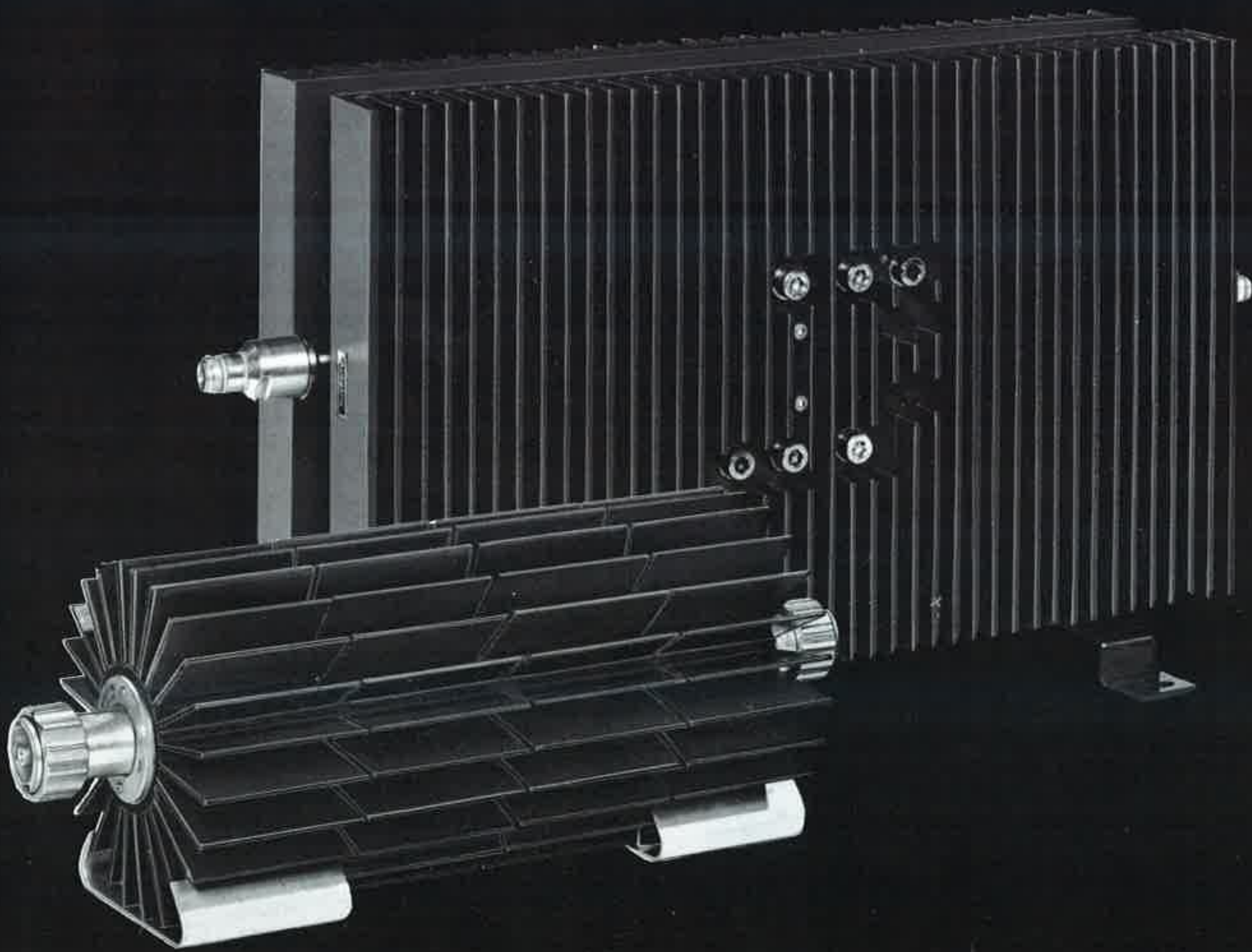
Two different models are available:

1. **Acceleration Pickup sensitive to acceleration only**
   Resonance frequency approx. 60 kHz
   Safe upper load limit 1000 m/s²
   Attached by built-in permanent magnet or adhesive wax
   ▶ Order designation: EBVB 100.5890.02
2. **Acceleration Pickup sensitive to acceleration and force**
   Resonance frequency approx. 20 kHz
   Safe upper load limit 3000 m/s² or 30 N
   ▶ Order designation: EBVB 100.5884.02

For attaching the Acceleration Pickups, adhesive wax suitable for the temperature range between −10 and +80°C is available.

Terminations (dummy antennas) with test output (RBS, RBU);
details on pages 286 ff

Right:
High-precision RF attenuators
with manual control and remote control
via IEC-bus interface (DPSP, below)
and for manual setting only (DPS, right);
details on page 292



10

terminations · attenuators

Terminations and high-power attenuators

RNA

RMF 2

RMF

RMC

RNB

RBD, 3 W

RBU, 100 W

(can be disassembled: 100/80/30 W)

RAU, 100 W

RBS, 1000 W

(shown on smaller scale)

Overview Terminations

Terminations with a power rating of 100 W to 20 kW are listed in the data sheet N 3-123.

Notes: [1]) adaptable [2]) up to 500 MHz [3]) up to 300 MHz [4]) with calibration curve ±0.1 dB.

Terminations for measurements

Power rating W	Designation	Type	Order No.	Characteristic impedance Ω	Frequency range GHz	VSWR	Attenuation dB	Connector	Dimensions mm
0.3	Precision Termination	RNA	272.4510.50	50	0 to 12	<1.02 (1.07)	—	N male	22 dia.×48
0.25	Termination	RMF 2	265.6863.00	75	0 to 0.02	<1.01	—	BNC male	16 dia.×23
0.5	Termination	RMF	100.2927.50	50	0 to 0.03	<1.02 (1.06)	—	BNC male	16 dia.×55
			100.2927.70	75	0 to 0.03	<1.02 (1.06)	—	BNC male	16 dia.×55
1	Termination	RMC	100.2940.50	50	0 to 5	<1.02 (1.03)	—	Dezifix B¹)	45 dia.×55
			100.2940.60	60	0 to 5	<1.02 (1.03)	—	Dezifix B¹)	45 dia.×55
			100.2940.70	75	0 to 3	<1.03	—	Dezifix B¹)	45 dia.×55
		RNB	272.4910.50	50	0 to 4	<1.05 (1.2)	—	N male	21 dia.×35

High-power terminations and high-power attenuators

Power rating W	Designation	Type	Order No.	Characteristic impedance Ω	Frequency range GHz	VSWR	Attenuation dB	Connector	Dimensions mm
3	High-power Attenuator	RBD	100.2962.50	50	0 to 2.4	<1.08²)	10 ±0.2	Dezifix B¹)	48 dia.×140
30	High-power Attenuator	RBU 30	100.8654.25	50	0 to 1	<1.05	20 ±0.2	Dezifix B¹)	140 dia.×180
80		RBU 80	100.8654.05	50	0 to 1	<1.05	3 ±0.2	Dezifix B¹)	140 dia.×180
100		RBU 100	100.8654.35	50	0 to 1	<1.05	30 ±0.2	Dezifix B¹)	140 dia.×390
100		RBU 100	100.8654.15	50	0 to 1	<1.05	10 ±0.2	Dezifix B¹)	140 dia.×320
100	Termination	RAU	200.0019.02	50	0 to 2	<1.05 (1.4)	—	Dezifix B¹)	95×152×235
			200.0325.02	60	0 to 2	<1.05 (1.4)	—	Dezifix B¹)	95×152×235
			200.0019.55	50	0 to 2	<1.05 (1.4)	—	N female	95×152×235
1000	High-power Attenuator	RBS 1000	207.4010.55	50	0 to 0.4 (1)	<1.2	40 ±1⁴)	N female	500×285×152

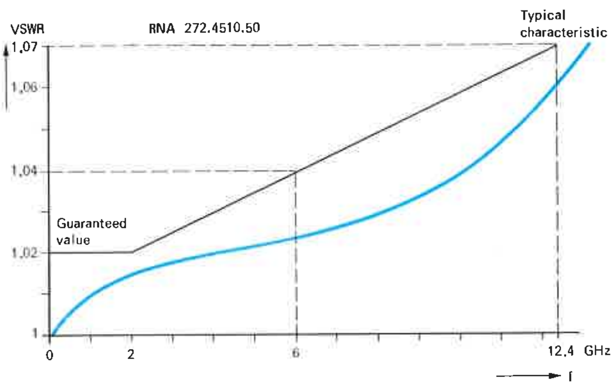
Characteristics and uses of terminations and high-power attenuators

Terminations. Understood here are all the components that are used solely as reflection-free terminations on instruments or cables, i.e. those having no test output. This is naturally applicable for small RF powers up to a few watts (an exception is the RAU for 100 W).

High-power attenuators. This category embraces the application as termination – e.g. as dummy antenna; the designation was chosen, however, because these terminations have a test output with a uniquely defined attenuation. They can therefore be used also as attenuators for extending the measurement range of power meters with lower ranges. For attenuators with lower power rating see next page.

Terminations for measurements

RNA A precision termination with N connector, featuring extremely low VSWR over the whole frequency range from DC to 12.4 GHz, mainly for use in electronic measurements.



RMF Reflection-free termination for instruments and test setups with BNC connectors. It has a nonwound resistance element without cap, the inductive reactance being compensated up to 50 MHz.

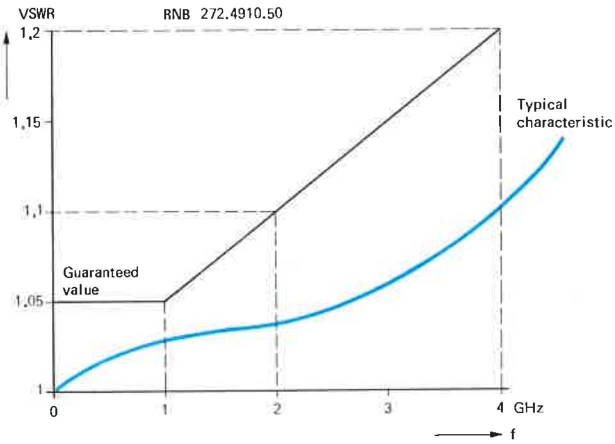
One end of the resistance element is connected to the inner conductor of the connector, the other end to the outer conductor.

The model with BNC connector can be used as a reflection-free termination for video transmission lines (VSWR $\leqq$1.02 up to 10 MHz).

The Termination RMF 2 (265.6863.00) with a 75-Ω metal-film resistor for 0 to 20 MHz is available to meet the higher requirements of the insertion test signal technique; its return loss is >50 dB up to 5 MHz.

RMC Standard termination for coaxial test setups (21-mm outer diameter); acts as a termination on slotted lines and in impedance meters which are being used for measurements on cables and two-port networks as well as for adjusting directional couplers.

RNB Termination with N connector for general use in the frequency range from DC to 4 GHz; use of a stable metal-film resistor affords a power-handling capacity of 1 W.



High-power terminations and high-power attenuators

RBD High-power attenuator, used, e.g. as dummy antenna and for harmonic measurements on transmitters (via its test output). This high-power attenuator with ladder construction is cooled by air convection currents along the outer surfaces.

RBU The High-power Attenuator RBU 100 for 100 W, air-cooled (100.8654.35; 50 Ω), consists of four series-connected attenuators with 1/3/6/20 dB attenuation so that a total transmission loss of 30 dB at 100-W power-handling capacity is available.

The other models of the RBU as separate attenuators of 30 to 100 W are listed in the table.

RAU UHF termination (dummy antenna), especially for mobile or stationary transmitters; a low VSWR makes it also suitable for TV systems.

RBS (1000 W) This high-power attenuator is also cooled by air convection currents. In addition to functioning as a dummy antenna, it can be used for determining the fundamental-wave power and the harmonic suppression on transmitters as well as for extending the measurement range of microwave power meters.

Characteristics and uses of attenuator pads and matching pads

Attenuator pads (DSF/DPF/DNF) of different attenuation are important accessories in test setups where the attenuation does not have to be changed over long periods of time. Their handy design (easy to replace) makes them particularly valuable for use in mobile test setups.

Matching pads (see next page) create the necessary match between measuring instruments and transmission lines of different characteristic impedances of the standard values 50 and 75 Ω or (as feed-through termination) match 50-Ω lines to measuring instruments with high input impedance.

DPF These **attenuators** are designed for a power-handling capacity of up to 0.5 W. They have a maximum permissible pulse voltage of 1 kV. Of particular importance is their symmetrical construction enabling frequency-independent attenuation in both directions. Connectors: Dezifix A or Dezifix B (adaptable).

Attenuator pads

DSF The **DSF Attenuators** are low-cost, general-purpose components suitable for use at frequencies up to 1000 MHz. The attenuator elements are made up of π-networks of metal-film resistors.

DNF The **DNF attenuators** have N connectors and are mainly intended for lab use, integration into systems and range extension of power meters. High attenuation accuracy and flatness of frequency response together with low VSWR guarantee precise measurements. The DNF pads are very robust and immune to vibration in line with MIL-A-3933 and will withstand short-time overloading. Models available between 3 and 30 dB (see table below); power-handling capacity 2 W for 3-dB and 6-dB models, 1 W for other models.

Overview Attenuator pads

Frequency range	Designation	Type	Order No.	Characteristic impedance	Attenuation	Power rating	VSWR	Dimensions in mm	Text
0 to 1000 MHz	Attenuator	DSF	289.8766.00 289.8814.00 289.8866.00 591.4338.00	50 Ω 50 Ω 50 Ω 50 Ω	3 dB 6 dB 10 dB 20 dB	1 W 1 W 0.5 W 0.5 W	≦1.1 (up to 500 MHz) ≦1.2 (up to 1000 MHz)	50.5× 36 dia.	see above
0 to 4000 MHz	UHF Attenuator	DPF	100.1789.50 100.1820.50	50 Ω 50 Ω	5 dB 20 dB	} 0.5 W	<1.05 (<1.08)	100×36 dia. 125×36 dia.	see above
0 to 12.4 GHz	Attenuator	DNF	272.4010.00 272.4110.00 272.4210.00 272.4310.00 272.4410.00	50 Ω 50 Ω 50 Ω 50 Ω 50 Ω	3 dB 6 dB 10 dB 20 dB 30 dB	2 W 2 W 1 W 1 W 1 W	≦1.1 (up to 4 GHz) ≦1.2 (up to 10 GHz) ≦1.25 (up to 12.4 GHz)	56×21 dia.	see above

Matching pads

DAF **Matching Pads DAF** are unsymmetrical π sections with differing input and output impedances; they create the necessary match between measuring instruments and transmission lines having different characteristic impedances. Their voltage transformation ratio depends on the direction. The direction is marked by arrows. Series-opposed connection of two identical matching pads gives a total attenuation of 10 or 12 dB.

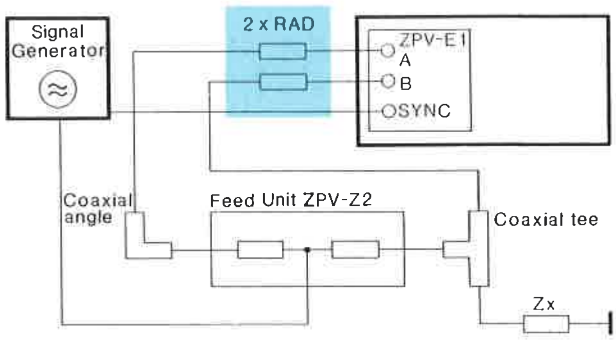
DAZ **Matching Pads DAZ** enable the characteristic impedance to be matched at one end since they only have one series resistor. They are used specifically for matching the output impedance of a signal generator of 50 Ω to lines or leads of 60 Ω of 75 Ω. A 50-Ω cable can be connected here between signal generator and matching pad. The advantage of these matching pads lies in their low attenuation.

Feed-through termination

RAD The **Feed-through Termination RAD** is used for matching 50-Ω lines to measuring equipment with high input impedance (e.g. oscilloscope with 1-MΩ input). The RAD contains a metal-film resistor, which is connected in parallel with the input impedance of the measuring equipment. The RAD must be plugged directly into the input socket to ensure optimum matching.

Typical application

When measuring transmission and reflection parameters in conjunction with the Vector Analyzer ZPV and Tuner ZPV-E1, Feed-through Terminations RAD are used to match the 50-Ω network to the high-impedance inputs (1 MΩ || 17 pF) of the ZPV.



Measurement of reflection coefficient and low impedance values

Overview Matching pads

Frequency range	Designation	Type	Order No.	Characteristic impedance	Voltage transformation →/← dB	VSWR	Power rating	Dimensions in mm
0 to 1000 MHz	Matching Pad	DAF	100.1872.02 100.1889.02 100.1895.02	75:60 Ω 75:50 Ω 60:50 Ω	6/4 7.8/4.2 5.8/4.2	≦1.05[1] ≦1.05[1] ≦1.05[1] [1]) up to 300 MHz, above: ≦1.15	0.5 W 0.5 W 0.5 W	165×50 dia.
				Connectors: Dezifix B at both ends, adaptable				
0 to 1000 MHz	Matching Pad	DAZ	242.1013.02 242.1513.02	50:60 Ω 50:75 Ω	0.8 1.8	≦1.04 ≦1.04	7 W 4.5 W	79×35 dia.
				Connectors: Dezifix B at both ends, adaptable				
0 to 1000 MHz	Feed-through Termination	RAD	289.8966.00	50 Ω		≦1.05 (up to 100 MHz) ≦1.1 (up to 500 MHz) ≦1.2 (up to 1000 MHz)	0.5 W	50.5× 14.5 dia.
				Connectors: BNC male/female				

Characteristics and uses of attenuator sets

Attenuator sets are two-port networks with adjustable, calibrated attenuation and the same constant characteristic impedance at both input and output. They are used for gain and attenuation measurements (Figs 1 and 2), for determining the noise figure of a receiver (Fig. 3), for linearity measurements (with an attenuator connected before and after the test item; Fig. 4) or as reference attenuator (e.g. the highly accurate DPVP; see Fig. 2). In addition, accurately-known small voltages are obtainable with the aid of an attenuator set when a given, exactly determined input voltage is available. Their special construction has afforded a high degree of accuracy as well as a very wide frequency range.

Programmable attenuator sets in combination with programmable signal generators are suitable for setting up fully or semi-automatic test assenblies (Fig. 5) especially in production and test shops. The attenuation settings are made with electro-magnetic motordriven switches. The setting times are very short and always of the same duration as all resistors necessary for obtaining a specific attenuation are switched at the same time (even when switching between the extreme attenuation values). Programming is possible in the ASCII code via the IEC bus (e.g. for DPSP) or with Code Converter PCW and card reader.

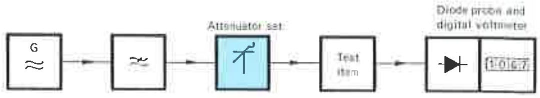


Fig. 1 Test setup with diode probe and digital voltmeter for gain and attenuation measurements at high test voltages

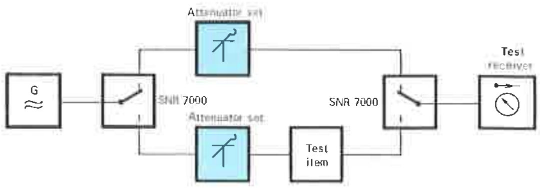


Fig. 2 Test setup with reference attenuator for measuring attenuation and gain with a high degree of accuracy

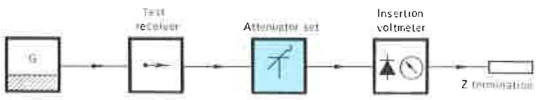


Fig. 3 Test setup for determining the noise figure of a receiver

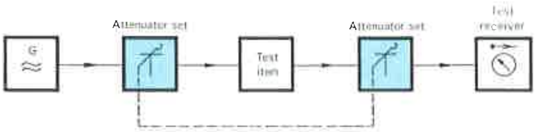


Fig. 4 Setup for measuring the linearity of two-port networks

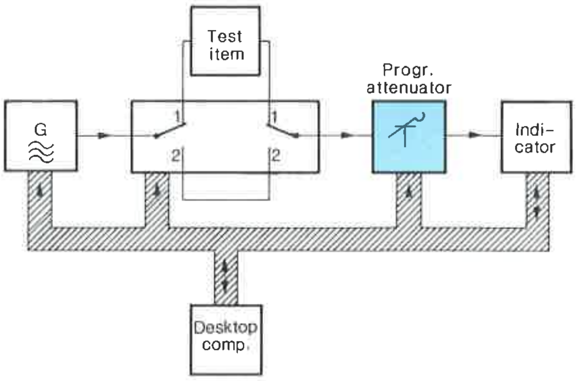


Fig. 5 Automatic test assembly for attenuation and gain measurements using programmable RF attenuators

Overview Attenuator sets

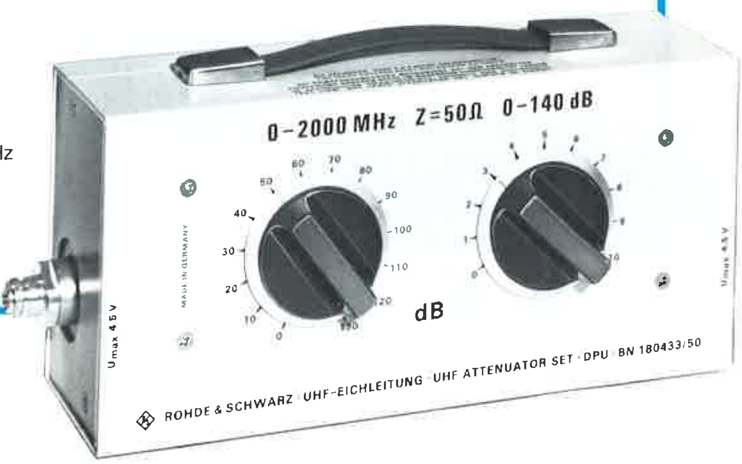
Frequency range	Designation	Type	Order No.	Charac-teristic impedance	Attenuation	Smallest increment	VSWR	Dimensions in mm	Text on page
0 to 2000 MHz	UHF Attenuator Set (with N connectors)	DPU	100.8960.50 100.8960.70 100.8960.55	50 Ω 75 Ω 50 Ω	0 to 140 dB	1 dB	<1.15 (<1.3)	335× 145×115	291
0 to 1000 MHz	Programmable Attenuator (with N connectors)	DPVP	214.8017.55	50 Ω	0 to 139.9 dB	0.1 dB	<1.1	484× 150×336	293
0 to 2700 MHz	RF Step Attenuator programmable	DPS DPSP	334.7217.02 334.6010.02	50 Ω 50 Ω	0 to 139 dB	1 dB	<1.2 (1.3)	241× 110×234	292

UHF Attenuator Set DPU

DPU

♦ 0 to 2 GHz/0 to 140 dB

- Precision instrument
  for attenuation and gain measurements,
  determination of receiver noise figures,
  adjustment of very small, accurately-known voltages
- High accuracy – average error <1% (0.5%) up to 1.5 GHz
- Small insertion loss – approx. 1 dB up to 2 GHz



The **UHF Attenuator Set DPU** is simple and convenient in use over its frequency range from DC to about 2 GHz. Its applications include primarily attenuation measurements and gain measurements as well as accurate adjustment of very low voltages.

Attenuation settings between 0 and 140 dB are possible in steps of 1 dB. The excellent shielding also permits the very high attenuation values to be reliably used. The attenuation setting is convenient to read so that it is easy to see in which direction the knob has to be turned for a particular change in attenuation. This avoids overloading sensitive test items.

Its accuracy makes the DPU a precision instrument. The electrical length and consequently the delay time are practically independent of frequency and attenuation, so that the Attenuator Set can handle very short pulses as well as sinewave voltages. The reflection at the input and the output is very low. Mechanical wear, temperature and humidity do not appreciably affect the characteristics of the instrument. This makes the DPU also suitable for use under adverse climatic conditions.

The Attenuator Set is available for the standard characteristic impedances of 50 Ω and 75 Ω. If the test setup calls for different characteristic impedances at the attenuator input and output it is possible, up to 1 GHz, to insert matching pads of the type series DAF and DAZ, enabling impedance transformation from 50 Ω to 60 Ω, from 50 Ω to 75 Ω and from 75 Ω to 50 Ω.

The DPU has a power-handling capacity of up to 0.4 W (pulse peak voltages: 300 V). The Dezifix B connectors are adaptable; model 55 is fitted with an N connector.

Specifications

Frequency range	0 to 2 GHz	
Attenuation range	0 to 140 dB switch-selected in steps of 10 dB and 1 dB	
Error limits	10-dB steps	1-dB steps
0 to 1.5 GHz		
Per step	±0.1 dB	±0.05 dB
Overall error	±0.4 dB	±0.15 dB
1.5 to 2 GHz		
Per step	±0.2 dB	±0.1 dB
Overall error	±0.8 dB	±0.2 dB
Insertion loss at 1 GHz	≦0.6 dB	
Characteristic impedance	50 Ω or 75 Ω, depending on model	
VSWR		
0 to 1.5 GHz	<1.15	
1.5 to 2 GHz	<1.3	
Delay	1.4 ns	
Power-handling capacity	0.4 W	
Permissible input voltage	sinewave	pulse
50-Ω model	4.5 V_{rms}	300 V_{pp}
75-Ω model	5.5 V_{rms}	300 V_{pp}
Connectors	Dezifix B, adaptable; 50-Ω model also with N female connectors	

General data

Rated temperature range	+15 to +45 °C
Dimensions, weight	335 mm×145 mm×115 mm, 4 kg

Ordering information

Order designation	▶ UHF Attenuator Set DPU
50-Ω model (Dezifix B)	100.8960.50
75-Ω model (Dezifix B)	100.8960.70
50-Ω model (N female)	100.8960.55

DPS
DPSP

RF Step Attenuators DPS and DPSP

♦ 0 to 2700 MHz/0 to 139 dB

- Attenuation steps of 1 dB, low residual attenuation
- Short setting time: less than 20 ms
- Very high life expectancy: 10^7 switching operations
- DPSP is system-compatible via IEC bus

IEC 625 Bus

Characteristics and uses

The **RF Step Attenuators DPS and DPSP** facilitate the quick and accurate performance of all tasks of attenuator sets in the frequency range from DC to 2700 MHz. This includes in the first place measurements of gain, attenuation and sensitivity (receiver noise figure) and the reduction of voltages to very small and uniquely defined values.

Differences between the types. All electrical characteristics are identical for DPS and DPSP, the two types differ only in the mode of operation (for details see below):

DPS manually operated by decade switches
DPSP can be manually operated by rotary switches with automatic carry and remotely controlled via IEC bus.

Common characteristics. With both these attenuators, attenuation values from 0 to 139 dB can be set in steps of 1 dB. Effective shielding guarantees full reliability of the result at the highest attenuation.

The **accuracy** complies with the usual requirements for precision instruments. Very short pulses are handled with the same precision as sinewave signals.

Input and output present extremely low reflection. On both types the RF connectors on the front panel can be rerouted by the user to the rear panel, no change of cables being involved.

The **carrying handle** can also be used as a stand or screwed off.

DPSP with stand

Manually operated Step Attenuator DPS

The attenuation value is set by decade switches. Batteries are incorporated for mobile applications; they are recharged during operation from the AC supply.

Programmable Step Attenuator DPSP

Attenuation can be set manually on the DPSP with two rotary switches, carryover being executed automatically. The switching functions are controlled by a microprocessor. In addition the unit has an IEC-bus interface and can be combined with other IEC-bus-compatible instruments and computers in automatic test systems. The setting time of the attenuator is 20 ms. With more than 10^7 switching operations a long service life is guaranteed even if extremely frequent switching is required. The DPSP can be incorporated into 19″ racks by means of an adapter.

Specifications

Frequency range	0 to 2700 MHz
Attenuation range	0 to 139 dB, 1-dB steps
Attenuation setting DPS	3 decade switches
DPSP	2 decade switches with automatic carry
Attenuation error	≦± (0.2 dB +1.3% of setting), max. 1 dB
typical	± (0.1 dB +0.6% of setting), max. 0.5 dB
Residual attenuation at 200 MHz	≦0.4 dB
1 GHz	≦0.8 dB; VSWR 1.2
2.7 GHz	≦1.2 dB; VSWR 1.4
Characteristic impedance	50 Ω, P_{max} average 1 W
Programming (DPSP only)	interface to IEC 625-1 standard; control of all functions, data transmission in listener function: AH 1, L 1, RL 1, DC 1
Setting time	≦20 ms
General data	
Life expectancy	10^7 switching operations
Connectors	N female on front or rear panel
Power supply AC	115/125/220/235 V ±10%, 47 to 440 Hz (10 VA)
battery (DPS only):	NiCd battery for 5000 switching operations, built-in charger
Rated temperature range	+5 to 45 °C
Storage temperature range DPS	−40 to +60 °C
DPSP	−40 to +70 °C
Dimensions, weight	241 mm × 110 mm × 234 mm, 3 kg

Ordering information

Order designation	▶ RF Step Attenuator
DPS	334.7217.02
DPSP	334.6010.02
Accessories supplied	power cable
Recommended extra	19″ Adapter ZZA-1 078.8016.00

Programmable Attenuator DPVP

DPVP

♦ 0 to 1000 MHz/0 to 139.9 dB

- Smallest increments of 0.1 dB
- High accuracy, small attenuation error
- Programmable in BCD code – TTL-compatible
- Built-in store – strobe input

Characteristics and uses

The **Programmable Attenuator DPVP** enables very accurately defined attenuation values of between 0 and 139.9 dB to be provided for 50-Ω networks. It can be used up to 1000 MHz.

Attenuation settings. The smallest attenuation step that can be manually set or programmed is 0.1 dB. All setting procedures are completed within 35 ms, even when switching from the lowest to the highest attenuation.

Programming, use in test systems. The DPVP is designed for programming in the BDC code. When using the Code Converter PCW, the Programmable Attenuator can be connected to the IEC bus and thus hooked up to automatic test systems; in this way, several DPVPs can be integrated in a system.

Programmable Attenuator DPVP plus Code Converter PCW (for programming via IEC bus)

Accuracy. The typical error of the individual attenuator sections (steps) is about 0.02 dB for frequencies <100 MHz and about 0.07 dB over the entire frequency range; a calibration table supplied with each instrument contains the reference values for seven frequencies. According to this table the error is less than 0.02 dB per attenuator section.

Description

The Attenuator DPVP consists of 15 attenuator sections in steps between 0.1 and 20 dB; the sections are switched into the attenuation path by means of a decoder circuit using noble-metal swivel contacts.

Switchover between manual and programmed operation is performed by means of the programming plug.

Programming itself is in positive-logic BCD code with TTL-compatible programming levels.

Specifications

Frequency range	0 to 1000 MHz		
Attenuation range	0 to 139.9 dB in smallest steps of 0.1 dB		
Attenuation setting	on four decade switches, manually or programmed		
Programming	via 50-pin connector at rear; positive logic, TTL-compatible, BCD code, common strobe input, built-in store		
Setting time	<35 ms		
Attenuator error	see text under accuracy (typ. total error at 0.07 dB)		
VSWR			
setting 0 dB	–	–	≦1.085
0.1 to 9.9 dB	–	–	≦1.13
10 to 139.9 dB	–	–	≦1.085
Residual attenuation:			
setting 0 dB	≦0.06 dB	≦0.15 dB	≦0.6 dB
Characteristic impedance	50 Ω		
Permissible input power	1 W		
Connectors	N female		
Nominal temperature range	+10 to +40 °C		
Power supply	115/125/220/235 V ±10%, 47 to 440 Hz (33 VA max.)		
Dimensions, weight	484 mm × 150 mm × 336 mm, 16 kg		

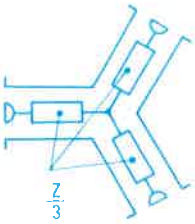
Ordering information

Order designation ▶ Programmable Attenuator DPVP 214.8017.55

Accessories supplied
1 power cable (2 m long); 50-pin connector for programming input

Recommended extras
Code Converter PCW 244.8015.92 with Coding Board 245.2510.02 for programming according to the IEC-bus standard

DVU 3



Three-port Junction Box DVU 3
⧫ 0 to 1000 MHz

- Three-port junction box for splitting up into or combining two channels with correct impedance matching
- Range of application up to and above 1000 MHz
- VSWR with impedance matching <1.15

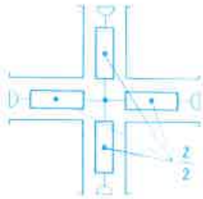
The Three-port Junction Box is equipped with three adaptable Dezifix-B or N female connectors. Matching is achieved by Z/3 impedances in a star configuration.

Characteristic impedance 50 Ω, 60 Ω or 75 Ω
Attenuation 6 dB
Max. load per input 1 W
Max. permissible pulse peak voltage 300 V
Dimensions 120 mm dia. ×35 mm

Order designation .... ▶ Three-port Junction Box DVU 3

50-Ω model	100.5203.50
60-Ω model	100.5203.60
75-Ω model	100.5203.70
50-Ω model, 3× N female, adaptable	100.5203.03

DVU 4



Four-port Junction Box DVU 4
⧫ 0 to 1500 MHz

- Four-port junction box for splitting up into or combining three channels with correct impedance matching
- Application, e.g. for measurements on radiotelephone equipment involving three signal generators
- VSWR with impedance matching <1.05 (up to 1 GHz), <1.3 (up to 1.5 GHz)

The Junction Box is a coaxial construction of four low-reflection, precision Dezifix-B or N female connectors. The matching is achieved by Z/2 impedances in a star configuration. The Termination RMC or RNB is recommended for terminating any outputs which are not used.

Characteristic impedance 50 Ω
Attenuation 9.5 dB
Max. load per input 0.25 W
Max. permissible peak voltage 300 V
Dimensions 120 mm × 120 mm × 35 mm

Order designation .... ▶ Four-port Junction Box DVU 4

With connectors

Dezifix B (adaptable)	201.4018.02
N female (adaptable)	201.4018.03

DVS

Power Splitter/Combiner DVS
⧫ 0.1 to 400 MHz

- Distribution or combination of signals (max. 1 W = 7 V into 50 Ω)
- High isolation between inputs (20 to 40 dB)

The attenuators used for decoupling when measurements are made with several signal generators normally require a high output voltage from the signal generators. This drawback can be overcome by using the Power Splitter/Combiner DVS, which exhibits a low transmission loss (typical value: 3 dB), so that no additional attenuators arre required.

Characteristic impedance ...	50 Ω, connectors: BNC female
Transmission loss	approx. 3 dB
Isolation between inputs	20 to 40 dB
Maximum continuous load ..	1 W = 7 V into 50 Ω
Dimensions	57 mm × 36 mm × 41 mm
Order designation	▶ Power Splitter/ Combiner DVS 342.1014.50

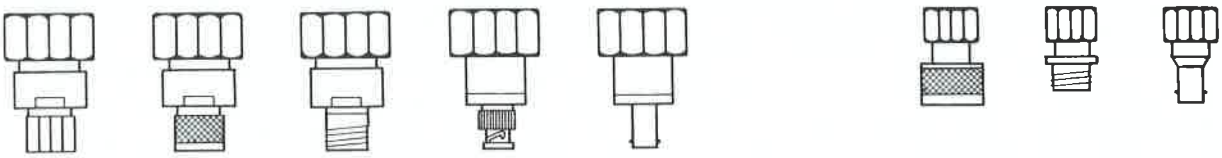
Connectors

Rohde & Schwarz measuring equipment is generally equipped with the internationally used standard connectors. Depending on the requirements (e.g. frequency range, power-handling capacity, reflection characteristics), either N, BNC or Dezifix connectors are used.

All older Rohde & Schwarz instruments fitted with adaptable Dezifix A or B bases or with RF sockets 4/13 DIN 47284 can be adapted to other connector systems by means of screw-in assemblies or screw-in connectors and without the need for any modifications to the instrument: this is the best solution, ensuring minimum mismatch. In many cases, satisfactory performance is also achieved using the adapters shown below as an economical way of connecting Rohde & Schwarz instruments to those of other manufacturers fitted with other connector systems.

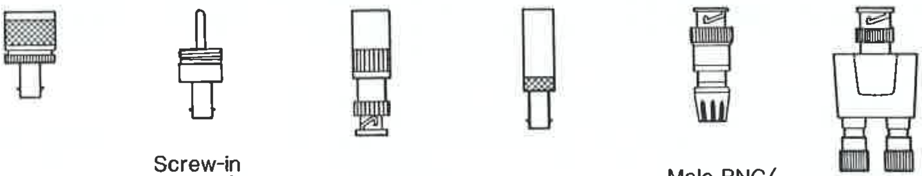
The following table also shows the most frequently required couplings, angle junctions and T connectors.

Adapters



Dezifix B to other systems					Dezifix A to other systems		
Dez. B/ Dez. A	Dez. B/ Male N	Dez. B/ Female N	Dez. B / Male BNC	Dez. B/ Female BNC	Dez. A/ Male N	Dez. A/ Female N	Dez. A/ Female BNC
408.4467.00	408.4644.00	408.4667.00	431.0006.00	430.8503.00	408.4521.00	408.4538.00	430.9451.00

Adaptation of systems of other makes



Male N/ Female BNC	Screw-in connector Female 4/13 Female BNC	Female 4/13/ Male BNC	Male 4/13/ Female BNC	Male BNC/ Knurled terminal	Male BNC/ Dual knurled terminal
118.2812.00	017.5975.00	408.4509.00	408.4480.00	017.6736.00	017.6742.00

Couplings/Angle junctions and T connectors

N Male/male	N Female/female	BNC Female/female	N Male/female	N Female-female/male	BNC Female/female/ male
092.6581.00	092.6700.00	017.6559.00	018.4495.00	018.4537.00	017.6588.00

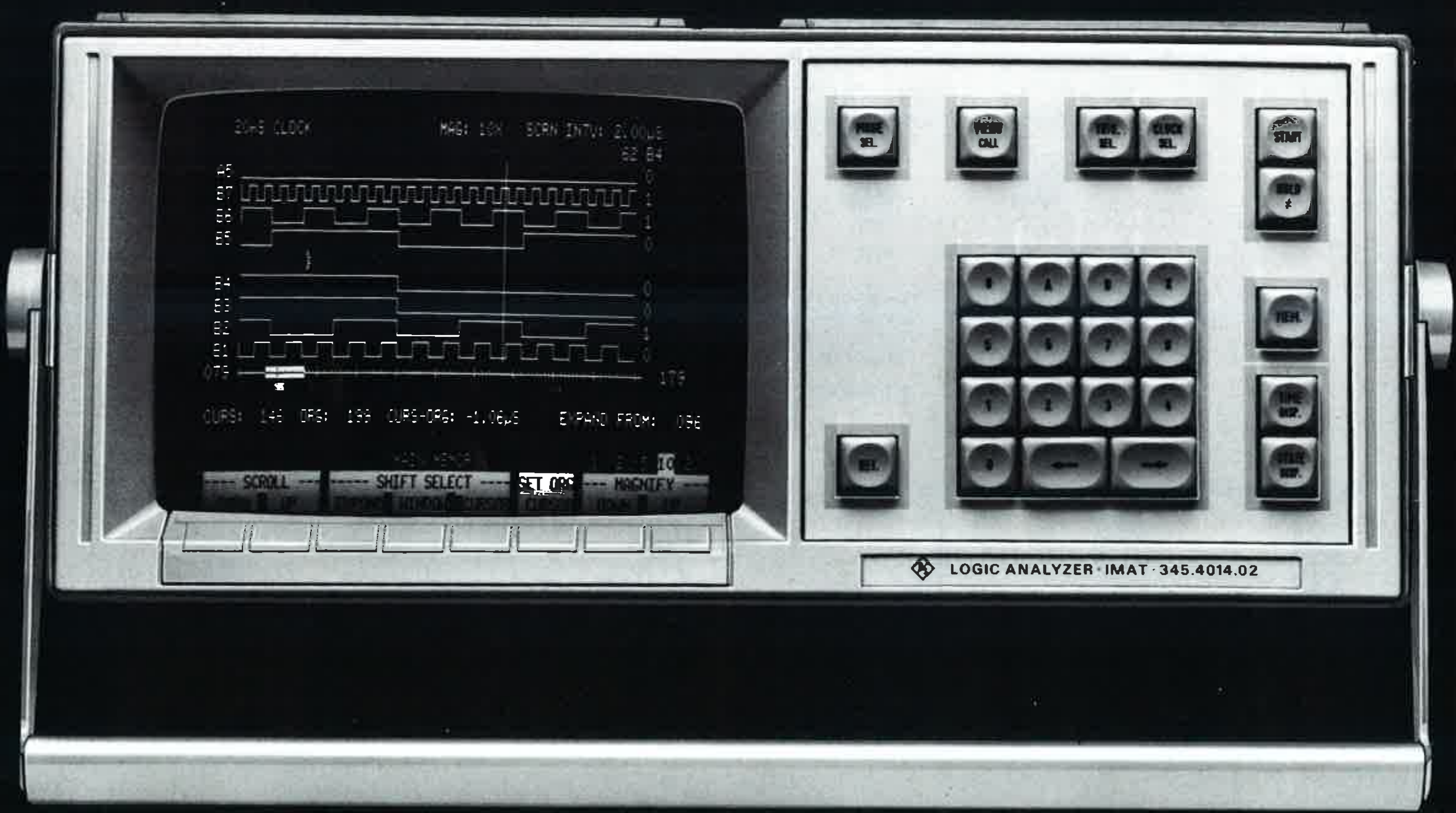
Shortcircuits

Dezifix B	Dezifix A	N connector
408.5028.00	408.4938.00	017.8080.00

Most common RF connecting elements

Blue: R&S ordering numbers

Logic Analyzer IMAT (below),
Logic Generator IGA plus Serial Data Driver IGA-Z9 (right);
for analyzer system and details on individual instruments
see pages 300 ff



11

logic test equipment

Logic measurements

The functioning of digital and analog circuits is basically different.

In the analog field, physical quantities such as voltage and current are handled. Thus analog measuring instruments have to detect, evaluate and display primarily physical signals.

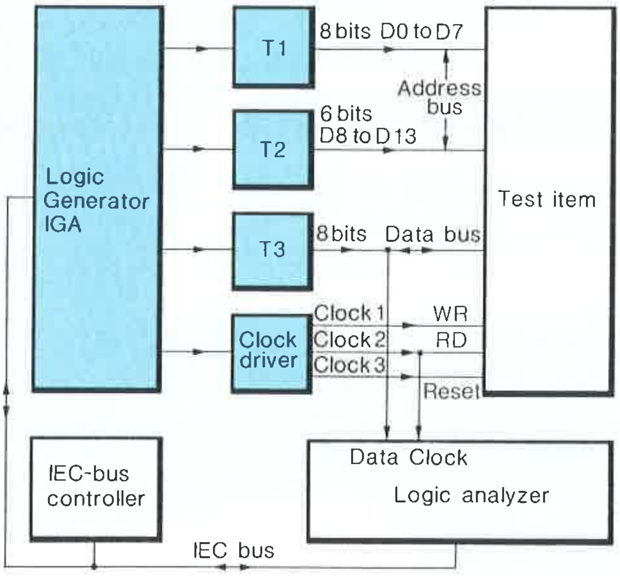
A completely different principle is used for **digital measurements.**

The signal present and processed in the digital circuit is not an analog quantity but a

logic combination of standardized physical states, for instance 0 and 1.

Thus, irrespective of the function of the digital circuit, the same electrical signal levels will always be used. For this reason, digital circuits require special measuring instruments which, are able to stimulate and analyze logic events.

Use of logic measuring instruments



Example for combination of logic generator and logic analyzer (for text see under application examples)

Logic measuring intruments can be classified into:

- logic analyzers
- digital generators (logic generators)
- combinations of analyzers and generators

The **logic analyzer** is at present most frequently used; there are the two basic types, i.e. logic timing and logic state analyzer.

The logic timing analyzer is especially suitable for accurate examination of the timing of digital functions. Its sampling frequency is high (at least 100 MHz) whereas the number of channels is low. The memory should, however, have a minimum capacity of 1000 words.

The logic state analyzer is used to detect and display the sequence of complex digital events. It has at least 32 channels and a low operating frequency (15 to 20 MHz) as well as a wide range of triggering modes. Data can be displayed in decoded form.

Digital generators are required for activating (and, in conjunction with logic analyzers, for analyzing) the examined functions, e.g. in the development and testing of subassemblies requiring external control to become operative.

Like with analyzers, a difference is made between

- timing word generators and
- logic generators.

Timing word generators are used to examine the sequence of events in digital circuits as a function of time at the maximum data rate. Due to the high costs of data channels featuring a high output rate, the number of channels used in timing word generators is small. Nevertheless, these instruments are expensive.

Logic generators are used in conjunction with logic state analyzers to check logic functions of digital circuits. They feature a great number of channels at a low price. They are able to drive bidirectional bus systems and take over data output functions of microprocessor circuits.

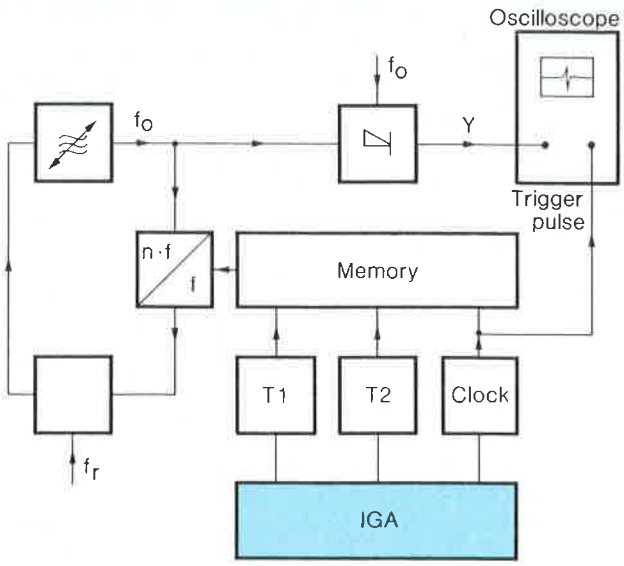
The combination of analyzer and generator forms practically always the basic configuration of a digital test assembly. In addition, there are also measuring instruments, such as the in-circuit emulator, which combine the functions of the analyzer and generator. Their use is, however, limited because they requier to be controlled by a CPU.

Application examples: generator/analyzer

A typical example of the combination of logic generator and logic analyzer is illustrated in the lefthand column: A test item driven by a data and address bus is checked. The logic generator controls the addressing, data entry and clock and the analyzer records the data obtained from the item under test.

In this way, IEC-bus-compatible instruments permit an automatic test system to be configured as an alternative to the conventional digital test systems.

Digital measuring instruments – in particular logic generators – are also useful for testing analog functional groups with a digital interface. The diagram below shows how the analog testing of a PLL is carried out with the aid of a logic generator which is also able to supply control signals with a variable data rate.

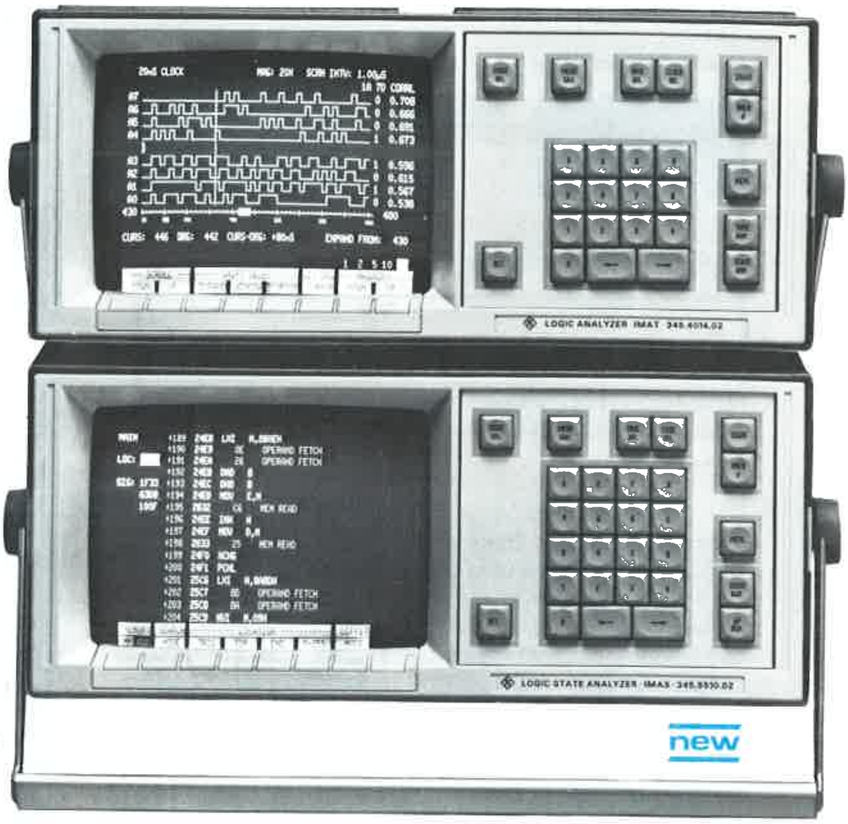


Digital control for the measurement of analog functions

System IMAS/IMAT = modular matching of price and performance

- System configuration with independent logic measuring instruments
- Separate use or system configuration for timing, state or function analysis in µP circuits
- Master-slave triggering
- IEC-bus-compatible

For details on individual instruments see pages 302 ff



IMAT +
IMAS (below)

IEC 625 Bus

System characteristics

The **Logic Analyzer System IMAS/IMAT** offers an especially economical solution to the increasing number of measurement tasks in the field of logic analysis.

Since the IMAS/IMAT assembly consists of independent instruments, it can be used as an **integrated system with maximum measuring performance** or split up yielding **separate test setups** for tasks in the field of conventional **timing and µP analysis.** This double use enables flexible adaptation of the instrumentation to the measurement problems to be solved. A special advantage is the possibility of using first only one instrument depending on the specific task on hand and adding the other one as soon as required. In this way the investment expenditure can be spread over the years. The number of the two system components (i.e. IMAT and IMAS) may vary so that the instrumentation pool is adaptable to the specific applications.

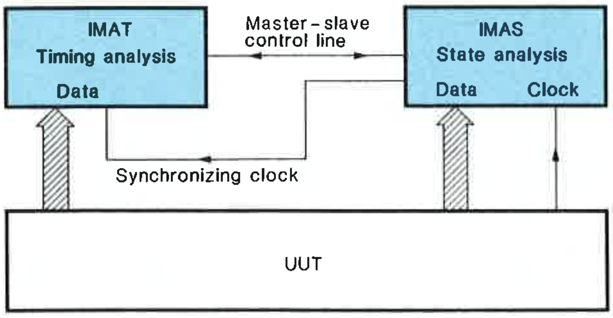
As both separate use and system configuration are possible, the two instruments are an especially economical solution when procuring logic analyzers. Another advantage of using two instruments is offered by the **two screens** where timing and logic state display is possible simultaneously.

Measurement and display capabilities of IMAS/IMAT system

IMAT Logic Analyzer	for timing and logic state analysis **Uses:** Timing analysis in µP and digital circuits, glitch detection or function analysis of µP and digital circuits
IMAT-B2 (option) Analog Recorder	for timing analysis of analog and hybrid circuits
IMAS Logic State Analyzer	for logic state analysis **Uses:** Function analysis of µP and digital circuits with high trigger intelligence and excellent selectivity, µP program analysis
IMAS-B1 (option) Counter/ Signature Analyzer	for performance analysis of µP programs, time measurement of digital functions
IMAS/IMAT System with Analog Recorder IMAT-B2	for simultenous timing and logic state analysis **Uses:** Simultaneous timing and function analysis; timing analysis in µP and digital circuits as well as µP programs with triggering in the state domain; function analysis with triggering by time events and on glitches; timing analysis of analog and hybrid circuits with triggering by logic or program functions

System IMAS/IMAT

System description

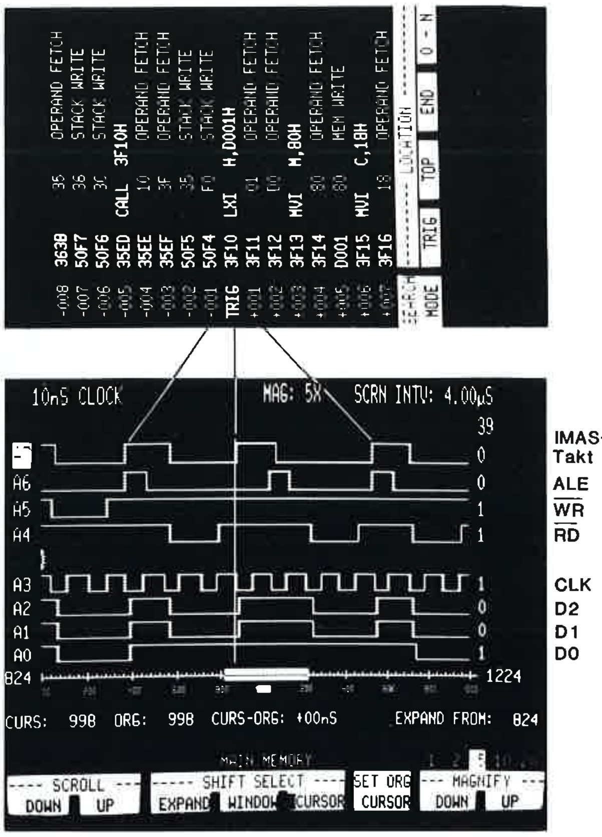


Master-slave control of timing and function analysis

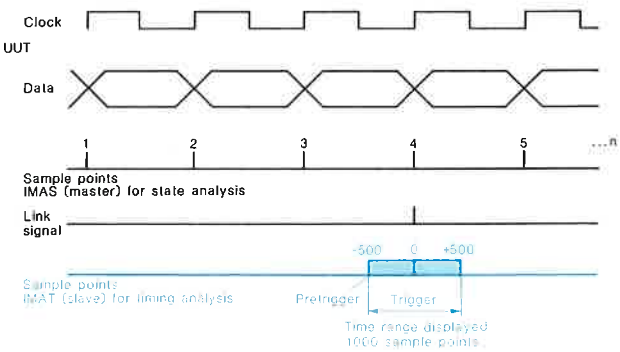
The Logic Analyzer System IMAS/IMAT is based on the principle of simultaneous timing and function analysis: Asynchronous timing analysis with internal clock and synchronous state analysis with external clock are performed separately in two independent instruments **at the same time.** This simultaneous analysis establishes the relation between the logic function and the timing of the function itself. The coordination can be shown by inserting a synchronizing clock into the timing display. Each clock identifies the point at which the logic state analyzer has recorded a new logic state (see righthand column, top). The synchronizing clock is available at a BNC output on the rear panel of the IMAS and can be applied to one of the data inputs on the IMAT (see diagram above).

As the two types of measurement are performed at the same time, it is possible to separate the analysis proper and triggering, i.e. the time-domain analysis can be triggered by logic states and vice versa. To this effect, bidirectional master-slave control is used so that each analyzer can act either as the master or the slave.

Control is performed such that, with its trigger condition reached, the analyzer acting as the master delivers a control signal which is processed by the slave analyzer(s). This signal may either cause a direct start or be linked with individual selectable trigger conditions of the slave analyzers.



Example of timing analysis with state-domain triggering and disassembler display
Timing display range 4 µs (400 sampling points with internal clock of 10 ns)
Logic state display range 16 µs (16 sampling points with mean external clock of 1 µs)



Simultaneous logic state and timing analysis

Advantages of master-slave operation

The master-slave configuration for timing and logic state analysis obtainable with the Logic Analyzer System IMAS/IMAT is considerably more powerful than conventional timing and logic state analyzers which – although capable of performing both types of analysis – cannot do this simultaneously.

Disadvantages of using a general-purpose analyzer for timing analysis with triggering in the time domain (see next page, bottom):

- Complicated and lengthy definition of trigger conditions
- Triggering of nested events often impossible
- At high sampling rate only narrow time windows displayed
- Consecutive display of long trigger sequences thus not possible
- Definition of trigger sequence in disassembler display mode not possible

Disadvantages of using a general-purpose analyzer for logic state analysis with triggering in the state domain:

- Information on test item timing not available
- Information on events between clocks not available
- Glitches not detected
- Triggering on time events impossible

These restrictions apply to all the general-purpose analyzers capable of performing both timing and logic state analysis as long as these two functions cannot be used simultaneously and independently. It is simultaneous timing and logic state analysis that avoids all the disadvantages listed since the results from the two domains are available at the same time supplementing each other in a meaningful way. This holds for the IMAS/IMAT combination featuring considerable merits:

- ▶ Timing analysis with extremely easy triggering on logic states or program steps in the state domain
- ▶ Display of a wide function range despite the high resolution of timing analysis
- ▶ State and program analysis with triggering on glitches or malfunctions in the time domain
- ▶ Simultaneous display of timing analysis and trigger sequence in the state domain thanks to two screens

Stimulation of test item

To expand the IMAS/IMAT system, the Logic Generator IGA is available for stimulation of the test item. It delivers the data and control signals required for timing and function analysis. Moreover, the IGA can be used to control the analyzer directly, which often simplifies triggering even further.

Logic Generator IGA; for details see page 302

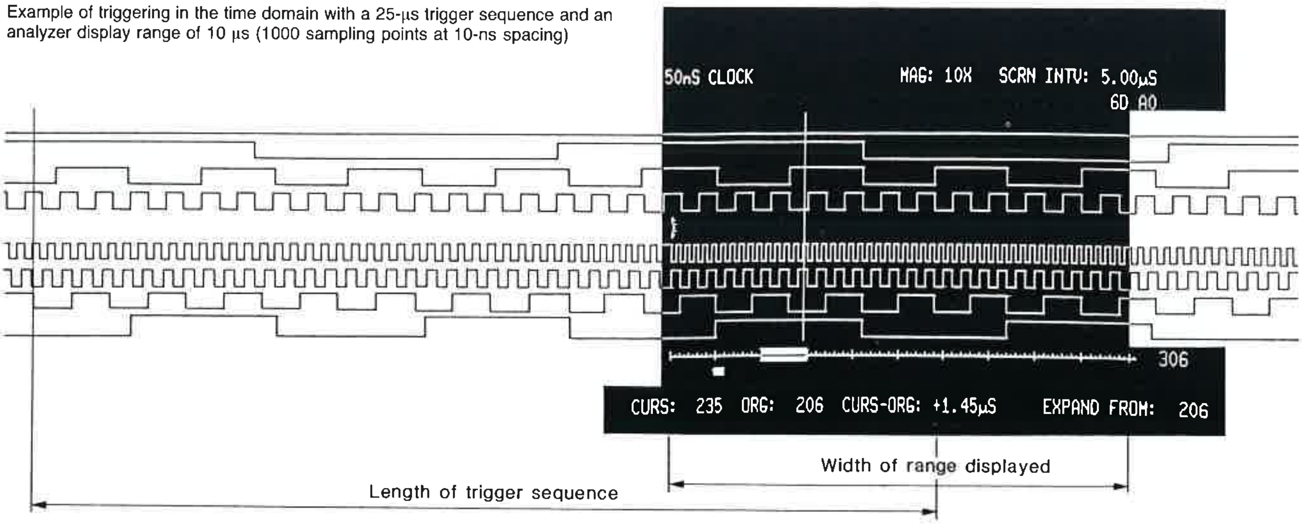
The configuration of IMAS/IMAT plus IGA constitutes a complete digital test system which meets all the requirements of modern digital measurements. It is an ideal tool for rationalizing the development and testing of digital systems.

Condensed data of IMAS + IMAT

For the complete specifications and ordering information see under the individual instruments: IGA on page 302, IMAT on page 308, IMAS on page 314.

Number of channels	64 = 16 timing and logic state channels (IMAT) 48 logic state channels (IMAS)
Clock frequency	max. 100 MHz, timing analysis (IMAT) max. 40 MHz, logic state analysis (IMAT) max. 12.5 MHz, logic state analysis (IMAS)
Memory depth	1000 words, timing and logic state analysis (IMAT) 250 words, logic state analysis (IMAS)
Trigger levels	2 timing and state triggers (IMAT) 16 state triggers (IMAS)
Master-slave operation	
Master-slave mode	IMAT and IMAS can be used either as master or slave analyzer
Number of masters	1
Number of slaves	max. 5
Combinations	any combination of IMAT and IMAS possible
Delay of master-slave control	approx. 200 ns
Remote control	via IEC bus (IEC 625-1/IEEE 488)
Dimensions (W × H × D)	470 mm × 396 mm × 484 mm
Weight	37 kg
AC supply	115/125/220/235 V ±10%, 47 to 63 Hz (385 VA)

Example of triggering in the time domain with a 25-μs trigger sequence and an analyzer display range of 10 μs (1000 sampling points at 10-ns spacing)



IGA

Logic Generator IGA ♦ 32 channels, 8 MHz max. clock frequency

- Programmable logic signal generator including memory for 1024 words in TTL and CMOS levels with battery backup
- Bit-serial data output with variable word length and memory depth up to 16,384 bits
- Control of bidirectional, bussed systems
- Microprocessor-compatible due to multi-clock output
- Large variety of accessories
- Option: cassette drive
- Waveform generation with analog driver option

IEC 625 Bus

The **Logic Generator IGA** ist both a **bit pattern generator** for analyzing logic signals and an **information generator** for checking the control and setting capability of digital systems (analog and engineering systems, too). It consists of the generator proper and plug-on drivers. In contrast to conventional word generators, the IGA is a general-purpose device on account of the following characteristics and capabilities:

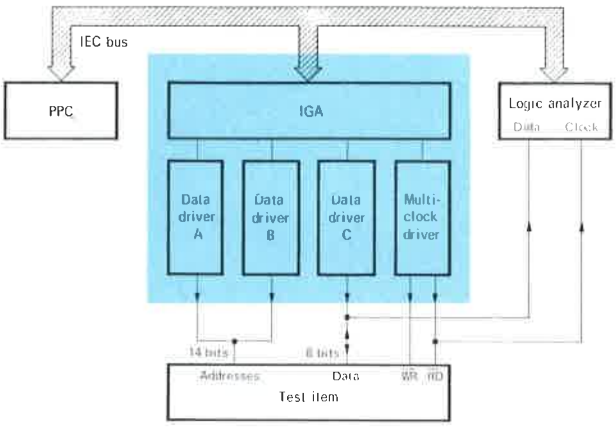
- Large storage capacity of 1024 words, data retention due to battery backup
- Tristate words programmable by channel groups for stimulating bidirectional data lines
- Multi-clock output for four strobe signals
- Sufficient number of data channels
- Data storage on magnetic-tape cassettes (option)
- Module-oriented data management with symbolic names and line numbers, fetching and outputting of bit patterns simplified by plain-language names, data entry and variation by way of powerful editor
- Data format either binary, octal, decimal or hexadecimal
- Possibility of linking data sets to form module sequences (with programmable pauses)
- Separate drivers with low-noise control of test items via short lines
- 3-wire handshake (IEC bus) and 2-wire handshake
- Programming via IEC bus
- In conjunction with Serial Data Driver IGA-Z9 (photos below and on page 307), generation of bit-serial data, two-channel operation with marker generation at any position

Logic Generator IGA with clock driver (including driver adapter, cable and mini-clips) and data driver

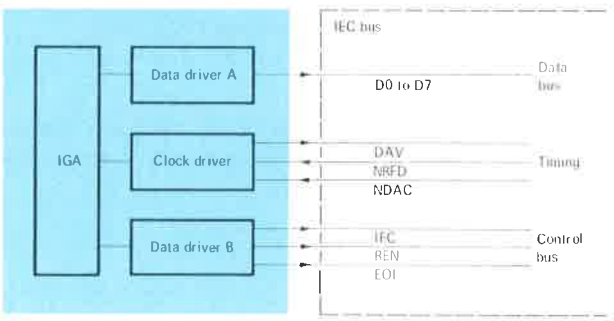
IGA with Serial Data Driver IGA-Z9 for bit-serial data generation (two Serial Data Drivers can be connected simultaneously)

Simplified generation of bit patterns. Thanks to its great ease of operation, the IGA permits bit pattern generation with considerably less outlay. The editor functions and the cassette drive afford completely new applications especially in the development of digital circuits with reduced time and cost factors. The **IEC-bus interface** makes the IGA system-compatible.

Testing of bus-controlled functions. The IGA is especially suitable for stimulating microprocessorized systems in its **multi-clock mode** and for functional testing of bussed systems by programming **tristate words** in channel groups (see diagrams below). In contrast to the conventional data and word generators, it thus covers all the applications involved in the stimulation of digital circuits.



Digital functional test in multi-clock mode (using IGA, logic analyzer and process controller)



Test of IEC-bus listener

Replacement of rigged-up generators. Thanks to the programmability of its functions, the IGA can be adapted to each measurement task without the need to resort to special, test-item-oriented solutions, thus saving time and reducing costs. Moreover, the use of a batch-produced instrument **reduces the risk of erroneous measurements** (and thus expensive down times). The risk of erroneous measurements due to unsatisfactory data retention is high in digital engineering. Here, in particular the variety of drivers available for the IGA (see photos on preceding page) offers a high degree of safety.

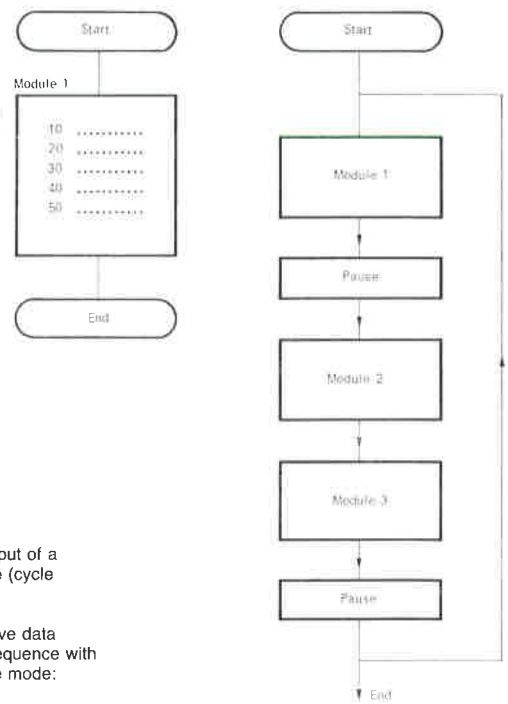
Technical details

Operation. The sloped keyboard which is divided into edit, data and run sections permits convenient entry of the desired bit patterns and activation of the data output. In the display section, the module name or line number appears on the left and the data are read out on the right.

Data management. The IGA uses **module-oriented** data management. A module consists of numbered data lines and is stored under a selectable, symbolic name; a maximum of 25 modules can be stored. By addressing the line numbers or calling up the module names, the data words or data blocks (modules) can be easily output (see diagrams below), varied, erased, duplicated, etc. By linking modules it is possible to obtain **module sequences** (with pauses) which are assigned a name of their own.

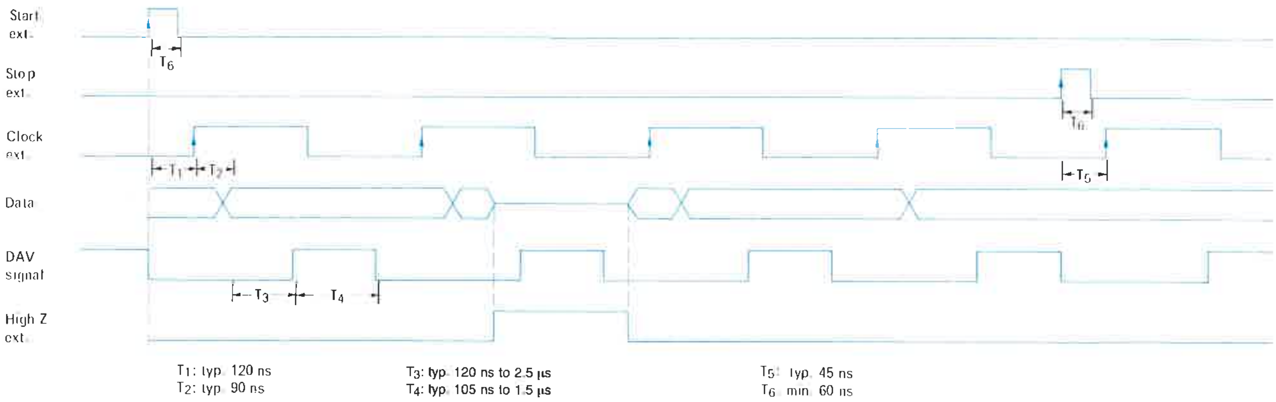
Data entry. The data can be entered in the binary, octal, decimal or hexadecimal numerical system. The format instruction permits the channels of the IGA to be divided into a maximum of four groups, each being able to handle a different numerical system. The kill instruction deletes entire data words. A **cursor** enables individual figures to be changed. To extend the existing data set, additional lines can be inserted between lines previously entered.

Waveform generation. In conjunction with the Analog Driver Option IGA-Z11, which contains a 12-bit D/A converter, the IGA can be used for generating any waveforms. It is of special advantage that the cassette drive can store these waveforms. The Analog Driver Option considerably expands the application range of the IGA: a single instrument is thus able to produce bit-parallel, bit-serial and analog signals.



Left: data output of a single module (cycle mode: single)

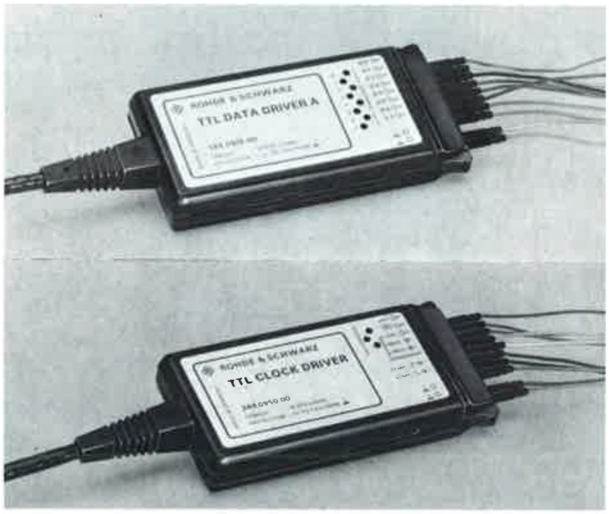
Right: repetitive data output of a sequence with pauses (cycle mode: repeat)



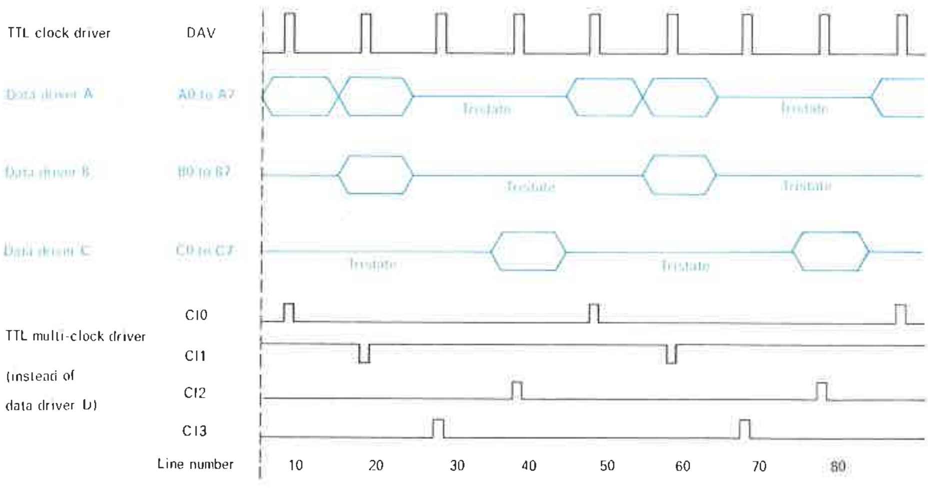
Timing diagram of data output (single module)

Data channels, adaptation. The IGA has 32 data channels and a storage capacity of 1024 words, thus enabling long data sequences to be stored. Battery backup ensures data retention if the IGA is switched off. Separate data drivers permit the data outputs to be connected in groups of eight channels to the test item (see righthand column). In addition to general-purpose drivers with **adjustable levels** (IGA-Z1) **TTL** drivers (IGA-Z4) are available. The driver adapters with individual plug-on cables are connected to the driver case so that the test items can be easily changed. To permit low-noise signal application, these cables are only 30 cm long and can be plugged onto wire-wrap pins (0.8 mm). IC (dual-in-line) adapters are supplied with the IGA. IC test clips and mini-clips are available as accessories. The data output can be clocked, single-stepped, single-shot and repetitive with programmable, variable pauses (see diagrams above and on page 303).

Programming of tristate words (see diagram below). For driving bidirectional bussed systems, the data channels can be switched in groups of eight lines from the active to the high-impedance state during the output. At the end of the data output, the channels can also be switched in groups to high impedance. In the tristate mode, the IGA can, for instance, instruct a subassembly to transfer data and then have its data lines go high impedance whereas the address lines remain active. The DAV line continues to supply the clock for the talking subassembly.



TTL Data Driver IGA-Z4 (top) and TTL Clock Driver IGA-Z5 (bottom)



Example for tristate mode (blue) and multi-clock mode covering several lines

Clock output. The IGA can be used with a built-in or an external **clock generator** up to 8 MHz. In addition, 3-wire handshake (corresponding to source handshake in accordance with IEC 625-1) and 2-wire handshake up to 1 MHz (with TTL drivers) can be selected. It is possible to set the start and the width of the clock pulse. The Clock Driver IGA-Z2 has **adjustable levels;** the Clock Driver IGA-Z5 delivers **TTL levels.** For the connection of the clock drivers see under data channels. The clock dirvers can be used for frequencies up to 3.5 MHz.

Generation of serial data. To generate bit-serial data, a driver (IGA-Z9) is available (see page 307) serializing up to 16 data channels of the IGA. In this way bit-serial data with word lengths freely adjustable between 2 and 16 bits can be produced. The available memory depth permits up to 16,384 bits to be stored depending on the word length. Data are output with TTL levels. When using the external clock input, the data rate can be increased to up to 30 MHz.

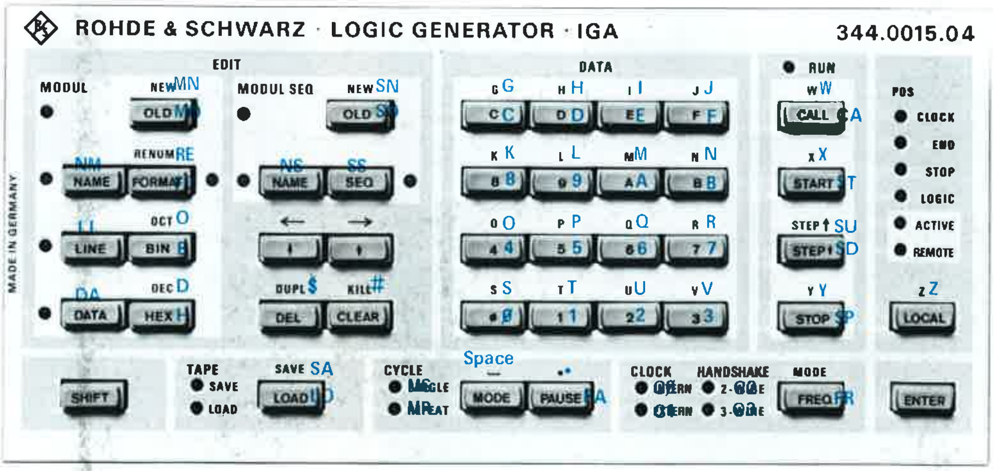
Multi-clock output. The stimulation of microprocessorized systems is possible with the aid of the multi-clock driver (IGA-Z6, see below; signal examples on preceding page, bottom) delivering **TTL levels.** The driver provides data for four channels and, in addition to the continuous clock signal, four separately programmable strobe signals whose polarity can be selected individually on the driver case. The number of data channels available is thus reduced to 28. The multi-clock driver must be used at low clock frequencies whereas at high clock frequencies (>3 MHz) strobe signals can be defined directly as data segments. This however reduces the memory capacity since at least three data words are required for each strobe signal.

TTL Multi-clock Driver IGA-Z6

Cassette compartment of Cassette Drive Option IGA-B2

Cassette drive (option; for illustration see above). Two times seven complete IGA memory contents, corresponding to the capacity of the cassette, or individual data sets can be stored on magnetic-tape cassettes (for instance for setting up a bit pattern library) and subsequently be read in again. In this way, the IGA can be used simultaneously for different tasks without losing data.

IEC-bus interface. This option makes the IGA programmable to IEC 625-1 with the front-panel keys (see photo below) and permits the logging of bit patterns on a printer. Moreover, data patterns generated in a desktop computer can be entered into the IGA via the IEC bus. In this way, the IGA acts as an intelligent, high-speed output interface for computers.



Association of programming commands (blue) with front-panel keys of IGA

IGA – Specifications

Data memory

Storage capacity	32 channels with 1024 words
Storage time (at +25 °C)	approx. 6 months (battery-buffered)

Data entry

Formal	binary, octal, decimal or hexadecimal; can be used simultaneously in one data line
Data expansion and variation	after fetching the freely selectable symbolic module name or a line number; editor-aided
Number of storable modules	max. 25
Display	date: 16 digits (7-segment indicators), module name and line number: 6 digits (LED matrix)

Data output

Modes	single-step/single-shot/repetitive with programmable, variable pauses
Start and stop	by keystroke or external TTL level

Data drivers (data signal outputs)

Number of data drivers connected	4
Test-item adaption	see text on page 304
General-purpose Data Driver IGA-Z1	
Channels	8
Levels	can be set on rear panel of IGA
Low	≦0.8 V
High	3 to 15 V
Fan-out (for high = 5 V)	1 standard TTL load
Capacitive loading	<50 pF
TTL Data Driver IGA-Z4	
Channels	8
Level	TTL
Fan-out	10 standard TTL loads
Permissible overloading	−1 V/+6 V
Continuous overloading	simultaneous overload on 2 channels max.
Rise and fall times	typ. 30 ns (with 10 standard TTL loads)
Serial Data Driver IGA-Z9	can be used instead of data drivers A, B and C, D
Channels	1 (2 outputs)
Level	output 1: TTL; output 2: current loop
Word length	2 to 16 bits, adjustable
Clock frequency	2 Hz to 8 MHz for internal clock, 0 to 30 MHz for external clock with the appropriate word length
Control inputs	
External clock	TTL (negative logic)
Ready	TTL (positive logic)
Control outputs	
Bit synchronization	TTL (negative logic), bit association switchable
Connectors	BNC

Tristate words	programmable for switching data channels to high impedance in every line
Switchable channels	8-bit groups
Maximum data channels available when using tristate words	28
End tristate	switching the data channels to high impedance at the end of the output
Control	internal or external

Clock control

Modes	internal/external/2-wire handshake/3-wire handshake (IEC 625-1)
Internal clock	1 Hz to 8 MHz
Setting resolution	2 digits
Frequency error	<0.1%
External clock	0 to 8 MHz
Active edge	can be set on rear panel of IGA
Handshake clock	0 to 1 MHz
Wait times	programmable
Interval between end of one cycle and beginning of next	0 to 60 s (resolution 1 ms)
Interval between data blocks	1 to 60 s, can be disabled (resolution 0.1 s)

Clock drivers (clock signal outputs) for f <3.5 MHz

Test-item adaptation	see text page 304
General-purpose Clock Driver IGA-Z2	
Synchronous clock outputs	DAV, inverted DAV
Levels	can be set on rear panel of IGA
Low	≦0.8 V
High	3 to 15 V
Fan-out (for high = 5 V)	1 standard TTL load
Capacitive loading	<50 pF
Asynchronous control lines (for 2-wire and 3-wire handshakes)	DAV, NRFD, DAC
TTL Clock Driver IGA-Z5	
Synchronous clock outputs	DAV, inverted DAV
Level	TTL
Fan-out	10 standard TTL loads
Asynchronous control lines (for 2-wire and 3-wire handshakes)	DAV, NDAC, NRFD (resistor wiring as per IEC 625-1)
TTL Multi-clock Driver IGA-Z6	can be connected to B and D instead of a data driver
DAV signal outputs	4; separately programmable
Polarity	can be separately changed over
Level	TTL
Fan-out	10 standard TTL loads
Data outputs	4 (same as on TTL data driver)
Delay of DAV signal with respect to data	150 ns to 2.5 µs } can be set on rear panel of IGA
Width of DAV signal	140 ns to 1.5 µs } can be set on rear panel of IGA

Control inputs and outputs ..... TTL level

Inputs:		
Start	start of data output	on clock driver
Start	start of data output (inverted signal)	on clock driver
Stop	stop of data output	on rear panel of IGA; BNC
Clock ext.	clock input	on rear panel of IGA; BNC
High Z	tristate	on rear panel of IGA; BNC
Output:		
End	end of data output	on rear panel of IGA; BNC

Cassette Drive IGA-B2 (option)

Capacity of cassette	2 × 7 IGA memory contents

Programming

System	IEC 625-1
Connector	24-way (Amphenol)
Interface functions	T5 talker
	L4 listener
	RL1 remote/local
	DC1 device clear
	DT1 device trigger
	SR1 service request

General data

Rated temperature range	+5 to +45 °C
Storage temperature range	−20 to +70 °C
AC supply	100/120/220/240 V ±10%, 47 to 63 Hz (70 VA)
EMC	to DIN 57875 (VDE 0875): RF suppression N −12 dB
Dimensions, weight	325 mm × 110 mm × 420 mm, 5 kg

Ordering information

Order designation .... ▶ Logic Generator IGA 344.0015.04

Accessories supplied

Dual-in-line adapter	
14-way	344.1234.00
16-way	344.1240.00
20-way	344.1257.00
24-way	344.1263.00
40-way	344.1270.00
Carrying case, power cord	

Options

Cassette Drive (including 6 cassettes 344.3114.02)	IGA-B2	344.2916.02

Recommended extras

General-purpose Data Driver	IGA-Z1	344.3414.02
General-purpose Clock Driver	IGA-Z2	344.3514.02
Adapter	IGA-Z3	344.3614.02
TTL Data Driver	IGA-Z4	344.3714.02
TTL Clock Driver	IGA-Z5	344.3814.02
TTL Multi-clock Driver	IGA-Z6	344.3914.02
Mini-cassettes	IGA-Z7	344.3114.02
Set of Mini-clips (20)[1]	IGA-Z8	344.1905.02
Serial Data Driver	IGA-Z9	344.3143.02
IC test clips, dual-in-line, 14-way		099.5222.00
16-way		099.5239.00
20-way		099.5268.00
24-way		099.5245.00
40-way		099.5251.00
Process Controller	PUC	see page 19
Analog Driver	IGA-Z11	356.8700.02

[1]) Supplied with the drivers

Serial Data Driver IGA-Z9

IGA-Z9

- Generation of any bit pattern required
- Bit rate: 1 Hz to 10 MHz with internal clock
  0 to 30 MHz with external clock
- Memory depth 16,384 bits or 1024 words
- Two-channel operation using two independently programmable data drivers

new

In conjunction with the Logic Generator IGA, the **Serial Data Driver IGA-Z9** permits the generation of bit-serial data. This considerably extends the application range of the IGA: Using the same instrument, it is possible to produce bit-parallel data with a word width of 32 bits and bit-serial data with a maximum length of 16,384 bits.

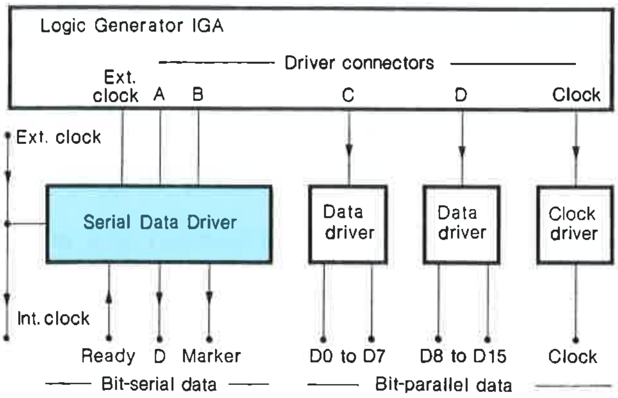
Typical applications

- Digital data transmission equipment
- Digital switching systems
- Data terminals
- PCM systems, remote-control systems, data networks

Characteristics

The Serial Data Driver IGA-Z9 accepts bit-parallel data words from the IGA, converts them into serial data and makes them available at the clock frequency set on the IGA (1 to 10 MHz when using the synthesizer incorporated in the IGA). The external clock signal input is suitable for frequencies of up to 30 MHz.

The mode control of the data output makes the data sequence available in the repeated or the single mode. For the repeated output mode, pauses can be inserted.



IGA plus Serial Data Driver

The data sequence is subdivided into **words** whose **length** can be varied from 2 to 16 bits with a rotary switch. A greater length can be obtained by combining several words.

A marker pulse available at a BNC output is produced in parallel with each data word. A rotary switch determines the bit position at which the marker appears within the word. The data output can be interrupted at any time via a **ready input.**

Data output ist performed in parallel via 2 connectors, one for TTL levels and the other for a 20-mA current loop. In addition a **clock output** is available delivering a synchronizing clock for each bit with internal clocking.

Display, storage. Any serial data word can be displayed on the readout of the IGA with a freely selectable format of up to 16 parallel bits. Like the bitparallel data, the bit-serial data can be stored in modules. The **editor** permits modification, duplication, insertion and erasure of data words or data modules as well as linkage of several modules to obtain module sequences.

The **cassette drive** makes it easy to store and load bit patterns thus rationalizing considerably data generation and management. Thus long data sequences can be produced.

Data pattern generation via the IEC bus. The IGA is fitted as standard with an IEC-bus interface and can thus be hooked up to the Process Controller PUC (or other controllers). In this way, both the automation of test sequences and computer-aided data generation are possible.

Two-channel operation. Two Serial Data Drivers can be connected simultaneously to the IGA. The data patterns of the two drivers can be programmed independently so that at the same time two bit-serial data channels with different contents are available.

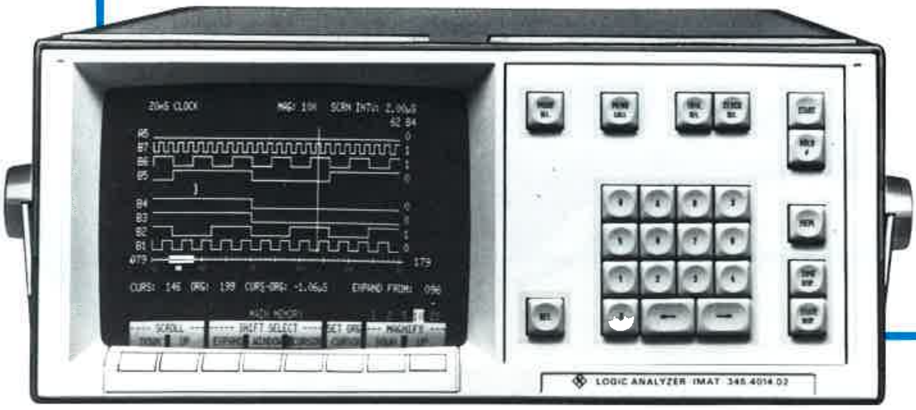
Specifications

Memory depth	16,384 bits or 1 024 words
Word length	2 to 16 bits, adjustable
Bit rate	1 Hz to 10 MHz with internal clock, 0 to 30 MHz with external clock max. 3 MHz × number of bits per word or 4 MHz with 2-bit words and 8 MHz with 3-bit words
Outputs	BNC connectors
Data output 1	TTL
Data output 2	current loop (20 mA, switchable logic)
Bit marking	TTL, bit assignment switch-selectable
Clock	TTL
Inputs	BNC connectors
External clock	TTL
Ready	TTL
Start	on clock driver of IGA
Stop	on rear panel of IGA
Connection on IGA	instead of data drivers A, B and/or C, D
General data	
Rated/storage temperature range	+5 to +45 °C/−20 to +70 °C
Dimensions, weight	155 mm×43 mm×85 mm, 0.6 kg
Order designation	▶ Serial Data Driver IGA-Z9 344.3143.02

IMAT

Logic Analyzer IMAT

- ♦ Sampling rate 100 MHz
- Analysis of digital and hybrid circuits
- Timing and analog display
- 1000-word memory depth
- Link operation
- Glitch display (down to τ=5 ns)
- Analog waveform measurement
- Frequency and time measurement
- Signature analysis



IEC 625 Bus

new

The **IMAT** is a general-purpose logic analyzer which stands out for ease of operation, large-area display of measured data and comprehensive measuring capabilities. Digital signals may be evaluated both in the timing and in the state mode and, using the analog recorder option, **analog signals** related to digital events can also be analyzed. Thus the Logic Analyzer IMAT is suitable for use in the wide field of **hybrid systems** handling analog and digital signals at the same time. The counter/signature analyzer option extends the Logic Analyzer for additional measurements on digital as well as on analog circuits.

This makes the IMAT a general-purpose tool for circuit analysis in development, production and servicing.

Operational setup, softkeys

The IMAT is set up with the aid of softkeys, i.e. softwaredriven keys located immediately at the lower screen edge. The current labelling of these 8 keys appears on the screen and is adapted to the selected mode. This reduces the number of panel controls and shortens the required setup procedure such that the instrument is ready for use after an extremely short time. Moreover, this safe method of **prompting the operator** ensures that wrong settings are virtually avoided.

Softkey detail

There is the special advantage that, in contrast to the usual menu displays, the screen labelling is located immediately above the key.

Parallel to the selective software setting, a **monitor menu** yields information on the overall instrument setup.

Operation, basic modes

A total of **six basic modes** can be selected on the IMAT, see photo and detail below.

Mode selection on Logic Analyzer IMAT

For normal measurements on digital circuits, the **16-channel** configuration is used. With a memory depth of 1000 words, this mode permits sampling at an internal clock frequency of 50 MHz or an external clock frequency of 40 MHz.

For accurate timing analysis, the **8-channel** configuration is used, the sampling rate being 100 MHz with a memory depth of 2000 words.

The **8-channel configuration plus glitch detection** permits optimum glitch analysis. In this case, 8 channels are sampled at 50 MHz whereas the memory for the 8 remaining channels is used as a glitch memory.

The **analog recorder** mode enables the digitization and display of analog signals.

In the **counter/timer** mode, the counter of the IMAT is enabled.

Finally, the **signature analysis** mode permits measurements up to 40 MHz.

Setup memory

Another aid for operating the IMAT is the batery-supported setup memory ensuring that ten complete setups are retained even after the instrument has been switched off. This memory proves to be particularly time-saving whenever different entry modes have to be used in the course of one measurement.

Adaptation

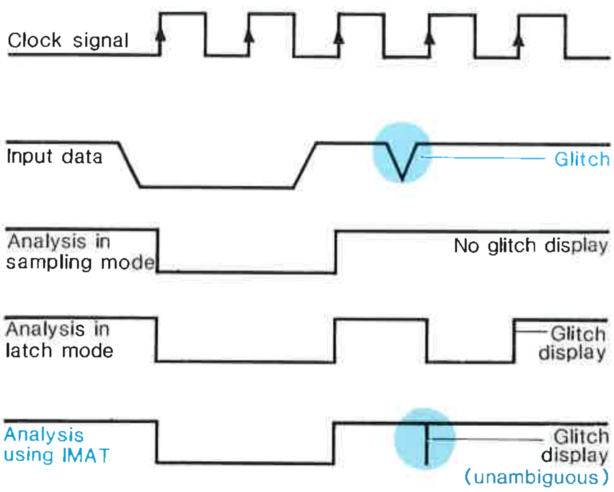
The Logic Analyzer IMAT is supplied with two timing probes, each fitted with 8 inputs. The probes can be connected to the test item via exchangeable adapters whose other end is fitted with push-on sleeves to accommodate R&S mini-clips; see photo to the right. If each probe is provided with its own adapter, a rapid change of the test item is facilitated.

Logic Analyzer IMAT plus timing probes A and B, adapter and push-on sleeves

Glitch measurement

Glitch detection is one of the most important tasks when analyzing digital circuits. The latch mode used by most logic analyzers for this purpose is suitable only to a limited extent since a data change between the individual clock edges can be easily taken for normal data. In the latch mode, glitches are not displayed as such but represented as normal additional data.

In contrast to this method, the IMAt uses a **glitch memory** permitting glitches to be marked clearly and unmistakably in the timing diagram (see below) in the basic 8-channel glitch measurement mode.



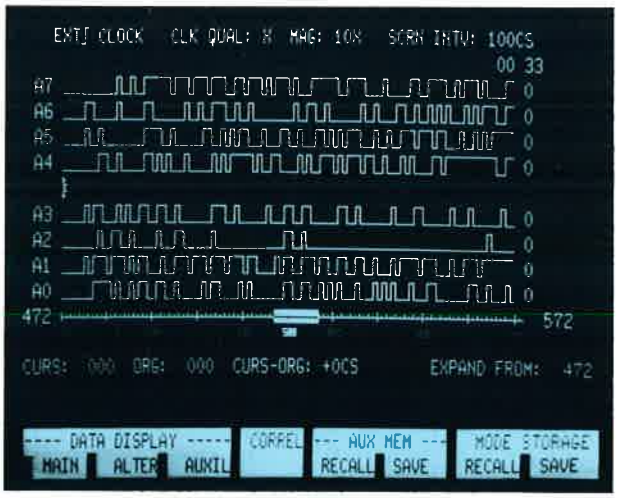
Glitch display in latch mode and with IMAT glitch memory

It is obvious at a glance whether the bit pattern measured contains glitches. In addition, there is the possibility of using one channel at a time for **glitch triggering.**

Reference memory

The IMAT contains a reference (auxiliary) memory of the same capacity as the main memory. The data from the main memory can be transferred to the reference memory. For comparing the two memories, special function sequences can be recalled; see photo below.

For **automatic troubleshooting,** the HOLD mode ensures that the analyzer automatically reads in new data until a difference between the main and the reference memory causes it to stop.



Comparison of reference and setup memories

Link operation

This capability is one of the most important characteristics of the Logic Analyzer IMAT. In the link mode, several analyzers are combined via a link line.

Master-slave synchronization. This mode permits several analyzers to be combined in a system. Thus the IMAT can be hooked up to the Logic State Analyzer IMAS. For further information see page 300.

IMAT – Logic Analyzer

Timing display

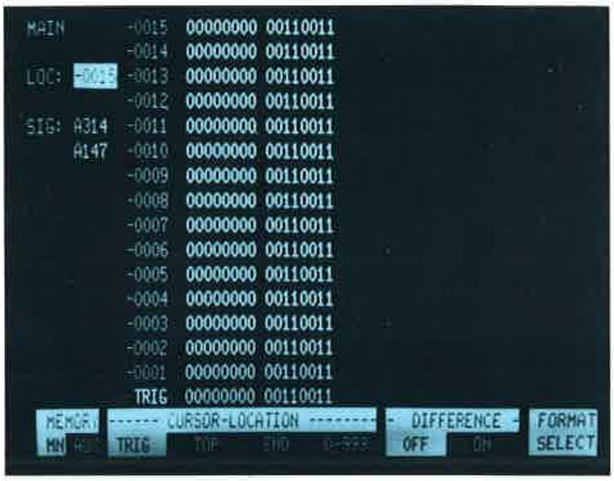
The timing display covers a maximum of 8 channels; the resolution can be increased by a magnification factor of up to 20. An additional scale shows the position of the **window (display range)** in the main memory.

Various aids are provided to facilitate localizing and positioning of the selectable data ranges. Glitches are clearly marked by vertical lines.

The IMAT features an extremely rapid display generation permitting the data to be shifted and expanded with exceptionally high speed. For comparing the main and the reference memories, the IMAT calculates a correlation factor thus marking the coincidence in the timing ranges. A cursor enables time difference measurements. The complete information relevant for evaluation is displayed in **text lines** parallel to the data display.

Logic state display

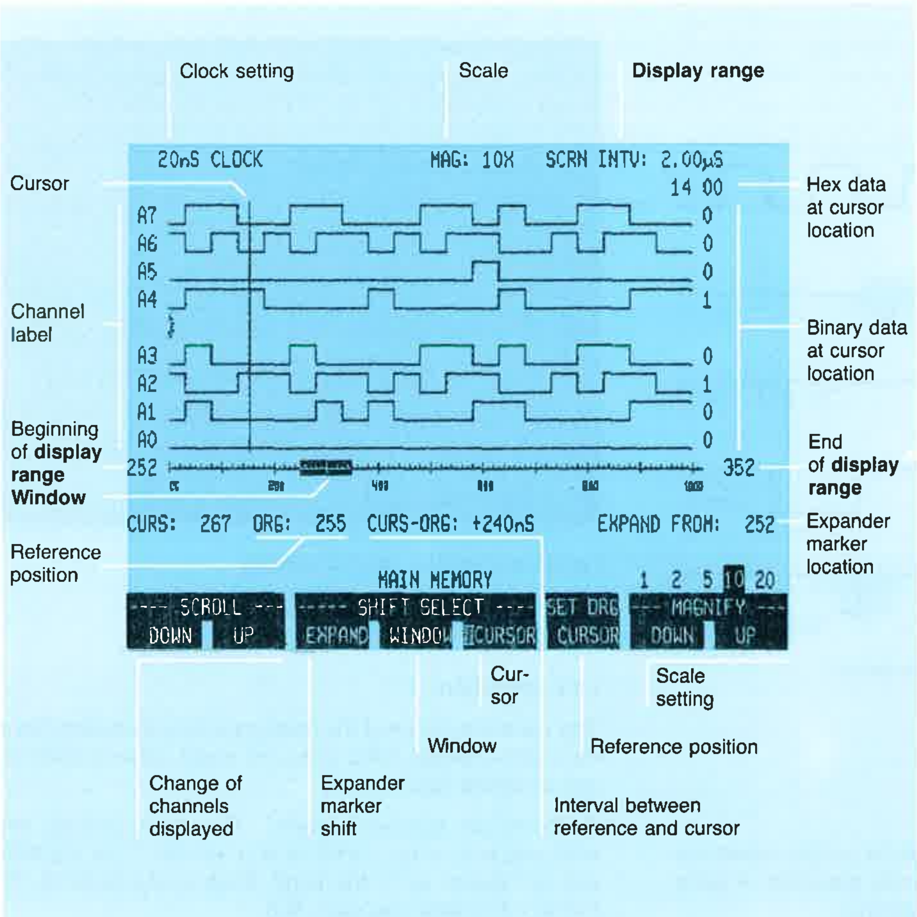
To display the logic state data, the data stored in the Logic Analyzer IMAT can be represented in the binary, decimal, hexadecimal, octal and ASCII codes.



Logic state display of IMAT memory contents

Various techniques are available for moving the cursor and the data. When comparing the main and the reference memories, the **difference mode** permits deviations to be rapidly localized.

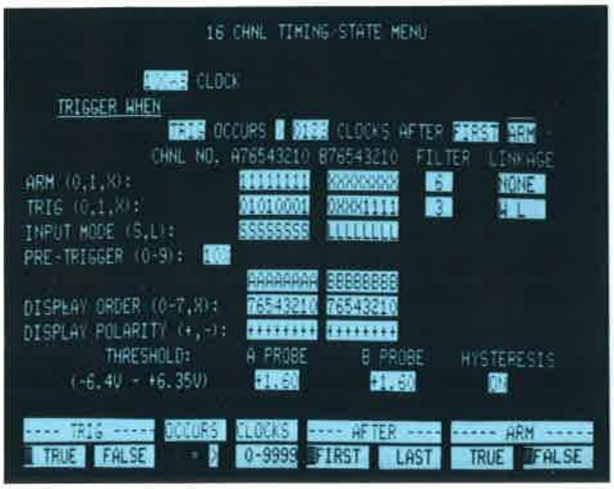
Moreover, rapid information on the IMAT memory contents is available since the instrument calculates and displays characteristic **signatures** for the complete data contents.



Hard copy of timing display on IMAT

Triggering

The IMAT has two trigger levels (ARM and TRIG), which consist of a data word and the linkage condition.



Setting the trigger linkage

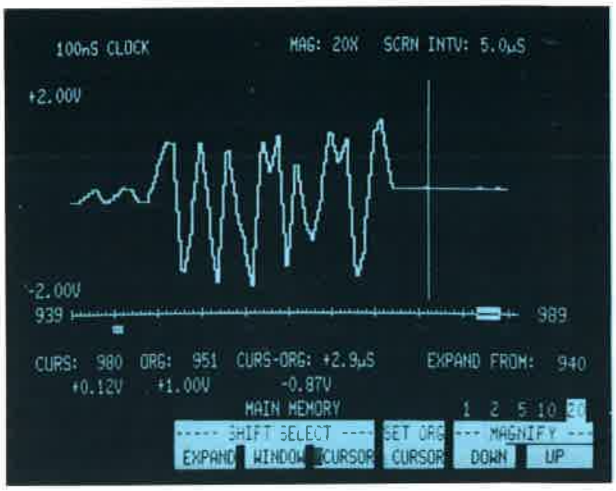
Arming and triggering can be linked in various ways. In this way, even complex events can be localized. Moreover, a programmable **filter function** is available for both arming and triggering. The pretrigger function permits continuous shifting into ranges before and after the triggering instant. The **trigger threshold** of the probes can be programmed in 50-mV steps so that the measurement of ECL signals is also possible. In addition, a hysteresis can be added. The **sample** or **latch mode** can be selected separately for each input channel.

Analog/digital measurement
Analog recorder

The analog recorder option is a transient recorder which accepts **analog signals** up to 10 MHz via a BNC input. For this purpose, a 6-bit A/D converter with a maximum sampling rate of 50 MHz and a 1000-word memory depth is used.

The input sensitivity, offset, couping and sampling frequency are programmable. The test result is displayed as an analog signal on the screen of the IMAT; see photo in the righthand column.

The analog recorder can be started if an analog trigger threshold is exceeded or by the digital trigger facility of the IMAT. Thus **analog measurements related in time to digital events** can be made. The analog recorder function can also be used in the link mode for instance by way of a microprocessor analyzer.



Analog recording display on screen of IMAT

The analog recorder augments the IMAT from a pure digital analyzer to a hybrid analyzing system. It permits the **analysis of analog signals driven by digital circuits or microprocessors** as used in control systems and in general in hybrid circuits. In particular, transients can thus be measured in the form of a dynamic response.

Counter/signature analyzer

The counter/timer option is also suitable for use in analyzing digital and analog circuits. The following modes can be selected: frequency measurement, period measurement, event counting and time-interval measurement. The occurrences counted can be either analog signals applied to a BNC input or freely defined data words. In this way, the frequency and the time spacing of equal and different data words can be measured with high accuracy. The limit frequency for measuring data words is about 10 MHz whereas analog signals can be measured up to 100 MHz.

The counter option of the IMAT also contains a signature analyzer permitting signature analysis up to a limit frequency of 40 MHz. In addition to the characteristics common to instruments of this type, the IMAT features the capability of defining the start and stop condition by 16-bit data words. This simplifies signature analysis of test items which do not have any special connectors for controlling the signature analysis.

The signatures are displayed both in the hexadecimal and in the usual standard formats. The signatures are identified on the screen by the appearance of the words STABLE or UNSTABLE. The signatures are collected by a normal oscilloscope probe.

Basic operating modes

Mode	Sampling rate	Memory depth	Data captured via
16 channels, logic analyzer	50 MHz asynchronous 40 MHz synchronous	1000 words	2 timing probes
8 channels, logic analyzer	100 MHz (asynchronous)	2000 words	probe A
8 channels, glitch memory	50 MHz (asynchron. only)	1000 data words 1000 glitch words	probe A
Analog recorder	50 MHz (10 MHz bandwidth)	1000 words	oscilloscope probe, probes A+B for triggering
Counter/timer	100 MHz for external signals 10 MHz for data words	—	oscilloscope probe, probes A+B for data word measurement
Signature analyzer	40 MHz	—	oscilloscope probe, probes A+B for start/stop

Additional technical data

Operation . . . . 8 softkeys
25 function keys
Capacity of setup memory . . . . 10 instrument setups

Inputs . . . . 16 data inputs
(via Timing Probes IMAT-Z1)
2 qualifier inputs
1 link line input
1 external clock signal input

Timing Probes IMAT-Z1
Number of timing probes required . . 2 (1), depending on mode
Inputs per probe . . . . 8 data inputs
1 qualifier input
1 clock signal input
each input is separately connected to ground
Input impedance . . . . 100 kΩ || 10 pF
Threshold setting . . . . ±6.4 V
Resolution . . . . 50 mV
Max. input voltage . . . . +100 V
Min. input voltage . . . . 0.5 V_{pp}
Hysteresis . . . . 0 or 200 mV (switch-selected)

Clock control
Sampling time with internal control . . 10 ms to 10 ns (8 channels)
10 ms to 20 ns (16 channels)
Resolution of setting . . . . 1, 2, 5 sequence
Error of clock frequency . . . . ±0.2%
External clock frequency . . . . 0 (DC) to 40 MHz
External clock signal input . . . . probe A
Clock qualifier 1

Timing of input channels
Skew . . . . <5 ns (asynchronous)
Setup time . . . . <10 ns (synchronous)
Hold time . . . . 5 ns (synchronous)

Memories
Data memory . . . . 16×1000 words (50 MHz)
8×2000 words (100 MHz)
8×1000 words (glitch memory)
Reference memory . . . . corresponds to data memory

Glitch detection
Mode . . . . latch mode or glitch memory
Minimum detectable glitch . . . . 5 ns with 0.25 V overdrive
Glitch memory . . . . 1000×8 with 1000×8 data words
Glitch display . . . . in "8-channel, glitch-memory" basic mode by vertical lines in timing diagram

Trigger
Pretrigger . . . . 0 to 900 words (16 channels)
0 to 1800 words (8 channels)
Number of trigger levels . . . . 2 (ARM and TRIG)
Trigger word length . . . . 16 bits
Trigger logic . . . . triggering on equality or nonequality
Trigger filter . . . . 1 to 9 clock events
Trigger delay . . . . 0 to 999 clocks or arm events
Modes of delay . . . . triggering **after** n clocks, **before** n clocks, at n clocks or at n events
Trigger state . . . . displayed

Link operation
Link-up . . . . a) for combining with other analyzers via link connector
b) for driving via external trigger qualifier connector
c) for driving by analog recorder (internal)
Link conditions . . . . selectable for both trigger levels

Link connector . . . . BNC female on rear panel
Level . . . . TTL (bidirectional)

Trigger qualifier (external)	
Connector	BNC female on rear panel
Input level	TTL
Qualifier condition	selectable for both trigger levels
Display	
Screen colour	green
Dimensions	23 cm diagonal
Output for external display unit	composite video signals
Connector	BNC female
Output voltage	≈1 V_{pp} (EMF)
Impedance	75 Ω
Display modes	timing display, data display, analog display (optional)
Coding for data display	hexadecimal, octal, decimal, binary, ASCII
Data compression	signatures for groups of 8 channels
Timing display	max. 8 channels simultaneously
Timing curcor	indicates time, hex and binary values at the corresponding cursor location
Timing magnification	1×, 2×, 5×, 10×, 20×
Display order	selectable on keyboard
Analog recorder	
Vertical format	level display with automatic scaling
Vertical resolution	6 bits
Timing magnification	1×, 2×, 5×, 10×, 20×
Cursor	indicates time and voltage

Analog Recorder Option IMAT-B2

Level resolution	6 bits
Sampling time	10 ms to 20 ns
Setting	1, 2, 5 sequence
Number of channels	1
Input	oscilloscope probe (10×/1×)
Connector	BNC female on rear panel
Input impedance	1 MΩ‖30 pF
Max. input level	±200 V DC
Input sensitivity	10 mV
Bandwidth	10 MHz (3 dB)
Level measurement error	±5%; f <1 MHz
Measurement range	5 mV/div to 10 V/div
Resolution of setting	1, 2, 5 sequence
Display range	8 divisions
Modes	AC, DC, GND
Input offset	adjustable up to 1 display range in each direction
Main memory depth	1000 words
Reference memory depth	1000 words
Trigger	
Analog	level and edge adjustable: 1 × display range, resolution 0.01 × display range
Digital	same as logic analyzer trigger
Sampling time	10 ms to 20 ns
Resolution of setting	1, 2, 5 sequence
Pretrigger	0 to 900 clocks

Counter/Timer Option IMAT-B1

Modes	frequency measurement, period measurement, time-interval measurement, event counting
Signal application	a) logic signals: via analyzer probes and internal word recognizer b) analog signals: via oscilloscope probe (10×/1×)
Analog signals	
Connector	BNC female on rear panel, impedance 1 MΩ‖30 pF
Setting of switching threshold	
Probe ×1	−2.56 to +2.54 V, resolution 20 mV
Probe ×10	−25.6 to +25.4 V, resolution 200 mV

Signal measurement	
Logic signals	
Max. clock frequency for data words	10 MHz
Analog signals	
Frequency measurement	100 MHz with prescaler 10 MHz without prescaler
Gate time	0.01μs to 10 s
Period measurement	25 MHz with prescaler 2.5 MHz without prescaler
Measurement range	0.01 μs to 10 s
Interval measurement	
Measurement range	0.2 μs to 10 s
Resolution	100 ns
Event counting	
Max. count	99.999.999 events
Measuring error	±0.01%

Signature analyzer (included in Option IMAT-B1)

Algorithm	16-bit standard
Display	standard format or hexadecimal format
Probability of correct signature	99.998%
Minimum gate open time	1 clock cycle
Minimum clocks required for signature display	4
Test input	oscilloscope probe (10×/1×) BNC female connector
Impedance	1 MΩ ‖ 30 pF
Setup time	15 ns with 0.2 V overdrive
Hold time	0
Max. input level	±200 V_p
Control inputs	analyzer data, qualifier and clock
Setup time	10 ns
Hold time	5 ns
Max. input level	±100 V
Start and stop words	1 to 16 bits
Clock frequency	0 (DC) to 40 MHz
Minimum pulse width	20 ns
Edge selection	switch-selected
Programming	interface to IEC 625-1, 24-way connector (Amphenol)
Interface functions	L4 listener T5 talker RL1 remote/local DC1 device clear SR1 service request

General data

Rated temperature range	+5 to +45°C
Power supply	115/125/220/235 V ±10%, 47 to 63 Hz (230 VA)
Dimensions (W × H × D), weight	470 mm × 206 mm × 484 mm, 18.5 kg

Ordering information

Order designation ▶ Logic Analyzer IMAT 345.4014.02

Accessories supplied

2 Timing Probes, 8 bits	IMAT-Z1	345.7213.02
2 Probe Adapters, 8 bits	IMAT-Z2	345.7313.02
Power cable, carrying case		

Options

Analog Recorder (including probe ×10)	IMAT-B2	345.7113.02
Counter/Signature Analyzer (including probe ×10)	IMAT-B1	345.7013.02

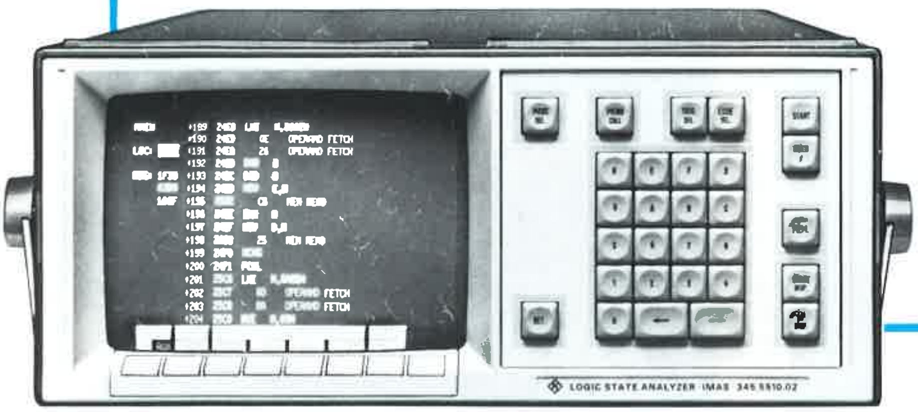
Recommended extras

Set of Mini-clips (20)	IGA-Z8	344.1905.00
Test Generator IMAT/IMAS	IMAT-Z7	345.7413.02
Extension Board IMAT/IMAS	IMAS-Z7	345.7913.02 (for servicing)
Logic Generator	IGA	344.0015.04 (32 channels)

IMAS

Logic State Analyzer IMAS

- 48 data channels
  12.5-MHz clock
- 3 clock inputs
- 16 trigger levels
- Reference and setup memories
- Signature analysis, event counting
- Serial data analysis and generation
- Disassemblers for 8- and 16-bit processors
- Selective read-in of data and instructions
- Frequency and time measurement



IEC 625 Bus

new

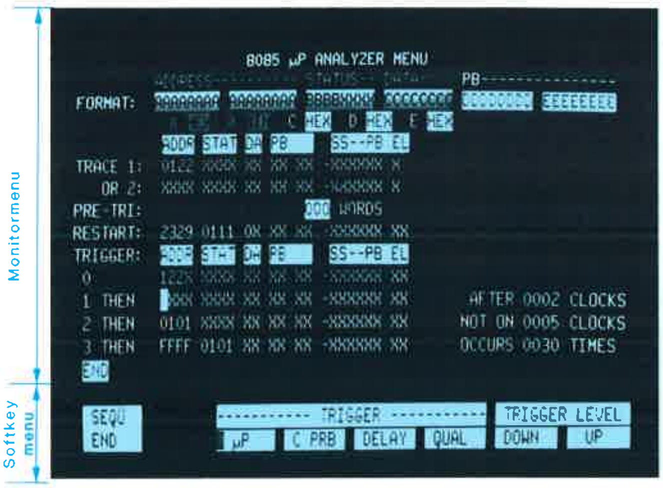
The **Logic State Analyzer IMAS** is part of the IMAS/IMAT logic analyzer system and performs universal logic state analysis. It stands out for ease of operation, features a large number of channels and is suitable both for analyzing microprocessors and testing bussed systems and generalpurpose logic circuits. The 16 trigger levels, numerous qualifier conditions and several clock inputs make the IMAS ideal for localizing complex logic and software functions.

The IMAS is an indispensable add-on for in-circuit emulators since it makes possible microprocessor program analysis in the original circuit under absolute real-time conditions. The IMAS is combined with the 100-MHz Logic Analyzer IMAT (see page 300) via the link line so that a complete logic analyzer system is obtained enabling simultaneous timing and logic state analysis.

This concept offers all the measuring capabilities of a combined general-purpose system making at the same time full economical use of the two separate instruments since,

> depending on the measurement task, the IMAS and IMAT can be used as a combined system or independent instruments

in different test assemblies.



Trigger sequence setting

Softkey control, monitor menu

The IMAS is mainly set up with the aid of **eight softkeys** (software-and microprocessor-driven keys) located immediately at the lower screen edge; the screen labelling of the softkeys is automatically adapted to the selected mode. The softkeys are driven by a microprocessor of their own simplifying the operation of the IMAS so that the user can perform complex measurements after a very brief period of familiarization.

The softkeys considerably reduce the number of front-panel controls and settings required.

Since only the keys required for the current mode are screen-labelled, wrong settings are virtually eliminated.

Parallel to the selective softkey operating menu, a **monitor menu** yields information on the overall instrument setup. In this way the settings performed can be permanently checked.

Setup memory

To define the measurement task to be solved, the large number of input channels and trigger levels may sometimes require the entry of large amounts of data. For this purpose, the battery-supported setup memory of the IMAS is an essential aid enabling complex instrument setups to be rapidly changed and retained even with the IMAS switched off.

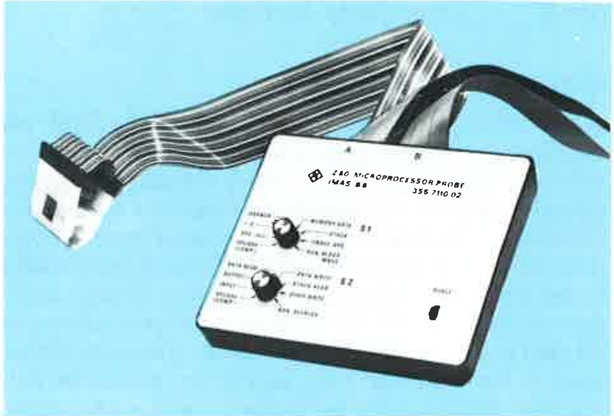
Basic modes

The IMAS combines the functions of five different instruments and operates in the following basic modes as a

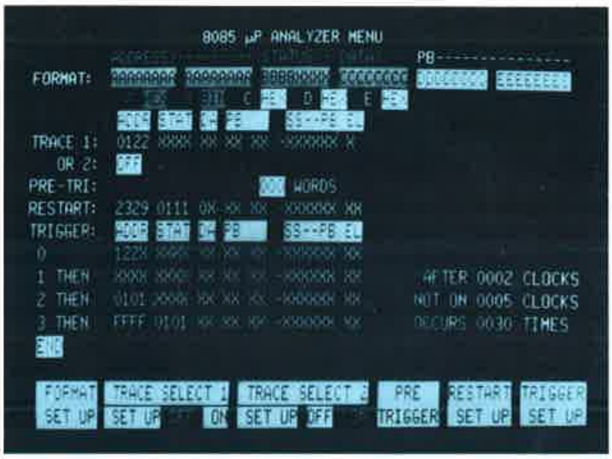
- microprocessor analyzer
- 48-channel logic analyzer
- serial data analyzer and generator
- frequency counter and timer
- signature analyzer

Microprocessor analyzer

The IMAS can be used for analyzing both 8-bit and 16-bit microprocessors. With a memory depth of 250 words, the maximum clock frequency is 12.5 MHz so that even the latest-state-of-the-art microprocessors with high clock frequencies can be tested. When analyzing 8-bit microprocessors, 16 additional channels are available.



Microprocessor Probe IMAS-B6 with selector switches



Basic menu for microprocessor analysis

Adaptation

The Logic State Analyzer IMAS is adapted to the microprocessor with the aid of the microprocessor probe (see photo, righthand column, top) which is connected to the module under test via a clip. A data probe with 16 data inputs and exchangeable probe adapter is available for the 16 analyzer channels. It is easy to test different types of microprocessor: merely the dedicated microprocessor probe and a plug-in ROM accomodating the disassembly program need to be changed.

Selective read-in of program functions

When reading in the data to be analyzed, data reduction by preselection is an efficient aid for simplifying the measurement task and rapidly localizing program functions of interest. For this purpose, the IMAS is fitted with trace selector switches which, depending on the microprocessor type under test, permit the selective read-in of program instructions, storage commands, I/O data, stack operations, program branches, etc. Moreover, the data can be reduces further by qualification with addresses and analyzer channels. Input selection is possible at two ORed levels. In this way, a variety of combinations can be used allowing for ample specification of the selection criteria.

Triggering

The IMAS has 16 trigger levels so that even program sections nested in several subroutines can be traced. A restart condition causes incorrect trigger sequences to be terminated. Moreover, it is possible to select or suppress trigger events using the selector switches on the microprocessor probe. The analyzer channels can also be used for defining the trigger conditions.

Display of program flow

The collected data can be displayed both as logic states and as assembly instructions (see photo below).

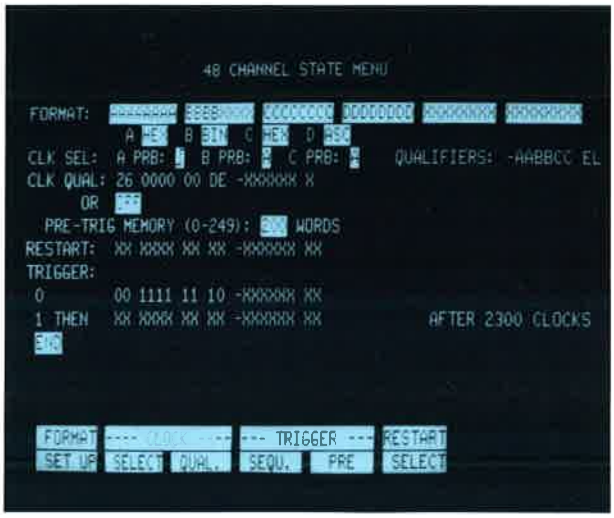
The logic state can be displayed in hexadecimal, octal, decimal, binary or ASCII format. When displaying assembler instructions, the addresses are hexadecimal whereas the data and analyzer-channel coding can be freely selected. A search word function as well as numerous cursor positions facilitate the localization of data within the memory. The complete memory contents of the instrument are identified by three signature numbers so that the equality or nonequality of data can be recognized at a glance.

Selective assembler display of program branches

IMAS – Logic State Analyzer

48-channel logic analyzer

In this mode, all the 48 data channels of the IMAS are available for universal logic analysis. The channels can be subdivided into six groups with freely selectable length and coding. Adaptation is performed via three data probes each provided with 16 data channels, two qualifier inputs and one clock input. Thus altogether three clock inputs are available for the analysis of multiphase clock systems. Whereas one of the clock inputs is used as the master clock for transferring all the data to the memory, the two remaining clock inputs are taken to the latch where the data of the associated data channels are stored until the master clock signal appears.



Basic menu of 48-channel logic analyzer

Triggering

There are 16 trigger levels, each with a 48-bit data word, seven qualifier inputs and one link input. In addition, one of five delay conditions can be defined for each trigger level. A restart word enables the trigger sequence to be started anew.

State display

The data collected by the IMAS on the 48 data channels can be displayed in the same format (binary, hexadecimal, octal or ASCII) or in mixed format with a maximum of six groups corresponding to those previously selected for the input channels. The search word and the cursor positioning function are available just as with microprocessor analysis.

Reference memory

The IMAS contains a reference memory of the same size as the main memory. For comparing the two memories, a difference function is available. In the hold mode an automatic comparison is performed, the IMAS reading in new data until a difference between the main and the reference memory causes it to stop.

Logic state display

System operation

The LINK connector of the IMAS permits the instrument to be combined with the Logic Analyzer IMAT via a coaxial cable. In the link mode, master-slave synchronization is possible, the IMAS driving a logic timing analyzer, i.e. the IMAT; for more information see page 300.

Combined timing and state analysis offers decisive advantages in the performance of measurements:

- Considerably simplified timing analysis since triggering of the timing analysis is performed in the state domain (e.g. at µP program steps). The analysis of a µP program step with triggering in the time domain is often difficult or impossible.
- Safe location of timing errors in functional and program flows. Triggering is performed in the time domain to determine timing errors whereas state-domain analysis records the function at the moment of the timing error.

Serial data analyzer and generator

When using the optional Serial Interface Probe IMAS-B2, the IMAS is suitable for analyzing serial data interface systems to standard RS 232. The IMAS then functions both as a data analyzer and a data generator. It is thus able to test all the functions of this interface and the current-loop interface in both directions. Selector switches on the IMAS-B2 option permit all the important parameters, such as the baud rate (50 to 19,200), parity and word length, to be set. The 48-channel analyzer function is used for **data evaluation.** With the ASCII format selected, the analyzed information can be displayed in plain text.

A separate generator menu capable of producing a total of 250 data words is used for **data generation.** Since the IMAS-B2 option uses only 16 analyzer channels, the remaining 32 channels are available for bit-parallel entry of data during the analysis. This enables the data transfer to be checked simultaneously at the bit-parallel end.

Frequency counter and timer

The optional Counter/Signature Analyzer IMAS-B1 permits

- the sequence of digital events to be measured in the frequency and the time domain,
- the frequency of data words to be determined (event counting) and
- the time spacing of equal and different digital events to be measured (time difference measurement).

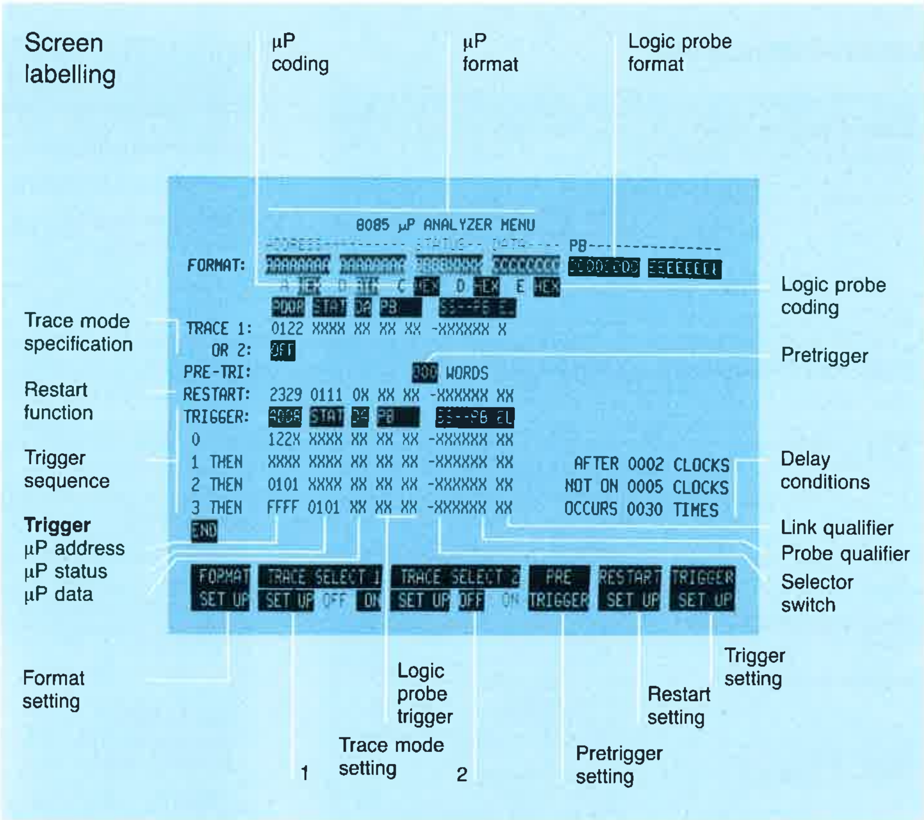
These characteristics are of special importance for microprocessor program analysis enabling the timing of programs to be checked. All the data and qualifier channels can be used for determining digital events so that a maximum of **56 bits per word** is available. The maximum clock frequency is 10 MHz.

The counter can also be used for **measuring analog events.** For this purpose, a test input is provided, handling signals up to 100 MHz.

Signature analyzer

The counter option of the IMAS includes the function of a signature analyzer which can be used up to the **limit frequency of 40 MHz.** The signatures can be displayed in the hexadecimal and the usual standard formats. They are identified on the screen by the appearance of the words STABLE or UNSTABLE.

The IMAS offers the advantage that the start and stop conditions can be defined by data words with a maximum length of 56 bits. Thus signature analysis is possible on programs under execution which do not feature any defined start/stop bit.



Combination with Logic Generator IGA

The combination IMAS/IGA yields a complete logic test assembly which, with its 32 generator and 48 analyzer channels, is a convenient tool for performance checking on digital subassemblies. In this test assembly, the IGA is the master controlling the read-in procedure of the IMAS. Since both instruments are IEC-bus-programmable, a fully automatic digital test system is obtained when adding the Process Controller PUC.

Programming

The Logic State Analyzer IMAS is fitted with an IEC-bus connector (24-pole Amphenol) via which all the functions of the instrument can be set and the analyzed data can be output. Additional system control commands permit the display to be modified. Thus the IMAS is ideal for use in automatic test systems.

IMAS – Basic operating modes

Mode	Sampling or measurement rate	Additional analyzer channels	Trigger levels	Data captured via
Microprocessor analyzer	12.5 MHz	16 for 8-bit-µP 0 for 16-bit-µP	16	1 µP probe +1 data probe 1 µP probe
48-channel logic analyzer	12.5 MHz	48	16	3 data probes
Serial data analyzer and generator	baud rate: 50 to 19,200	32	16	serial interface probe at RS-232-C interface +2 data probes
Frequency counter/timer	10 MHz 100 MHz ext.	—	—	data probes for logic signals; oscilloscope probe for analog signals
Signature analyzer	12.5 MHz	—	—	data probes for data, qualifiers and clock; oscilloscope probe

Additional technical data

Basic operating mode: Microprocessor analyzer

Data collection/connector .... via 1 microprocessor probe (dedicated, see options), 1*) Data Probe IMAS-Z1 (see 48-channel logic analyzer)

Number of additional analyzer channels .... 16*)
Clock qualifier inputs .... 2 on data probe*), 1 on rear panel
Trigger qualifier inputs .... 2 on data probe*), 2 on rear panel
Clock frequency .... max. 12.5 MHz

Selective read-in
(depending on µP) .... program instructions, program branches, I/O data, memory data, stack operations, undefined program instructions, additional qualification by addresses, data and analyzer channels
Simultaneously effective selection levels .... 2 (ORed)

Selective suppression .... same as selective read-in, however, without additional qualification by addresses and data
Number of trigger levels 16
Selective triggering .... same as selective read-in, however, independent of read-in mode
Time, time-difference measurement and event counting of µP functions .... using option IMAS-B1

Further characteristics corresponding to 48-channel logic analyzer

Microprocessor program display
State display .... see 48-channel logic analyzer
Coding: addresses .... hexadecimal
other data .... freely selectable

Disassembled display
Display of program flows in assembler language depending on microprocessor type

*) With 8-bit µPs only.
**) 20-µA mode for high-impedance circuits (can be selected on probe case for data and qualifier inputs).

Basic operating mode: 48-channel logic analyzer

Data collection/connector .... via 3 Data Probes IMAS-Z1
Number of data channels 48

Data Probe IMAS-Z1
Number of inputs .... 16 data channels, 2 qualifier inputs, 1 clock input
Input impedance or current .... 44 kΩ || 15 pF or 20 µA**)
Setting range of trigger threshold .... ±6 V at 44 kΩ or ±3 V at 20 µA**)
Edge .... switch-selected on IMAS-Z1
Max. input voltage .... ±20 V at 44 kΩ or ±10 V at 20 µA**)
Min. input voltage .... 0.5 V_{pp}

Clock signal
Number of clock inputs 3
Clock frequency .... DC to 12.5 MHz
Minimum pulse width .... 20 ns
Number of clock qualifier words .... 2 (ORed)
Word width .... 55 bits
Setup time for input data .... 20 ns
Hold time .... 0 ns
Clock output .... for qualified clock signals; BNC female connector, TTL level

Memory depth
Main memory .... 250 words
Referency memory .... 250 words

Trigger
Pretrigger .... 0 to 249 words
Number of trigger levels 16
Trigger word width .... 48 bits
Trigger qualifier inputs .... 6 on data probes, 2 on rear panel
Trigger logic .... triggering on equality or nonequality
Trigger delay .... 0 to 9,999 clocks or events
Delay modes .... triggering **after** n clocks, **not after** n clocks, **before** n clocks, **at** n clocks; **at** n events
Comparison trigger .... displayed if main memory not equal to reference memory
Trigger restart function .... 48-bit data word, 8 qualifier conditions
Trigger state .... displayed

Basic operating mode: Serial data analyzer and generator

Data collection/connector	via Serial Interface Probe IMAS-B2, interfaces (switch-selected): a) RS 232 C, b) 20 mA (current loop); connector: 25-pole Cannon, male and female

Serial data analysis

Baud rate	50 to 19,200; external clock selectable
Data character length	5 to 8 bits, selectable
Stop character	1 to 2 bits, switch-selected
Parity check for	even/odd, switch-selected
Memory depth	250 words
Display format	hexadecimal, octal, decimal, binary, ASCII; can be separately set for data and control characters

Serial data generation

Data entry format	hexadecimal or octal
Modes	single-shot or recurrent

For further data see serial data analysis

Basic operating mode: Frequency counter and timer (Option IMAS-B1)

Modes	frequency measurement, period measurement, time-interval measurement, event counting
Signal collection	a) logic signals: via analyzer probes and internal word recognizer b) analog signals: via oscilloscope probe (10×/1×)
Analog signals	
Connector	BNC female on rear panel, impedance 1 MΩ || 30 pF
Setting of switching threshold	
Probe (1×)	−2.56 to +2.54 V, resolution 20 mV
Probe (10×)	−25.6 to +25.4 V, resolution 200 mV

Signal measurement

Logic signals	
Max. clock frequency for data words	10 MHz
Word width	56 bits
Analog signals	
Frequency measurement	100 MHz with prescaler, 10 MHz without prescaler
Gate time	0.01 µs to 10 s
Period measurement	25 MHz with prescaler 2.5 MHz without prescaler
Measurement range	0.01 µs to 10 s
Time-interval measurement	
Measurement range	0.2 µs to 10 s
Resolution	100 ns
Event counting	
Max. count	99.999.999 events
Measuring error	±0.01 %

Basic operating mode: Signature analyzer (Option IMAS-B1)

Algorithm	16-bit standard
Display	standard or hexadecimal format
Probability of correct signature	99.998%
Minimum gate open time	1 clock cycle
Minimum clocks required for signature display	4
Test input	oscilloscope probe (10×/1×), BNC female connector
Impedance	1 MΩ || 30 pF
Setup time	15 ns with 0.2 V overdrive
Hold time	0 ns
Max. input level	±200 V_p
Control inputs	analyzer data, qualifier and clock
Setup time	20 ns
Hold time	0 ns
Max. input level	±20 V
Start and stop words	1 to 56 bits
Clock frequency	0 (DC) to 12.5 MHz
Minimum pulse width	20 ns
Edge	switch-selected

Display

On IMAS	CRT, 23 cm diagonal
Output for external display unit	composite video signal
Connector	BNC female
Output EMF	1 V_{pp}
Impedance	75 Ω

Programming

System	interface to IEC 625-1 and IEEE 488, 24-pole connector (Amphenol)
Interface functions	L4 listener T5 talker RL1 remote/local DC1 device clear

General data

Rated temperature range	+5 to +45°C
Power supply	100/120/220/240 V ±10%, 47 to 63 Hz (155 VA)
Dimensions (W × H × D), weight	470 mm × 198 mm × 484 mm, 18.5 kg

Ordering information

Order designation ▶ Logic State Analyzer IMAS 345.5510.02

Accessories supplied

3 Data Probes, 16 bits	IMAS-Z1	345.7713.02
3 Probe Adapters, 16 bits	IMAS-Z2	345.7813.02
Power cord, carrying case		

Options

Counter/Signature Analyzer	IMAS-B1	345.7613.02
Serial Interface Probe	IMAS-B2	356.6213.02
8080 Microprocessor Probe	IMAS-B3	356.6413.02
8085 Microprocessor Probe	IMAS-B4	356.6613.02
8086 Microprocessor Probe	IMAS-B5	356.6813.02
Z80 Microprocessor Probe	IMAS-B6	356.7110.02
6800 Microprocessor Probe	IMAS-B7	356.7310.02
6809e Microprocessor Probe	IMAS-B8	356.7510.02
8088 Microprocessor Probe	IMAS-B9	356.7610.02

Recommended extras

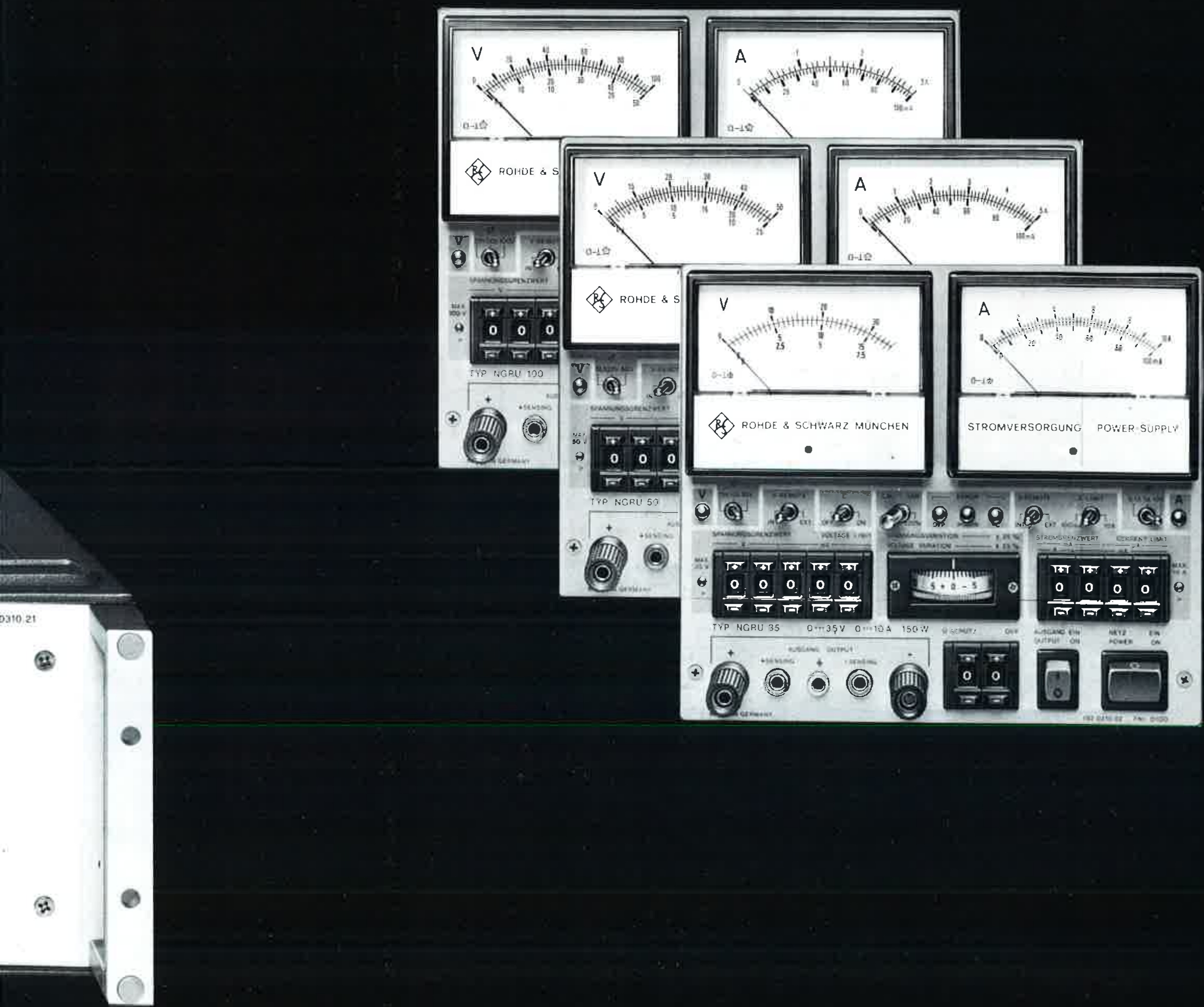
Set of mini-clips (20)	IGA-Z8	344.1905.00
Test Generator IMAT/IMAS	IMAT-Z7	345.7413.02
Extension Board IMAT/IMAS (for servicing)	IMAS-Z7	345.7913.02

Recommended system instruments

Logic Analyzer IMAT	345.4014.02
Logic Generator IGA (32 channels)	344.0015.04
Process Controller PUC	344.8900.10
+ Keyboard	s. page 19

Power Supplies of
Type Series NGRU (right)
and programmable
DC Power Supply NGPV

power supplies



Power supplies

The wide Rohde & Schwarz line of power supplies, covering several hundred different models, comprises the following **main groups:**

a) **Bench models with output powers up to 350 W – nine type series with a total of 26 basic models**

b) **19″ models with output powers up to 2000 W – two type series with a total of 29 basic models**

c) **Programmable power supplies (IEC 625-1/IEEE 488) – two type series with a total of 20 basic models**

Beyond these, a **programmable voltage source** for IEC-bus systems is available. It has two independent outputs and its output voltages can be programmed manually or by a controller.

This product line is being continuously expanded and adapted to the state of the art (please specify requirements not covered by the program listed).

The table below includes the **complete line** from which the appropriate type can be selected to meet the maximum voltage and current requirements.

The power supplies of group a) appear in the blue section. For more details on this group see the table on page 324 where the different types are listed in alphabetical order.

The power supplies of group b) are listed in the white section. For details see page 327.

The power supplies of group c) and the programmable voltage source are described in full on their own pages.

Common features

If higher currents or voltages are required, all power supplies can be parallel- or series-connected. Protecting diodes ensure that no hazards are created by such connections.

Most of the models feature overvoltage protection to counteract accidental voltage surges (e.g. in case of maloperation). For exceptions see tables and specifications.

Complete line of power supplies

Blue section: group a), bench models up to 350 W; for specifications see page 324.

White section: groups b) and c), high-output power supplies up to 2000 W and programmable 19″ power supplies; for specifications see from page 328 onwards.

Maximum current A	Maximum settable voltage in V																
	6	7,5	8	10	15	16	20	25	30	32	35	40	50	70	100	280	300
0.1																NGM	
0.2																NGK	
0.3																	NGPV
0.4																	
0.5														NGM			
0.6											NGL/T						NGPV
0.8								NGT									
1							NGT				NGM/D			NGK	NGPV		
2					NGM						NGK			NGA	NGPV		
3												NGPV			NGRU		
4		NGM			NGK						NGA						
5	NGT						NGPV			NGAS		NGPV	NGRU	NGB	NGRE		
8					NGA												
10			NGPV			NGAS	NGPV		NGRE	NGB/AS	NGRU		NGRE	NGPU	NGRE		
15		NGA							NGRE				NGRE	NGC	NGRE		
20				NGRE	NGRE				NGRE				NGRE	NGPU	NGRE		
30	NGRE			NGRE	NGRE				NGRE		NGC		NGRE				
40	NGRE			NGRE	NGRE				NGRE				NGRE				
60	NGRE			NGRE	NGRE				NGRE								
80	NGRE																

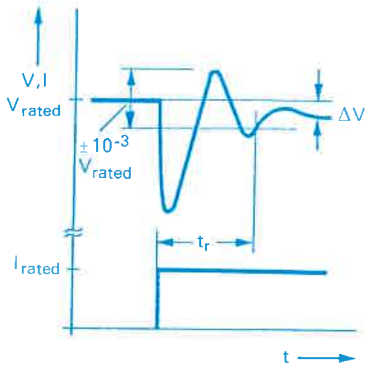
General features and definitions

All power supplies of the R&S line are electrically designed to offer **essentially the same qualitative features:** floating outputs, permissible test voltage of the outputs to chassis or ground – or with dual or triple power supplies to one another – 1000 V.

Operating temperature range −10 to +40°C (NGPV: +50°C). Panel engravings German and English. Power cable is supplied.

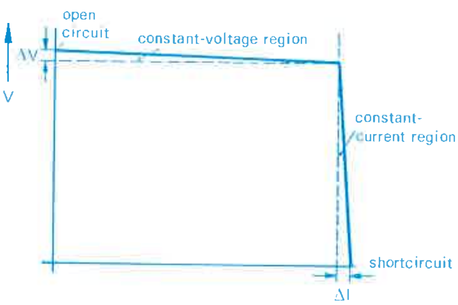
All models comply with VDE 0411, safety class 1, and are designed for operation from 220/110 V AC. Units of type series NGRE and NGC are supplied for voltages differing from 220 V on request only, but without increase in price.

Transient response time t_r following step change in load



Setting of voltage and current starts from a threshold near zero. The rated values of voltage and current are the maximum settable levels. Almost all types of this line are constant-voltage/constant-current power supplies, meaning that they can be used as current regulators.

Voltage-current characteristic for combined constant-voltage/constant-current power supplies



The series NGA and NGAS and the triple supplies NGT and NGL incorporate current limiting which can be continuously adjusted to any value between zero and the rated current. In the NGAS series current limiting can be adjusted to 1,5 times rating (see page 325).

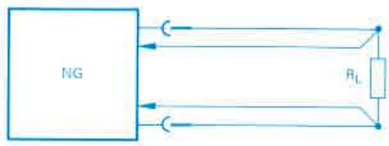
Mode indication. Pilot lamps or LEDs indicate whether the unit is operating in the constant-voltage/constant-current mode or whether current limiting takes place.

Internal impedance is specified in the table to describe the effect of load variations on the output quantiy. For example, with constant-current operation of a 100 V/1 A unit, the specified internal impedance of 30 kΩ implies that a load variation from 0 to 100 Ω at a nominal current of 1 A causes a current deviation of 3 mA or 0.3%.

Transient response time t_r. The value specified refers to a sudden change from open circuit to full loading with constant-voltage operation. After t_r the output voltage is again within tolerance. In constant-current operation t_r strongly depends on the load (<100 μs to 1 s).

Lead-resistance compensation (remote sensing). With the models of >70 W output power, the voltage drop which varies with the load current on the lead can be corrected, if separate sensor leads are connected to the terminals of the load. A variation of 0.5 V (1 V with NGPV) on the plus and minus leads can be compensated for.

Use of sensing leads to compensate for supply-lead voltage drops



Remote control. The NGRE power supplies can be equipped for remote control on request. The NGRU units can be remote-controlled through external analog voltages. NGRE page 328, NGRU page 326.

Programming. The power supplies NGPS, NGPV and NGPU are suitable both for manual operation and for control via the IEC bus, i.e. for integration in automatic test assemblies; for details see page 330 ff.

Cooling. The supplies cannot be damaged by thermal overloading. The models of the NGM, NGK, NGMD, NGT, NGL, NGRU and NGPS series have rear-mounted convectional heatsinks. In the units with higher output power rating, a two-stage thermostat-controlled cooling fan is used. At low demands the fan is scarcely noticeable; only when high output is required is it switched fully on. The fans are driven by quiet, maintenance-free motors.

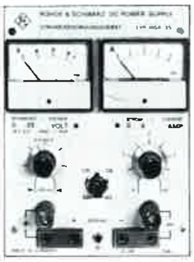
Overvoltage protection. To provide protection against undesirably high voltages caused by misuse or faults, the power supplies are fitted with independent crow-bar circuits with an adjustable operating threshold (for exceptions see table). An external overvoltage protection unit is availabe:
▶ NG-Z4, 5 to 100 V/10 A Order No. 100.5103.02

Power supplies for up to about 350 W · compact bench models

Units for higher power (up to about 2000 W) on page 328

1

NGM

2

NGA, NGAS

3

NGK

4

NGRU

5

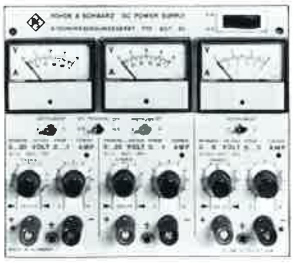
NGB

6

NGMD

7

NGL

8

NGT

Type	Photo No.	▶ Order No.	Voltage range V	Current range A	Resolution V %	Resolution I %	Max. dev. of output with ΔV (AC supply) ±10% V %	ΔV (AC supply) ±10% I %	ΔT_{amb} −10 to +40 °C V %/°C	ΔT_{amb} −10 to +40 °C I %	Int. impedance for V mΩ	Int. impedance I kΩ	t_r for V µs	Max. ripple rms V mV	Max. ripple rms I mA	Remote sensing/overvoltage protection S	S/O O	Dimensions (W/H/D), weight mm/kg
Single Power Supplies																		
NGA 7.5	2	192.0010.02	0.01 to 7.5	0.2 to 15	0.02	1	0.01	0.2	0.01	0.1	0.2	—	75	0.15	—	S	—	129×172 ×330/8
15		192.0010.03	0.01 to 15	0.1 to 8	0.02	1	0.01	0.2	0.01	0.1	0.3	—	75	0.15	—	S	—	
35		192.0010.04	0.01 to 35	0.05 to 4	0.02	1	0.01	0.2	0.01	0.1	0.5	—	75	0.15	—	S	—	
70		192.0010.05	0.01 to 70	0.025 to 2	0.02	1	0.01	0.2	0.01	0.1	1	—	75	0.15	—	S	—	
NGAS 16	2	289.8514.02	0.01 to 16	0.1 to 10 (15)	0.02	1	0.01	0.2	0.01	0.1	0.5	—	75	0.2	—	S	—	129×172 ×330/8
32		289.8520.02	0.01 to 32	0.1 to 5 (7.5)	0.02	1	0.01	0.2	0.01	0.1	0.5	—	75	0.2	—	S	—	
32/10		192.0803.04	0.01 to 32	0.1 to 10 (15)	0.02	1	0.01	0.2	0.01	0.1	0.5	—	75	0.2	—	S	—	
NGB 32	4	117.7210.90	0.01 to 32	0.02 to 10	0.02	0.02	0.001	0.001	0.01	0.01	0.2	15	50	0.2	1.5	S	O	190×172 ×330/10
70		117.7227.90	0.01 to 70	0.01 to 5	0.02	0.02	0.001	0.001	0.01	0.01	0.4	30	50	0.5	1.5	S	O	
NGK 15	3	192.0003.02	0.01 to 15	0.01 to 4	0.02	0.02	0.001	0.001	0.01	0.01	0.5	30	50	0.2	0.1	S	O	190×172 ×278/8
35		192.0003.03	0.01 to 35	0.01 to 2	0.02	0.02	0.001	0.001	0.01	0.01	1	100	50	0.2	0.02	S	O	
70		192.0003.04	0.01 to 70	0.01 to 1	0.01	0.02	0.001	0.001	0.01	0.01	5	500	50	0.2	0.01	S	O	
280		192.0003.05	0.01 to 280	0.002 to 0.2	0.01	0.02	0.001	0.001	0.01	0.01	50	500	50	2	0.002	S	—	
NGM 7.5	1	117.7110.12	0.01 to 7.5	0.01 to 4	0.02	0.02	0.001	0.001	0.01	0.01	0.5	15	50	0.2	0.1	—	O	95×172 ×278/4
15		117.7110.13	0.01 to 15	0.01 to 2	0.02	0.02	0.001	0.001	0.01	0.01	1	60	50	0.2	0.05	—	O	
35		117.7110.14	0.01 to 35	0.01 to 1	0.02	0.02	0.001	0.001	0.01	0.01	2	250	50	0.2	0.01	—	O	
70		117.7110.15	0.01 to 70	0.01 to 0.5	0.01	0.02	0.001	0.001	0.01	0.01	10		50	0.5	0.005	—	O	
280		117.7110.06	0.01 to 280	0.002 to 0.1	0.01	0.02	0.001	0.001	0.01	0.01	100		50	2	0.001	—	—	
NGRU 35	4	192.0210.03	0.01 to 35	to 10	see specifications page 327											S	O	190×180 ×330/9
50		192.0210.05	0.01 to 50	to 5												S	O	
100		192.0210.08	0.01 to 100	to 3												S	O	
Dual Power Supplies																		
NGMD 35	6	117.7127.02	0.01 to 35 (2×)	0.01 to 1	0.02	0.02	0.001	0.001	0.01	0.01	2	250	50	0.2	0.01	—	O	190×172 ×278/8
Triple Power Supplies																		
NGL 35	7	192.0026.02	0.01 to 35 (3×)	0.01 to 0.6	cont.	1	0.01	0.2	0.1	0.1	10	—	75	0.1	—	—	—	190×172 ×278/7
NGT 20	8	117.7133.02	0.01 to 20 (2×) 0.01 to 6 (1×)	0.01 to 1 0.01 to 5	0.02	1	0.01	0.2	0.01	0.1	2 1	— —	75	0.1	—	—	— O	190×172 ×278/7
NGT 25	8	192.0503.02	0.01 to 25 (2×) 0.01 to 6 (1×)	0.01 to 0.8 0.01 to 5	0.02	1	0.01	0.2	0.01	0.1	2 1	— —	75	0.1	—	—	— O	190×172 ×278/7
NGT 35	8	191.2019.02	0.01 to 35 (2×) 0.01 to 6 (1×)	0.01 to 0.6 0.01 to 5	0.02	1	0.01	0.2	0.01	0.1	2 1	— —	75	0.1	—	—	—	190×172 ×278/7

Special features

Single power supplies

in order of increasing power; NGRU series on page 326

NGM, NGK – 35/70-W laboratory models

- High-resolution ten-turn potentiometers for V and I
- Single switched meter on NGM-series – separate meters on NGK-series models

The supplies of the **NGM series** can be used either as constant-voltage or as constant-current source. The mode of operation at any time is indicated by a pair of light-emitting diodes. These power supplies are precision instruments whose excellent performance will be appreciated in many applications, especially in the laboratory.

The supplies of the **NGK series** provdie twice the output current of the corresponding members of the NGM series. For this reason they feature remote-sensing sockets to permit compensation of the voltage drop in the leads connecting the supply to the load.

NGA – compact 120-W models

- High-resolution ten-turn potentiometers for V and I
- Separate meters, remote-sensing sockets

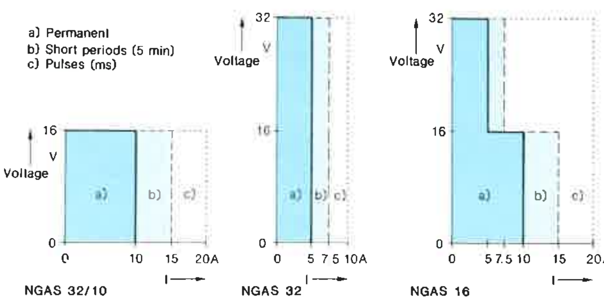
The supplies of the **NGA series** are for use as constantvoltage sources; they incorporate fixed-value current limiting at a level set by a front-panel potentiometer. The onset of current limiting is indicated by a light-emitting diode. These units are particularly suited for supplying assemblies and subassemblies during testing or development.

NGAS – compact 160-W models, high surge capability

- High surge capability – twice the rated current can be supplied for short periods
- Use as battery eliminators

The supplies of the **NGAS** type are suitable both for general use in laboratories and for use with loads characterized by high-surge or pulse-type current demands, such as in automobile electronic test systems or for transceivers powered by converters.

The current characteristics are shown below. The current limiting threshold can be set to 1.5 times the rated current. This limit current may be drawn for up to 5 minutes. With delayed current limiting, twice the rated current may be drawn for several milliseconds.



Current drain of NGAS as a function of output voltage

Thanks to their compact design the NGAS power supplies are suitable for mobile use. They can supply 160 W/240 W for up to 5 minutes. They are also insensitive to RF voltages radiated by other equipment or a nearby antenna.

NGB – 350-W bench models

- High-resolution ten-turn potentiometers for V and I
- Surge-current capability – several times rated current may be drawn for short periods

Constant-voltage as well as constant-current sources with automatic transition form voltage to current regulation (indication by LEDs). Use as battery eliminator with switch-selected delay for current regulation (higher surge current), e.g. for incandescent lamps, blinkers, voltage converters. Additional features: large panel meters for voltage and current, voltage compensation on feeders up to 1 V, adjustable obervoltage protection.

Dual power supplies

NGMD 35 – 2×0 to 35 V/1 A

- Independent or tracking operation
- Mutually isolated floating outputs, permanent-shortcircuit proof

Two instruments of the type NGM 35 are accommodated in a single cabinet and can be used separately or in tracking operation, switch-selected on the front panel. With tracking operation, unit II follows unit I; the NGMD supplies, with respect to a common reference point, a positive and a negative voltage each of 0 to 35 V that are equal in quality and can be proportionally varied together (adjustable with helical potentiometer on unit I). The current limits can be adjusted independently of each other.

Triple power supplies

NGL 35 – 3×0 to 35 V/0.6 A

- Three voltages at the same time; series or parallel mode possible
- Thermal overload protection with automatic cut-in

The **NGL 35** has three separate identical and floating outputs which are independently adjustable between 0 and 35 V; the current-limiting threshold can be set from 0 to 0.6 A. Tripling of the voltage or current limit value is possible by parallel or series connection.

NGT 20 – 2×0 to 20 V/1 A; 1×0 to 6 V/5 A
NGT 25 – 2×0 to 25 V/0.8 A; 1×0 to 6 V/5 A
NGT 35 – 2×0 to 35 V/0.6 A; 1×0 to 6 V/5 A

- Independent or tracking operation of 20/25/35-V supplies
- Permanent-shortcircuit proof, adjustable overvoltage protection of 6-V supply

The **NGT** combine three independent constantvoltage sources in a single instrument. Each output can be monitored on an individual panel meter (switchable for either voltage or current) and the onset of current limiting is shown by three separate light-emitting diodes.

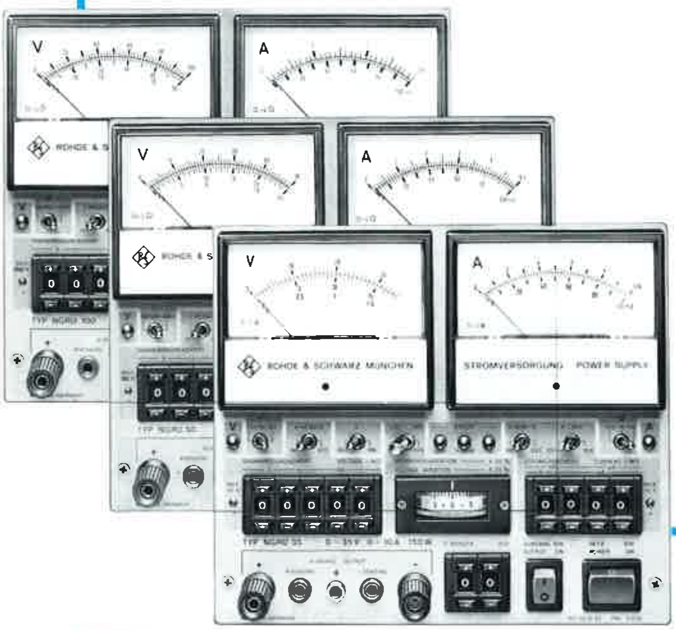
The **20 V/25 V/35 V supplies** are intended primarily for use with **linear integrated circuits.** They can be used independently, or connected in series or in parallel. A front-panel switch also permits these two outputs to be operated in the tracking mode.

The separate **6-V supply** has a high output-current capability of 5 A making it particularly suitable for powering digital integrated circuits. The built-in overvoltage protection has a continuously adjustable threshold.

NRGU

Power Supplies NGRU – compact bench models up to 150 W

- High resolution and repeatability by the use of digital potentiometers
- Output voltage continuously variable with calibrated potentiometer
- Full power over a wide range of the output voltage ensured by automatic power matching
- Digitally settable overvoltage protection
- Output voltage can be modulated (simulation of interfering quantity)
- Remote programming for voltage and current
- Panel meters for voltage and current with three ranges for each
- Large LED displays for overload, excess temperature, overvoltage and operating mode
- Switch-selected output capacitor



new

Power Supplies of the **NGRU** Series are precision laboratory units providing high accuracy of setting and repeatability of voltage and current through digital potentiometers.

Three models are available:

NGRU 35 0 to 35 V/0 to 10 A
NGRU 50 0 to 50 V/0 to 5 A
NGRU 100 0 to 100 V/0 to 3 A

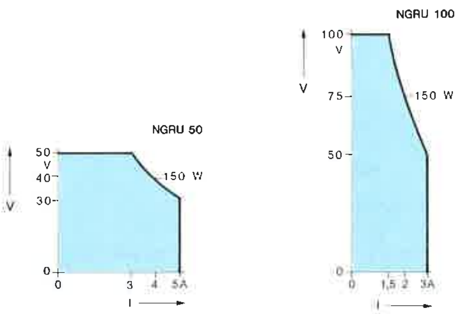
Operation of the NGRU Series is versatile and practical. The voltage can be set in five digits and continuously varied by ±25% of the digitally set value by means of a calibrated potentiometer. The current is set in four digits and has two ranges. The low ranges is 100 mA for all NGRU models. Currents even in the μA range can thus be reliably regulated. The overvoltage protection is also adjustable through a digital potentiometer. In addition to the manual operation, remote programming of the voltage and current can be accomplished via analog control signals.

Constant-voltage or constant-current sources. The NGRU Power Supplies operate as constant-voltage or constant-current sources. The maximum output power consumption is 150 W and remains constant over a wide voltage range. The current drain depends on the output voltage; with a low output voltage, a higher current can be drawn.

Output capacitor. The output capacitor can be switch-selected to match the load: small capacitor with little energy content for sensitive semiconductor circuits, large capacitor for dynamic loads.

Facilities. The NGRU Series is equipped with monitoring, signalling and indicating devices. LEDs indicate operating points incorrectly set beyond the constant-load characteristic, the response of the overvoltage protection, excessive temperature due to insufficient cooling and, of course, also the selected operating mode. An input for analog modulation signals (simulation of interfering quantities), remotesensing sockets and large meters are further beneficial features.

Versatile use. Due to compactness, high reliability and other outstanding features the units of the NGRU Series are ideal for use in development, research and testing.



V/I characteristics of Power Supplies NGRU 35 and NGRU 100

Specifications

Power Supply Type	NGRU 35	NGRU 50	NGRU 100
▶ **Order number**	192.0210.03	192.0210.05	192.0210.08
Voltage setting in 5 digits	<1 mV to 35 V	<1 mV to 50 V	<1 mV to 100 V
Resolution	1 mV		
Error at 20 °C	±10⁻⁴ of set value ±20 mV		
analog (continuous)	±25% with ±0.5% setting error of scale		
Resolution	0.1%		
Current setting (2 ranges) in 4 digits			
High range	<1 mA to 10 A	<1 mA to 5 A	<1 mA to 3 A
Resolution	1 mA		
Error at 20 °C	±2 × 10⁻³ of set value ±10 mA		
Low range	<10 µA to 100 mA		
Resolution	10 µA		
Error at 20 °C	±2 × 10⁻³ of set value ±0.2 mA		
Max. constant current (150 W)	up to 15 V: 10 A 20 V: 7.5 A 35 V: 4.5 A	up to 30 V: 5 A 40 V: 4 A 50 V: 3 A	up to 50 V: 3 A 75 V: 2 A 100 V: 1.5 A

Power Supply Type	NGRU 35	NGRU 50	NGRU 100
Specifications for **constant-voltage supply**			
Deviation of output voltage			
with AC supply variations of ±10%		$<\pm 10^{-5}$	
with temp. var. from 0 to 45 °C		$<\pm 10^{-5}$/K	
with load var. from 0 to 100%		$<10^{-4}$	
Superimposed noise voltage (V_{rms})	<0.3 mV	<0.5 mV	<1 mV
Transient recovery time		<40 µs	
Specif. for **constant-current supply**			
Deviation of output current			
with AC supply var. of ±10%		$<\pm 10^{-5}$	
with temp. var. from 0 to 45 °C		$<\pm 10^{-4}$/K	
with load var. from 0 to 100%		$<10^{-4}$	
Superimposed noise current			
in high range (I_{rms})	<1 mA	<0.5 mA	<0.1 mA
in low range (I_{rms})		<20 µA	
Remote-sensing sockets			
Max. voltage compensation	<0.5 V	<1 V	<1.5 V

Common specifications

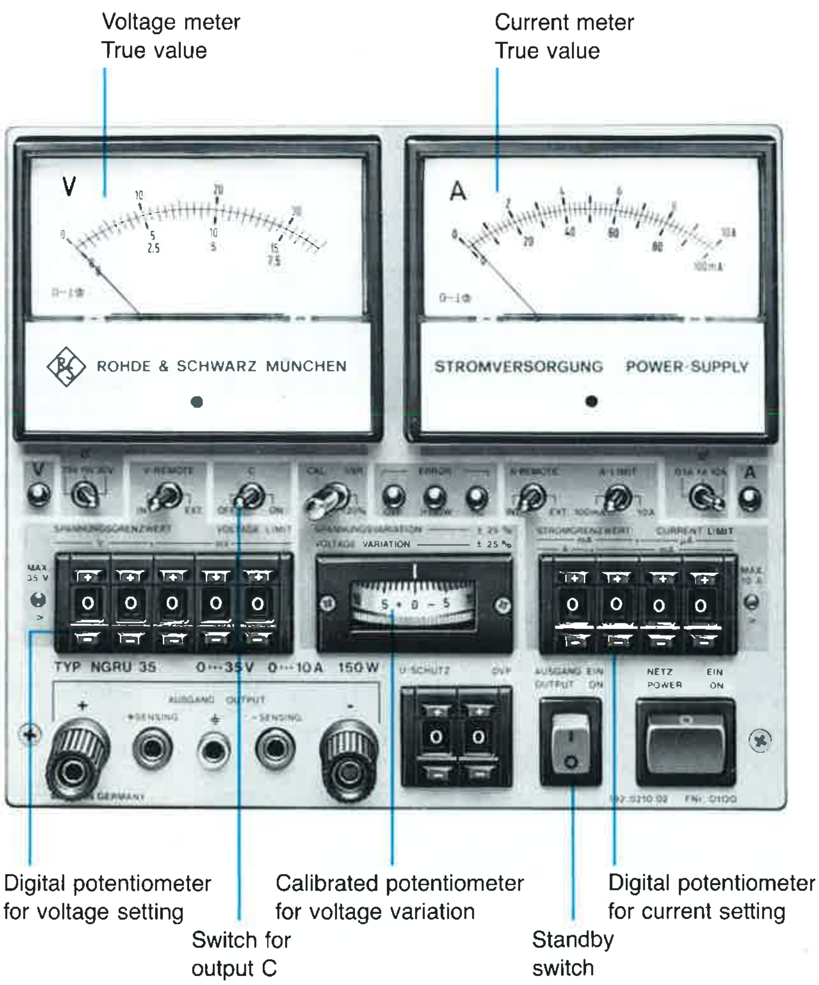
Modulation of output voltage
(BNC socket, floating) .... V_{pp} = 10 V for 10% modulation, 50 Hz to 1 kHz
Overvoltage protection
Setting range .... 1 to 99 V (response threshold approx. 5% higher)

Programming (external analog)
for output voltage 0 to 100% ..... 0 to 10 V
for output current 0 to 100% ..... 0 to 10 V
Setting time .... <3 ms
Connector .... 5-way Tuchel socket
Internal impedance .... R_i = 10 kΩ
Reference potential .... to positive terminal

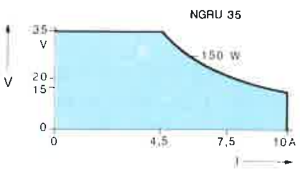
General data

Meter accuracy .... ±2.5% of full scale
Operating temperature range ...... 0 to 45 °C
Safety class I .... VDE 0411
Output terminals .... 4 mm, floating, test voltage 1000 V/ground
Line voltage .... 110/127/220/242 V ±10%, 47 to 63 Hz
Power consumption .... approx. 440 VA
Dimensions .... 190 mm×180 mm×330 mm
Weight .... 9 kg

Order designations .... ▶ see above



V/I characteristic (below) and front panel (right) of Power Supply NGRU 35



19″ power supplies 1000 W with high efficiency

NGC series

- High efficiency
- Surge-current capability – several times rated current may be drawn for short periods

The high efficiency of the NGC units is achieved through the use of continuous preregulation. A subsequent series-pass regulator provides for excellent static and dynamic characteristics. Careful design allows easy integration into RF systems.

Specifications

	NGC 35	NGC 70
Voltage	<10 mV to 35 V	<10 mV to 70 V
Current	<50 mA to 30 A	<25 mA to 15 A
Resolution	<0.02%	<0.02%
Voltage stability		
with AC supply variations of ±10%	$<\pm10^{-5}$	
with temperature variations from 0 to 40°C	$<\pm10^{-4}$/K	
with load variations from 0 to 100%	$<10^{-4}$	
Current stability		
with AC supply variations of ±10%	$<\pm10^{-4}$	
with temperature variations from 0 to 40°C	$<\pm10^{-3}$/K	
with load variations from 0 to 100%	$<10^{-3}$	
Noise and ripple		
Voltage, rms	<1 mV	<2 mV
Current, rms	<20 mA	<20 mA
Transient response time	<50 µs	
Remote sensing	1 V max.	
Surge capability for 1 ms/0.2 s	80/60 A	50/20 A

General data

Rated temperature range	−10 to +40°C
Meter accuracy	2.5% of full scale
AC supply	220 V ±10%, 50 Hz, 2.4 kVA (other values: please enquire)
Dimensions (W×H×D)	484 mm×194 mm×509 mm
Weight	40 kg

Ordering information

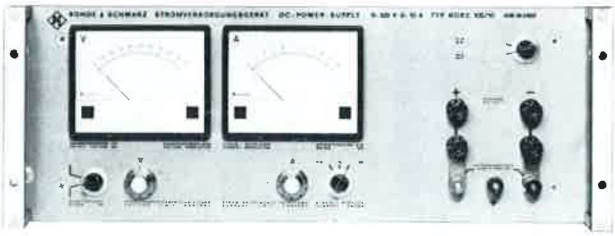
Order designation	▶ 1000 W 19″ Power Supply
NGC 35	192.0032.02
NGC 70	192.0032.03

19″ power supplies from about 200 to 2000 W

Units for lower power on page 324

NGRE series

NGRE models A and B, code numbers 16 and 17



- Protection against sustained short circuit, thermal overload protection
- Series and parallel connection of several units possible

NGRE model C, code number 19

Voltage and current are set by means of high-resolution ten-turn potentiometers and indicated on separate panel meters. The power supplies are fitted with remote-sensing sockets for output-lead voltage-drop compensation. A quiet cooling fan with two-stage thermostat-controlled operation is incorporated.

Adjustment of current ranges. NGRE models 16 and 17 with outputs up to 30 A can be equipped, on request, with current ranges switchable in decade steps, e.g. a 10-A supply can be switched to 0.1/1/10 A.

Transient response time t_r. The value given in the table on page 329 applies for operation at constant voltage at a load varying between no load and full load. With constant-current operation, t_r is between <100 µs and 100 ms and load-dependent to a great extent.

Remote control. The following functions of the models 12, 13, 16, 17 can be modified for remote control: output voltage, output current and power switch "on/off/standby" as well as control of the power regulating element. Instruments of the type series NGRE, which are adapted to remote control, are suitable for

master/slave operation (parallel-connected). This mode of operation – control of the power output by only one of the employed instruments – is of great advantage, since, especially with higher powers, equal loading of all units is ensured.

Overvoltage protection. Each instrument of the type series NGRE is also available as a special model with built-in overvoltage protection.

Current surge capability. 2 to 3 times the rated current can be drawn briefly from the NGRE units. An external or internal (model code number 19) switch is provided for this purpose.

The type series NGRE comprises power supplies with high output power (above approximately 200 W). Extreme versatility is won by the use of standard modules: most of the 27 basic types (see table below) come in 5 different models.

The **basic types** differ only in the maximum adjustable values of voltage and current and the internal impedance.

The **available models** of each basic type are equipped differently – meters, operating controls, connectors – and are designed as cabinet model or as rackmount.

The power supplies of series NGRE are designed for operation from 220 V. Other voltages are possible without an increase in price; please enquire.

Order designations. Because of the great variety of instruments, division into two groups – basic type and model variations – was necessary. A nine-figure number (combination from both tables) should always be stated when placing an order (last two digits marked blue; e.g. 50 V/20 A, model 17: order number 100.8231.17).

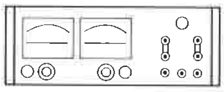
Dimensions

	Cabinet model mm	Rackmount mm	Seated depth mm
Model A	484×194×436	483×177×425	347
Model B	484×194×509	483×177×498	420
Model C	608×394×284		–

Front views

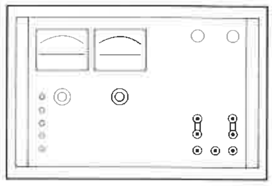
Models A and B

Front panel for code numbers 12 and 13



Front panel for code numbers 16 and 17

Model C



Front panel for code number 19

Voltage range V	Current range A	▶ Order No.	Max. deviation of output values for ΔV AC supply ±10% V, I (%)	for Δt_{amb} (−10 to +40°C) V, I (%)	Internal impedance const. V mΩ	I (kΩ)	t_r for V µs	Max. ripple and noise rms V µV	I mA	Power consumption at 220 V/50 Hz kVA	Case types (see above)	Weight incl. cabinet kg
NGRE series												
0 to 6	0 to 30	100.8402...	±0.001	0.01	1	(1)	<50	300	9	0.9	A, C	22
	0 to 40	100.8419...	±0.001	0.01	0.1	(1)	<50	300	12	0.9	A, C	22
	0 to 60	100.8425...	±0.001	0.01	0.1	(1)	<50	300	18	0.9	A, C	28
	0 to 80	100.8431...	±0.001	0.01	0.1	(1)	<50	300	24	1.8	B, C	39
0 to 10	0 to 20	100.8354...	±0.001	0.01	1	(2)	<50	300	6	0.9	A, C	19
	0 to 30	100.8360...	±0.001	0.01	1	(2)	<50	300	9	0.9	A, C	28
	0 to 40	100.8377...	±0.001	0.01	0.1	(2)	<50	300	12	1.8	A, C	28
	0 to 60	100.8383...	±0.001	0.01	0.1	(1)	<50	300	18	1.8	A, C	37
0 to 15	0 to 20	100.8319...	±0.001	0.01	1	(2)	<50	300	6	0.9	B, C	28
	0 to 30	100.8325...	±0.001	0.01	1	(2)	<50	300	9	1.8	A, C	28
	0 to 40	100.8331...	±0.001	0.01	0.1	(2)	<50	300	12	1.8	A, C	37
	0 to 60	100.8348...	±0.001	0.01	0.1	(1)	<50	300	18	2.5	B, C	39
0 to 30	0 to 10	100.8254...	±0.001	0.01	1	(5)	<50	300	3	0.9	A, C	19
	0 to 15	100.8260...	±0.001	0.01	1	(5)	<50	300	4.5	0.9	A, C	28
	0 to 20	100.8277...	±0.001	0.01	1	(3)	<50	300	6	1.8	A, C	28
	0 to 30	100.8283...	±0.001	0.01	1	(2)	<50	300	9	1.8	A, C	37
	0 to 40	100.8290...	±0.001	0.01	0.1	(2)	<50	300	12	2.5	B, C	39
	0 to 60	100.8460...	±0.001	0.01	0.1	(2)	<50	300	18	3.5	C	50
0 to 50	0 to 10	100.8219...	±0.001	0.01	1	(5)	<50	300	3	0.9	A, C	28
	0 to 15	100.8225...	±0.001	0.01	1	(5)	<50	300	4.5	1.4	A, C	28
	0 to 20	100.8231...	±0.001	0.01	1	(5)	<50	300	6	1.8	A, C	37
	0 to 30	100.8248...	±0.001	0.01	1	(3)	<50	300	9	2.5	B, C	39
	0 to 40	100.8454...	±0.001	0.01	0.1	(2)	<50	300	12	3.5	C	50
0 to 100	0 to 5	100.8160...	±0.001	0.01	1	(10)	<50	500	1.5	0.9	A, C	28
	0 to 10	100.8183...	±0.001	0.01	1	(10)	<50	500	3	1.8	A, C	37
	0 to 15	100.8190...	±0.001	0.01	1	(5)	<50	500	4.5	2.5	A, C	39
	0 to 20	100.8448...	±0.001	0.01	1	(5)	<50	500	6	3.5	C	50

DC Power Supplies NGRE (additional characteristics and completion of Order Nos.)

▶ Code number of models (last two figures of Order No.)[1]	Form of housing	Adjusting V and I: Precision pot. on front panel	Adjusting V and I: Screw-driver adjustment on rear panel	I range in three decades (up to 30 A) extra price	Four extra fixed voltages, pushbutton selected	Large V and I meters
... 13	19" cabinet[2]		●			
... 17		●		●		●
... 12	19" rackmount[2]		●			
... 16		●		●		●
... 19	Alum. housing[3]	●			●	●

[1]) Against extra price (please enquire):
a) master-slave operation
b) external analog programming of voltage and current.

[2]) Model A or B, acc. to table above.
[3]) Model C (waterproof, shock-absorbent aluminium housing).

NGPS

Programmable Voltage Source NGPS for IEC-bus systems

⧫ 2 × ±40 V/±16.38 V, max. 100 mA

- Two separate bipolar sources with 0.5 mV or 2 mV resolution: 65,536 steps in low range 40,000 steps in high range
- IEC-bus programming and manual operation
- Shortcircuit-proof outputs

IEC 625 Bus

The **Programmable Voltage Source NGPS** has two independent channels (A and B) and its output voltages can be programmed manually or by a computer. The unrestricted combination of the two outputs provides for many **applications.**

Setting, resolution. The bipolar voltages can be set or programmed from −16.3835 V to +16.3835 V in the low range in 65,536 steps (2^{16}, resolution 0.5 mV). Resolution in the high range is 2 mV/step with a maximum output voltage of ±40 V (corresponding to a swing of 80 V).

Maximum permissible current drain is 100 mA. Any increase beyond this limit is signalled as malfunction of the analog section of channel A or B.

The **six-digit display** permits observation of programmed test sequences. In the programming mode (data acceptance) or listen only (LON) mode of the NGPS the address lamp is lit.

In the **combined mode** (manual and programmed) the digital voltage setting can be varied manually. The speed of variation depends on how long the plus or minus button is pressed.

Output-voltage range coding is possible by selecting the secondary device address or using the built-in microprocessor, and also by means of special characters.

With up to 31 settable instrument addresses, a listen-only switch and different assignable end-of-message characters for programming, the unit constitutes a general-purpose, flexible listener in IEC-bus systems.

By applying a status byte to the data line of the IEC-bus input through the parallel-poll or serial-poll function the NGPS can notify the selected operating mode or a fault, if any, to a computer.

The **trigger facility** permits rapid switching of preset voltages and thus defined timing of test sequences.

Automatic voltage sweep can be programmed such that upon a trigger command the output changes from a start to a stop value. Step size (n×count) and duration (n×700 µs) can be preset. Triggering may be single, cyclic or with different step size/duration for forward and return sweep.

Remote-sensing sockets offer the possibility of keeping the voltage at the load or test item (or at the controlling equipment) constant even if high currents and long leads are involved.

The **talker capability** of the NGPS enables continuous interrogation of the voltage inputs to channels A and B, functional checking of the analog section and notification of the selected trigger states.

Specifications

Outputs	2 separate floating channels (A and B) in parallel with rear outputs
Output voltage per channel	
Low range	−16.3835 to +16.3835 V
High range	−40.00 to +40.00 V
Setting	pushbuttons; variation in steps or continuous within one range or programmed
Resolution Low/High range	0.5 mV/2 mV
Indication (with polarity sign)	6 digits for one channel
Output current	100 mA max. limiting threshold approx. 130 mA
Stability, ripple and noise	
Voltage deviation	
with AC supply variation ±10%	$<10^{-5}$
with temperature variation	$<8 \times 10^{-6}$/K +50 µV
with load variation	$<5 \times 10^{-6}$
Instability	$<2 \times 10^{-6}$/hr (low), $<4 \times 10^{-6}$/hr (high)
Capacitive load	≦0.1 µF (80-V step)
Ripple and noise (rms) up to 3 kHz	<100 µV (low), <200 µV (high)
Nonlinearity (Low/High range)	< ±700 µV <±3 mV
Response time	<700 µs (100 µs for smallest program step)
Remote-sensing sockets	compensation for 0.5 V max.
Programming	via IEC-bus (IEC 625-1/IEEE 488) for ranges and voltage, manual operation switch-selected
Connector	24-way, floating
Functions	SH1, AH1, T2,TE2, L1, LE1, SR1, RLØ, PP1, CØ, DC1, DT1
Response time, programming	<1 µs
Output ON/OFF	1 µs/>62µs
Data rate	42 kbyte/s max.
Programming time	>183 µs
General data	
Rated temperature range	+5 to +40°C
Power supply	110/220 V ±10%, 50 to 60 Hz (120 VA)
Dimensions, weight	492 mm×116 mm×392 mm, 6.2 kg

Ordering information

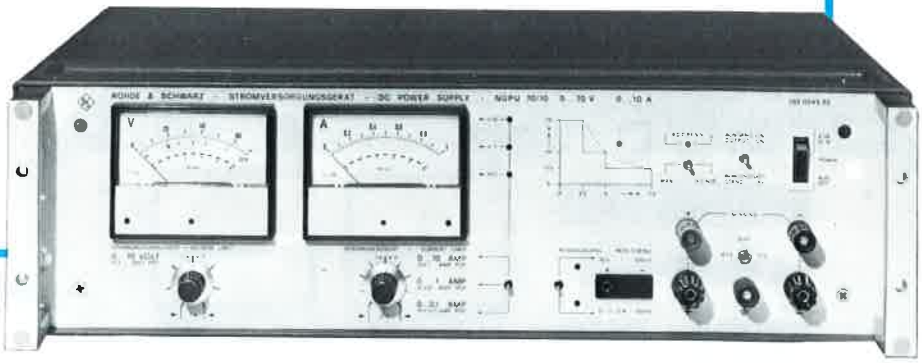
Order designation	▶ Programmable Voltage Source NGPS 192.0061.02
Recommended extras	
IEC-bus Cable PCK	lengths 0.5 to 4 m, see page 19
Relay Matrix PSN	290.9210.02

Programmable Power Supplies NGPU

NGPU

- IEC-bus programming and manual operation
- Three-digit programming of voltage and current (1000 steps), resolution: 10 to 100 mV, 10 to 20 mA
- Three decade current measurement ranges

IEC 625 Bus

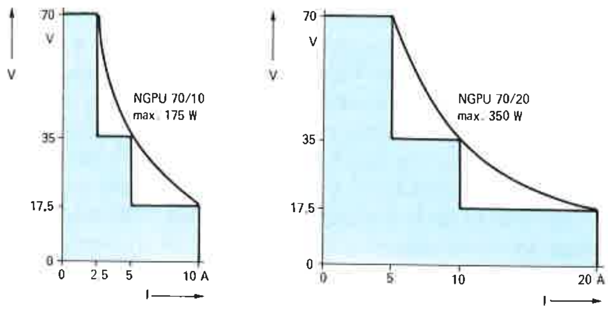


The **NGPU series of programmable power supplies** represents a valuable extension to the existing R&S range of IEC-bus-compatible test equipment. Two models are available, distinguished by their output powers:

NGPU 70/10: 175 W (70 V/max. 10 A),
NGPU 70/20: 350 W (70 V/max. 20 A).

Both may be operated either as constant-voltage or as constant-current source and are suitable for programmed operation via the IEC bus or for manual use.

The maximum load current is a function of the output voltage; the full output power is available over approximately 80% of the output-voltage range. As the figure shows, the output characteristics are a combination of three individual curves: each NGPU combines the performance of three single power supplies.



Loading characteristics of programmable power supplies NGPU as function of output voltage

Since the current drain of many loads, such as a transceiver, falls with increasing supply voltage, this stepped loading characteristic of the power supplies is fully compatible with practical requirements.

In continuous operation the shaded area shown in the diagram can be fully utilized up to the limit-power line. An auxiliary scale on the panel voltmeter indicates the permissible continuous load current at each voltage setting. The unit can withstand brief, pulse-type currents which exceed the limit line. If, a set voltages above 15 V, a current greater than the limit value is accidentally drawn for an extended period, the temperature-monitor circuit within the power supply causes the instrument to be disconnected from the AC supply.

The output voltage and/or current may be set via the IEC bus interface. The switchover between programmed and manual control is made on the front panel. The resolution of the voltage setting may be chosen to be fixed at 100 mV or to be variable between 10 and 100 mV.

The power supplies may be programmed from **any IEC-compatible control device.** The various input lines are electrically isolated from each other. By making use of the settable address it is possible to operate several NGPUs in parallel.

Specifications

Output	adjustable with ten-turn potentiometer or via IEC bus	
Resolution		
Manual operation	0.02%	
IEC bus	1000 steps/range; voltage adjustable 10 to 100 mV/step	
Voltage	<10 mV to 70 V	
Current	**NPGU 70/10**	**NPGU 70/20**
3 ranges	0.1/1/10 A	0.2/2/20 A
Stability		
with AC supply var. of ±10%	$<\pm10^{-5}$	
with temp. var. from 0 to 40°C	$<\pm10^{-4}$/K +100 µV	
with load var. from 0 to 100%	$<10^{-4}$	
Noise and ripple		
Voltage, rms	<1.5 mV	
Current, rms	<2 mA	
Transient response time	<50 µs	
Remote sensing	1 V max.	
Programming	IEC 625-1 (IEEE 488), 24 way	
Test output		
for voltage	100 mV at 70 V	
for current	100 mV for full scale	
Overvoltage protection	adjustable from 4.5 to 75 V	
Operating temperature range	+10 to +40°C	
General data		
AC supply	110/220 V ±10%, 50 to 60 Hz	
Power consumption	600 VA	1250 VA
Dimensions (W×H×D) in mm	492×161×514	492×205×514
Weight	14 kg	19 kg

Ordering information

Order designations	▶ Programmable Power Supply
NGPU 70/10	192.0049.92
NGPU 70/20	192.0055.92
Recommended extras	
IEC-bus Cable PCK 1 m	292.2013.10
or 2 m	292.2013.20
or 4 m	292.2013.40

NGPV

Programmable Power Supplies NGPV

- Digital setting, high resolution
- No discrete output C, true current source
- IEC-bus-programmed and manual operation
- Short down response time thanks to current sink
- Two current ranges – current monitoring output
- LEDs for operating status and errors

IEC 625 Bus

new

The **NGPV Power Supplies** are suitable for both system applications and general laboratory use. Nine models graded by voltage and current are available in the power range up to 200 W.

NGPV 8/10:	0 to 8 V / 0 to 10 A; 80 W,
NGPV 20/5:	0 to 20 V / 0 to 5 A; 100 W,
NGPV 20/10:	0 to 20 V / 0 to 10 A; 200 W,
NGPV 40/3:	0 to 40 V / 0 to 3 A; 120 W,
NGPV 40/5:	0 to 40 V / 0 to 5 A; 200 W,
NGPV 100/1:	0 to 100 V / 0 to 1 A; 100 W,
NGPV 100/2:	0 to 100 V / 0 to 2 A; 200 W,
NGPV 300/0.3:	0 to 300 V / 0 to 0.3 A; 90 W,
NGPV 300/0.6:	0 to 300 V / 0 to 0.6 A; 180 W.

The user has the choice of two versions. The one for system and laboratory use can be programmed via the IEC-bus (IEC 625-1 or IEEE 488) or operated manually. The units of this version have the required operating controls, a LED display for the indication of all input data (including that entered via the IEC bus) and meters for actual voltage and current. The pure system version – without operating controls – provides particularly cost-effective IEC-bus-programmable 19″ units for rackmounting or for use on the bench.

Power Supply NGPV for system applications

System use. The system power supply is characterized by the short settling time of 2 ms (for the rise and, thanks to a controlled current sink, also for the fall). The NGPVs do not have a discrete output capacitance so they can regulate very small currents. Relay contacts will not be damaged by the switching of current paths. An appreciable output capacitance, however, is provided internally and can be connected manually or via the program as required.

Remote sensing. Remote sensing makes the NGPV particularly suitable for system applications. It is performed automatically, no sensing links are required. The compensation range is 1 V in each lead. When remote sensing is in operation the maximum output voltage of the power supply exceeds the nominal voltage by the amount of the voltage drop in the leads. The result is that with the NGPV 8/10, for example, the full value of 8 V is available at the load even if a voltage drop of up to 1 V exists in each lead. The maximum voltage increase occurring at the load due to an interruption of the sensing leads is 1 mV, which is negligible for practical purposes.

Current regulation. The special capability of the NGPV as a current regulator is afforded by two current ranges, which ensure a high resolution of 1 mA and 0.1 mA, respectively.

Laboratory and system use. The NGPV models equipped with meters and front-panel controls are also versatile laboratory power supplies. Output voltage and current can be read from large analog meters. LEDs indicate the operating mode and operating status. A digital display shows the values entered, also those programmed via the IEC bus. Parallel outputs and sockets for a current monitoring output (referred to the positive terminal) are located on the front and rear panels.

Cooling. The blowers are thermostat-regulated and run at low RPM in the partial-load region.

Specifications

Power Supply Type	NGPV 8/10	NGPV 20/5	NGPV 20/10	NGPV 40/3	NGPV 40/5	NGPV 100/1	NGPV 100/2	NGPV 300/0.3	NGPV 300/0.6
▶ **Order designation**									
System model[1])	192.0310.80	192.0310.20	192.0326.20	192.0310.40	192.0326.40	192.0310.10	192.0326.10	192.0310.30	192.0326.30
System and laboratory model[2])	192.0310.81	192.0310.21	192.0326.21	192.0310.41	192.0326.41	192.0310.11	192.0326.11	192.0310.31	192.0326.31
Voltage setting	0 to 7.99 V	0 to 19.99 V		0 to 39.99 V		0 to 99.9 V		0 to 299.9 V	
Resolution (mV/steps)	10 mV/800	10 mV/2000		10 mV/4000		100 mV/1000		100 mV/3000	
Deviation (of full scale)	$<10^{-3}$	$<10^{-3}$		$<10^{-3}$		$<10^{-3}$		$<10^{-3}$	
Current setting (2 ranges) in A range	0 to 9.99 A	0 to 4.99 A	0 to 9.99 A	0 to 2.99 A	0 to 4.99 A	0 to 0.999 A	0 to 1.99 A	0 to 0.299 A	0 to 0.599 A
Resolution (mA/steps)	10 mA/1000	10 mA/500	10 mA/1000	10 mA/300	10 mA/500	1 mA/1000	10 mA/200	1 mA/300	1 mA/600
Deviation (of full scale)	$<10^{-3}$	$<2 \times 10^{-3}$	$<10^{-3}$	$<3 \times 10^{-3}$	$<2 \times 10^{-3}$	$<10^{-3}$	$<4 \times 10^{-3}$	$<3 \times 10^{-3}$	$<2 \times 10^{-3}$
in mA range	0 to 999 mA	0 to 999 mA		0 to 999 mA		0 to 99.9 mA		0 to 99.9 mA	
Resolution (1000 steps)	1 mA	1 mA		1 mA		0.1 mA		0.1 mA	
Deviation (of full scale)	$<10^{-3}$	$<10^{-3}$		$<10^{-3}$		$<2 \times 10^{-3}$		$<2 \times 10^{-3}$	
PARD[3])	<200 µV	<250 µV		<400 µV		<500 µV		<700 µV	
Output C (OFF/ON)	500 pF/220 µF	500 pF/100 µF	750 pF/220 µF	500 pF/47 µF	750 pF/100 µF	500 pF/22 µF	750 pF/47 µF	500 pF/10 µF	750 pF/22 µF
Overvoltage protection	4 to 15 V	4 to 25 V		4 to 50 V		5 to 110 V		5 to 330 V	

[1]) System model for IEC-bus programming (no operating controls and meters) in 19" cabinet.
[2]) System and laboratory model for IEC-bus programmed and manual operation with meters for voltage and current.
[3]) PARD = periodic and random deviation.

Common data

Constant-voltage source
Deviation of output voltage
with AC supply variations of ±10% . . . $< \pm 10^{-5}$
with temperature variations
from 0 to 45 °C . . . . $< \pm 2 \times 10^{-5}$/K
with load variations from 0 to 100% . $<10^{-4}$
Transient recovery time
(10 to 90%/90 to 10%) . . . . <75 µs (within $\pm 10^{-3}$)

Constant-current source
Deviation of output current
with AC supply variations of ±10% . . $< \pm 10^{-5}$
with temperature variations
from 0 to 45 °C . . . . $< \pm 5 \times 10^{-5}$/K
with load variations from 0 to 100% . $<10^{-4}$
Transient recovery time,
output C OFF/ON . . . . <50 µs/<2 ms
PARD rms
in mA range . . . . 10 µA
in A range . . . . 100 µA

Programming . . . . IEC 625-1 (IEEE 488)
Connector 24-pin
Functions . . . . SHØ, AH1, TØ, TEØ, L1, LEØ, SRØ, RL1, PP1, DC1, DT1, CØ
Setting time
0 to 100%/100 to 0% . . . . <2 ms (within $\pm 2 \times 10^{-3}$)
Remote sensing
max. voltage compensation . . . . 1 V in each lead

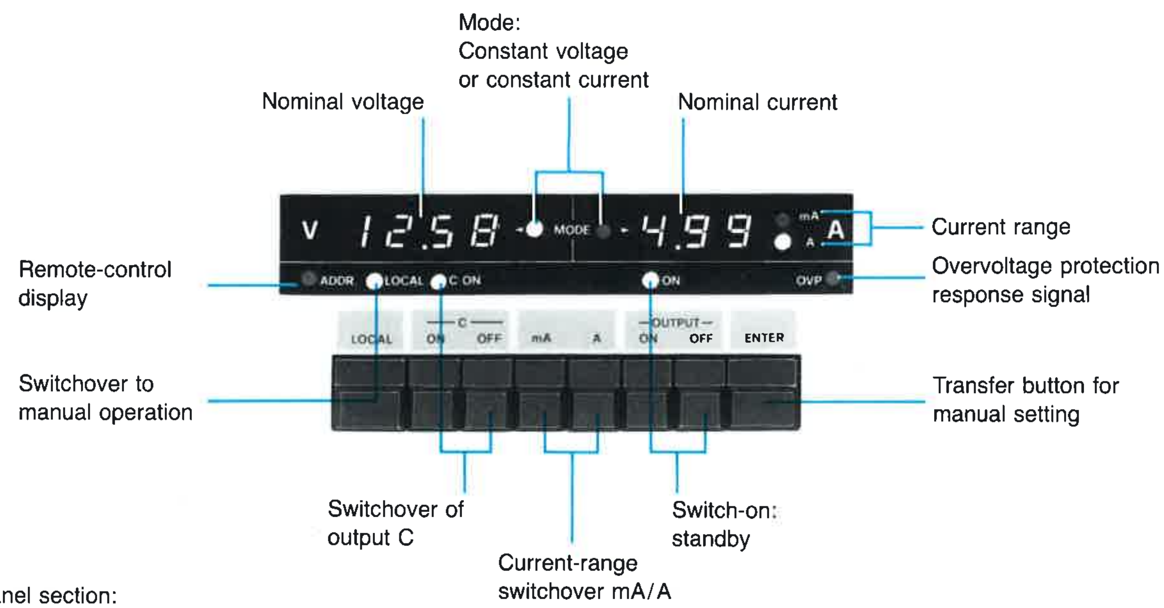
Current monitoring output, Z_{out} = 1 kΩ
(referred to positive terminal)
in mA range . . . . 100 mV for full scale
in A range . . . . 10 mV/A

General data

Meter error . . . . ±2% of full scale
Rated temperature range . . . . 0 to +50 °C
Safety specifications . . . . comply with VDE 0411, class 1
EMI specifications . . . . comply with VDE 0871/6.78 level B
Output terminals . . . . 4 mm, floating; test voltage 1000 V/ground
AC supply . . . . 110/127/220/242 V ±10%, 47 to 63 Hz

Order No.	192.0310...	192.0326...
Power consumption	ca. 250 VA	ca. 500 VA
Dimensions (W×H×D in mm)	492×161×392	492×161×420
Weight	12 kg	19 kg

Order designations . . . . ▶ see table above



Front-panel section:
key row and LED display

Company divisions (special fields) of Rohde & Schwarz

As already mentioned in the outline of the company's history on page 2, the product- and user-related activities of Rohde & Schwarz are distributed amongst the company divisions

- Measuring Instruments and Systems — Division 1
- Sound and TV Broadcasting — Division 2F
- Radiocommunications — Division 4F
- Radiomonitoring, Radiolocation — Division 4P

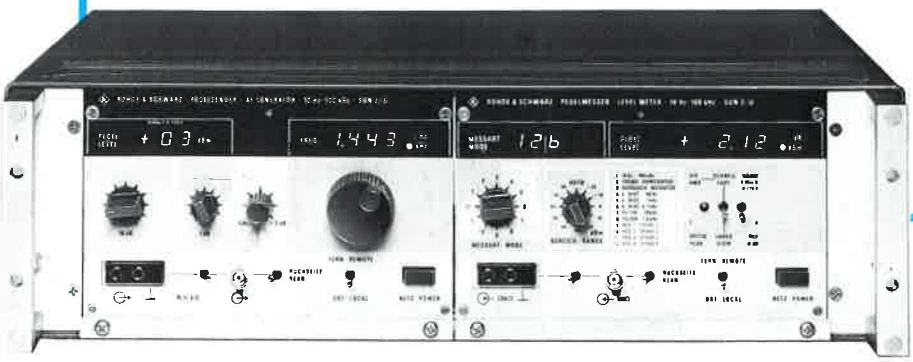
Whereas in the introduction to the catalog the activities of all four divisions are described, the catalog itself only deals with the measuring instruments and systems of **division 1.**

A few products of the **other divisions** are however described in detail on the following pages to give an example of the great variety of products, equipment and systems which on the whole are related to the measuring instruments and systems.

SUN 2

AF Transmission Measuring Set SUN 2 ◆ 10 Hz to 100 kHz

- Measures levels, weighted and unweighted SNR and harmonic distortion
- Versatile thanks to choice of cassettes



The **AF Transmission Measuring Set SUN 2** is used for in-service measurements on broadcasting and television-sound transmitters as well as for routine measurements on AF studio equipment and in laboratories. Thanks to the instrument's high accuracy, **single-knob tuning** over the entire frequency range on the AF Generator and **autoranging** for all modes on the Level Meter enable rapid, convenient and accurate measurements in AF engineering.

The AF Generator and the Level Meter can be used **separately;** combined they yield a **test assembly** (photo above) permitting weighted and unweighted SNR as well as harmonic distortion to be measured. In addition, the feature of being able to select a reference level enables level variations to be determined.

The AF Generator SUN 2/S is a precision AF generator with digital frequency setting; large LED digits ensure frequency and level indication. The SUN 2/S uses frequency synthesis and single-range tuning. The crystal-controlled frequency is displayed with a resolution of about 0.3%. The output voltage can be set in steps of 1 dB and continuously over about 3 dB and is available with good amplitude stability at a balanced and an unbalanced output.

The Level Meter SUN 2/U is a precision AF voltmeter with digital indication. It has an unbalanced and a transformer-isolated balanced input. Range selection is automatic; switchover to manual operation with 10-dB steps is possible.

A quasi-rms responding rectifier in line with DIN 45633 produces an rms-proportional voltage from signals up to a peak factor of 5. Quasi-peak responding rectification complying with DIN 45405 can be switch-selected for weighted noise measurements.

The DC voltage proportional to the measured value is digitized and converted into dB by a microprocessor for display and further processing.

Readout characteristics are specified in existing standards for psophometric measurements. Conventional psophometers implement the required characteristics through the rectifier and meter time constants.

The Level Meter SUN 2/U simulates the characteristics of a moving-coil meter electrically, the digital display indicating the mean rms value or the maximum peak value during the display time.

Filters can be inserted in the amplifier path for measuring unweighted and weighted signal-to-noise ratio and **harmonic distortion.** The level generator then operates in the difference mode: it measures and stores the reference quantity, then measures the unknown via the filters and subtracts one from the other.

Linear **DC and AC outputs** permit connection of analog processing equipment such as recorders.

Level Meter SUN 2/U as a self-contained bench unit

Specifications

AF Generator SUN 2/S

Frequency	10 Hz to 100 kHz, tunable
Indication	4 digits, floating point; Hz, kHz
Indication error	$\leqq 1 \times 10^{-3} \pm 1$ digit
Resolution	0.25 to 0.5%

Output level

Range	−20 to +12 dBm (0 dBm = 0.775 V)
Setting in range −20 to +9 dBm	least step 1 dB
Additional fine adjustment	0 to +3 dB (±0.1 dB)
Indication	−20 to +9 dBm; 2 digits, polarity sign
Setting error (1000 Hz)	$\leqq \pm 0.1$ dB
Source impedance	approx. 5 Ω; $Z_{load} \geqq 600\ \Omega$ ‖ $\leqq 4.7$ nF
Frequency response flatness referred to 1000 Hz	30 Hz to 70 kHz: $\leqq \pm 0.1$ dB other frequencies: $\leqq \pm 0.3$ dB
Harmonics	$\geqq 65$ dB down (30 Hz to 30 kHz) $\geqq 60$ dB down (30 to 100 kHz) $\geqq 40$ dB down (10 to 30 Hz)
DC component	$\leqq \pm 1$ mV

Outputs

Front panel (switch-selected)	unbalanced; BNC female connector balanced: 3-way connector (DIN 41628)
Rear panel (instead of front-panel output)	3-way female chassis connector (similar to DIN 41524), lockable; in parallel with 30-way male connector (DIN 41622)

Level Meter SUN 2/U

Frequency range	10 Hz to 100 kHz
Operation with filter inserted	see under "filter"
Level measurement range	−84 to +32 dBm (0 dBm = 0.775 V)
Range stepping	10-dB steps (−80 to +20 dBm)
Individual range	approx. −10 to +12 dBm about mid range
Range selection	automatic or manual
Indication	4 digits, polarity sign; dBm, dB; readout blinking in the case of over-ranging and underranging
Resolution	0.02 dB

Error limits of indication
(inherent noise level not taken into account)

Error with sinusoidal voltages and rms-value indication (1000 Hz)	$\leqq \pm 0.1$ dB
Frequency response flatness with rms-value indication (referred to 1000 Hz)	30 Hz to 70 kHz: $\leqq \pm 0.1$ dB; other frequencies: $\leqq \pm 0.2$ dB
Weighting error of rms-responding rectifier	up to crest factor 3: $\leqq \pm 0.5$ dB up to crest factor 5: $\leqq \pm 1$ dB (in accordance with DIN 45633 and IEC 179)
Error limits and dynamic range with quasi-peak-responding indication	in accordance with DIN 45405 (1981) and CCIR Rec. 468-2
Inherent noise level (rms)	$\leqq -90$ dBm ($Z_s \leqq 20$ kΩ)

Meter detectors

rms mode	quasi-rms-responding rectifier in accordance with DIN 45633, sheet 2, and IEC 179
Integration time	FAST: 35 ms SLOW: 145 ms
Measured value indication	mean value of detector voltage during integration time (145 ms)
Peak mode	quasi-peak-responding rectifier in accordance with DIN 45405 (1981) and CCIR Rec. 468-2
Measured value indication	maximum value of detector voltage during integration time (35 ms)
Distortion measurement	L_2 subtracted from L_1 automatically
Reference measurement	±dB variation from any selected reference value

Inputs

Front panel (switch-selected)	unbalanced: 1 MΩ ‖ ≈50 pF, BNC female connector; balanced: $\geqq 20$ kΩ, 3-way connector (DIN 41628)
Rear panel	balanced: $\geqq 20$ kΩ, 30-way male connector (DIN 41622), in parallel with 3-way female chassis connector (similar to DIN 41524), lockable
Common-mode rejection and ratio of balanced voltage to voltage between centre tap and earth	$\geqq 125$ dB (50 Hz) $\geqq 85$ dB (1 kHz) $\geqq 60$ dB (16 kHz)
Permissible DC voltage at unbalanced input	max. ±100 V

Outputs

Outputs	telephone jacks on rear panel
DC voltage	+0.1 to +1 V, proportional to V_{in}
Source impedance, load	$R_{out} \approx 10\ \Omega$, $R_{load} \geqq 1$ kΩ
AC voltage	max. $\geqq 0$ dBm, proportional to V_{in}
Source impedance, load	$Z_{out} \approx 10\ \Omega$, $Z_{load} \geqq 1$ kΩ
Useful dynamic range (instrument used as amplifier)	$\geqq 60$ dB

Filters

Unweighted	bandpass filter 31.5 Hz to 16 kHz in accordance with DIN 45405 (1981) and CCIR Rec. 468-2
Weighted	psophometric filter in accordance with DIN 45405 (1981) and CCIR Rec. 468-2 (exchangeable plug-in board)
Distortion (d)	highpass filter 80 Hz (for $d_{(40\ Hz)}$), highpass filter 2 kHz (for $d_{(1\ kHz)}$), highpass filter 9.4 kHz (for $d_{(4.7\ kHz)}$)
Distortion (separately for d_2 and d_3)	bandpass filter 180 Hz for $d_{3\ (60\ Hz)}$ and $d_{2\ (90\ Hz)}$, bandpass filter 1.6 kHz for $d_{3\ (533\ Hz)}$ and $d_{2\ (800\ Hz)}$
Highpass filters (f_o = frequency of fundamental)	
Passband attenuation between 2 f_o and 45 kHz	$\leqq \pm 0.3$ dB
Stopband attenuation at f_o	$\geqq 65$ dB
Bandpass filters (f_p = passband frequency)	
Passband attenuation at f_p	$\leqq \pm 0.3$ dB
Stopband attenuation at 0.33 f_p and 0.5 f_p	$\geqq 65$ dB
Stopband attenuation at $\geqq 1.33\ f_p$ to 45 kHz	$\geqq 40$ dB
Special filters	space and four switch positions provided for special filters
Inherent noise indication with distortion measurement	$\geqq 65$ dB ($\geqq 60$ dB for $d_{(40\ Hz)}$ and balanced input)

General data

Rated temperature range	+5 to +45 °C
Storage temperature range	−20 to +70 °C
AC supply	110/125/220/235 V +10/−15%, 47 to 63 Hz
Power consumption	AF Generator: 30 VA Level Meter: 25 VA
Dimensions	
19" bench model	492 mm×161 mm×392 mm
19" rackmount	483 mm×132 mm×384 mm
½ 19" rackmount SUN 2/S or SUN 2/U	245 mm×154 mm×347 mm
Weight	
19" bench model	10.2 kg
19" rackmount	8.6 kg
½ 19" rackmount SUN 2/S	4.9 kg
SUN 2/U	5.1 kg

Ordering information

Order designations

Test assembly comprising SUN 2/S and SUN 2/U	▶ AF Transmission Measuring Set SUN 2
19" bench model	190.2750.02
19" rackmount	190.2744.02
Rackmount SUN 2/S	▶ AF Generator SUN 2/S 282.2010.03
Rackmount SUN 2/U	▶ Level Meter SUN 2/U 282.4213.03

Accessories supplied

Power cord, manual, adapter board; one of each of these for the AF Generator and for the Level Meter

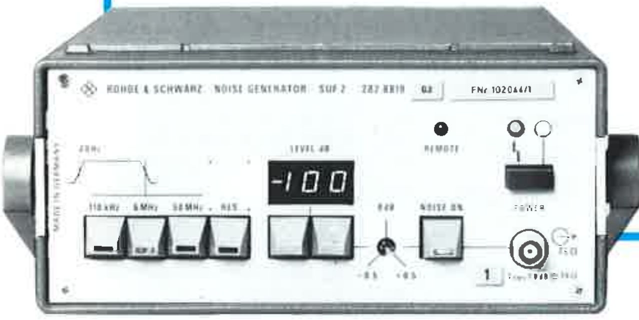
Recommended extras

Panelling SUN 2-Z to convert ½ 19" rackmount for use as bench model	085.6421.00
Cassette Adapter SUN 2-Z for any two cassettes of the SUN 2 system	282.5910.03
Panelling SUN 2-Z to convert Cassette Adapter for use as bench model	085.1459.00

SUF 2

Noise Generator SUF 2 ♦ 20 Hz to 50 MHz

- General-purpose generator for white, pink, triangular and audio-spectrum noise
- Output level 1 V into 75 Ω
- Easy to operate; remote-control option



IEC 625 Bus

The basic version of the **Noise Generator SUF 2** delivers a noise spectrum with a constant mean energy content which is uniformly distributed over all frequencies (white noise). A variety of options permits the SUF 2 to be adapted without difficulty for virtually all applications in audio and video noise-voltage and distortion measurements (including digital systems); it can be remote-controlled for use in automatic test systems.

Output signals, weighting filters, options

- White noise 20 Hz to 110 kHz/6 MHz/50 MHz (switch-selected)
- Pink noise 20 Hz to 16 kHz (option); spectral components decreasing by 3 dB/octave
- Triangular noise 20 Hz to 6 MHz (option)
- Weighting filter in accordance with CCITT Rec. G.227 (option for simulating telephony signal)
- Weighting filter in accordance with CCIR Rec. 559 (option for simulating an LF/MF/HF signal)
- Weighting filter in accordance with CCIR Rec. 571 (option for simulating a 15-kHz program signal)
- Please enquire for other filters.
- Program option in accordance with CCIR Rec. 571
- Bus interface (optional) in accordance with IEC 625-1 (IEEE 488)

Uses (see examples)

Radio engineering: Measurement of crosstalk due to non-linearity, and intermodulation, using the noise to mimic a sound-program signal.

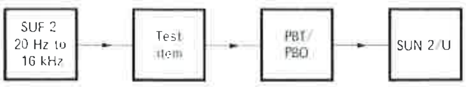
Video engineering: Measurement of interference effects on all the components of transmission systems.

Architectural acoustics: Using a noise signal – because it is similar to speech/music – for the measurement offers advantages over the fixed-frequency test methods.

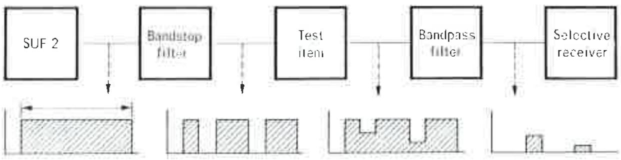
Frequency response measurement: Pink noise permits rapid and repeatable measurements.

Control engineering: Simulation of noise sources in system control and general control circuits.

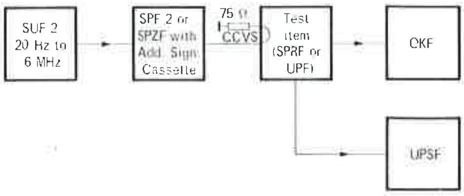
Research: Analysis of stochastic processes.



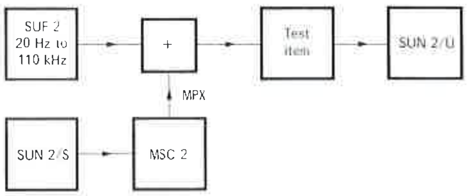
Rapid AF frequency response measurement with pink noise using one-third-octave or octave filter and level meter



Harmonic distortion measurement in a crowded frequency band with simulated gaps



Measurement of noise rejection in video circuitry (amplifiers, sync separators, clamping circuits, test equipment)



Measurements on stereo systems and analog frequency-multiplex and telephony transmission systems (60 to 108 kHz, international)

Specifications

Frequency range	20 Hz to 50 MHz
Output level (white noise)	≦1 V_{rms} into 75 Ω (BNC); 0.775/0.7 V, link-selected
Frequency response flatness	≦±0.5 dB
Bandwidths, options	see text
Level setting and accuracy	1-dB steps, ±0.5 dB continuously
with 20 Hz to 50 MHz bandwidth	0 to −80 dB ±0.5 dB
with 20 Hz to 110 kHz/6 MHz bandwidths	0 to −100 dB ±0.5 dB
Remote control	attenuation: in BCD code; bandwidths and filter options: 2-bit binary code
AC supply	110/115/220/235 V ±10% (20 VA)
Dimensions (without stand), weight	210 mm×110 mm×347 mm, 4 kg

Ordering information

Order designation .... ▶ Noise Generator SUF 2 282.8819.03

Plug-in options

Controllers (one only):		
IEC-625-bus Interface	SUF 2-Z1	282.9915.00
CCIR Rec. 571 Program	SUF 2-Z6	282.9673.00
Filters (one only):		
Triangular Noise	SUF 2-Z2	282.9715.00
Pink Noise	SUF 2-Z3	282.9815.00
CCIR Rec. 559 – Filter	SUF 2-Z4	282.9615.00
CCIR Rec. 571 Filter	SUF 2-Z5	282.9644.00
CCITT Rec. G. 227 Filter	SUF 2-Z7	282.8860.00

FM/AM Demodulator FAB

FAB

♦ Bands I, II, III and IV/V

- Tunable oscillator plug-ins for bands I to V, fixed-frequency plug-in: IF + band II
- Performance complying with ARD specifications 5/3.4 for FM (AM) demodulators
- Built-in frequency-deviation standard and mono/stereo indication

Photo: FAB with oscillator plug-in for band III

The **FM/AM Demodulator FAB,** which is also suitable for stereo operation, is designed for testing and permanent monitoring of **FM sound broadcast and TV transmitters.** Lamps are provided to signal mono or stereo operation.

Measurements on the transmitter

using FAB alone	with accessory units
Modulation frequency response	Frequency response of AF amplitude
Centre-frequency error	Frequency response of phase
Frequency deviation	Distortion
Spurious amplitude modulation	Intermodulation distortion
	Intermodulation products
	Weighted and unweighted noise voltage (FM and AM)

To select the desired frequency band, the FAB must be equipped with one of the oscillator plug-ins (see specifications). The selected reception frequency is indicated on a drum dial (with the fixed-frequency plug-in, on the push-buttons). When the FAB is to be operated at a fixed frequency, the oscillator can be switched to crystal-controlled operation (crystals should be ordered separately).

Indication. The measured or monitored quantities are read from a meter calibrated in kHz for the centre-frequency error and on a switchable multi-purpose meter.

Specifications

Frequency setting	with oscillator plug-ins, tunable through the corresponding range (crystal control of fixed frequencies possible) or with fixed-frequency plug-in
Frequency ranges of oscillator plug-ins	
Band I (FAB-E1)	48 to 68 MHz
Band II (FAB-E2)	87.5 to 108 MHz
Band III (FAB-E3)	175 to 230 MHz
Band IV/V (FAB-E4)	471 to 853 MHz
Fixed frequencies (FAB E5)	5.5[1]/21.4/33.4[1]/38.9[1]/ 87.5 to 108[2] MHz
Band I (OIRT) (FAB-E6)	52 to 75 MHz
RF input	switchable: Dezifix B on front panel/self-engaging plug-and-socket connection on rear panel
Input impedance	50 Ω or 60 Ω, depending on order no.
RF input voltage	1 to 5 V (0.1 to 1 V without AM measurement)

Outputs

Test output (output 1)	stereo multiplex output (unbalanced); RF female connector 4/13, DIN 47 284, adaptable
Monitoring output (output 2)	mono output (balanced, floating), twin panel female connector, DIN 41 628

[1]) Please enquire for other frequencies between 4.5 and 6 MHz or 30 and 46 MHz.
[2]) Operation possible only with channel crystal (to special order).

FM measurement	**Output 1**	**Output 2**
Source impedance	≦10 Ω (free from DC)	≦30 Ω
Permissible load	≧600 Ω ‖ ≦5 nF	≧600 Ω
Deemphasis (time constant)	50 µs (switched)	50 µs (fixed)
Band limitation by lowpass filter (at 19 kHz)	≧40 dB (switched together with deemphasis)	≧40 dB (fixed)
Output level with 40-kHz deviation in band II, with 30-kHz deviation in bands I/III/IV/V, f_{mod} = 500 Hz and specified load	+6 dBm ±0.25 dB	+6 dBm ±0.25 dB

Nonlinear distortions (with frequency deviations up to ±75 kHz)

Distortion in the range 40 Hz to 15 kHz	≦0.25% (output 1 or 2)	
Intermodulation distortion		
2nd order	≦0.15%	40 Hz to 15 kHz outputs 1 and 2, 15 kHz to 53 kHz output 1 only
3rd order	≦0.2%	

Deviation indication

Ranges	0 to 500 Hz/10/50/100 kHz		
Reading error at f_{mod} = 500 Hz (after calibration with built-in standard)			
Range	10/50/100 kHz	500 Hz	500 Hz
in band	I to V	I, II, III	IV/V
Free-running oscillator	±3% of fsd	<50 Hz	no tolerance
Crystal oscillator	±3% of fsd	<25 Hz	<150 Hz
Fixed-frequency plug-in	±3% of fsd	<25 Hz	—
Frequency-response flatness of deviation indication	≦0.2 dB (40 Hz to 53 kHz)		

Indication of amplitude modulation

Ranges (modulation depth)	0 to 1/5/10%
Reading error at f_{mod} = 500 Hz	≦ ±10% of fsd
Frequency-response flatness of AM indication, referred to indication at f_{mod} = 500 Hz	≦5%
S/N ratio, unweighted, referred to 100% AM	≧56 dB
S/N ratio, weighted, referred to 100% AM	≧66 dB
Output level at 10% AM	−14 dBm ±0.25 dB

General data

Rated temperature range	+5 to +35 °C
AC supply	115/125/220/235 V +10/−15%, 47 to 63 Hz (35 VA)
Dimensions, weight	
19" bench model	484 mm×150 mm×336 mm, 17 kg
19" rackmount	483 mm×133 mm×325 mm, 14 kg

Ordering information

Order designation	▶ FM/AM Demodulator FAB	
Basic unit without oscillator plug-ins	50 Ω	60 Ω
19" bench model	206.9418.52	206.9418.62
19" rackmount	206.9418.51	206.9418.61
Oscillator plug-in		
FAB-E1 (band I)	207.6012.02	
FAB-E2 (band II)	207.7019.02	
FAB-E3 (band III)	207.8015.02	
FAB-E4 (band IV/V)	207.9011.02	
FAB-E5 (fixed frequencies)	289.6911.02	
FAB-E6 (band I, OIRT)	235.3714.02	

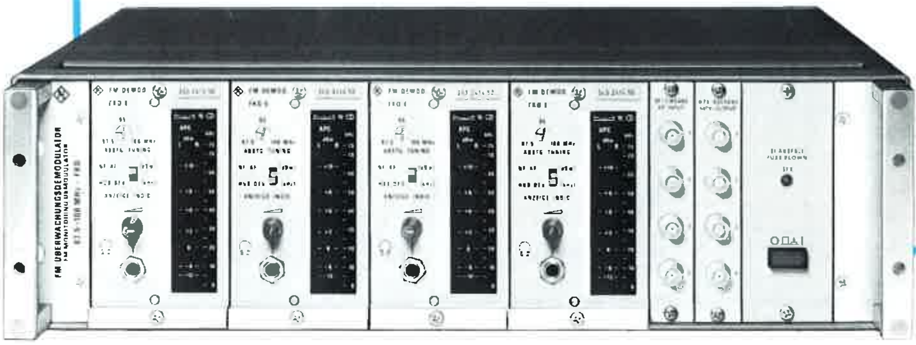
Recommended extras

Crystals are to be ordered separately; ordering information: crystal for oscillator for FAB, band (I, II, III or IV/V) and channel frequency.

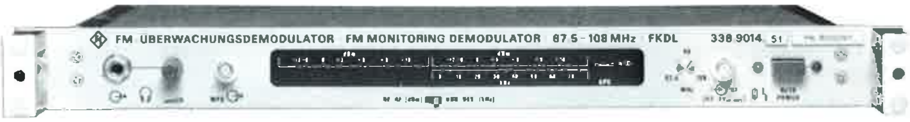
FKD
FKDL

FM Monitoring Demodulator FKD/FKDL ♦ 87.5 to 108 MHz

- Outputs for multiplex, L, R and mono signals; headphones output
- L and R signal-level or peak-deviation indication
- FKD: Maximum of four demodulator cassettes in one 19″ rackmount including the power supply
- FKDL: a single demodulator cassette plus the power supply in a 19″ rackmount



Photo, top: Frame FKD-B with four FM Demodulators FKD-E



Photo, bottom: Successor model FKDL

The continuously tunable **FM Monitoring Demodulators FKD and FKDL** are used for monitoring carrier signals modulated with mono or stereo signals in accordance with the relevant CCIR recommendation. They are connected to the transmitter output via directional couplers or voltage dividers and deliver demodulated mono, multiplex, L and R signals for checking the performance of FM transmitters.

Models. In addition to the FKD model principally designed for central monitoring and accommodating up to four FM Demodulators FKD-E in one 19″ Adapter Frame FKD-B, the FM Monitoring Demodulator FKDL is available; it consists only of one demodulator in the form of a 19″ rackmount and is provided for incorporation into transmitters. The FKDL, too, is available for European paging transmitters.

Indication. Analog display of the **AF voltages** of the L and R channels is provided by two LED arrays (32 diodes). The 80-mm scale can be read even from a distance of several meters. The righthand LED array can be switched over at the front panel to indicate the **frequency deviation** of the transmitter. Two additional LEDs signal that the stereo mode is selected and that the RF input voltage is sufficient.

FM Demodulator FKD-E

Outputs. A low-impedance output on the rear panel delivers the **mono signal** for monitoring and measuring purposes. The **multiplex signal** is available at two parallel, low-impedance outputs on the front and rear panels. A **headphones output** for the **L and R signals** is fitted on the front panel.

Construction. The FM Demodulator FKD-E comes as a cassette for insertion into an Adapter Frame FKD-B which provides space for a maximum of four FKD-E cassettes and contains the power supply unit. If the FKD-E is used without this adapter frame, an external ±15-V power supply is required. The RF voltages coming from the transmitters are applied via BNC female connectors on the rear panel. After changing over the internal cabling, the RF voltage can also be fed in on the front panel. The FKD is available as a 19″ rackmount or as a bench model with the necessary panelling.

The FM Monitoring Demodulator FKDL comes as a 44-mm high 19″ rackmount with a power supply of its own and is fitted with connectors on the rear panel.

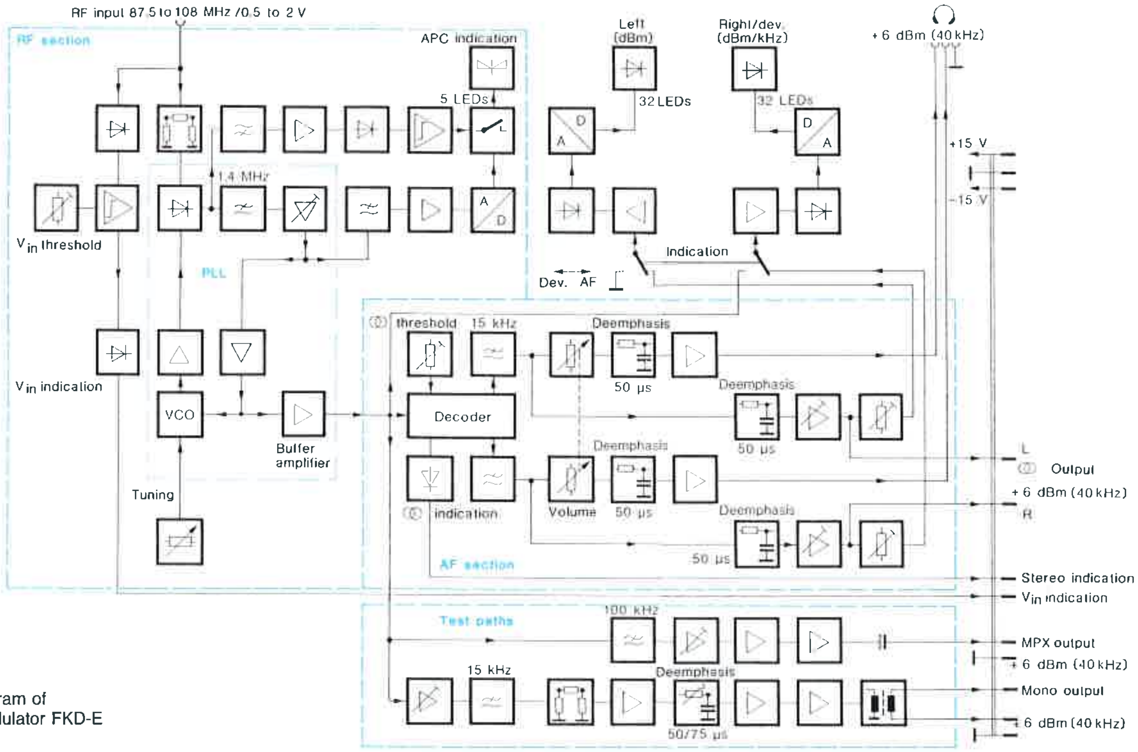
Operation. The RF section of the FM Monitoring Demodulators includes a variable-frequency oscillator whose frequency can be modulated and which is automatically synchronized to the frequency of the transmitter to be measured. A five-LED array indicates the tuning with respect to carrier midpoint. The AC component of the correction voltage is used after peak-rectification for indication of the FM deviation. The stereo decoder module, working on the time-division-multiplex principle, automatically switches over to mono operation if the pilot tone is absent.

Filter module. For the suppression of cross-modulation products arising from the linking up of several transmitters via diplexers, a filter module is available.

Specifications

FM Monitoring Demodulators FKD-E and FKDL

Frequency range	87.5 to 108 MHz (tunable)
Input voltage	0.5 to 2 V_{rms}
Input impedance	50 Ω (unbalanced)
Return loss	≧20 dB
Tuning	manual
Spurious signals ≧±1 MHz off carrier frequency	down ≧30 dB referred to carrier



Block diagram of
FM Demodulator FKD-E

Deviation indication	0 to 77.5 kHz (peak-voltage indication)
Resolution	2.5 kHz (32 LEDs)
Indication error[2]	≦±5% of fsd (f_{mod} = 40 Hz to 60 kHz)
Indication error after change of channel, without external calibration	<±10% (f_{mod} = 40 Hz to 60 kHz)

Test outputs

Multiplex signal output	≦30 Ω (unbalanced)
Output level at ±40 kHz deviation	+6 dBm ±0.5 dB into 600 Ω[2])
Frequency response flatness	
30 Hz to 53 kHz	≦±0.3 dB
53 to 100 kHz	≦±1 dB
Harmonic distortion at ±75 kHz deviation[1])	≦0.5%, typ. 0.3% (30 Hz to 15 kHz)
Unweighted S/N ratio[1])	≧64 dB
Weighted S/N ratio[1])	≧64 dB
Crosstalk measured via stereo-decoder[1]) without preemphasis and deemphasis	100 Hz to 10 kHz: ≧40 dB down 40 to 100 Hz: ≧34 dB down
Mono signal output	≦30 Ω (balanced)
Output level at ±40 kHz deviation, f_{mod} = 500 Hz	+6 dBm ±0.5 dB into 600 Ω[2])
Frequency-response flatness referred to 50-µs deemphasis	±0.5 dB (40 Hz to 15 kHz)
Harmonic distortion at ±75 kHz deviation	≦0.5% (30 Hz to 15 kHz)
Unweighted S/N ratio[1])	≧68 dB
Weighted S/N ratio[1])	≧68 dB
Identification signal suppression (f_{mod} = 500 Hz; with deemphasis)	≧60 dB

Monitoring outputs

Stereodecoder outputs	for L and R signal; Z_{out} ≦30 Ω (unbalanced)
Output EMF with ±40 kHz deviation, f_{mod} = 500 Hz	+6 dBm ±1 dB into 600 Ω
Crosstalk between L/R channels	typ. 30 dB (40 Hz to 15 kHz)
Frequency-response flatness 40 Hz to 15 kHz	≦±1.5 dB (deemphasis 50 µs)
Headphones output	max. +12 dBm (adjustable); on front panel; Z_{out} ≦30 Ω
Frequency response flatness 40 Hz to 15 kHz	≦ ±1.5 dB (deemphasis 50 µs)
Filter module	to derive max. four carrier signals
Insertion loss	6 dB per selective circuit
Selectivity	typ. 13 dB ±1.5 MHz off the carrier

[1]) Measured with deemphasis (at multiplex signal output via stereodecoder, e.g. MSDC 2); noise voltage weighted in accordance with CCIR 468-2, referred to nominal output level.
[2]) After external calibration in operating channel.

AF level indication	−12 to +12 dBm
Indicator	LED array (2×32 LEDs, scale lenght 80 mm)

General data

FM Monitoring Demodulators FKD-E and FKDL

Rated temperature range	+5 to +40 °C
Operating temperature range	0 to +45 °C
Storage temperature range	−20 to +50 °C
Power supply of FKD-E	+15 V (±2%), 300 mA −15 V (±2%), 150 mA
FKDL	115/125/220/235 V +10/−15%, 47 to 63 Hz (15 VA)
Dimensions of FKD-E	76 mm×132 mm×316 mm
FKDL	483 mm×44 mm×364 mm
Weight of FKD-E/FKDL	1.35 kg/3.3 kg

Adapter Frame FKD-B with power supply

Connectors (also applicable for FKDL)	
RF inputs	BNC female (on front and rear panels)
L, R, MPX, mono outputs	30-way male
Status-signal contacts for RF carrier and identification signal monitoring	30-way male
Headphones	jack
AC supply	115/125/220/235 V +10/−15%, 47 to 63 Hz (60 VA for four demodulator cassettes)
Dimensions, weight (without demodulator cassettes)	
19″ bench model (design 80)	492 mm×161 mm×514 mm, 7.5 kg
19″ rackmount	483 mm×132 mm×506 mm, 4.6 kg

Ordering information

Order designation (19″ rackmounts)

Adapter Frame with cassettes	▶ FM Monitoring Demodulator FKD	
	Conn. on front panel	also on rear panel; with filter
with 1 demodulator cassette	343.2014.51	343.2014.53
with 2 demodulator cassettes	343.2114.51	343.2114.53
with 3 demodulator cassettes	343.2214.51	343.2214.53
with 4 demodulator cassettes	343.2314.51	343.2314.53
Single-demodulator rackmount	▶ FM Monitoring Demodulator FKDL 338.9014.51	
19″ bench model	338.9014.52	
Adapter Frame FKD-B with MPX outputs and RF inputs on front panel, without demodulator cassettes	343.2814.50	
FM Demodulator FKD-E with MPX output	343.2414.50	
Panelling for FKD-B	085.1342.00	
Filter FKD-B	343.3210.50	

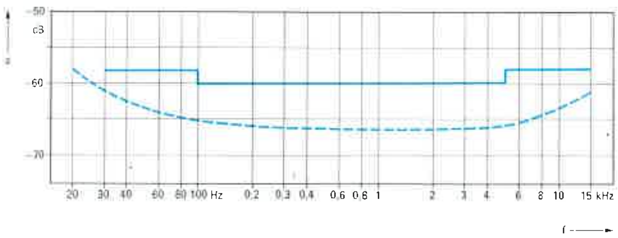
MSC 2

Precision Stereocoder MSC 2 ⧫ 30 Hz to 15 kHz

- High-quality test coder complying with CCIR, EBU and FCC standard
- AF generator with 6 fixed frequencies
- SCA option can be retrofitted

The **Precision Stereocoder MSC 2** produces the standard multiplex signal with **high precision.**

In the **standardized technique of stereo multiplex broadcasting,** the sound-program signals for the left and right channels are carried in the frequency range 30 Hz to 53 kHz together with a pilot tone. This stereo multiplex signal is generated in the Precision Stereocoder MSC 2 with high precision. The excellent data – for example distortion ≦0.1% up to 12.5 dBm, unweighted S/N ratio ≧80 dB, frequency-response flatness ≦±0.15 dB and crosstalk attenuation between left and right channels >60 dB (see diagram below) – result from the new coding method employed in the MSC 2.



Stereo separation of the Precision Stereodecoder MSC 2 between the right and left channels; full line: guaranteed values; dashed line: typical values

The Precision Stereocoder MSC 2 is used as **reference unit** for all measurements with stereo multiplex signals, since its data far exceed the standard specifications of the broadcasting corporations.

In conjunction with a stereo-signal generator, the MSC 2 is a useful instrument for the **development and production** of radio receivers. A simple measurement of crosstalk between the two AF channels gives a good idea of the main characteristics of the RF and IF sections of a receiver, without requiring elaborate frequency-response measurements; it is also a good test of the performance of the stereodecoder section. Together with a stereodecoder of similar quality, such as the MSDC 2 (see page 343), all kinds of measurements can be made on equipment that handles and thereby possibly deteriorates multiplex signals, for instance FM transmitters, modulators, relay receivers and switchboards. In such cases it is particularly important that the inherent error of the test assembly should not falsify the measurement.

For its use as a measuring instrument, the stereocoder is fitted with an AF generator producing six fixed frequencies with high amplitude stability and low distortion, with the result that an external generator will not be required in most cases. The internal generator is used for the modulation modes:
L
R
L = R (mono signal)
L = −R (difference signal)

The phase and amplitude of the pilot tone (19 kHz) are adjustable with front-panel controls so that the characteristics of the decoder under test can be measured in any operating conditions. The amplitudes of the AF and multiplex signals can also be adjusted over a wide range. A peak voltmeter indicates the modulation of the coder.

Specifications

Inputs for L and R channels	30 Hz to 15 kHz; balanced/unbalanced, Z_{in} ≧30/20 kΩ
Attenuation (f ≧19 kHz)	≧54 dB
Input level at 1 kHz for output level of +6 dBm of M signal or of S signal modulated onto subcarrier	+6 dBm (nominal input)
Preemphasis 50 µs/75 µs/off	
Auxiliary-signal inputs	2; ≧2 kΩ, unbal.; 53 to 100 kHz
Pilot-tone frequency	19 kHz (subcarrier 38 kHz)
Multiplex-signal outputs	2 (shortcircuit-proof), Z_{out} ≦20 Ω
Output level	+6 dBm/−∞ to +12 dBm optional (without pilot tone)
M-signal output	—
Pilot-frequency output	1 V_{pp} (Z_{out} ≦100 Ω), squarewave
Frequency response flatness (ref. 500 Hz) measured after decoder 40/30 Hz to 15 kHz	≦±0.15 dB
53 to 75 kHz	—
Crosstalk between M/S	≧46 dB down (30 Hz to 15 kHz)
L/R	≧60 dB down (100 Hz to 5 kHz) ≧58 dB down (30 Hz to 15 kHz)
Signal/THD ratio at output levels up to +12.5 dBm	≧60 dB
Unweighted S/N ratio	≧80 dB, quasi-peak (to DIN)
Weighted S/N ratio	≧78 dB, quasi-peak (to DIN) ≧76 dB, quasi-peak (CCIR 468-2)
Power supply	115/125/220/235 V +10/−15%, 47 to 63 Hz (10 VA)
Dimensions, weight 19″ bench model	492 mm×116 mm×392 mm, 6.7 kg
19″ rackmount	483 mm×88 mm×384 mm, 4.5 kg
Order designation	▶ Precision Stereocoder MSC 2
19″ bench model	230.9314.04
19″ rackmount	230.9314.03
SCA Modulator	230.9014.00

Precision Stereodecoder MSDC 2

MSDC 2

♦ 30 Hz to 75 kHz

- High-grade decoding of multiplex signals
- Very high channel separation: typically 64 dB
- Extremely low intrinsic distortion

The **Precision Stereodecoder MSDC 2** is used to measure and monitor stereo multiplex signals. Its performance far exceeds the requirements set by ARD in all significant points. Thus the MSDC 2 can be employed as a reference standard in the development and production of stereo coders and decoders, as well as in transmitter networks to ensure high transmission quality.

Input. The input of the MSDC 2 is balanced; common-mode rejection exceeds 60 dB for the lower frequencies. The input amplifier handles frequencies from about 0.1 Hz to 1 MHz without introducing distortion. Amplitude and phase errors thus remain so small that high separation performance is achieved (same values as for MSC, see diagram on page 342).

The **decoder** uses a time-division-multiplex decoding technique. The stereo signal is connected alternately at a rate of 38 kHz to the right and left channels. This circuit arrangement provides a carrier suppression of more than 40 dB.

To obtain the specified channel separation, it is essential that switching is in exact synchronism with the pilot tone. For frequency deviations up to ±2 Hz and level variations up to +6/−12 dB the time shift of the squarewave switching voltage referred to the 19-kHz pilot tone may not exceed 50 ns.

Outputs. The signals of the left and right channels, the centre signal M = (L+R)/2 and the side information S = (L−R)/2 are delivered with extremely low distortion at separate outputs. Apart from the S-signal output they are balanced. Toroidal core transformers are used, giving distortion of less than 0.1%, even at a frequency of 30 Hz and a signal level 6 dB above nominal.

Indication. A selector switch allows the levels of the output signals and of the pilot tone to be indicated on the panel meter. The measurement range for the output signals (−66 to +18 dBm) is large enough to permit even the intrinsic error of the MSDC 2 or a coder working directly into the MSDC 2 to be measured. The pilot-tone voltage can be measured over a range of −7.5 to −17 dB relative to the setting of the input attenuator. This permits exact level adjustment, even with an unknown stereo multiplex signal.

Specifications

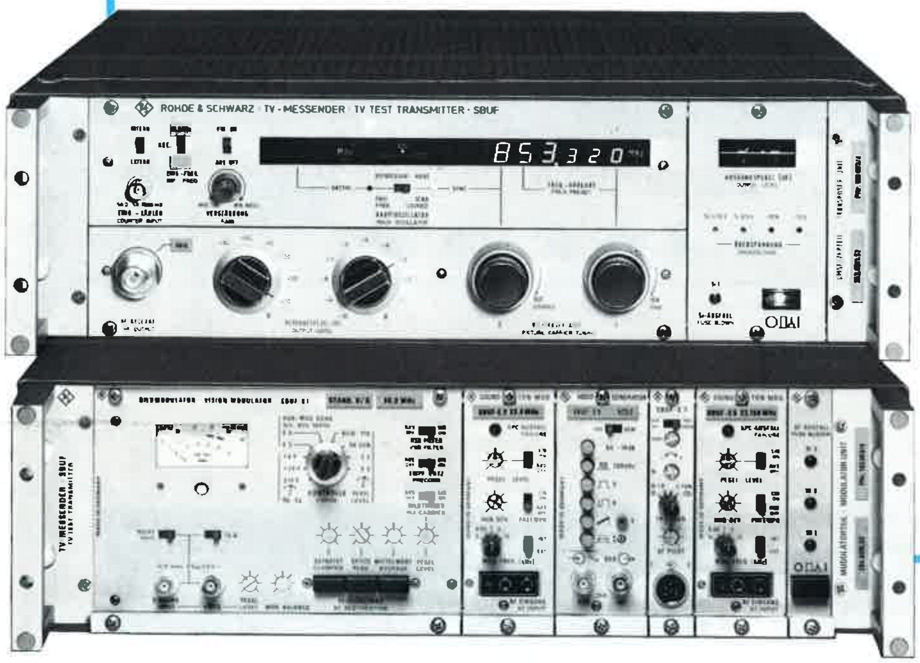
Stereo multiplex input	
Frequency range	30 Hz to 75 kHz
Input impedance	≧40 kΩ bal., ≧20 kΩ unbal.
Common-mode rejection	≧58 dB at <150 Hz ≧46 dB at 150 Hz to <15 kHz ≧36 dB at 15 to <100 kHz
Input level	−12 to +12 dBm (0 dBm = 0.775 V into 600 Ω)
Setting	6-dB steps, ±3 dB continuous
Overdrive limit	≧6.5 dB
AF outputs	
L, R, M signal outputs (balanced)	+6 dBm, Z_s ≦20 Ω, Z_L ≧200 Ω
S signal output (unbalanced)	+6 dBm, Z_s ≦500 Ω
Linear distortions	
Frequency response flatness at the outputs, relative to 500 Hz	≦±0.15 dB for 30 Hz to 15 kHz
Deemphasis	50 µs ±2%/75 µs ±2%/off
Linear crosstalk	
M/S channels	≧46 dB (typ. 50 dB)
L/R channels, 100 Hz to 5 kHz	≧60 dB (typ. 64 dB)
30 Hz to 15 kHz	≧58 dB (typ. 60 dB)
Nonlinear distortions	
Harmonic distortion at 6 and 12.5 dBm	≦0.1%
Difference-frequency intermodulation distortion to DIN 45403 at 12.5 dBm	d_2 ≦0.05%, d_3 ≦0.1%
Weighted and unweighted noise (with 50-µs deemphasis) relative to +6 dBm at 1 kHz	
Unweighted S/N ratio, rms measurement	≧80 dB (30 Hz to 100 kHz)
Weighted S/N ratio, peak-value measurement (CCIR)	≧78 dB
peak-value measurement (DIN)	≧80 dB
Pilot-tone suppression	≧90 dB
SCA suppression (SCA level −16 dB relative to multiplex signal)	≧76 dB (56 to 96 kHz)
Meter indication	L, R, M, S or pilot-tone level
Indicating error	≦0.2 dB of rdg +1.5% of fsd
Pilot-tone indication	−7.5 to −17 dB
AF indication (10-dB steps)	+18 to −66 dBm
General data	
Rated temperature range	+5 to +45 °C
Rear connectors	30-pole male
Power supply	115/125/220/235 V +10/−15%, 47 to 63 Hz (12 VA)
Dimensions, weight	
19" bench model	492 mm×116 mm×392 mm, 6.7 kg
19" rackmount	483 mm×88 mm×384 mm, 4.5 kg

Ordering information

Order designation (19" rackmount)	▶ Precision Stereodecoder MSDC 2 281.0514.03
Panelling	085.1313.00

SBUF

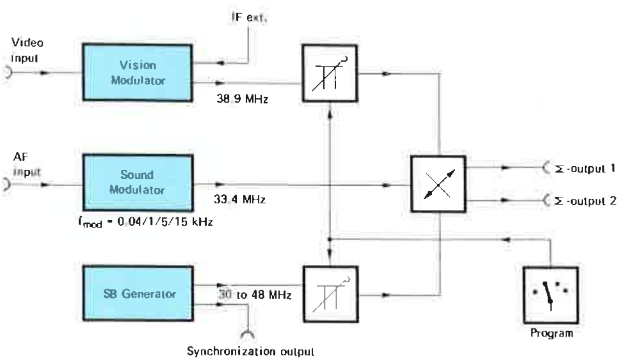
TV Test Transmitter SBUF ♦ 25 to 1000 MHz



- Modular construction of modulator section for adaptation to different TV standards
- Transposer section with digital vision carrier indication to an accuracy of ±1 kHz
- Programmed pushbutton selection of vision, sound and sideband levels; programmable for use in systems
- Measurement of intermodulation, spurious responses and line-time nonlinearity using sinusoidal sideband signals
- Full-field signals to 525- and 625-line standards
- Dual-sound coding and modulation

Photo: Transposer Unit SBUF (top) and Modulator Unit SBUF/SBTF 2 with second sound modulator

The **TV Test Transmitter SBUF** offers a variety and quality of high frequency TV test signals that have not until now been attained by any other test transmitter with continuously variable tuning. These attributes open up a wide field of applications in laboratories, test and service shops, in the development, testing and maintenance of TV receivers, amplifiers and transposers, as well as their modules and in CATV systems. Together with ancillary equipment it is also suitable for instance for use with automatic test systems in research and production. It consists of two self-contained functional units, the Modulator Unit SBUF/SBTF 2 and the Transposer Unit SBUF, which are available as separate items of equipment, each with its own power supply.



Block diagram of Modulator Unit of TV Test Transmitters SBUF and SBTF 2

Modulator Unit SBUF/SBTF 2

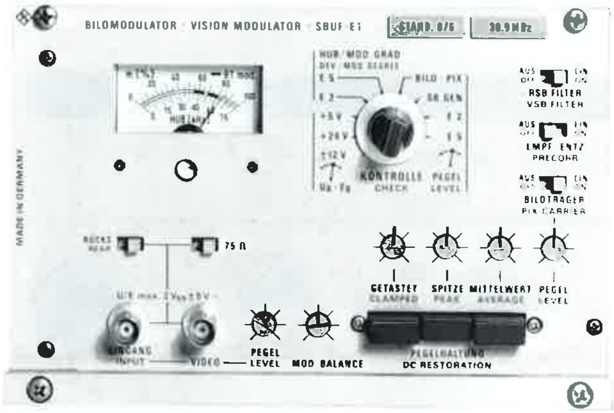
Thanks to its modular design, the Modulator Unit can be adapted to a full range of measurement tasks. The basic equipment comprises the Vision Modulator and the Sound Modulator (for FM or AM depending on the standard) which are accommodated in a Modulator Frame SBUF-B (19"; with power supply). The following configurations are possible:

Cassette	SBUF-	Combinations		
Vision Modulator	E1	×	×	×
Sound Modulator 1 (FM/AM)	E2	×	×	×
SB Generator	E3	×		
Program Selector	E4	×		
Sound Modulator 2 (FM)	E5		×	
Video Generator	E6	×	×	
TV Dual-sound Coder	E7		×	
Local Oscillator SBTF 2-E				×
Transmitter Unit SBTF 2-E				×

The Modulator Unit (block diagram to the left) generates IF carrier signals modulated with vision and sound components in accordance with the standard involved. For the measurement of intermodulation distortion, a static or swept sideband can be added to this signal.

Vision Modulator SBUF-E1. The video signal can be applied at switch-selected loop-through inputs on the front or the rear panel. The receiver precorrection filter can be disabled. The balanced modulator uses one of the following modes of clamping:

1. clamping to the sampled value of the back porch
2. peak-value rectification to sync pulse level
3. mean-value clamping for symmetrical modulation signals

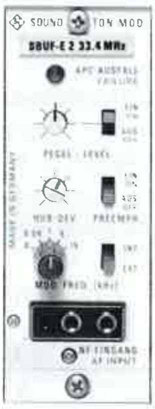


The carrier frequency is supplied by an internal crystal oscillator or an external signal source. A switch is fitted for **double-sideband modulation** (1-dB bandwidth ± 8 MHz) or – via a group-delay-equalized filter – **vestigial-sideband operation.**

The check meter indicates either supply voltages, deviation (or modulation depth) of the sound carrier or output level of the Vision or Sound Modulator.

For the **CATV mode** using adjacent TV channels Vision Modulators with increased selectivity (surface wave filters) are available for Standards B/G and M.

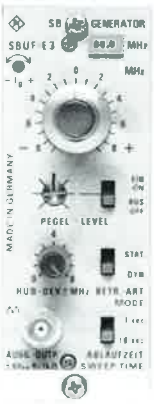
FM Sound Modulator SBUF-E2. The Sound Modulator is designed both for mono transmission and for **modulation of stereo signals.** A low-distortion signal from an internal sinewave generator which can be set to 0.04/1/5/15 kHz or an external signal (two parallel balanced inputs) is used for frequency modulation. The preemphasis can be disconnected. The centre frequency is stabilized by **frequency and phase control loops.** The FM deviation can be continuously adjusted.



AM Sound Modulator SBUF-E2 (for Standards C, L, L'). The AM Sound Modulator can be used instead of the FM Sound Modulator. It is also suitable for internal and external modulation; the modulation depth is continuously adjustable.

SB Generator SBUF-E3. The frequency of the voltage-controlled oscillator (30 to 48 MHz) can be set by hand or swept at one of two speeds over a continuously adjustable sweep width. The triangular sweep signal is available at a front-panel output.

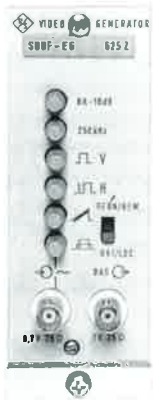
The SB Generator enables simple **determination of the intermodulation products and the linearity** of amplifiers – in particular of TV transposers.



Program Selector SBUF-E4. Five static programs (no modulation; see specifications) and the dynamic program (normal mode) can be pushbutton-selected. In the dynamic mode, the modulated vision and sound carrier signals are available at the sum outputs in the ratio 10:1. **External program selection** is possible by applying TTL levels.

FM Sound Modulator SBUF-E5 for TV dual-sound or stereo measurements (the specifications are the same as those of Sound Modulator E2). The TV Dual-sound Coder E7 is required for operation (see below).

Video Generator SBUF-E6. The SBUF-E6 delivers a standard composite video signal (625 or 525 lines) with a selectable test signal for rapid checking and measuring of the transmission characteristics of TV transmission systems, in particular receivers and transposers. It makes the SBUF or SBTF 2 into a complete TV test transmitter. The five test signals can be selected either by pushbuttons or by external TTL levels. A mean grey pedestal can be connected for application of external signals (e.g. a sweep signal).

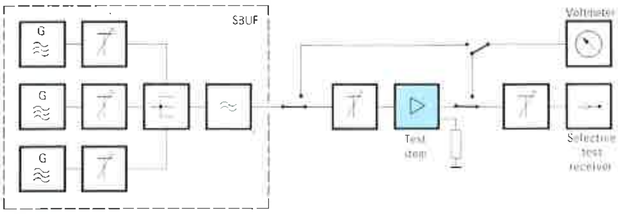


TV Dual-sound Coder SBUF-E7. The plug-in permits encoding of the AF signals for the FM Sound Modulators E2 and E5 and adjustment of amplitude and phase of the two sound channels. The E7 also delivers the frequencies for mode identification (for pilot modulation) and the pilot frequency.

SBUF – TV Test Transmitter

Output signal. The combined signals from the Vision Modulator, Sound Modulator 1, Sideband Generator and Sound Modulator 2 are brought out to two sum outputs for frequency conversion in the Transposer Unit. The levels of the signal components are determined by attenuators in accordance with the selected program. Adjustment by a further ±3 dB is also possible on each component, or the components can be switched off.

The nonlinear distortion of the device under test can be efficiently measured with the aid of these signals by evaluation with an analyzer or selective receiver. The expense of three continuously variable signal generators with calibrated attenuators and decoupling networks, the separate tuning to three frequencies and the setting of three levels can thus be eliminated (see diagram below).



Test setup for moiré measurement on a channel amplifier

Transposer Unit SBUF

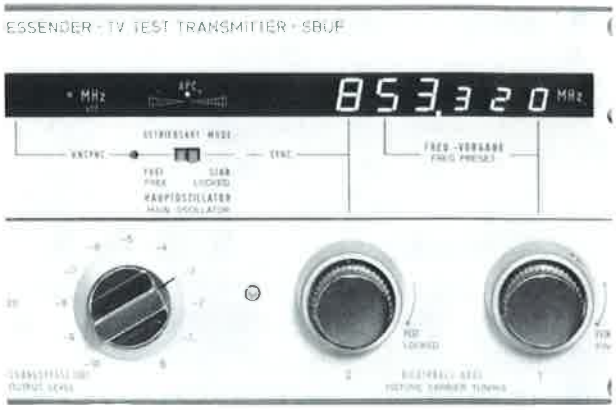
In the transposer section the sum IF signal from the modulator section is up-converted and down-converted to obtain a carrier frequency anywhere in the range 25 to 1000 MHz. Unwanted spurious emissions are suppressed by fixed bandpass filters and a lowpass filter.

Frequency setting. The frequency can be set in one of two ways:

"Unsync." mode. Adjustment with tuning knob II only; frequency indication calibrated in MHz (error ≦ ±10 MHz), 3½ digits (produced by analog/digital conversion of the tuning voltage).

"Sync." mode. Additional presetting with tuning knob I; frequency indication calibrated for 0 to 100 MHz to an accuracy of ±1 kHz via a counter. The channel frequency is set ignoring the 100-MHz decade, which is derived from the adjustment of tuning knob II after phase locking.

It is thus possible to set and read off the desired channel frequency without an IF signal being applied at the input of the transposer.



Frequency setting (bottom right) and readout (top) on Transposer Unit SBUF

By way of a **counter input** with a 10:1 prescaler the reference-frequency input can be used for measuring external frequencies in the range **25 to 300 MHz.**

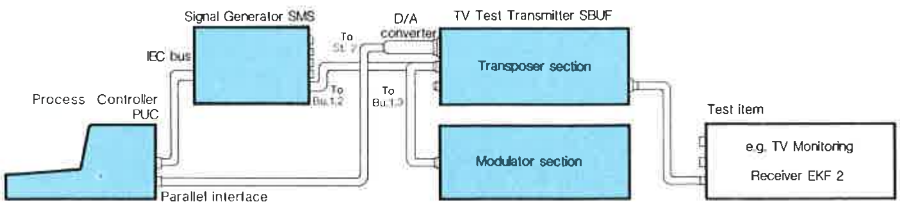
Second intermediate frequency. An option (please enquire) is available to provide the Transposer Unit with a second input IF, for instance 45.75 MHz in addition to 38.9 MHz (switch-selected on the front panel). This option is also available with an IF of 32.7 MHz (Standard L/L') for the lower sideband. Another application is the conversion of the nominal IF into a second IF.

Output level. The levelled output signal can be continuously adjusted by varying the overall gain and is indicated by a row of LEDs. A **calibrated attenuator** further allows the output level to be set in smallest steps of 1 dB.

To increase the output level to 2 V, the **CATV Broadband Amplifier AKF** can be connected after the SBUF for 25 to 300 MHz.

CATV Broadband Amplifier AKF

Programmed operation. Channel setting is also possible by an external frequency for tuning I and by an external voltage for tuning II. A signal is delivered in the case of synchronization.



Block diagram of computer-controlled test assembly for rapid channel change, the reference frequency is delivered by the Signal Generator SMS and the tuning voltage produced by a D/A converter (e.g. Motorola MC 1408)

Specifications Modulator Unit SBUF/SBTF 2

Vision Modulator SBUF-E1

Video input signal

Signal level	0.5 to 2 V_{pp} (CVS)
DC offset	max. ±5 V
Input (switch-selected)	loop-through filter, BNC connectors; high-impedance or 75-Ω termination; front or rear panel
Return loss (0 to 8 MHz)	
Front-panel input	≧34 dB, external termination ≧26 dB, internal termination[1]
Rear-panel input	≧20 dB, internal termination

IF output signal

Vision carrier	38.9 MHz (B/G, D/K, I, M) 32.7 MHz (L) 45.75 MHz (M-CATV)
Frequency error	$\leqq \pm 1 \times 10^{-5}$
Output level[2]	200 mV_{rms}, sync peak (white level with standard L)
Setting range	approx. ±3 dB, carrier can be disabled

Modulation characteristics

Type of modulation	C3F (A5C), negative (B/G, D/K, I, M) C3F (A5C), positive (L)
Modes of operation	double sideband, vestigial sideband, with or without receiver group-delay correction filter
Clamping (pushbutton-selected)	
Sampled	to back porch
Peak	by peak rectification to sync level
Mean value	for symmetrical modulation

Transmission characteristics

Transmission range (IF)	±8 MHz, ref.: vision carrier
Amplitude response	
Double-sideband operation	<±0.2 dB, ±10 Hz to ±6 MHz <±0.5 dB, ±6 Hz to ±8 MHz
Vestigial-sideband filter	see bottom left
Receiver group-delay correction	additional amplitude response:
Standard B/G	±0.2 dB, 10 Hz to 4.8 MHz
D/K	±0.2 dB, 10 Hz to 5.5 MHz
I (South Africa)	±0.2 dB, 10 Hz to 4.8 MHz
L and I (Great Britain)	0 (no correction)
M	±0.2 dB, 10 Hz to 3.8 MHz
Group-delay response	
Double-sideband operation	<10 ns, ±10 Hz to ±6 MHz
Vestigial-sideband operation	additional ripple (peak-to-peak value):
Standard B/G	≦40 ns, −4.8 to +0.5 MHz
B/G – CATV	≦70 ns, −4.8 to +0.5 MHz
D/K	≦40 ns, −5.5 to +0.5 MHz
I	≦30 ns, −5.2 to +1.0 MHz
L	≦40 ns, −1.25 to +6.0 MHz
M	≦40 ns, −4.0 to +0.5 MHz
M – CATV	≦70 ns, −4.0 to +0.5 MHz
Receiver group-delay correction	see bottom right

[1]) Applies only if no cable is used.
[2]) Level at rear-panel IF summing outputs.

Nonlinearity of modulation characteristic	≦3%, 8 to 100% modulation
Differential gain at colour subcarrier frequency	≦2%, 10 to 85% modulation
Differential phase at colour subcarrier frequency	≦2°, 10 to 85% modulation
Signal-to-noise ratio[3])	
for 0.1 to 5 MHz	≧64 dB (rms)
for 0 to 1 kHz	≧60 dB (peak-to-peak)
Hum suppression[3]) in clamped mode	≧57 dB (with 30% superimposed hum)
Check meter	for carrier level, modulation and supply voltages
Monitoring connector (vision carrier)	test output: approx. 0.5 V into 50 Ω oscillator input: 1 to 3 V

Sound Modulator 1 SBUF-E2 and Sound Modulator 2 SBUF-E5

AF input signal

Signal level	+6 dBm for 0 to ±80 kHz deviation, continuously adjustable
Frequency range	40 Hz to 75 kHz
Input	floating, Z_{in} approx. 5 kΩ, switchable external/internal
Connector	front panel: 3-way female rear panel: 30-way male

Internal AF generator

Frequency, switchable to	0.04/1/5/15 kHz and "off"
Amplitude response	<±0.3 dB, ref. to 1 kHz
Harmonic distortion	<0.3%

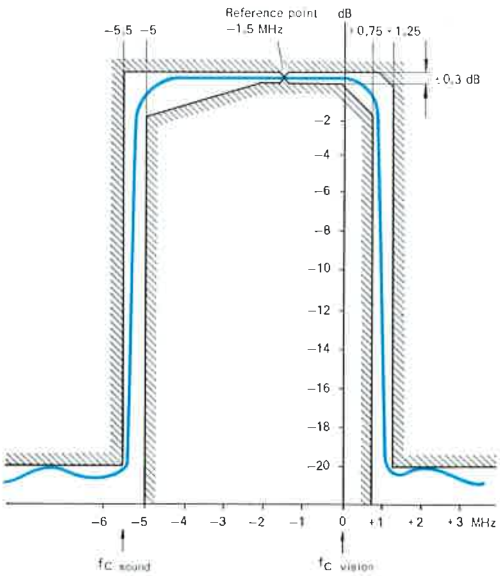
IF output signal

Sound carrier frequency[4])	
Standard B/G	33.4 MHz (sound 2: 33.158 MHz)
D/K	32.4 MHz
I	32.9 MHz
M	34.4 MHz (CATV: 41.25 MHz)
Frequency error	<±500 Hz
Centre frequency stabilization	frequency and phase control; ref.: vision carrier
Output level[2]) SBUF-E2	≦45 to ≧90 mV_{rms} } carrier can be disabled
SBUF-E5	≦20 to ≧40 mV_{rms} } carrier can be disabled
Nominal level for single sound	45/63/90 mV, corresponding to vision/sound power ratio 20:1/10:1/5:1
dual sound	45 mV (20:1) for sound 1, 20 mV (100:1) for sound 2

Modulation characteristics for standards B/G, D/K, I, M

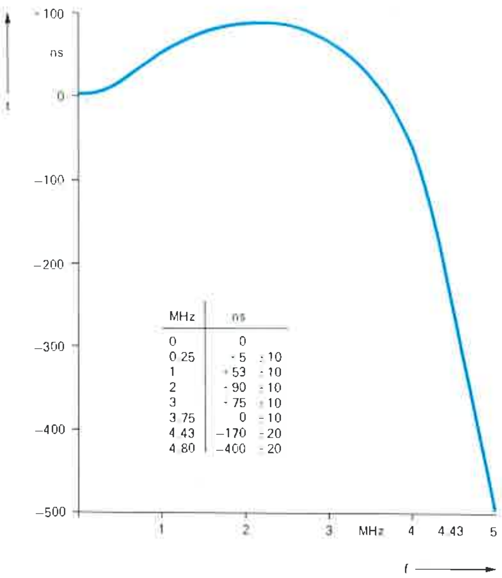
Type of modulation	F3E (F3), with preemphasis
Modulation frequency response flatness	<±0.3 dB, 40 Hz to 53 kHz <±0.5 dB, 53 to 75 kHz ref.: 1 kHz, preemphasis disabled

[3]) Measured via TV Demodulator AMF 2; ref.: black-to-white transition.
[4]) Please enquire for different frequencies.



Left:
Tolerance mask for frequency response of IF sideband spectrum (standard B/G)

Right:
Group-delay/frequency response of video group-delay precorrection



SBUF – TV Test Transmitter

Preemphasis (switched)	50 µs ±5% (M: 75 µs)
Modulation distortion	≦0.5%, 40 Hz to 15 kHz, deviation ±75 kHz (preemphasis disabled)
Stereo crosstalk	>40 dB down, 0.1 to 5 kHz (measured with coder and decoder)
Signal-to-noise ratio	>70 dB (mono), >66 dB (stereo), weighted and unweighted; ref.: ±40 kHz deviation
Incidental AM	>40 dB down; for f_{mod} 1 kHz and deviation ±40 kHz; ref.: 100% modulation

Modulation characteristics for standard L (differing characteristics)

Type of modulation	A3E (A3), without preemphasis
AF input signal, level	+12 dBm for 0 to 100% modulation, continuously adjustable
Frequency range	30 Hz to 15 kHz
IF output signal	
Sound carrier frequency	39.2[1]) MHz ±500 Hz, crystal-controlled
Output level[2])	≦50 to ≧100 mV_{rms}
Modulation frequency response flatness	<±0.5 dB, 30 Hz to 15 kHz; ref.: 1 kHz
Modulation distortion	≦1% (up to 90% modulation)
Signal-to-noise ratio	>70 dB, weighted and unweighted; ref.: 100% modulation

SB Generator SBUF-E3

Frequency range	30 to 48 MHz
Frequency setting	manual or swept
Sweep width	0 to ±8 MHz; ref.: 38.9 MHz
Sweep time, switch-selected	1 or 10 s (triangular)
Nominal output level	−16.5 dB (approx. 30 mV); ref.: vision carrier at summing output
Setting range	approx. ±3 dB, carrier can be disabled; can be controlled from SBUF-E4
Frequency response flatness	≦2% (automatic control)
Harmonics	≧40 dB down
Output for triangular signal	±5 V ±5%; Z_{out} approx. 1 kΩ

Program Selector SBUF-E4

Coupling network for vision, sound and SB signals	passive, attenuators selected with program buttons or externally
Program types	5 static programs plus normal operation, see text

Levels for the different programs

Program	Vision carrier	Sound carrier	Sideband
IM	0 dB	−10 dB	off
IM/K	−8 dB	−10 dB	−16.5 dB
IM/B	−5.5 dB	−11.5 dB	−11.5 dB
LIN 1	−2.5/−8 dB*)	−10 dB	−32 dB
LIN 2	−2.5/−20 dB*)	−10 dB	−32 dB
DYN	0 dB	−10 dB	off

*) alternating every 2 s

External program selection: by TTL level: 0 = active

Sound Modulator SBUF-E5 same as E2

Video Generator SBUF-E6

Pulse generator: mode H+V

System	625 lines	525 lines
Line frequency	15.625 kHz ±0.1%	15.750 kHz ±0.1%
Field frequency	50 Hz	60 Hz
Colour subcarrier frequency	4.433618 MHz ±10 Hz	3.579545 MHz ±10 Hz

CVS output signal (data common to the signals listed below)

Picture component, switch-selected	0.7/0.22 V (0/−10 dB)
S component, fixed	0.3 V
Output (front panel)	75 Ω; A ≧34 dB (up to 10 MHz); BNC
Signal-to-noise ratio	>50 dB (peak measurement at grey pedestal, ref. to 0.7 V)
Rise and fall times	200 ns −10/+20 ns

[1]) Please enquire for different frequencies.
[2]) Separate IF outputs for vision and sound carriers if separate Channel Unit SBTF 2 is used; IF summing output for Transposer Unit SBUF.

250-kHz squarewave

Tilt	≦1%
Synchronization	H signal

V squarewave

Tilt	≦1%

H squarewave and 2T pulse

Squarewave (duration)	approx. 17 or 52 µs
Tilt/overshoot	≦1%/≦2%
2T pulse, switch-selected	normal/inverted position

Sawtooth with superimposed RF (CCIR signal No. 3)

Sawtooth signal (duration)	approx. 12 to 64 µs after S leading edge
Superimposed colour subcarrier	100 mV/32 mV ±10% (corresponding to picture component 0/−10 dB)
Diff. gain/phase	≦0.2%/≦0.3°

Pedestal plus external signal

Input signal	0.7 V for 10 to 70% superimposed RF
Frequency response flatness	<±0.1 dB (50 Hz to 6 MHz)
Input (front panel)	75 Ω; A ≧34 dB (up to 10 MHz); BNC
Blanking	3 µs before to 12 µs after S leading edge
Grey pedestal, adjustable	30 to 100% picture component
Signal selection	by pushbuttons or external signal (TTL level when inserted in compartment 3)
Accessories supplied	75-Ω cable, BNC, 0.5 m long

TV Dual-sound Coder SBUF-E7

AF input signals	L/R or AF 1/AF 2
(Nominal) signal level	+6 dBm for ±30 kHz deviation
Maximum input level	+12.5 dBm
Preemphasis, can be disabled	50 µs ±5%
Input (front panel)	Z_{in} approx. 5 kΩ; 6-way

AF output signals (coded)

(Nominal) signal level	+6 dBm	
Frequency response flatness	<±0.5 dB (40 Hz to 15 kHz)	
Signal type	sound channel 1	sound channel 2
Mono without pilot	AF 1	AF 2
Mono with pilot	AF 1	AF 2 + pilot
Dual sound	AF 1	AF 2 + pilot
Stereo	M = 0.5 (L+R)	R + pilot
Crosstalk dual sound/stereo	>70 dB/>50 dB down	
Setting of deviation symmetry	level approx. ±0.5 dB phase approx. ±3° (at 15 kHz)	

Pilot carrier	in sound channel 2
Pilot level	−15.6 dBm, ±6 dB adjustable (corresponding to deviation ±2.5 kHz)
Pilot frequency	54.6875 kHz (= 3.5 f_H)
Frequency stabilization	
with vision modulation	synchronized with line frequency f_H
without vision modulation	accurate to within ±5 Hz
Operating mode identification	pilot carrier amplitude-modulated with identification frequency
Identification frequencies	mono: without (unmodulated) dual sound: 274.1 Hz (= f_H/57) stereo: 117.5 Hz (= f_H/133)
Modulation depth	adjustable from 40 to 60%
Accessories supplied	female multipoint connector for use with Sound Modulators

Specifications Transposer Unit SBUF

Frequency and level

Input frequency range	38.9 MHz ±7 MHz, 45.75 MHz ±6 MHz, 32.7 MHz ±7 MHz } for standard, see Modulator Unit (combinations possible, see ordering information)
Nominal input level	200 mV ±0.5 dB
Input	BNC female connector on rear panel, Z_{in} = 50 Ω, return loss ≧20 dB
Output frequency f_{out} with f_{in} = IF_{vision}	25 to 1000 MHz continuous tuning range
Frequency stabilization	APC with indicator, switched
Output frequency indication	1. with APC via counter, accurate to 10 kHz ±1 kHz 2. without APC via A/D converter and digital voltmeter, error <±10 MHz
Gain from input to output	adjustable from −6 to 0 dB
Frequency-response flatness of gain	≦2 dB with AGC ≦6 dB with manual setting
within f_{out} ±7 MHz of output frequency	≦±0.5 dB, ±0.2 dB typ., channel-dependent

Output level	30 µV to 200 mV into 50 Ω (106 dB(µV) max.), may be reduced in steps of 1 and 10 dB by calibrated attenuator
Error of output attenuator	fine ≦±0.2 dB coarse ≦±0.5 dB
Output	N female connector, adaptable; Z_{out} = 50 Ω, return loss ≧6 dB with output attenuator set to 0 dB, or BNC female connector; Z_{out} = 75 Ω (with matching pad)
Monitor outputs for local oscillators	approx. 0.1 V into 50 Ω, BNC female connectors on rear panel
Nominal frequency of first LO	70.366833 MHz
Nominal frequency of second LO and timebase	100.00000 MHz
Oscillator-frequency adjustment	≧5×10⁻⁶ with rear-panel potentiometers
Effect of crystal aging	≦2×10⁻⁸/day (manufacturer's data)
Output-level monitor	row of LEDs
Input for tuning signal I	150 to 250 MHz, 0.5 to 1 V_{rms}, BNC female connectors (rear panel)
Input for tuning signal II	0 to 5 V for 0 to 1000 MHz

Transmission characteristics

Spurious signals with vision/sound ratio of 10:1 (gain −6 dB)

Spurious emissions	≧66 dB down, 70 dB typ.
Vision carrier −5.5 MHz and +11 MHz	≧56 dB down, 60 dB typ.
Crossmodulation products	≧70 dB down
Harmonics	≧40 dB down
Spurious signals outside tuning range	≧40 dB down

Video signal-to-noise ratio at 0 dB gain, referred to black-to-white transition

0.1 to 5 MHz (noise)	≧60 dB (rms)
0 to 1 kHz (hum)	≧56 dB (peak-to-peak)
Audio signal-to-noise ratio up to 15 kHz (with pre- and deemphasis)	≧66 dB, referred to 40-kHz deviation

Frequency counter

Frequency counter for measurement of output frequency	switched external/internal
Frequency range for ext. use	25 to 300 MHz
Input voltage	50 mV_{rms} to 1 V_{rms} into 50 Ω
Input	50 Ω, BNC female connector (front panel)
Frequency of timebase	100 MHz ±5×10⁻⁷

CATV Broadband Amplifier AKF (option)

Frequency range	25 to 300 MHz	
Gain	27 ±1.5 dB	
Frequency-response flatness	≦±1 dB, for ±7 MHz: ≦±0.3 dB	
Output level	≦2 V_{rms} into 50 or 75 Ω corresponding to 126 dB(µV)	
Spurious components	for V_{out} = 1 V	2 V
Spurious signals, vision/sound ratio 10:1	≧56 dB down	≧50 dB down
Intermodulation products (DIN 45004 K)	≧70 dB down	≧66 dB down
Harmonics	≧30 dB down	
Noise figure	≦14 dB	
Input (front or rear panel)	50 or 75 Ω; BNC	
Return loss	≧20 dB	
Output (front or rear panel)	50 or 75 Ω; BNC	
Return loss	≧10 dB	
Checking of output level	meter, 120 to 126 dB(µV)	
AC supply	115/125/220/235 V (16 VA)	
Dimensions, weight	492 mm×116 mm×514 mm, 5.4 kg	

General data

Rated temperature range	+5 to +35 °C
Operating temperature range	+5 to +45 °C
Storage temperature range	−20 to +70 °C
Connectors on Modulator Unit (rear panel)	
IF summing output (BNC)	2 for modulator configuration 1 for channel transmitter configuration
Return loss	≧18 dB, 30 to 48 MHz
Monitoring output	for vision carrier, 50 Ω, BNC
Video input	loop-through filter, BNC; see SBUF-E1
AF/control/status lines	30-way male connector to DIN 41622
AC supply	110/125/220/235 V +10/−15%, 47 to 63 Hz
Power consumption Modulator Unit	70 VA for Vision and Sound Modulators, 125 VA for fully equipped frame
Transposer Unit	130 VA
Overall dimensions (W×H×D)	
19" bench model (design 80)	492 mm×161 mm×514 mm
19" rackmount	483 mm×132 mm×506 mm
Weight of Modulator Unit	
19" bench model	17 kg fitted with Vision and Sound Modulators, 21 kg fully equipped
19" rackmount	15 kg fitted with Vision and Sound Modulators, 19 kg fully equipped
Weight of Transposer Unit	25 kg

Ordering information

Modulator Unit SBUF/SBTF 2

The basic version comprises the Modulator Frame SBUF-B plus the power supply, fitted with the Vision Modulator SBUF-E1 and the Sound Modulator SBUF-E2 (sound 1).

Order designations

Modulator ▶ Modulator Unit SBUF/SBTF 2

Standard	19" rackmount	19" bench model
B/G – general	341.0014.11	341.0014.12
B/G – general – CATV	341.0014.41	341.0014.42
B/G – Norway	341.0014.81	341.0014.82
B/G – Sweden (A)	341.0014.83	341.0014.84
B/G – Denmark	341.0014.85	341.0014.86
B/G – Australia	341.0014.87	341.0014.88
B/G – New Zealand	341.0014.89	341.0014.90
D/K – CCIR Rep. 308	341.0214.11	341.0214.12
D/K – Czechoslovakia/Hungary	341.0214.15	341.0214.16
I – Great Britain	341.0414.11	341.0414.12
I – South Africa	341.0414.13	341.0414.14
L – France	341.0814.11	341.0814.12
M – 38.9 MHz	341.0614.11	341.0614.12
M – 45.75 MHz – CATV	341.0614.41	341.0614.42

Accessories supplied termination 124.0324.00, power cord 025.2365.00

Recommended extras

SB Generator SBUF-E3	294.6416.00	
Program Selector SBUF-E4	294.7012.00	
Sound Modulator (sound 2) SBUF-E5 for standard		
B/G (33.158 MHz)	294.7312.00	
D/K	294.7512.00	please specify sound carrier frequency
I	294.7412.00	please specify sound carrier frequency
M	294.7612.10	please specify sound carrier frequency
M – CATV	294.7612.20	please specify sound carrier frequency
Video Generator SBUF-E6		
625-line standard (CCIR)	340.8211.76	
525-line standard (FCC)	340.8211.75	
TV Dual-sound Coder SBUF-E7	241.3812.00	
Adapter cables for servicing		
13-way	341.5274.00	
21-way	294.1420.00	
50-Ω cable	341.5245.00 (2 cables recommended)	

Transposer Unit SBUF

Order designations ▶ Transposer Unit SBUF

Transposer section (one IF only):

IF_{vision} MHz	38.9¹)	38.9²)	45.75	32.7²)
19" bench model				
50 Ω	292.8011.52	292.8011.58	293.8215.52	293.8415.56
75 Ω	292.8011.72	292.8011.78	293.8215.72	293.8415.76
19" rackmount				
50 Ω	292.8011.51	292.8011.57	293.8215.51	293.8415.55
75 Ω	292.8011.71	292.8011.77	293.8215.71	293.8415.75

Transposer section, two-standard version (IF switch-selected):

$IF_{vision\ 1}/IF_{vision\ 2}$ MHz	38.9/45.75	38.9/32.7	45.75/32.7
19" bench model 50 Ω	292.8011.54	292.8011.56	293.8215.56
75 Ω	292.8011.74	292.8011.76	293.8215.76
19" rackmount 50 Ω	292.8011.53	292.8011.55	293.8215.55
75 Ω	292.8011.73	292.8011.75	293.8215.75

¹) Please enquire for IF_{vision} = 38.0 MHz.
²) Can be switch-selected to lower or upper sideband.

Please enquire for further standards and special versions.

Accessories supplied connecting cable (50 Ω) 292.8970.00, power cord 025.2365.00

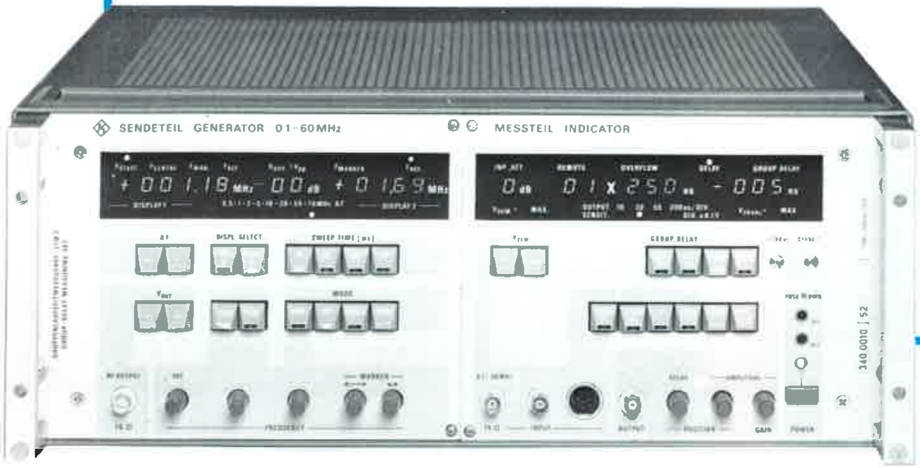
Recommended extras

CATV Broadband Amplifier AKF (for specifications see left)

Input 50 Ω, output 50 Ω	262.9010.52
Input 50 Ω, output 75 Ω	262.9010.72
Input 75 Ω, output 75 Ω	262.9010.73
30-way female connector	063.9770.00 (with shell)
Three-way male connector	019.0458.00 (AF line jack)

LFM 2

Group-delay Measuring Set LFM 2 ♦ up to ±1000 ns 0.1 to 60 MHz (1000 MHz)



- Measurement of group delay up to ±1000 ns of absolute delay up to 12 µs
- Resolution ±1 ns
- Digital display – curve representation on external VDU
- Suitable for measurements on TV links

IEC 625 Bus

The **Group-delay Measuring Set LFM 2** is used to determine the group delay and the absolute delay of active and passive two-port networks; it is also suitable for measurements on TV systems with line sync pulses (measurements with field-sync pulses are possible if certain restrictions are acceptable for the DELAY mode) and on **TV links.** Compensation of absolute delay is automatic. Fitted with the IEC-bus Option LFM 2-B (IEC 625-1; IEEE 488), the LFM 2 can be used in **automatic test assemblies.**

Configuration. The LFM 2 consists of the

Generator with
a frequency range of 0.1 to 60 MHz (which can be extended to 1000 MHz by using the TV Transcope MUF 2, Mixer MUF 2-Z2 and Wideband Demodulator LFM 2-Z1), digital frequency indication and the

Indicator with
a probe-frequency generator (20 kHz, test and reference signals),
a phase meter (digital readout, chopper for simultaneous display of delay and amplitude on external VDU),
demodulator (0.1 to 60 MHz).

Measuring principle. The Group-delay Measuring Set LFM 2 uses the probe-frequency method. The RF carrier is amplitude-modulated with the 20-kHz probe-frequency signal. After passing through the item under test, the signal is demodulated and the phase difference between the demodulated probe frequency and the 20-kHz reference signal determined. The LFM 2 uses two different measuring methods:

Method A. The reference signal is routed via the item under test. This offers the following advantages:

- Compensation of the absolute delay is not required.
- Measurements on TV links are possible.
- A high measuring accuracy is achieved.

Method B. The reference signal is taken directly to the phase meter (measurements on TV links are not possible). This offers the following advantages:

- The absolute delay is indicated and can be compensated.
- Measurements can be performed with separate generators modulated with the probe frequency.

The TV Transcope MUF 2, which is designed for simple connection to the LFM 2, can be used to extend the operating frequency range up to 1000 MHz and as a VDU.

Output signals. For display on a VDU, the group-delay and frequency-response characteristics are available separately or in chopped form. The LFM 2 supplies a 200-ns squarewave signal for calibrating the VDU.

TV system measurements. If the LFM 2 is used for measurements on TV systems requiring sync pulses for operation (e.g. TV transmitters), the test signal must be added to a TV sync signal (comprising the sync plus blanking components) using an external video mixer. Evaluation in the Indicator is performed with the TV button pressed.

Digital readout. Two displays are provided on the Generator to permit indication of the frequencies, which are

Digital display on Generator: Display 1: either start, centre, reference or manually set frequency; display 2: either marker or reference frequency; centre, top: output level; centre, bottom: selected sweep

Digital display on Indicator: From left: input attenuation of wideband demodulator, absolute or group delay; centre, bottom: set scale of delay signal output for display on CRT freely selectable within the sweep range (see page 350, bottom left).

When using method A, the group-delay difference between the reference signal and the selected frequency (point-by-point measurements) or the marker frequency highlighted on the display (swept operation) is indicated on the readout.

When using method B, the absolute delay at the selected frequency in the manual mode or the marker frequency unblanked on the CRT in the sweep mode is displayed on the indicator after pressing the DELAY button. The absolute delay of the test item is determined by subtracting the value previously measured with the test item shorted across. The maximum absolute delay that can be measured is 12 µs.

TV link measurements. For measurements on TV transmission links two LFM 2 sets are required. All the signals required for the test sequence at the receiver end are transmitted via the link.

Additional characteristics

An ALC circuit in the **Generator** ensures that the level value is maintained at any frequency.

The probe-frequency generator in the **Indicator** produces the crystal-controlled probe (20 kHz), reference (20 kHz) and identification (10 kHz) frequencies.

The phase meter included in the Indicator delivers the reference signal (20 kHz) with crystal accuracy and keeps it in phase with the transmitted probe-frequency signal (method A).

The generator-output and the demodulation signals can be adjusted via calibrated attenuators. An overload indicator (LED) permits the signal coming from the item under test to be kept at the optimum level for driving the demodulator.

Extras

Wideband Demodulator LFM 2-Z1 (10 to 1000 MHz) for AF and probe-frequency signals

Video Filter LFM 2-Z2 (cutoff frequency 200 Hz) to eliminate interference at the delay measuring output (swept-frequency measurements only with 160 and 320 ms)

Mixer MUF 2-Z2 for measurements on TV transposers

XY Recorder Adapter LFM 2-Z3 (for instance for XYT Recorder ZSKT)

Impedance Transformer SBTF 2-Z for measuring instruments with a characteristic impedance of 50 Ω

Amplifier MUF 2-Z3 for boosting the test item output voltage by 27 dB

IEC-bus Option LFM 2-B (24-pole connector to IEEE 488)

Specifications

Group-delay measurement range	up to ±1000 ns
Absolute-delay measurement range	up to 12 µs
Resolution	±1 ns
Interface (option)	IEC 625-1 (IEEE 488)

Generator

Frequency range	0.1 to 60 MHz (can be extended up to 1000 MHz by MUF 2)
Sweep range	−10 to +60 MHz
Sweep width (adjustable)	0.5/1/2/5/10/20/50/70 MHz
Frequency setting within sweep range	start or centre frequency, frequency marker (brightup marker on VDU), reference frequency, manual
Resolution of readout	10 kHz (manually: 1 kHz)
Readout accuracy	≦±1.5 kHz ±1 digit
Output voltage	1±0.05 V_{pp} (stabilized)
Output attenuator	30 ±0.5 dB in steps of 2 ±0.01 dB
Harmonics	≧40 dB down
FM noise	≦1 kHz
Modulation	probe frequency (approx. 60% mod.)
Total sweep times	40/80/160/320 ms
Control signal for VDU	0 to +10 V or −10 V (sawtooth), adjustable by −10 dB

Indicator

Probe-frequency generator	
Probe frequency	20 kHz $\pm5\times10^{-6}$
Reference signal	20 kHz $\pm5\times10^{-6}$
Identification pulse frequency	10 kHz $\pm5\times10^{-6}$
Output voltage	1 V_{pp} ±5%
Output impedance	75 Ω ±5%
Phase meter	
Measurement range	±1 to ±1000 ns
Indication	3½ digits with ± display
Error	≦±1% ±1 ns
Output signal for VDU	10/20/50/200 ns
Input voltage range	
Probe frequency	8 mV_{pp} to 0.8 V_{pp}
Reference signal	25 mV_{pp} to 0.8 V_{pp}
Identification pulse frequency	25 mV_{pp} to 0.8 V_{pp}
Delay error in input voltage range	0.8 to 0.08 V: ±5 ns 80 to 24 mV: ±10 ns
Compensation of absolute delay	in 250-ns steps
Demodulator	
Frequency range	0.1 to 60 MHz
Input voltage range	2 V_{pp} to 50 mV_{pp}
Group-delay error in the case of input voltage variation of 10 dB	≦10 ns
20 dB	≦20 ns
Group-delay error	100 kHz to 15 MHz: ≦±2 ns 15 to 60 MHz: ≦±5 ns
Input attenuator	7 dB ±0.5 dB in 1-dB steps ±0.1 dB
Input impedance	75 Ω
Return loss	100 kHz to 20 MHz: ≧34 dB 20 to 60 MHz: ≧30 dB

Extras

Wideband Demodulator LFM 2-Z1	10 to 1000 MHz
Max. input voltage	≦5 V_{rms}, ≦10 V DC
for group-delay measurement	≧1 V_{rms}
Group-delay error	≦10 ns/100 MHz (10 to 1000 MHz) ≦50 ns over total range
Connector, RF input	N female; 50 Ω
Video Filter LFM 2-Z2	cutoff frequency: 200 Hz
Attenuation in passband	0 dB ±0.2 dB
Connectors, input	5-pole male; R_{in} <100 Ω
output	BNC
XY Recorder Adapter LFM 2-Z3	deflection time: approx. 1 min
X output signal	approx. 0 to 5 V
Signal for pen lift	TTL (polarity internally switchable)
Connectors	BNC (power supply: 6-pole)

General data

Rated temperature range	+5 to +40 °C
Operating temperature range	0 to +45 °C
Storage temperature range	−20 to +70 °C
AC supply	115/125/220/235 V +10/−15%, 47 to 63 Hz (110 VA)
Dimensions, weight	
19" bench model (design 80)	492 mm×205 mm×514 mm, 18 kg
19" rackmount	483 mm×177 mm×506 mm, 14 kg

Ordering information

Order designation	▶ Group-delay Measuring Set LFM 2	
	19" bench model	19" rackmount
Line frequency 15,625 Hz	340.0010.72	340.0010.71
15,750 Hz	340.0010.74	340.0010.73

Recommended extras

Wideband Demodulator	LFM 2-Z1	340.6302.53
Video Filter	LFM 2-Z2	340.6425.02
Mixer	MUF 2-Z2	349.8820.50
XY Recorder Adapter	LFM 2-Z3	340.5906.02
Impedance Transformer	SBTF 2-Z	341.6935.57
Amplifier	MUF 2-Z3	353.5816.50
IEC-bus Option, for LFM 2 with		
Serial Nos. 871 739 and 300 974	LFM 2-B1	340.3103.02
for other LFM 2 models	LFM 2-B2	340.3103.03
Connecting Cable (to MUF 2) for LFM 2 with Serial Nos.		
871 739 and 300 974	MUF 2-Z1	337.7824.00
for other LFM 2 models	MUF 2-Z4	337.7830.00

EU 200
EU 201

VHF FM Relay Receivers EU 200 and EU 201 ♦ 87.5 to 108 MHz

- Stereo/mono receivers complying with ARD standard specifications, with automatic switchover through 19-kHz pilot
- EU 200: continuously tunable
  EU 201: single-channel receiver
- High overload capability

Photo: EU 200 (EU 201 see next page)

The **VHF FM Relay Receivers EU 200 and EU 201** are designed in accordance with the CCIR standards for the 19-kHz pilot-tone method. They can receive stereo-modulated and mono sound broadcasts (automatic switchover) and can modulate slave transmitters with accurate level signals. They can also be used for retransmission of road traffic, SCA and auxiliary channels. The operating status is indicated by LEDs; floating contacts are provided for remote signalling.

RF section. The EU 200 and the EU 201 only differ in the RF sections:

EU 200: quasi-continuous frequency setting in **crystal-referenced 10-kHz steps,** frequency memory, 5-digit LED display,

EU 201: **crystal-referenced channel receiver** for fixed-frequency-reception (channel can be changed).

Outputs. The relay receivers have two MPX outputs suitable for traffic radio broadcasts and two mono signal outputs (with an additional output of each type on the front panel) with common level setting plus a broadband SCA signal output (level adjustable). With mono broadcasts the mono signal is switched via a 15-kHz lowpass filter to one of the MPX signal outputs. A **squelch** circuit with adjustable threshold level suppresses the noise.

Automatic switchover. Each receiver contains an automatic switchover circuit, which can be turned off for operation in passive standby mode (the receivers can be set to act as main or standby).

Specifications of EU 200 and EU 201

Frequency range	87.5 to 108 MHz (EU 200 variable, EU 201 single-channel)
RF input	50 Ω; BNC female connector
Noise figure EU 200/EU 201	≦10 dB/≦9 dB
Required EMF for constant V_{out} (mono) EU 200/EU 201	V_{rms} ≧10 μV/≧6 μV
Frequency drift	≦±2 kHz (+5 to +40 °C)
Oscillator reradiation at input EU 200/EU 201	≦10 μV/≦3 μV
AF outputs	2 MPX (unbalanced, isolated) and mono (balanced, isolated), one parallel output of each type on front panel
Source impedance	≦30 Ω; Z_{out} ≧600 Ω (MPX), ≧300 Ω (mono)
Output level (deviation ±40 kHz, f_{mod} 500 Hz); adjustable	+6 dBm into 600/300 Ω; ±3 dB
Stopband attenuation at 19/100 kHz	≧50 dB/20 dB
Deemphasis (mono)	50/75 μs (disconnectible)
Squelch	response threshold at 20 μV EMF

Broadband output 40 Hz to 100 kHz (SCA signal)	unbalanced
Source impedance	≦50 Ω at Z_{out} ≧600 Ω
Output level (deviation ±40 kHz, f_{mod} 500 Hz); adjustable	+6 dBm into 600 Ω; ±3 dB
Linear distortion (deviation ±40 kHz, referred to 500 Hz)	
Frequency response for	
40 Hz to 15 kHz	≦±0.5 dB (mono, with deemphasis)
40 Hz to 43/53/61/70/75 kHz	≦±0.1/0.3/0.5/1/3 dB (stereo)
Phase response for 40 Hz to 43/53/58/61 kHz	≦±1°/3°/5°/10° (stereo)
Stereo crosstalk (measured via decoder) for 40 Hz to 0.1/5/15 kHz	≦40/46/43 dB down (without deemphasis)
Non linear distortions	
Distortion for 40 Hz to 5 kHz with ±75 kHz/±100 kHz deviation	≦0.5%/≦1%

Intermodulation distortion (to DIN 45403), f_{diff} 1 kHz	5 to 15 kHz	15 to 53 kHz
±75 kHz deviation	d_2 ≦0.25%	d_2 ≦0.5%
	d_3 ≦0.37%	d_3 ≦0.75%
±100 kHz deviation	d_2 ≦0.5%	d_2 ≦1%
	d_3 ≦0.74%	d_3 ≦1.5%

S/N ratios (measured in line with CCIR Rec. 468-2); referred to: ±40 kHz, deviation, f_{mod} 500 Hz; useful EMF: mono ≧200 μV, stereo ≧2 mV

Unweighted S/N ratio	≧60 dB (typ. ≧65 dB)
Weighted S/N ratio	≧60 dB (typ. ≧65 dB)

Selectivity		MPX	Mono	
Adjacent-channel selectivity (ratio of interfering to wanted signal)	±100 kHz	≧61 dB	≧4 dB	±75 kHz deviation, f_{mod} 500 Hz
	±200 kHz	≧11 dB	≧0 dB	
	±300 kHz	≧−15 dB	≧−16 dB	
	±600 kHz	—	≧−46 dB	
	±1.2 MHz	—	≧−54 dB	
Common-channel selectivity				
Unmodulated interfering signal		≧49 dB	≧49 dB	
f_{mod} 500 Hz, ±40 kHz deviation		≧63 dB	≧44 dB	

Image-frequency rejection	EU 200: ≦20 mV; EU 201: ≦1 V (mono: ≦0.1 V)	interfering EMF for f_{image} and f_{IF} ±6 kHz
IF rejection	≦2 V	
Automatic switchover (with signalling contacts)	response level 20 μV to 5 mV EMF	
General data		
Panel meter	for V_{in}, centre-frequency error, frequency deviation and all output levels	
Rated temperature range	+5 to +40 °C	
Power supply	115/125/220/235 V, 47 to 63 Hz; 30 VA (EU 200), 20 VA (EU 201)	
Dimensions, 19" rackmount	483 mm×88 mm×384 mm	
19" bench model (design 80)	492 mm×116 mm×392 mm	
Weight rackmount/bench model	8 kg/10 kg	

Ordering information

Order designation ▶ VHF FM Relay Receiver

	19" bench model	19" rackmount
EU 200 (continuously tunable)	264.2012.52	264.2012.51
EU 201 (please specify frequency)	280.0510.52	280.0510.51

Recommended extras

BNC connector (RF input and MPX outputs)	497.7144.00
3-way male connector (mono output on front panel)	019.0458.00
3-way male connector (mono, MPX output on rear panel)	018.5340.00
Adapter rail for 19" rack	264.3854.00

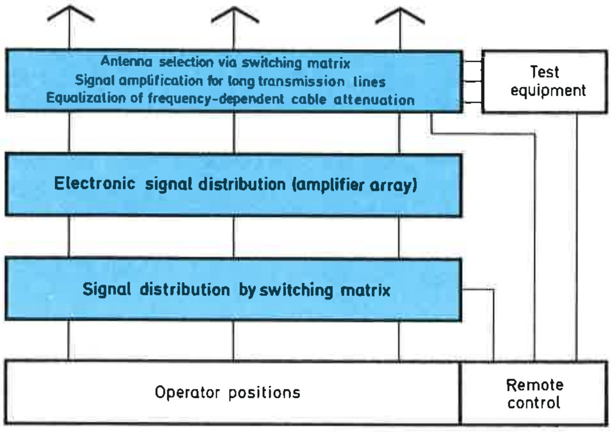
Equipment of divisions 4F ▶
page 354

4P ▶
page 356

VHF FM Relay Receiver EU 201 – description see previous page

Antenna signal transmission and distribution using the modular system NV 14/NZ 14

A flexible, maintenance-free modular system which offers a solution to nearly all the problems pertaining to the transmission and distribution of antenna signals in **short-, medium- and longwave** receiving systems.



Principle of a system for distribution and transmission of antenna signals in short-, medium- and longwave receiving systems

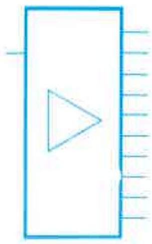
The **modular design** of the individual units enables the configuration of distribution systems of any required capacity with minimum space requirement.

All switching functions can be **remote-controlled** manually or **by program control** either from the operator's position or also from a central position. The distribution systems are mainly accommodated in a rack; system parts and small systems are also available as bench or wall-mounted models, see photo.

Examples of configuration

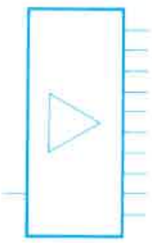
right	Multicoupler and power supply in equipment cabinet
below	Rack-mounting adapter, fitted with eight modules plus power supply (hidden behind)

Characteristics of system units



VLF-MF Multicoupler NV 12 T

The low-noise broadband amplifier NV 12 T is the most important system module for multiple utilization of antennas in the **medium- and longwave band.** It enables the operation of up to 10 receivers from one antenna and can be cascaded to feed an even far greater number of receivers. A rack-mounting adapter with power supply for accommodation of eight multicouplers is provided for large systems. The Antenna Selectors NZ 14 S1 and NZ 14 S2 are available for antenna switching and antenna signal distribution.



HF Multicoupler NV 14 T

Via the NV 14 T several (with triple cascading even up to 1000) **shortwave receivers** can be operated from one antenna, the full power received being available to each receiver. The NV 14 T has 10 outputs, can be cascaded and is designed for the following applications:

a) Feeding of small receiving stations (up to 10 receivers), e.g. in embassies, police stations, etc.

b) Feeding of large receiving stations (more than 10 receivers) – using additionally antenna selectors; rack-mounting configuration.

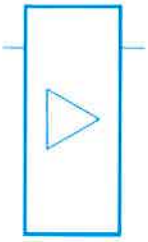
Specifications

NV 12 T

Frequency range	10 kHz to 1.6 MHz
Input/output impedance	50 Ω
Number of outputs	10
Isolation between outputs	>40 dB
Gain	0 ±1 dB
Noise figure	<12 dB at 0.1 MHz and above
Input/output connectors	BNC female
Supply voltage (DC)	24 V ±0.5 V (<500 mA)

NV 14 T

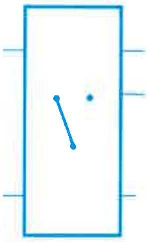
Frequency range	1.0 to 30 MHz or 1.6 to 30 MHz
Input/output impedance	50 Ω
Number of outputs	10
Isolation between outputs	up to 10 MHz: >50 dB; up to 25 MHz: >40 dB
Gain	0 ±0.5 dB
Noise figure	typically 7 dB
Input/output connectors	BNC female
Supply voltage (DC)	24 V ±0.5 V (max. 450 mA)



HF Line Booster NV 14 L

Module for distribution systems where antenna signals must be passed on with low loss over greater distances than usual. The voltage gain is 10 dB; higher losses can be compensated by using several line boosters. Input and output are protected against overvoltages (induced by lightning).

NV 14 L	
Frequency range	1.0 to 30 MHz or 1.5 to 30 MHz or 1.6 to 30 MHz
Input/output impedance	50 Ω, BNC female connectors
Gain	10 dB ±0.5 dB
Noise figure	typically 7 dB
Suppression of	
2nd order mixture products	>70 dB
3rd order mixture products	>80 dB

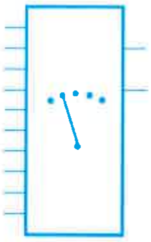


Antenna Selectors NZ 14 S1 and NZ 14 S2

Remote-controlled RF switches

NZ 14 S1: two inputs, one output and an additional pair of sockets for interconnecting line boosters. In the case of a power supply failure these additional sockets are bypassed and one input is through-connected to the output.

NZ 14 S2: two 1-out-of-5 or one 1-out-of-10 selection capability. Inputs and outputs can be interchanged.

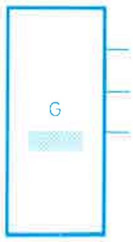


Remote control units for Antenna Selector NZ 14 S2: available as 19″ rackmount or bench model:

NZ 14 FB1 with keyboard for two 1-out-of-5 antenna selections,

NZ 14 FB2 with 10 keys for 1-out-of-10 selection.

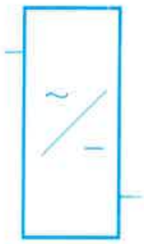
NZ 14 S1/14 S2	**NZ 14 S1**	**NZ 14 S2**
Frequency range	0 to 30 MHz	0 to 30 MHz
Inputs and outputs	2 inputs, 1 output, 1 additional pair of sockets	2 × 5 inputs, 2 × 1 output
Impedance	50 Ω	50 Ω
Isolation	>80 dB	>80 dB >40 dB between groups of five
Transmission loss	<0.5 dB	<0.25 dB
Power supply (DC)	24 V ±0.5 V (max. 65 mA)	24 V ±0.5 V (max. 10 mA/switch)



Noise Generator NZ 14 R

The remote-controlled, broadband noise generator is the testing unit of the distribution system. It supplies a constant noise power. The Antenna Selector NZ 14 S1 is provided for switching from antenna signal to noise generator signal.

NZ 14 R	
Frequency range	1 to 30 MHz
Outputs	3, BNC female connectors
Output impedance	50 Ω
Isolation between outputs	>10 dB
Noise power at each output	approx. 66 dB; (100 μV into 50 Ω at 10 kHz bandwidth)
Power supply (DC)	24 V ±0.5 V (75 mA)

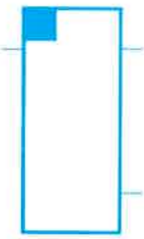


Cabinet NV 142 K and Power Supply NV 142 N

Cabinet NV 142 K: offering space for one unit plus the associated Power Supply NV 142 N. It is suitable for small systems or system parts. Available as bench model or for mounting to the wall (W×H×D: 122 mm×150 mm×185 mm).

Power Supply NV 142 N: used for feeding one unit. The power supply is of modular design and accommodated in the Cabinet NV 142 K together with the module to be fed.

NV 142 N	
AC supply voltage	110/220 V +10/−15% (47 to 63 Hz)
Output voltage	24 V ±0.5 V (stabilized)
Output current	max. 600 mA



Serial Control Interface NZ 14 P

The NZ 14 P is an accessory module enabling remote control of the Antenna Signal Distribution System NV 14/NZ 14 via data bus or program control. It functions as a memory and decoder for control information of antenna selectors with up to 100 contacts. If required, it can be switched for manual control.

NZ 14 P	
Connector	64-way to DIN 41612 (VG 95324)
Through-connected outputs	max. 20 mA/1 V
Other outputs	open collector, max. 30 V
Power supply (DC)	24 V (15 to 28 V), 30 mA

ESM 500

VHF-UHF Receiver Family ESM 500 ♦ 20 to 1000 MHz

- Compact receivers for radiomonitoring applications
- High frequency setting accuracy due to synthesizer, tunable in 1-kHz steps (10 Hz for SSB)
- Non-volatile memory for 99 frequency settings
- Built-in IF panoramic display
- SSB demodulator
- Remote-control capability (IEC bus, RS 232 C)

IEC 625 Bus

Characteristics

The intelligent, versatile **VHF-UHF receivers** of the **ESM 500** series enable an economical solution of the diversified radiomonitoring tasks.

ESM 500 A for 20 to 1000 MHz and
ESM 500 B for 20 to 500 MHz.

The receivers featuring high sensitivity, high overload capacity and a tracking preselection filter can be fully remotely controlled thanks to the microprocessor technique and are extremely easy to operate. Their common features also include:

- Wide dynamic range free from spurious responses (3rd order intercept point = +10 dBm)
- Scanning of 99 memory locations for receiver status per frequency
- Built-in test equipment (BITE)
- S/N ratio squelch or adjustable carrier squelch
- Addressing of ten slave receivers
- AC supply operation as well as DC supply 19 to 30 V without exchanging the power supply
- Automatic control of antenna switching panels

Versatility

When fully equipped the receiver features four selectable IF bandwidths, AM-FM demodulators, an SSB demodulator for USB and LSB and selectable tuning steps of 10 kHz and 1 kHz. An AM-FM demodulator with separate video outputs and IF bandwidths of 300 kHz and 2 MHz is provided to demodulate wideband signals.

An AF filter (300 Hz to 3.3 kHz) can be connected into the AF monitoring section. A frequency offset meter controlled by a crystal discriminator is used as a tuning indicator. The sensitivity of the offset meter is matched to the selected IF bandwidth to facilitate centre-tuning. If the frequency of the signals is unstable digital AFC can be switched into circuit to automatically track the input.

Specified characteristics

Frequency entry and tuning. Quasi-continuous manual tuning **by means of the familiar rotary control** together with digital control and the synthesizer offers exceptional advantages. The number of frequency steps per rotation depends on the speed of rotation of the tuning knob, so that this type of tuning is comparable to a mechanical coarse/vernier drive with six tuning rates.

The required frequency is entered **via a decimal keyboard;** adding the decimal point after the 1-MHz digit reduces errors. The frequency set is read out on a small display for checking and is transferred to the tuning circuit and the memory at the push of a button. Normal operation is not interrupted by setting a new frequency, loading the frequency into the memory or scanning the content of the 99 memories.

In addition to the current receive frequency, additional information such as IF bandwidth and type of demodulation can simultaneously be stored in the memory.

Automatic gain control. The AGC range is 120 dB, 80 dB being provided by the IF control and 40 dB by an attenuator which is automatically cut into circuit at high signal levels.

Wideband IF amplifier. It demodulates wideband signals, e.g. directional radio signals, and has an independent gated AGC; IF bandwidths 300 kHz/2 MHz.

SSB demodulator. It demodulates signals without modulation as well as SSB and ISB emissions. In the SSB mode, 10-Hz tuning steps are automatically selected.

IF panoramic display. The built-in IF panoramic display with a spectral display of ±100 kHz about the receive frequency furnishes information on the occupancy of the adjacent channels and is an invaluable tuning aid. **RF panoramic display** is possible up to a sweep width of 500 MHz when using the Panoramic Adapter EZP (page 246).

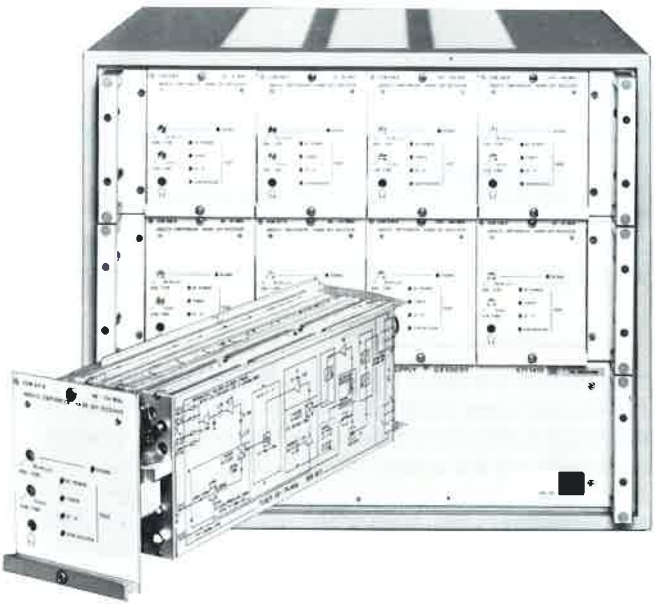
Squelch. In addition to the adjustable squelch of the usual type, the ESM 500 has also an S/N ratio squelch which only enables the AF channel if the S/N ratio is satisfactory.

Self-testing facility. The receiver is permanently monitored by the built-in test equipment. A code number displayed on the occurrence of a fault furnishes information on the type of fault.

Hand-off Receivers ESM 508 K, 517 K, 540 K

In radiomonitoring systems a great number of frequency channels must often be monitored. When using standard receivers (like the ESM 500 A/B) for this purpose, the investment costs would be too high. It is more economical to use receivers which are tailored to certain frequency bands. For this reason the Receiver Family ESM 500 offers the so-called **cassette receivers** or hand-off receivers which can be remote-controlled from a central control station. In most cases the receiver settings are made by a computer which also evaluates the information supplied by the receivers.

Each cassette (size: ¼ of 19″ plug-in, see photo) is a self-contained receiver with no front panel controls, buth with its own tuner, synthesizer and IF/AF amplifier, and features an extremely favourable price/performance ratio.



Eight hand-off receivers including power supply in a 19″ cabinet

Up to eight cassettes can be operated from one Control and Power Supply Unit GX 500 D1 which contains a microprocessorized control system, a 10-MHz reference oscillator, a power supply and an IEC-bus interface for data input and output to the central control system.

The control system may consist of:

- an ESM A/B, addressing via A0 to A9,
- a process controller with IEC-bus interface, e.g. the PUC from R&S,
- an Automatic Receiver ESP with computer (e.g. Data General NOVA 4 or ROLM 1602 B) and IEC-bus interface.

Self-testing facility. Each receiver is fitted with self-testing facilities which do not only report failures of modules to the control and power supply unit, but also indicate them on the front panel of the receiver concerned. In addition, each receiver contains the facilities required for the overall loop test.

Specifications

	ESM 500 A, B	ESM 5.. K
Frequency range ESM 500 A	20 to 1000 MHz	
ESM 500 B	20 to 500 MHz	
ESM 508 K		20 to 85 MHz
ESM 517 K		68 to 174 MHz
ESM 540 K		220 to 400 MHz
Frequency setting	a) quasi-contin. with rotary knob b) via keyboard on front panel c) entered from int. memory d) entered from ext. memory	by entry of frequency information from control and power supply unit
Resolution	1 kHz/100 Hz/ 10 Hz	1 kHz
Readout (in SSB mode shiftable by 3 digits)	6-digit display, 6 digits for auxiliary display during frequency entry, 2 digits for memory location	
Frequency error	$\pm 1 \times 10^{-8}$	$\pm 1 \times 10^{-8}$
Antenna input	50 Ω, N female	50 Ω
Oscillator reradiation	<1 µV	<1 µV
Input selectivity	tracking filters	tracking filters
Frequency memory	99 frequencies, type of demodulation and IF bandwidth	
S/N ratio (V_{in} = 1 µV, B = 30 kHz)	≧10 dB with AM ≧25 dB with FM	≧10 dB with AM ≧25 dB with FM
Intercept point 2nd/3rd order	typ. 50/12 dBm	typ. 50/12 dBm
IF bandwidths (fully equipped)	2.3/8/15/30/ 100/300 kHz/2 MHz	8/15/30/100 kHz
Image frequency rejection	>90 dB	>80 dB
IF rejection	>90 dB	>90 dB
Demodulation	AM, FM, SSB with option	AM, FM
Squelch	S/N ratio squelch and carrier squelch adjustable from 0 to 80 dBµV	carrier squelch adjustable from 0 to 80 dBµV
AF filter (disconnectible)	300 Hz to 3.3 kHz	300 Hz to 3.3 kHz
AF delay		100 ms (can be switched off)
COR	floating switching contact	floating switching contact
Gain control AGC	IF control for V_{in} ≦80 dBµV RF control for V_{in} ≦120 dBµV	same as ESM 500
MGC	IF control 80 dB RF: 40 dB, switch-selected	external control same as ESM 500
Indication: level/offset	on meter	—
Panoramic display		
IF sweep width	200 kHz	—
Resolution	4.5 kHz	
Screen size	4 cm × 3 cm	
RF sweep width (with EZP)	500 MHz, IF max. 2 MHz	—
Built-in test equipment	monitoring of subassemblies and loop test	same as ESM 500
Outputs	level, offset, AF, AM video, FM video, IF 10.7 (wide/narrow), for EZP, COR, headphones, built-in loudspeaker	level, offset; AF, AF (delayed), IF 10.7 (wide/-narrow), headphones, COR
Inputs	external control, squelch threshold	external control (analog)
Remote control	IEC bus, RS 232 C	same as ESM 500
General data		
Operating temperature range	−10 to +55 °C	−10 to +55 °C
Power supply	110/220 V or 10 to 30 V DC, 40 W	via control and power supply unit; 7 W per receiver, 150 VA max.
Dimensions, bench model (in mm)	492×161×514	8-receiver block:
rackmount	483×132×506	520×445×535
Weight	20/18 kg	60 kg (3.5 kg per receiver)

Ordering information

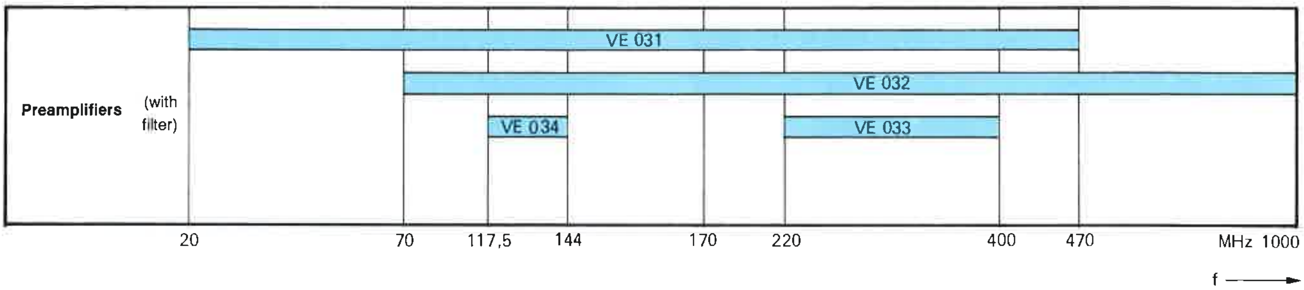
	Order number:
▶ VHF-UHF Receiver	
ESM 500 A, bench model	570.5012.02
rackmount	570.5012.03
ESM 500 B, bench model	570.5012.04
rackmount	570.5012.05

Further information on equipment and options: see Info N 6-011.

VE 031 to VE 034

Preamplifiers for radio receiving systems
⧫ 20 to 1000 MHz

- Low noise
- High linearity
- Built-in filter
- High reliability
- Powered via RF cable

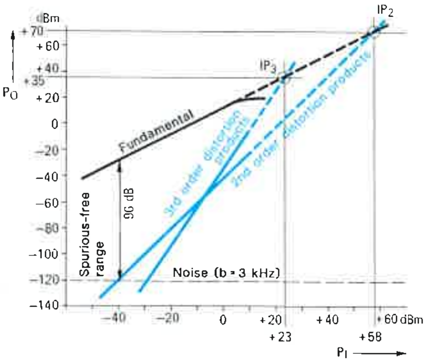


The weather-protected **Preamplifiers of the VE 03. series** are used to compensate for the line losses between the antenna and the receiver, e.g. in radiomonitoring and air traffic control systems.

The amplifiers **VE 031** (20 to 470 MHz) and **VE 032** (70 to 1000 MHz) have been primarily designed for use in radiomonitoring systems. The **VE 033** (220 to 400 MHz) and **VE 034** (117.5 to 144 MHz) comply with the special requirements of ATC systems. The Multicouplers VE 340 and VE 341 that are suitable for connection to the preamplifiers are listed on the following page.

Design

The broadband push-pull amplifiers (including input filter circuits and lightning protection circuits) are mounted on a central heat sink. The temperature rise is thus well below the limit permitted for the semiconductors, ensuring high reliability.



2nd and 3rd order intercept points (IP_2 and IP_3) of Preamplifier VE 031;
P_I = input level,
P_O = output level

The amplifiers are delivered without a power supply and in a weatherproof case suitable for various different methods of attaching it to the antenna mast. The supply voltage is fed to the amplifier via the coaxial antenna cable.

High reliability. The actual MTBF (mean time between two failures) is even better than the calculated MTBF of 300,000 hours due to the careful selection of the components and the performed burn-in tests.

Specifications

Type		VE 031	VE 033	VE 032	VE 034
Frequency range		see above and ordering information			
Gain (midrange, +1/−0.5 dB)	dB	12	12	13.5	20
Frequency response	dB	≦2	≦2	≦2	≦1
Noise figure	dB	≦6.5	≦6.5	≦7.5	≦3.5
Max. input EMF	V_{rms}	10	10	2	10
Intercept point					
2nd order IP_2	dBm	≧+70¹)	≧+80²)	≧+54³)	≧+70²)
3rd order IP_3	dBm	≧+31	≧+31	≧+25	≧+33
Input/output impedance	Ω	50	50	50	50
VSWR		≦2	≦2	≦2	≦2

General data (for all types)

Rated/operating temperature range	−25 to +55/−40 to +70 °C
Humidity	class F operation to DIN 40040, tested to VG 95332: 95% at +40 °C over 24 hours
Power supply	+18 V, approx. 0.1 A; fed via coaxial cable
Dimensions, weight	140 mm×360 mm×90 mm, 3 kg

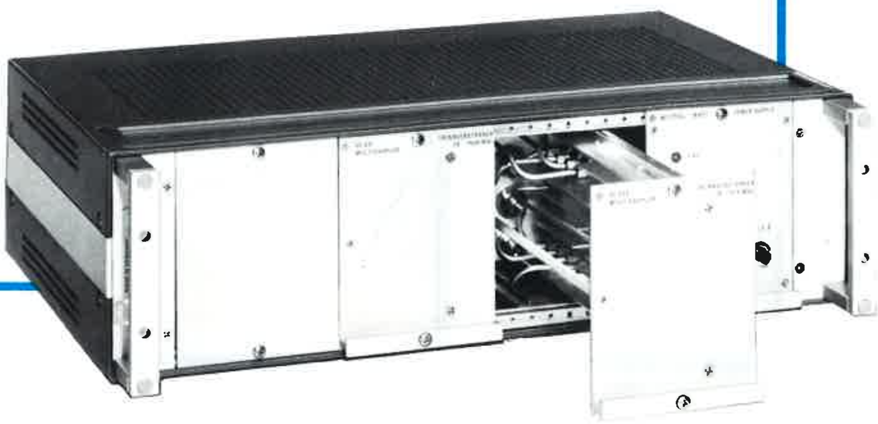
Order designation	▶ Preamplifier
VE 031, 20 to 470 MHz	562.0415.02
VE 032, 70 to 1000 MHz	562.1611.02
VE 033, 320 to 400 MHz	562.0715.02
VE 034, 117.5 to 144 MHz	562.1311.02

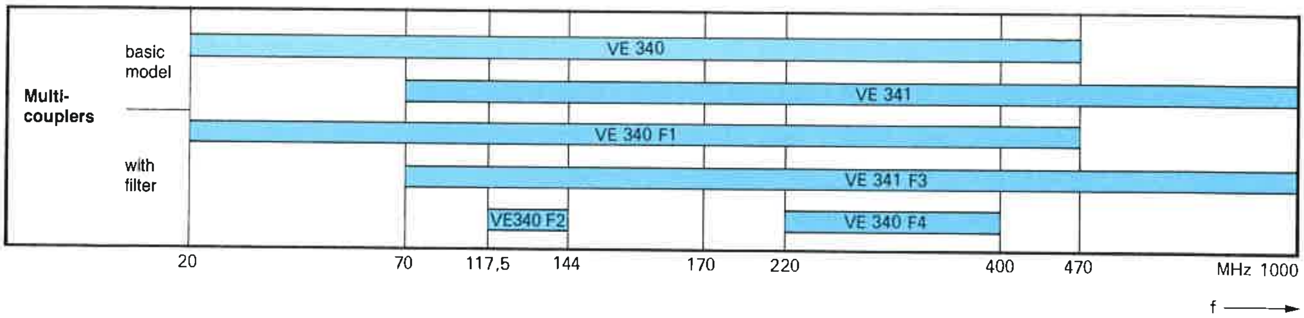
¹) For $f_1/f_2/f_{d2}$: 70/100/30 MHz; ²) In rated frequency range;
³) For $f_1/f_2/f_{d2}$: 400/470/70 MHz.

Broadband Multicouplers for radio receiving systems
♦ 20 to 1000 MHz

VE 340, VE 341

- Eight isolated outputs
- High linearity
- Low noise
- Built-in filter, if required
- High reliability





The broadband **Multicouplers VE 340** (20 to 470 MHz) and **VE 341** (70 to 1000 MHz) permit **up to eight receivers** or – via an inserted DC feed unit – further multicouplers with as many subsequent receivers to be simultaneously operated from one antenna. For operation without preceding Preamplifiers VE 031 to VE 034, these multicouplers are available with filters for limiting the frequency range (see specifications).

Design

Since the multicouplers, which are designed with push-pull-circuits are mounted on a solid heat sink, the temperature of the semiconductors is so low that the actual MTBF (mean time between two failures) is even better than the calculated MTBF of 300,000 hours.

The multicouplers and the power supply are designed as plug-ins (each a quarter of 19″ wide). Up to three multicouplers and one power supply can be accommodated in a 19″ adapter. The cable connectors of the multicouplers are located on the rear of the plug-ins. It is however possible to modify the multicoupler such that the RF connectors are on the front panel. The power supply also feeds the preceding Preamplifiers VE 031 to VE 034 via the RF cables.

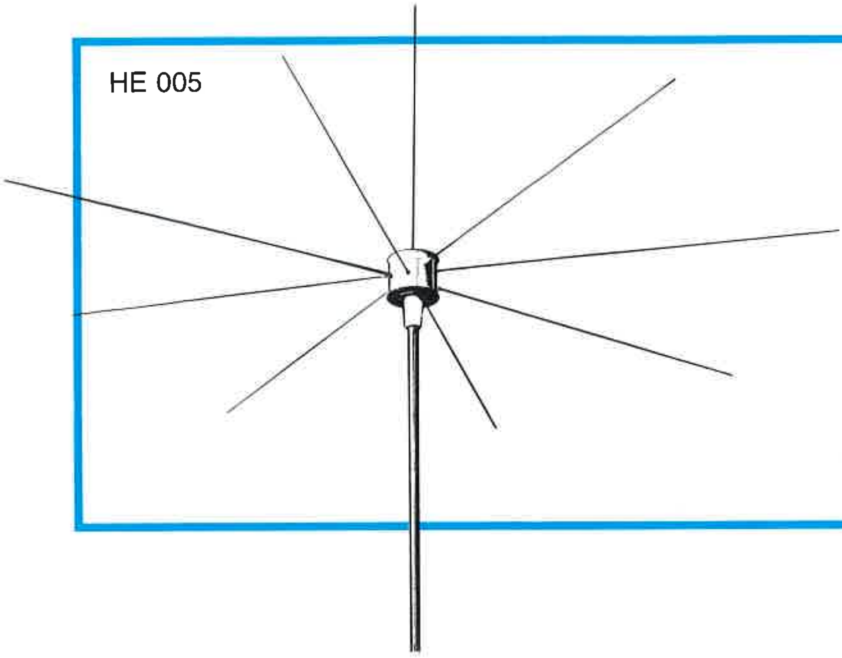
Specifications

Type	**VE 340**	**VE 341**
Frequency range	see above	
Gain (midrange)	1 dB ±1 dB	1 dB ±1.5 dB
Noise figure	≦8 dB	≦8 dB
Input	unbalanced; inner conductor provides +18 V to feed a preamplifier	
Max. input EMF	10 V_{rms}	2 V_{rms}
Input impedance	50 Ω, N female	50 Ω, N female
VSWR	≦2	≦2.5
Outputs	8, unbalanced, floating	8, unbalanced, floating
Output impedance	50 Ω, N female	50 Ω, N female
VSWR	≦2	≦2
Interference rejection		
Isolation between outputs	typ. 25 dB	typ. 25 dB
Intercept point 2nd order IP_2	≧ +70 dBm per output	≧ +50 dBm per output
at $f_1/f_2/f_{d2}$	70/100/30 MHz	400/470/70 MHz
3rd order IP_3	≧ +26 dBm per output	≧ +20 dBm per output
Power Supply IN 027	feeding from AC supply or battery	
AC supply	115/125/220/235 V +10/−15%	
Battery supply	19 to 32 V	
General data		
Rated/storage temperature range	−10 to +55/−40 to +70°C	
Dimensions		
19″ rack adapter	483 mm×132 mm×384 mm	
19″ bench model adapter	492 mm×161 mm×392 mm	

Ordering information

Order designation	▶ Multicoupler
VE 340, 20 to 470 MHz	562.3014.02
VE 341, 70 to 1000 MHz	562.3514.02
With filter for	
20 to 470 MHz, VE 340 F1	562.2618.02
117.5 to 144 MHz, VE 340 F2	562.2218.02
220 to 400 MHz, VE 340 F4	562.2818.02
70 to 1000 MHz, VE 341 F3	562.2818.02
Power supply for max. 3 multicouplers	570.3010.02

HE 005



Active HF Antenna System HE 005
♦ 1.5 to 30 MHz

- Extremely small dimensions: rod height 1.5 m only, dipole length 3 m only
- High sensitivity
- High linearity
- High immunity to nearby lightning strokes
- Performance test without auxiliarry equipment and emergency operation by means of bypass circuit

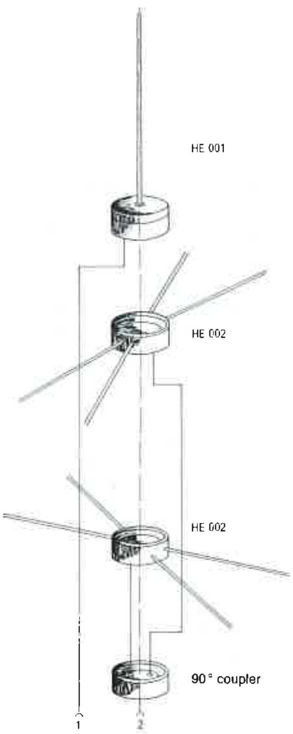
Active receiving antennas offer advantages due to their dimensions being reduced by almost a factor of four as against comparable passive antennas with same sensitivity of the receiving system.

Rohde & Schwarz has developed a system concept, in which the basic modules

Active HF Rod Antenna HE 001 and
Active HF Dipole Antenna HE 002

(which can also be used individually) can be combined to form various systems for different requirements.

The **Active HF Antenna System HE 005** is one of the possible combinations, consisting of HE 001, 2×HE 002 plus a 90° coupler. The system is in line with CCIR Rep. 373-2 and has the following special features:



- Omnidirectional reception of ground waves and vertically polarized, low-angle sky waves
- Omnidirectional reception of horizontally polarized waves, even with small angles of elevation
- Constant sensitivity for high-angle sky waves with any position of the E vector

Specifications

	Elements HE 001 (above conducting earth)	HE 002 (on 6-m mast)
Frequency range	1.5 to 30 MHz	
Input impedance	50 Ω	50 Ω
VSWR	≦1.5	≦1.5
Suppression of intermodulation distortion for 2nd order mixture products (for 2×0.1 V/m interfering field strength)	≧75 dB	≧70 dB
corresponding to IP_2	≧60 dBm	
for 3rd order mixture products (for 3×0.1 V/m interfering field strength)	≧110 dB	≧100 dB
corresponding to IP_3	≧38 dBm	
Antenna factor $k_a = V_{out}/E$	0.4 m	0.7 m
Maximum permissible interfering field strength		
at 10 kHz	5×10^5 V/m	2.5×10^5 V/m
100 kHz	5×10^4 V/m	2.5×10^4 V/m
1 MHz	5×10^3 V/m	2.5×10^3 V/m
10 MHz	500 V/m	250 V/m
100 MHz	50 V/m	25 V/m

General data

Operating temperature range	−40 to +80°C
Storage temperature range	−55 to +125°C
Connectors	BNC
Supply voltage	18 V ±10%/100 mA[1])
Dimensions of rod	1500 mm, 1.6 kg
dipole	3000 mm, 2 kg

Ordering information

Order designation .... ▶ Active HF Antenna System HE 005 275.5447.50

Recommended extras

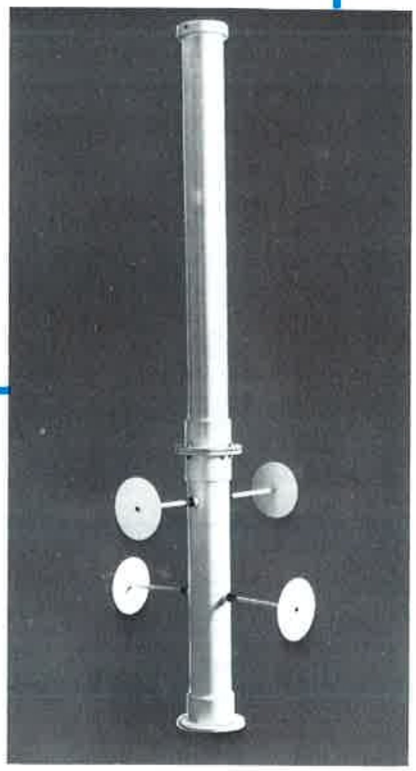
Plug-in Mast KM 011 (6 m; including guy ropes and pegs) . 273.9116.02
Power Supply IN 014 .... 235.7610.02

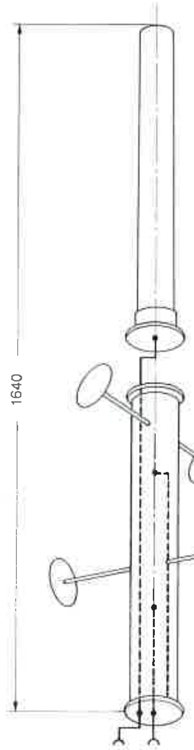
[1]) The antenna is fed from the Power Supply IN 014 via the coaxial RF antenna cable.

HE 115

Active Antenna System HE 115
♦ 20 to 200 MHz

- Adaptation to any receiving conditions due to compact antenna system
- High sensitivity in spite of small size
- High large-signal handling capability (like that of a passive antenna with high-grade preamplifier)
- High immunity to nearby lightning strokes





Active Antenna System HE 115

The **Active Antenna System HE 115** is made up of the

Active Receiving Dipole HE 101 (2 off) and the
Active Vertical Dipole HE 109 (see illustration on the right).

This antenna system meets any requirement in the fields of **radiomonitoring and radiocommunications.** It features

- omnidirectional reception of vertically and horizontally polarized waves

and ensures a high detection probability. Due to their very small dimensions, light weight and low wind load the antenna elements and also the whole system represent an ideal solution, especially for **mobile use** and where space is at a premium. The output voltages are available at separate outputs for horizontal and vertical polarization.

The **Active Receiving Dipole HE 101** (see illustration on the right) is mainly designed for horizontal orientation, i.e. for reception of horizontally polarized waves. The extremely small dimensions of the HE 101 (dipole length: 0.5 m) make it easy to orientate it in any direction. The HE 101 is delivered with a bracket having an arm for fixing the antenna to a tubular mast (20 to 54 mm diameter).

Omnidirectional reception over the whole frequency range 20 to 200 MHz, however, is achieved with the **Active Vertical Dipole HE 109** (see illustration on the right) which, for example, is mounted on top of the mast. The centre feed of the dipole ensures high isolation from currents on the supporting mast.

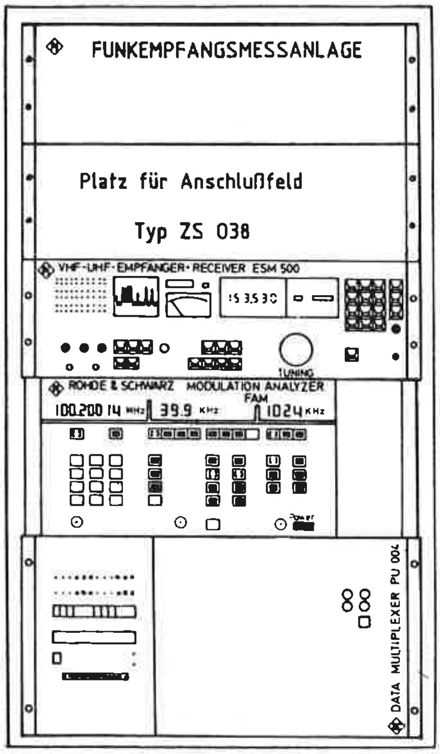
Order designation .... ▶ Active Antenna System HE 115
530.6718.02

Recommended extras

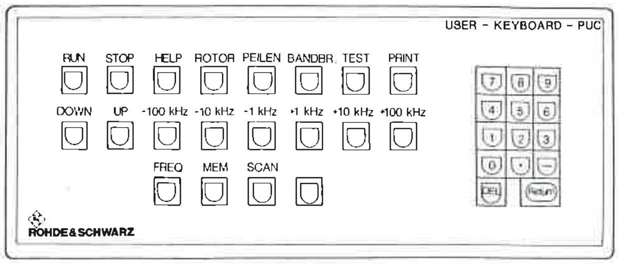
Bracket for mounting the antennas on tubular masts	530.6953.00
Power Supply IN 014	235.7610.02

EA 020

Radio Receiving and Measuring System EA 020



- ♦ 20 to 1000 MHz
- Remote control over any distance
- Programmable control unit
- Clear display of setting and measured data
- Easy extension of control and receiving station thanks to IEC-bus compatibility



User keyboard of process controller

The remote-controlled **Radio Receiving and Measuring System EA 020** is suitable for setting up radiomonitoring networks. From a central station unattended measuring systems – installed at sites offering favourable receiving conditions – can be controlled over the public telephone network. Each system, including its antennas, can be controlled in all necessary operating modes and measuring routines and immediately provides the measured values, such as receive frequency, frequency offset, RF signal level, frequency deviation, modulation depth, angle of incidence, as well as the demodulated signal. Switchover between several receiving stations of one control station is made via lines. Remote control and return-signalling of the measured values need not be made via lines, it is also possible via directional radio links, the transfer rate being usually 1200 bauds.

The system is controlled from the user keyboard (above right), which can be set up remotely, in the form of a user-friendly dialog program. The user can also write his own programs in BASIC or modify existing programs. This offers then the possibility of extending the system, e.g. for direction finding and evaluation via IEC-bus-compatible equipment.

The results, equipment settings and additional information are displayed on the screen of the process controller, for which a high-resolution graphics option is also available.

The Data Multiplexer PU 004 in the receiving station can be retrofitted to enable control and data return-signalling of the Doppler Direction Finder PA 005.

Overall concept of a radio receiving and measuring system

- ▶ Equipment configuration for the measuring station
- ▶ Equipment configuration for the control station

System configuration/function

Control station. Process Controller PUC (see also page 14), with two built-in floppy disk drives (156 kbyte capacity each), enabling a great number of customer-specific operating, measuring and locating routines to be called up.

Measuring station. The PU 004 receives via a modem the setting and measuring commands from the central station. Omnidirectional receiving antennas and one log-periodic antenna (with crossed dipoles, on rotator) are available. Instead of the log-periodic antenna the Doppler Direction Finder PA 005 can be used for better determination of the direction.

The ESM 500 (page 356) with SSB option and IEC-bus interface is used as receiver. The units for antenna selection, antenna rotation, radio reception, measurements and data transmission are accommodated in a 19″ light-metal cabinet.

Specifications

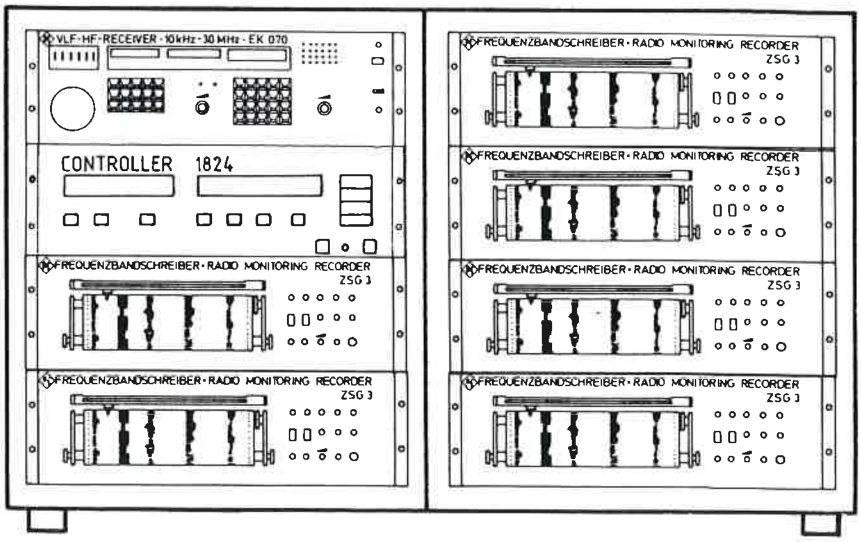
Reception	corresponding to the specifications of the VHF-UHF Receiver ESM 500, see pages 356/357
Frequency range	20 to 1000 MHz
Demodulation modes	AM, FM, SSB
2nd/3rd order intercept point	typ. +50 dBm/typ. +12 dBm
Noise figure	typ. 9 dB
Measurement	corresponding to the specifications of the Modulation Analyzer FAM, see page 256
Frequency measurement	
Resolution	1 Hz/10 Hz
Modulation measurement	
AM	10 to 100%
FM	1 to 500 kHz
Control and display	Process Controller PUC, page 14
Ordering information	depending on system configuration, details on request

Automatic RF Spectrum Occupancy Recording Equipment EA 110, EA 115

EA 110, 115

♦ 10 kHz to 30 MHz or 10 kHz to 1300 (2500) MHz

- Wide frequency range – up to 2.5 GHz
- High frequency resolution with 25 Hz analyzing bandwidth
- Quasi-parallel recording on up to six recorders
- Modern, clear operating and display concept



The **Automatic RF Spectrum Occupancy Recording Equipment EA 110** and **EA 115** measure and record the occupancy of frequency bands over extended periods of time. The recordings clearly show any unduly high or low signal density at certain frequencies and times. With suitably adjusted sweep width and resolution, the plotted graph can also provide information on the frequency stability, type of modulation and class of emission of the transmitters observed.

Rohde & Schwarz can deliver the following system configurations:

▶ **System EA 110 A1, 10 Hz to 30 MHz**
1 Receiver EK 070, 1 Controller 1824, 1 Recorder ZSG 3

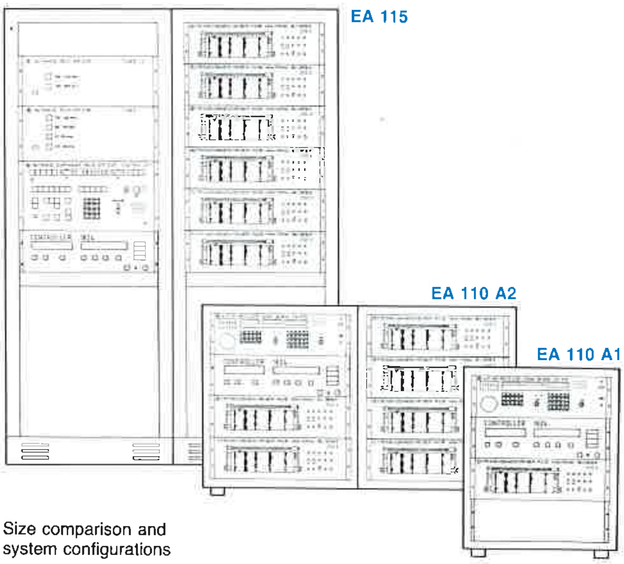
▶ **System EA 110 A2, 10 kHz to 30 MHz**
1 Receiver EK 070, 1 Controller 1824, 6 Recorders ZSG 3

▶ **System EA 115, 10 kHz to 1300 (2500) MHz**
1 Automatic Receiver ESP (up to 1300 MHz, with Tuner II up to 2500 MHz), 1 Controller 1824, 6 Recorders ZSG 3

The Controller 1824 used in all systems controls via a microprocessor the respective receiver in about 1000 steps between the selected start and stop frequency and calculates the optimum sweep width and resolution bandwidth.

Triggered by the controller, the receiver searches up to six frequency bands at maximum speed. All frequencies of the occupied channels are written into a semiconductor memory in accordance with the lines on the recording paper. When reproducing the results, the lines can be linked up – depending on the selected time – so that no signal will be lost and the paper feed is matched to the period of observation.

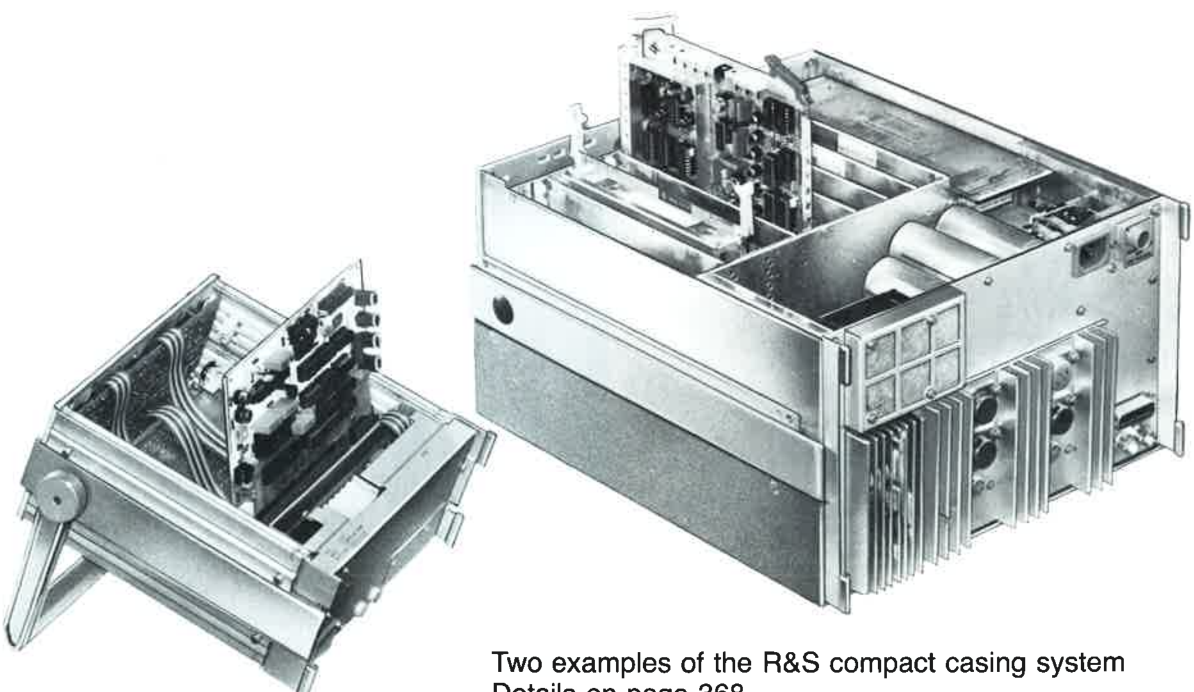
The equipment of the EA 110 A1 and EA 110 A2 systems is accommodated in 19" cabinets (one for EA 110 A1, two for EA 110 A2; 550 mm high), that of the EA 115 system in two light-metal racks (1450 mm high).



Size comparison and system configurations

Specifications

Frequency range EA 110 A1, EA 110 A2	10 kHz to 30 MHz receiver: EK 070
EA 115	10 kHz to 1300 MHz, can be extended to 2500 MHz using Tuner II option
Analysis filter bandwidth EA 110, A1, A2	25/50/100/300/600 Hz/ 1.5/3/6 kHz
EA 115	25/50/100/300 Hz/ 1/7.5/25/100 kHz/2 MHz
Dynamic range	≧60 dB for bandwidth ≦1 kHz ≧90 dB for bandwidth ≧1 kHz
Recording	on Radiomonitoring Recorder ZSG 3
Recorded subranges	6 (only 1 with EA 110 A)
Analysis ranges	1 to 6 with selectable start/stop frequencies
Frequency lines	max. 10 vertical lines from 1 kHz to 100 MHz manually adjustable in steps of ten
Response threshold	adjustable from 0 to 90 dB in 1-dB steps
Time marking	by built-in digital clock
Response reliability	a signal is recorded if it is 2 dB above the limit sensitivity of the receiver at all analysis bandwidths
Non-volatile storage	in battery-buffered memory of controller



Two examples of the R&S compact casing system
Details on page 368

Dimensions in tables and texts, cabinets

Design 80

Compact casing system

Rack mounting

Dimensions

The **dimensions** of Rohde & Schwarz instruments are defined as follows:

a) Overall **width×height×depth** in mm, looking onto the front panel (this also holds for pocket-sized instruments).

In general, the indicated dimensions refer to cabinet models (bench models).

b) **In addition** to a), an abbreviated code form has been introduced to simplify the specification of dimensions in tables and texts, see table on next page.

The code has not been used in the present catalog. The table on the next page gives cross references between cabinet (bench model) and rackmount dimensions. The order numbers for matching cabinet covers and rack adapters are also given in the table.

Cabinet designs

New designs of cabinets and casing systems are the result of the constantly increasing degree of utilization of equipment volume made possible by ever smaller and more complex components.

The present Rohde & Schwarz line comprises the following three design forms:

Design 70 (present design)
Design 80 (see page 366)
Compact casing system (see page 368)

Design 70 – also for measuring instruments of mixed design with conventional subassemblies – will be superseded in future by design 80 and compact casing system.

Design 80. The width of a bench model (19″ rackmount plus panelling corresponding to the former cabinet model of W = 484 mm) is 492 mm.

Compact units have widths*) of ½, ¾ or ¹⁄₁ of 19″ with different heights and depths.

*) The actual width is slightly less than the calculated width for constructional reasons.

Rack mounting

19″ rackmounts of design 70 and design 80 may be inserted as required into 19″ racks or mounted in DIN racks with the aid of adapters. **Compact units** can be set up in the same way after having been fitted with 19″ adapters (see table on page 368; vacant inserts are supplied with the adapters).

Mounting in 19″ racks (DIN 41 494)

Guide rails are supplied in pairs for KCJ 19″ racks (R&S) or single for other 19″ racks (length 740 mm, no drilled holes); they are suitable for units of design 70 and design 80 (Fig. 1 left).

Brackets are used to secure the appropriate connection panel (specify equipment type when ordering) for self-engaging connection (Fig. 2).

Mounting in DIN racks (DIN 41 490)

Adapter bars (2 ea, angle section) extend the 19″ size to DIN width (Fig. 1 right and Fig. 3).

Front-panel adapters (three parts) reduce the width and height of the DIN frame to 19″ front-panel size (Fig. 3).

Guide rails for rack mounting (Fig. 1 right) can be made of commercial angle-profile bars.

Brackets see above.

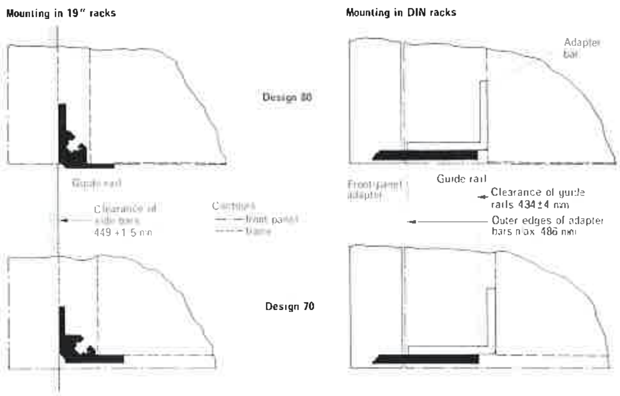


Fig. 1 Guide rails, adapter bars and front-panel adapter fitted for left side of rackmount

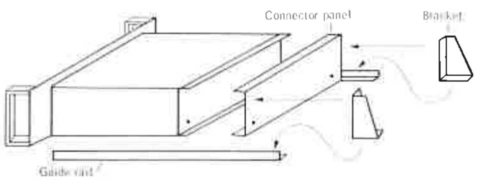


Fig. 2 Fitting the connector panel by means of brackets (19″ and DIN racks)

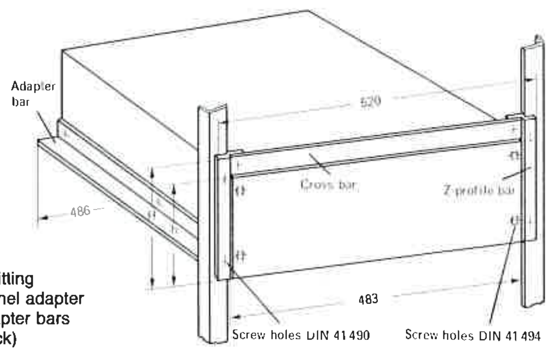


Fig. 3 Fitting front-panel adapter and adapter bars (DIN rack)

Key to dimension code for use in tables and texts,
order numbers for cabinet covers, guide rails and 19″ adapters

All dimensions are in mm

Equipment of 19″ width

a) **present design** designated **D 70** in the table)
b) **design 80** (designated **D 80** in the table)

For details on design 80 see next page ▶

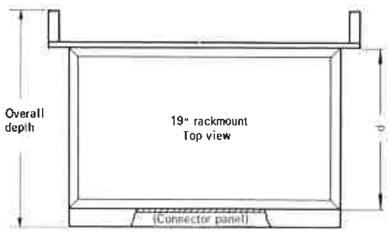
Code for height (= DIN 41 494 Sh. 2) ▼	19″ equipment dimensions: Height in units (1 E ≈ 44 mm)	**Rackmount** (front-panel width 483) Front-panel height D 70	D 80	**Bench model** (width D 70: 484, D 80: 492) Overall height D 70	D 80	Cabinet cover: **Cover for bench model** Order Nos. D 70	D 80 D 70	Rack mounting D 70 and D 80: **Brackets** Order Nos. (for 1 set) 19″ racks	DIN racks	**Front-panel adapter** Order Nos. (DIN racks) RAL 7001
1	1 E	44	—	61	—	082.5882.00	085.6550.00	Please enquire		034.0910.00
2	2 E	88	88	105	116	043.3818.00	085.6567.00	281.3765.00	281.3842.00	034.0990.00
3	3 E	133	132	150	161	043.3930.00	085.6573.00	281.3771.00	281.3859.00	034.1074.00
4	4 E	177	177	194	205	043.4037.00	085.6580.00	3 E brackets are used for heights of 4 E and more.		034.1145.00
5	5 E	222	221	239	250	043.4114.00	085.6596.00			034.1222.00
6	6 E	266	266	283	294	043.4743.00	085.6609.00			034.1300.00
7	7 E	311	—	328	—	043.4820.00	—			034.1380.00
8	8 E	355	—	372	—	043.4908.00	—			034.1468.00
9	9 E	400	—	417	—	043.4972.00	—			034.1545.00
10	10 E	444	—	461	—	043.5040.00	—			034.1622.00
11	11 E	488	—	505	—	043.5110.00	—			034.1700.00
12	12 E	533	—	550	—	043.5191.00	—			034.1768.00

for depth ▼	Overall depth D 70	D 80	Depth d (see drawing) D 70	D 80	Overall depth without cover D 70	D 80	**Adapter bars** Order Nos. (for DIN width) D 70	D 80	**Guide rails** Order Nos. for 19″ racks[1]	
A	326	384	247	305	336	392	281.3788.00	281.3813.00	For R&S rack KCJ (1 pair): 281.3742.00	For other racks[2]: 281.3759.00
B	426	506	347	427	436	514	281.3794.00	281.3820.00		
C	499	—	420	—	509	—	281.3807.00	—		

[1]) Use commercial angle-profile bars for DIN racks.
[2]) Single guide rails: 740 mm long, no holes drilled.

Dimension d

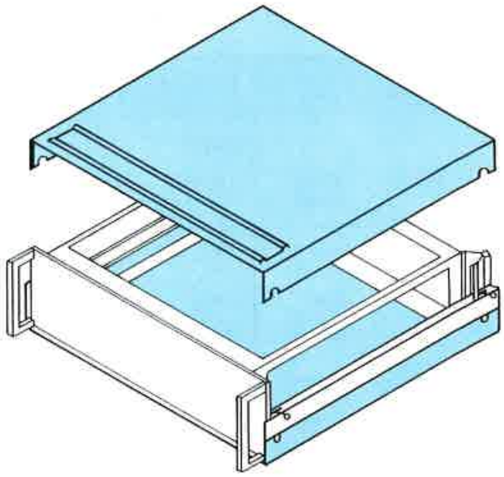
The dimension given in the table indicates the seated depth of 19″ rackmounts according to the diagram on right. For the overall depth, 79 mm have to be added: front projection for front panel (4 mm) and handles, including plastic stoppers (51 mm), and rear projection for connecting panel (24 mm).



R&S design 80

New Rohde & Schwarz instruments are being produced in design 80 and the compact casing system, the new style for the eighties which, in its outward appearance, represents the third generation of equipment in the company's history of 50 years.

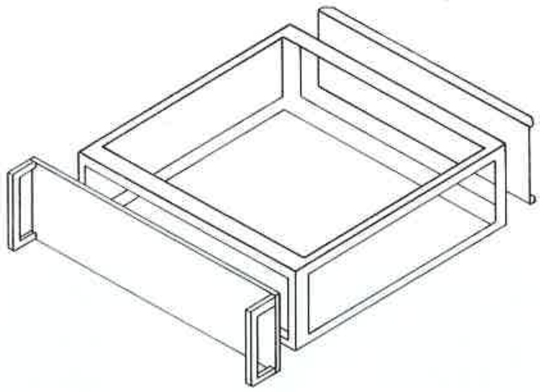
Design 80 is a modern and universal **modular system** which meets differing requirements. It is characterized by exemplary styling, optimum utilization of space, high strength and low weight. The system covers mainframes, panelling, cassettes, adapters for rack mounting, plug-in PCBs and integrable small equipment.



19″ bench model in design 80:
mainframe plus panelling (enclosure detached)

Basic mainframe

The mainframe corresponds to the 19″ standard in accordance with IEC recommendation 297 and DIN 41 494.



19″ basic rackmount in design 80; frame, front and rear panels

Extruded aluminium sections are used which, due to their mutually engaging design, can be assembled without any special equipment, making them suitable for one-offs as well as standard production. The form of the sections ensures that the mainframe is true in angle and stable while remaining light in weight and large in capacity, the latter offering high packing density.

Sizes of two to six units in height (1 unit corresponding to 44.45 mm) and two frame depths (305 and 427 mm) have been standardized.

Panelling

In contrast with conventional instrument cases, the panelling of the bench model consists of two metal cover panels with extruded aluminium side strips (see photos right). With sizes from three units in height, the side panels are provided with recessed, fold-out handles.

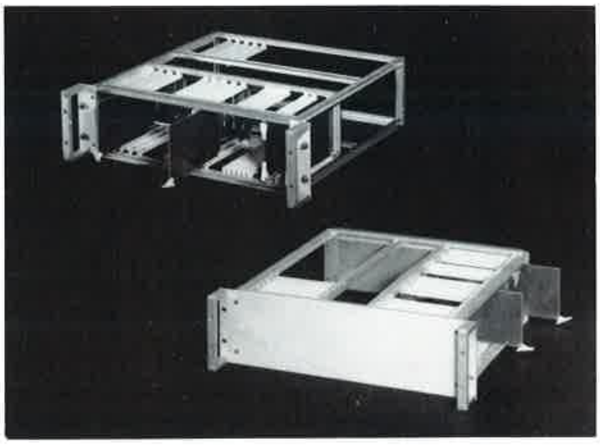
Due to the use of panelling, it is normally only necessary to remove the lightweight covers without having to remove the complete unit when requiring access to the interior.

Insertion of PCBs

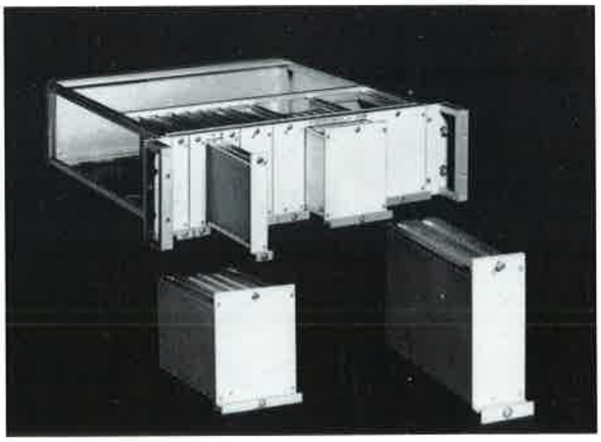
The insertion of PCBs requires but a few standardized accessories (see photo below). The basic format is the 100 mm×160 mm Eurocard in line with DIN 41 494.

Cassettes

Cassettes for self-contained functional groups are likewise suitable for holding plug-in cards and other subassemblies.



Mainframe with PCBs arrange for ease of maintenance
19″ rackmount with cassettes



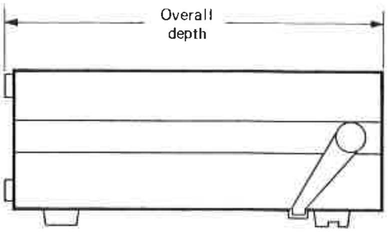
Compact casing system – equipment dimensions

Dimensions						Rack mounting	
Width			**Height**		**Depth**	**19″ Adapter**	
of 19″	overall	without handle	overall	in units	overall (without controls)	Type	Order Nos.
½	241	210	110	2 *)	219	ZZA-12	079.0631.00
				2 *)	349	ZZA-12	079.0631.00
	245	210	154	3 *)	349	ZZA-13	079.0702.00
¾	347	312	206	4	349	ZZA-4	078.8500.00
				4	471	ZZA-5	078.8645.00
⅟₁	470	435	118	2	349	ZZA-6	078.8274.00
			162	3	349	ZZA-7	078.8400.00
				3	471	ZZA-8	078.8439.00
			206	4	349	ZZA-10	078.8722.00
				4	471	ZZA-9	078.8751.00
			251	5	471	ZZA-11	079.1109.00

*) To combine a 2E and a 3E unit side by side in a rack, use 19″ Adapter ZZA-13.

Note on equipment depth

While for designs D 70 and D 80 the overall depth is uniquely defined by the handles, these constituting the largest projections, the depth for compact cases can be given only by the diagram below, since the operating controls differ according to equipment type.



R&S compact casing system

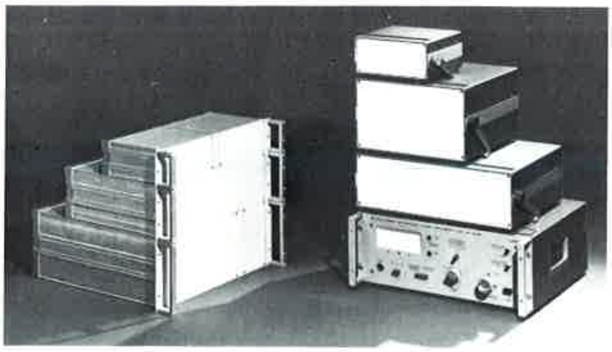
Design 80 is rounded off by a casing system for compact instruments ½ or ¾ or ⅟₁ of 19″ wide, which are also suitable for mobile applications.

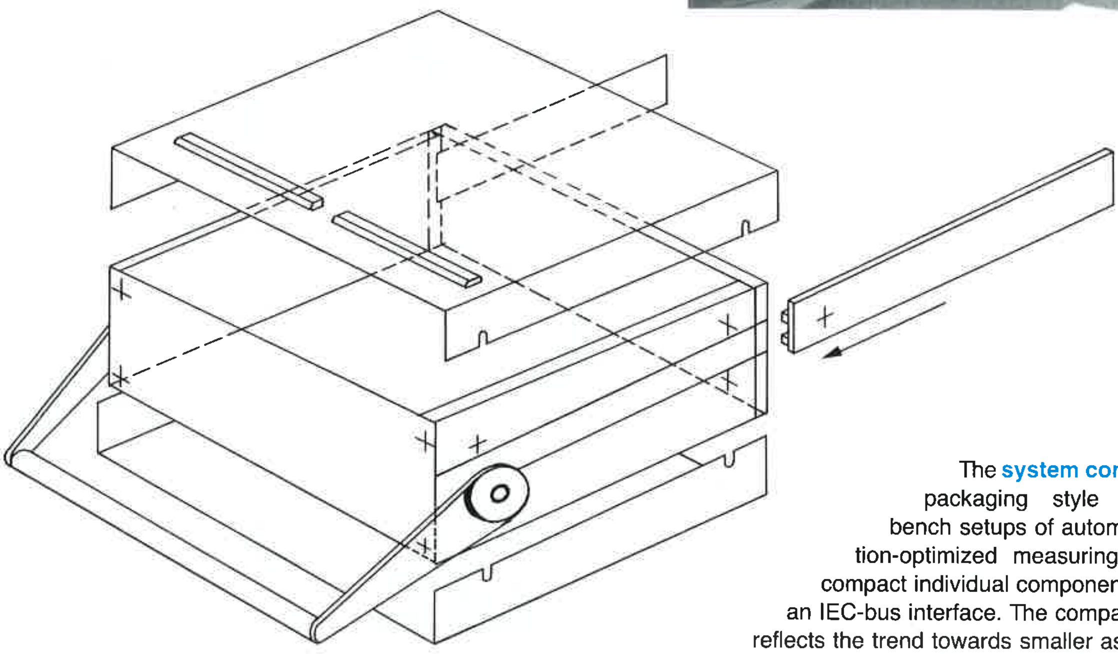
This compact casing system copes with the current trend towards complex modules integrating more and more functions in less and less space and complies with users' requirements for economizing space, on benches and in racks.

This easily manufactured system is just as much in line with the international 19″ standard as design 80; it is similar in layout, but is even more compact and thus particularly suitable for space-saving setups on a bench (drawing below and photo right).

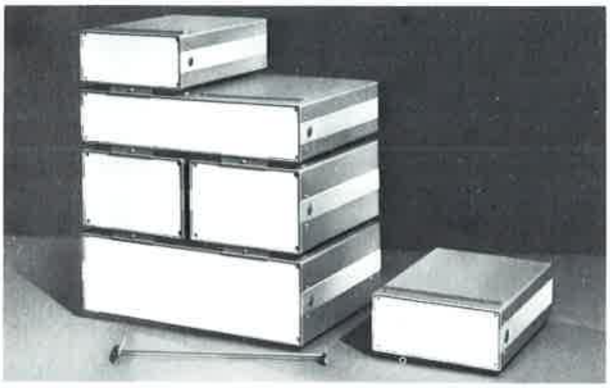
The **emphasis** of this new style is on producing compact, light-weight and thus easily transported instruments for use singly and as building blocks in space-saving test setups on the bench.

Right: compact units of ½, ¾ and ⅟₁ of 19″ width stacked on 19″ design-70 unit; left: different compact units adapted for 19″ rackmounting

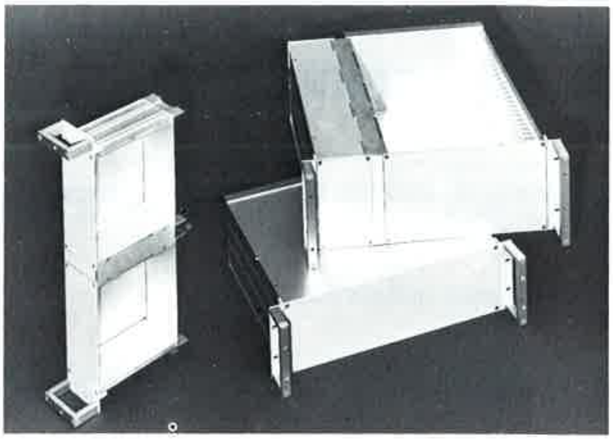




The **system compatibility** of this packaging style enables simple bench setups of automatic and application-optimized measuring systems, using compact individual components, e.g. units with an IEC-bus interface. The compact casing system reflects the trend towards smaller assembly units.

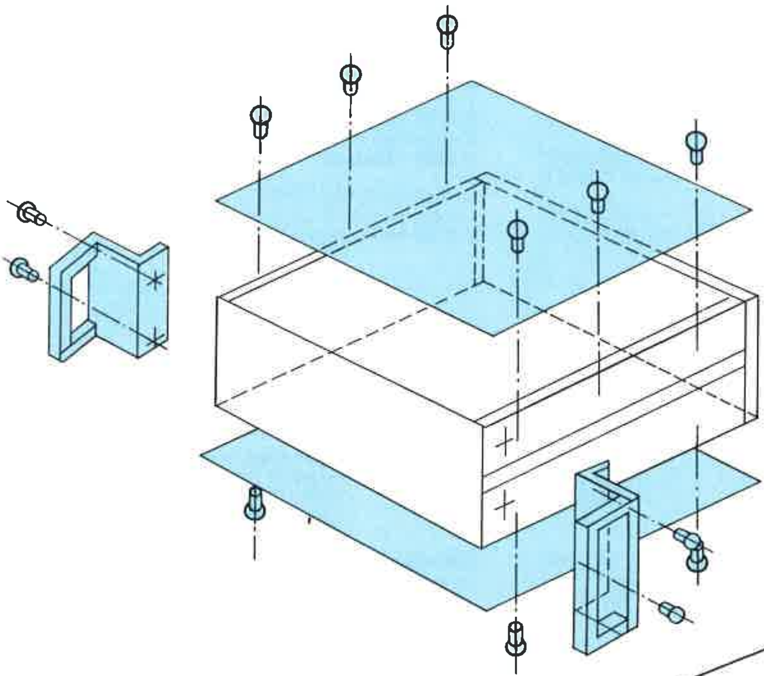


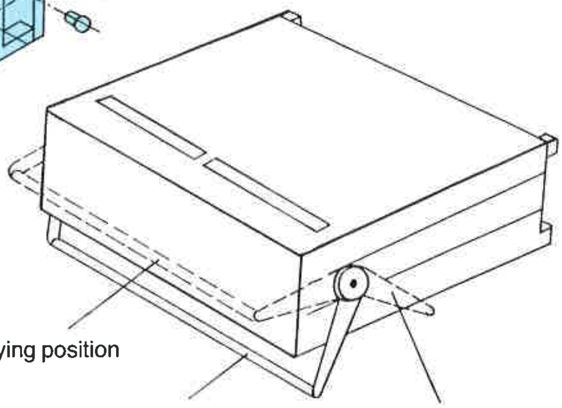
Test assembly made up of compact units, which may be screwed together with connecting elements



Compact cases adapted for 19″ rackmounting, with and without cover

19″ Adapter





The compact units can be stacked with 19″ design-70 and design-80 units and can be fitted into any 19″ rack by means of adapters. The assembly is easy to carry out: first the panelling, the handle and the side strips are removed. After fitting a 19″ adapter (in the simplest case just four parts) the unit can be pushed into a 19″ rack like a 19″ instrument built to design 80 (see drawing and photo above right). Where equipment dissipating a large amount of heat is involved, one unit of height should be left vacant on top and covered by a blank panel.

The **self-supporting construction** of the compact cases complies with standards DIN 40046 (Sheet 8), IEC 68-2-6 and VG 95332 (Sheet 24/25); it enables sturdy, space-and-weight-saving equipment forms (see photo on page 364). Despite compactness there is no lack of servicing ease. Fold-out or snap-in/snap-out circuit boards make for good accessibility in testing and servicing.

The **swivel handle** of the new compact units makes them easier to pick up and put down and also serves as a stand. When units are stacked, the handle can be tucked underneath. It is also easily removed by undoing two screws, if this should be desired, for example, in an assembly of several instruments.

The position of the handle is changed by simultaneously pressing both axles and swivelling.

Rear panel. The compact cases also have a recessed rear panel to protect the connectors when the equipment is set down.

ROHDE&SCHWARZ

ROHDE & SCHWARZ GmbH & Co. KG
D-8000 München 80 · Mühldorfstraße 15 · Postfach 80 14 69
Tel. (089) *41 29-1
+49 89 41 29 1 · Telex 5 23 703 (rs d)
cables: rohdeschwarz muenchen

ROHDE & SCHWARZ HANDELS-GMBH
Ernst-Reuter-Platz 10
D-1000 Berlin (West) 10
Tel. (0 30) 3 41 40 36
Telex 1 81 636 (rshb d)

ROHDE & SCHWARZ VERTRIEBS-GMBH
Zweigniederlassungen

Steilshooper Allee 47
D-2000 Hamburg 60
Tel. (0 40) 6 30 70 46
Telex 2 173 748 (rsvh d)

Graf-Zeppelin-Straße 18 · Postfach 90 01 49
D-5000 Köln 90
Tel. (0 22 03) 2 10 46
Telex 887 4444 (rsvc d)

Technisches Büro Bonn
Meckenheimer Allee 121
D-5300 Bonn 1
Tel. (02 28) 65 80 27
Telex 8 869 569 (rsvb d)

Technisches Büro Frankfurt
Herzogstraße 61
D-6078 Neu-Isenburg
Tel. (0 61 02) 31 36
Telex 4 185 641 (rstf d)

Rüppurrer Straße 84 · Postfach 5229
D-7500 Karlsruhe 1
Tel. (07 21) 3 49 51
Telex 7 826 730 (rsvk d)

Berg-am-Laim-Straße 47 · Postfach 80 14 49
D-8000 München 80
Tel. (0 89) 40 30 73
Telex 524 960 (rsdvm d)

Technisches Büro Nürnberg
Münchener Straße 342
D-8500 Nürnberg 50
Tel. (09 11) 8 67 47
Telex 626 535 (rsvn d)

ROHDE & SCHWARZ
Engineering and Sales GmbH
Graf-Zeppelin-Straße 18 · Postfach 98 02 60
D-5000 Köln 90
Tel. (0 22 03) *49-1
Telex 8 873 288 (rse d)

ROHDE & SCHWARZ WERK KÖLN
Graf-Zeppelin-Straße 18 · Postfach 98 02 60
D-5000 Köln 90
Tel. (0 22 03) *49-1
Telex 8 874 525 (rsk d)

ROHDE & SCHWARZ WERK TEISNACH
Kaikenrieder Straße 27
D-8376 Teisnach
Tel. (0 99 23) 592, 593

MESSGERÄTEBAU GMBH
Riedbachstraße 58 · Postfach 16 52
D-8940 Memmingen/Allgäu
Tel. (0 83 31) *108-0
Telex 54 512 (mbmgn d)

EXPORT		Tel. Telegr. Telex
Argentina Argentinien	Oton R. Klein S. A Carlos Calvo 229 (1102 Buenos Aires) Casilla Correo 568 **1000 Buenos Aires**	(1) 3627770 pioneer baires 18739 (klein ar)
Australia Australien	ROHDE & SCHWARZ (Australia) Pty. Ltd. 13-15 Wentworth Ave. (Darlinghurst, N.S.W. 2010) P.O.B. A 274 **Sydney South,** N.S.W. 2010	(2) 2672622 — 26372 (randsa)
Austria Österreich	ROHDE & SCHWARZ ÖSTERREICH Ges.m.b.H. Sonnleithnergasse 20 **A-1100 Wien**	(222) 626141 — 133933 (rsoe a)
Bangladesh Bangladesh	Business International Ltd. 146/A, New Baily Rd., P.O.B. 727 **Dacca 2**	(-) 405920 sony 65632 (bil bj)
Belgium Belgien	Algemene Elektronica P.V.B.A. Electronique Générale S.P.R.L. Rue des Aduatiques, 71-75 **B-1040 Bruxelles**	(2) 7352193 roelectron 23241 (b)
Bolivia Bolivien	Sistemas Electronicos Hoehne, Ltda. Calle Teniente Oquendo 141, Casilla 5075 **La Paz**	(-) 326880 — —
Brazil Brasilien	Hoos Máquinas Motores S.A. Rua Paula Souza 79-4° and. (01027 São Paulo) Caixa Postal 7500 **01000 São Paulo**	(11) 2282566 maquimotor 1122260 (hoos br)
Brunei Brunei	Logistics Eng. & Maint. Serv. Ltd. Unit 112, 1st Fl.,Bangunan Gadong Kumbang Pasang P.O.B. 298 Mile 2, Jalan Gadong **Bandar Seri Begawan**	(-) 21175 — 2309 (lems bu)
Bulgaria Bulgarien	ROHDE & SCHWARZ Österreich-Service: V.M.E.I. Lenin Dervenitsa, Bl. 2, Room 2534 (BG-1156 Sofia) P.O.B. 43 **BG-1111 Sofia**	(-) 665784 — 22576
Canada Kanada	Rusint Electronics & Sales Canada Ltd. 25 D, Northside Rd. **Nepean (Ottawa) K2H 8S1**	(613) 8293944 — 533662

		Tel. Telegr. Telex
Chile Chile	Importadora Janssen y Cia. Ltda. Agustinas 2356 P.O.B. 13570, Correo 21 **Santiago de Chile**	(2) 91222 oroco 340489 (oroco ck)
Colombia Kolumbien	Hanseatica Cia. Ltda. Calle 15 No. 68 D-78, Ap. Aéreo 14467 **Bogotá** D.E.1	(7) 2624207 hanseatica 44790 (hans co)
Cyprus Zypern	Chris Radiovision Ltd. 23 Crete St., P.O.B. 1989 **Nicosia**	(21) 66121 radiovision 2395 (radoviso cy)
Czecho-slovakia Tschecho-slowakei	ROHDE & SCHWARZ Österreich-Repräsentant: ZENIT Holubova 11 **CS-15000 Praha 5-Radlice**	(2) 536921 — 121801
	ROHDE & SCHWARZ Österreich-Service: Kancelsarske Stroje, K.U.O. Radlicka 2 **CS-15046 Praha 5**	(2) 549233 — **121988**
Denmark Dänemark	Tage Olsen A/S Ballerup Byvej 222 **DK-2750 Ballerup**	(2) 658111 tocopen 35293 (toas dk)
Ecuador Ecuador	SUMITEC. Quisquis 1509-1511, P.O.B. 4492 **Guayaquil**	(-) 396002 sumitec 43361 (pbcgye ed) „para sumitec"
Ethiopia Äthiopien	General Industrial & Commercial Pvt. Ltd. Co. Ras Desta Damtew Av. Kidane Beyene Bldg. P.O.B. 2240 **Addis Ababa**	(-) 41400 gicomco 21192 (gic addis)
Finland Finnland	Orbis Oy Sorolantie 16 (SF-00420 Helsinki 42) P.O.B. 15 **SF-00421 Helsinki 42**	(0) 538066 orbis 123134 (orbis sf)
France Frankreich	ROHDE & SCHWARZ France 45/46, Place de la Loire, Silic 190 **F-94563 Rungis Cedex**	(1) 6872506 ruselec 204477 (ruselec f)

		Tel. Telegr. Telex
Great Britain Großbritannien	ROHDE & SCHWARZ UK Ltd. Roebuck Rd. **Chessington,** Surrey KT9 1LP	(1) 3978771 rusco 928479 (rsukco g)
Greece Griechenland	Mercury Ltd. 8 Sekeri & Kanari St. **Athinai 138**	(1) 3633834, — 214887 (merc gr)
Hongkong Hongkong	Schmidt & Co (H.K.) Ltd., 28 Fl. Wing on Centre 111 Connaught Rd. Centr., G.P.O. 297 **Hongkong**	(5) 8521222 schmidtco 74766 (schmc hx)
Hungary Ungarn	ROHDE & SCHWARZ Österreich-Service: ROZMARING Fehérvári ut. 121, B.O.B. 86 **H-1525 Budapest 11**	 (1) 653187 — 226863
India Indien	Toshniwal Bros. (Delhi) Pvt. Ltd. 3 E/8, Jhandewalan Extension **New Delhi 110055**	(1) 523366 vigyantre 312886 (tbpl in)
Ireland Irland	see Great Britain siehe Großbritannien	
Italy Italien	Roje Telecomunicazioni S.P.A. Via Sant' Anatalone 15 **I-20147 Milano**	(2) 4154 141,-3 rojetel 332202 (roje i)
Japan Japan	Dipl.-Ing. Adolf Zihler Okamoto 5-chome 11-9 (Kobe 658), Port P.O.B. 586 **Kobe 651-01**	(078) 4318485 — 5622150 (zihler j)
Kenya Kenia	ROHDE & SCHWARZ Eng. & Sales Co. Ltd. A.B.C. Place Bldg. 2, Waiyaki Way, P.O.B. 46658 **Nairobi**	(2) 62326 engsales 22030 (engsales)
Luxembourg Luxemburg	see Belgium siehe Belgien	
Malaysia Malaysia	Dagang Teknik SDN BHD 96 M & 98 M, Jalan SS 21/35, Damansara Utama **Petaling Jaya,** Selangor	(–) 787628-29 — ma 37832 (danik)
Mexico Mexiko	MYASA, Maquinaria y Accesorios, S.A. Alfonso Reyes 15 **06170 Mexico 11, D.F.**	(5) 5162512 azuma 1774217 (myacme)
Netherlands Niederlande	ROHDE & SCHWARZ Nederland B.V. Maarssenbroeksedijk 6 A (NL-3606 AN Maarssen) Postbus 233 **NL-3600 AE Maarssen**	(3465) 60324 — 70339 (rsned nl)
New Zealand Neuseeland	Elekon (Overseas) Ltd. 222 Lambton Quay, P.O.B. 10161 **Wellington**	(4) 721728 elkonlit (elekon nz) 30102
Nigeria Nigeria	ROHDE & SCHWARZ (Nigeria) Ltd. 73 Tafawa-Balewa Square, P.O.B. 2278 **Lagos**	(1) 635804 lafaks 22517
Norway Norwegen	Morgenstierne & Co. A/S Konghellegate 3, P. Boks 6688 Rodelökka **N-1010 Oslo 5**	(02) 356110 morof 71719 (morof n)
Pakistan Pakistan	TELEC, Electronics & Machinery Ltd. 415, Mahboob Chambers, Abdullah Haroon Rd., P.O.B. 7430 **Saddar-Karachi 0301**	(–) 512648 elco 2690 (elco pk)
Peru Peru	Estemac Peruana S.A. Avda. Petit Thouars 4620, Casilla 224 **Lima 18** (Miraflores)	(–) 455530 estemac 25385 (pu)
Poland Polen	ROHDE & SCHWARZ Österreich-Repräsentant: T.H.M. Eximpol S.A. ul. Stawki 2, pietro 28 **PL-00-950 Warszawa** ROHDE & SCHWARZ Österreich-Service: INCO ul. Tarnogajska 11/13 **PL-50-950 Wroclaw**	 (22) 398423 — 814640 (7) 674081 — 712357
Portugal Portugal	Mattos Tavares-Electrónica, Lda. R. Grégório Lopes, Lote 1513-1° Restelo (P-1400 Lisboa) Apartado 2171 **P-1104 Lisboa Codex**	(19) 616262 ustamante 12220 (matali p)
Romania Rumänien	ROHDE & SCHWARZ Österreich-Service: I.C.E. Calea Floreasca Nr. 169, Sector 2 **R-72321 Bucuresti 2**	 (–) 333583 — 10076
Singapore Singapur	Assoc. Techn. Services (Pte.) Ltd. 11 Keppel Rd, No. 03-01 Keppel House **Singapore 0208**	(65) 2211533 ateas 21297 (patspor)
South Africa Südafrika	S.A. Electro-Medical (Pty.) Ltd. Stand. Gen. House, 10th Floor, 215 Proes Street (Pretoria 0002) P.O.B. 1784 **Pretoria 0001**	(012) 217431 saelmed 30756
Spain Spanien	REMA Leo Haag S.A. José Abascal No. 18 **Madrid 3**	(1) 4423900 rema 42838 (rema e)
Sweden Schweden	Teleinstrument AB Maltesholmsvägen 138, Box 4490 **S-162 04 Vällingby**	(8) 380370 — 15770 (telinst s)
Switzerland Schweiz	Roschi Télécommunication AG. Giacomettistrasse 15/III, P.O.B. 63 **CH-3000 Bern 31**	(31) 442711 — 32137 (ragbe ch)
Turkey Türkei	Electronic Service & Engineering Necatibey Caddesi No. 90/2 **Karaköy-Istanbul**	(11) 441546 — 23353 (mse tr)
U.S.A. USA	ROHDE & SCHWARZ Sales Co., Inc. 13 Nevada Drive **Lake Success** N.Y. 11042	(516) 4887300 230960072 (rsa ffld)
Venezuela Venezuela	EQUILAB C.A., Centro Seguros La Paz 6° Piso, Locales E-61/N-62 Ava. Francisco de Miranda, Boleita (Caracas 1070) Apartado 60497 **Caracas 1060 A**	(2) 364533 equilab 21860 (equix)
Yugoslavia Jugoslawien	IMP-IZIP Ljubljana, Tozd Marketing n.sol.o. Titova 37 P.O.B. 144 **YU-61001 Ljubljana** ROHDE & SCHWARZ-Service: IMP, – IZIP, Tozd-Tovarna Elektronaprav Vojkova 58 **YU-61001 Ljubljana**	(61) 323788 imp 31348 (yu imp) (61) 345061 — 31599 (yu imp pe)

*N = Article in the specified issue of house journal NEWS FROM ROHDE & SCHWARZ.
I = Detailed information brochure that can be obtained under this number in addition to the data sheet available for each instrument.

*N = Article in the specified issue of house journal NEWS FROM ROHDE & SCHWARZ.
I = Detailed information brochure that can be obtained under this number in addition to the data sheet available for each instrument.

TEST ASSEMBLIES

Test assemblies are generally not allocated a type designation code since they are made up of a number of different instruments.

Although test assemblies can be found by reference to the subject index inside the back cover (e.g. RT test assembly under R), a special alphabetical listing by application area is given here in the interests of clarity and in view of the increasing importance of these high-efficiency measuring systems.

Application area	Designation	Documentation*	Page
Cable, RF	Automatic Test Assembly for RF Cables		118
Car radio	Stereo-car-radio Tester	N 98	28
Components, Modules (AF, RF)	RF Component Tester	N 100	30
	Automatic Test System TSR 6060: digital, analog, hybrid and RF test systems	N 100	32
Field-strength, EMI/EMC, EMI filters	Automatic Test Equipment MSUP 25 to 1000 MHz	N 85	248
	Automatic Test Equipment MSUP + ESH3 9 kHz to 1000 MHz	N 95	249
	Automatic Test System for Useful and Interfering Signals	N 97	29
Group delay	Group-delay Measuring Set LFM 2,	N 94	350
	see also under "Network analysis"	N 83	146
Intermodulation/ cross modulation	Automatic Test Assembly for Intermodulation and Crossmodulation Measurements	N 62, 74	116
Logic measurements	Logic Analyzer System IMAS/IMAT	N 97, 98	299
Network analysis; impedances, group delay, s-parameter	Computer-controlled Network Analyzer ZPV+ computer	N 79, 82, 83, 84 N 86; I 001 1 06	146
	s-parameter Test System		28
Radio equipment, general	Automatic Radio Test System ATS-TR4		26/100
	Test System to CEPT T/R 17 (for AM-, φM-, SSB transceivers)	N 98	27
	Reference System for Transceiver Test	N 102	27
Radiotelephony equipment	Radiotelephone Test Assembly SMDU	N 73	104
	Mobile Testers SMFP 2/SMFS 2	N 94	80
	Automatic RX/TX Tester SMAT	N 94	94
Swept-frequency measurements	Polyskop SWOB 5	N 85, 89 I 001 102	132
VOR-ILS airborne equipment	Test Assembly for Airborne VOR-ILS and Communication Equipment	N 71, 82	110

*N = Article in the specified issue of house journal NEWS FROM ROHDE & SCHWARZ.
I = Detailed information brochure that can be obtained under this number in addition to the data sheet available for each instrument.

Order numbers

In handling orders R&S makes use of electronic data processing and a corresponding system of order numbers. The first seven digits of these **nine-digit numbers** identify the equipment and the last two digits specify the model (50-Ω or 60-Ω impedance, cabinet or rackmount, etc.).

Symbols

The meaning of the symbols used in the tables and texts is given below:

a to b	a is the initial value and b the end value, regardless of whether the intervening range is divided into subranges or not. The range is continuously adjustable between the two values.
a/b/c/d	values a, b, c and d are adjustable in steps
a to b/c/d	short for a to b, a to c, a to d
a/.../b	uniform steps, such as decades
I... II...	the instrument has various test channels, inputs or outputs, etc.
a (b)	the value in parentheses, which is generally inferior, is only applicable at the limits of the frequency or measurement range.
(W×H×D)	overall dimensions: width×height×depth in mm. An additional size code number (e.g. 3B) refers to the rackmount version; for details see page 366.

Data without tolerances: order of magnitude only.

Subject to change.

READER SERVICE

ROHDE & SCHWARZ

Please use the attached reply cards if you would like to receive more information on the products described in this catalog, e.g. data sheets, a detailed quotation or a demonstration.

Any documentation on our products available in addition to the data sheets is listed in the "Index by instrument type".

You will find the address of your nearest R&S representative on pages 370 and 371.

ROHDE & SCHWARZ

MEASURING INSTRUMENTS CATALOG READER SERVICE CARD 1984

I would like to receive more information on the following products:

Equipment (Type/page)	Data Sheet	Quotation	Demonstration

Name/Company: ______

Address: ______ Telephone: ______

Date:

ROHDE & SCHWARZ

MEASURING INSTRUMENTS CATALOG READER SERVICE CARD 1984

I would like to receive more information on the following products:

Equipment (Type/page)	Data Sheet	Quotation	Demonstration

Name/Company: ______

Address: ______ Telephone: ______

Date:

ROHDE & SCHWARZ

MEASURING INSTRUMENTS CATALOG READER SERVICE CARD 1984

I would like to receive more information on the following products:

Equipment (Type/page)	Data Sheet	Quotation	Demonstration

Name/Company: ______

Address: ______ Telephone: ______

Date:

ROHDE & SCHWARZ

MEASURING INSTRUMENTS CATALOG READER SERVICE CARD 1984

I would like to receive more information on the following products:

Equipment (Type/page)	Data Sheet	Quotation	Demonstration

Name/Company: ______

Address: ______ Telephone: ______

Date:

Other enquiries, comments, etc.:

Affix postage here

(Please enter the address of your nearest R&S representative)

Other enquiries, comments, etc.:

Affix postage here

(Please enter the address of your nearest R&S representative)

Other enquiries, comments, etc.:

Affix postage here

(Please enter the address of your nearest R&S representative)

Other enquiries, comments, etc.:

Affix postage here

(Please enter the address of your nearest R&S representative)

subject index

this catalog describes

Automated computer-controlled test systems (IEC bus)
Test assemblies for module and component testing
Signal generators and AF, RF and RT test assemblies
Swept-frequency test equipment and network analyzers
Standard-frequency and standard-time systems

Voltmeters
Power meters
Recorders
Selektive voltmeters
Test receivers and field-strength meters

Wave and modulation analyzers

Acoustic test equipment, sound-level and noise meters

Terminations, attenuators
Coaxial components

Logic test equipment

Power supply units

other products

Test equipment for television
and sound broadcasting

Mobile and fixed transmitters, receivers, antennas
for HF, VHF sound broadcasting and television
of all standards

TV transposers and relay receiving systems

Direction finders, ATC and radiolocation systems
Ground and airborne transceivers
Automated check-out systems

Multicouplers and tuning units
Antenna rotators, remote-control systems

ROHDE & SCHWARZ

50 YEARS of **electronic precision** 1933-83

ROHDE & SCHWARZ GmbH & Co. KG
D-8000 München 80, Mühldorfstr. 15, P.O.B. 80 14 69
Tel. (0 89) 41 29-1 · International +(49 89) 41 29-1
Telex 5 23 703 (rus d) · Telegrams rohdeschwarz muenchen

Printed in the Federal Republic of Germany · Subject to change 883 (W)