HEWLETT hp PACKARD

BENCH BRIEFS

SERVICE INFORMATION FROM HEWLETT-PACKARD

MARCH–APRIL 1977

Signature Analysis

A NEW CONCEPT IN DIGITAL TROUBLESHOOTING

by Jim Bechtold, Editor

Troubleshooting an analog circuit is a lot like playing horseshoes — being close counts — but the digital world is unforgiving. One bad bit out of a thousand can cause a malfunction. The technique of signature analysis finds those bad bits.

The HP 5004A Signature Analyzer is a technician's tool for field troubleshooting microprocessor-based instruments down to the component level, when the instrument has been designed with the necessary features required for signature analysis. It has been learned that although the microprocessor has simplified instrument design, it has complicated troubleshooting to no end. However, when signature requirements are designed into an instrument, the 5004A can process lengthy bit streams from the instrument into short four-digit signatures (see Figure 1 for examples). The technician compares these with the correct signatures noted on the instrument's schematic. If a bit stream is faulty the technician can trace it back through gates and memory elements until he isolates an element with correct inputs but faulty outputs. This method has a 99.998% certainty of spotting a faulty bit stream, regardless of its length or how subtle its faults.

Signature analysis uses the advantages of analog equipment troubleshooting where the service man uses an annotated schematic (see Figure 2 for an example) that clearly shows voltages and waveforms and allows him to make repairs *without* a detailed understanding of the circuits. By comparing actual voltmeter readings and oscilloscope traces to those displayed on the schematic, he determines the point at which circuit operation becomes faulty and from there traces the problem back to a failed component in the unit.

But in the programmed digital world, service schematics are devoid of waveform voltage and other service information for the not very comforting reason that all bit streams look pretty much alike on an oscilloscope. The problem is compounded with microprocessors, state machines, and controllers, for a more subtle reason: with them there is no longer a one-to-one association between product features and particular sections of hardware. For example, if a keyboard-debouncing function fails in an older random-logic product, a service manual might advise checking the integrated circuits that control that function. With microprocessors, on the other hand, key debouncing is more likely a timeshared function, tying up the whole processor for a brief moment. When it fails, any one of a large number of IC's could be faulty.

The signature analyzer is a troubleshooting tool designed specifically for microprocessor-based products. More instruments that are microprocessor based will be introduced this year than the sum of all computer systems installed to date. Microprocessors are relatively low in cost and easy to design around. But, they are just as complex and difficult to repair as computers because of time-related faults. Industry predicts that ten million IC's will fail in the field this year, many of them in microprocessor products, which will cost one to two billion dollars in repairs. Thus, the signature analyzer promises to have a significant impact on present service costs.

THE TECHNIQUE IN USE

As an example, consider the first HP instrument to use signature analysis — the 3455A Digital Voltmeter from the HP Loveland Instrument Division in Colorado. The digital portion is quite extensive; it is microprocessor controlled and contains a self-test program stored in ROM. If the self-test fails, a jumper inside the enclosure is removed breaking feedback loops and also enabling the signature-analysis routine which is used now to diagnose the instrument. The decision to go with signature analysis influenced the product design in several ways, all of which make it easier to troubleshoot down to the component level. The whole digital portion is on one board. The elimination of connectors and a multitude of smaller PC assemblies reduce the production cost and also make all the parts easily accessible for testing without the use of special extender boards.

Naturally, some extra design time, a few more ROM locations and the extra jumper wire were the price paid for this kind of serviceability. The cost evaluation proved to be interesting: the production cost actually fell and the extra design time amounted to approximately 1% of the overall development time. Toward the goal of serviceability Hewlett-Packard now has about 40 projects underway, with some products already being introduced.

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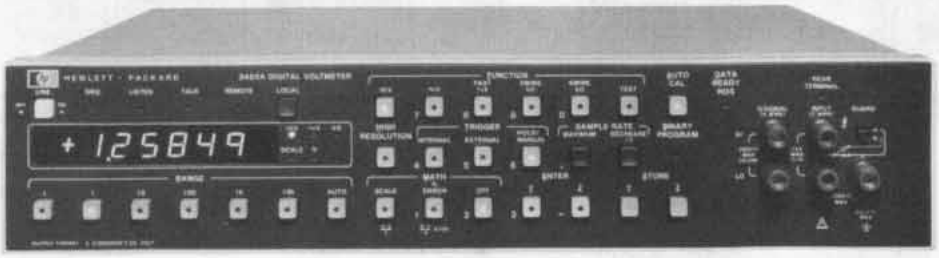


THE OPERATING AND SERVICE MANUAL

Besides the design engineer, the writer of the service manual made an important contribution to the successful application of the signature analysis to the 3455A Voltmeter. The service manual is written in such a way that a technician, unfamiliar with the signature analyzer can walk up to a defective voltmeter, read the instructions and within a short time locate the fault. One element in the manual is a troubleshooting flow chart (see Figure 3) that systematically guides the technician through the fault finding process.

The initial tests may or may not rely on signature analysis. They allow isolation of the fault down to a specific area. Diagnostic programs cannot carry on from here, since they do not have access to individual nodes, but it is from here on down to the components that signature analysis excels.

At this level the repair man uses the annotated schematics and graphs of board layouts together with the flow chart, to find the bad node. A node is defined as a terminal of any branch of a network, or a terminal common to two or more branches. Also called junction point, vertex or nodal point. In some cases the manual includes instructions as to which IC to replace. In other cases the use of a logic probe, which is an integral part of the logic tracer may be required. A current sensor, such as the HP 547A, helps to find short circuits between traces or to ground and is particularly helpful when bus problems are encountered.

The 3455A Service Manual shows pictures of the board and defines the set up for each test (see Figure 3). Each picture shows only the signatures related to the particular test directing the technician's effort toward the important areas on the board. The ROM program even simulates interrupt signals, ensuring however, that they occur predictably at the same spot within a window so that stable signatures result.

The signature analyzer has its own self check. Each test set up is tested by touching the power supply voltage with the instrument's probe to input a sequence of all one's. If this characteristic signature is correct the setup conditions and framing of the measurement window are verified. Specifically, this tells the user that the switches on the signature analyzer, as well as all the jumpers, switches and control buttons in front and rear of the voltmeter are correctly set. This means the confidence level of the user is very high at the start of a test.

WHAT'S A SIGNATURE?

Everything depends on the signature. A kind of compressed "fingerprint" of the data present on a node, it is compared with the correct signature printed on the schematic of the product so that any discrepancy may be noted and traced to the source. The signature is derived through linear-fedback shift registers, which generate pseudo-random binary sequences. For signature analysis, bit sequences being measured are summed in modulo 2 with the register feedback. The register is clocked by the same clock as the bit stream under measurement. Input sequences may be any length, but at the end of the measurement, only the residue remaining in the register is looked at. These 16 bits, when displayed in a 4 digit format, comprise the signature of the measured bit stream. Figure 4 shows a simplified block diagram of this concept.

DESIGNING IN SIGNATURE ANALYSIS

A portion of the circuits read-only-memory — perhaps 5% — must contain a special program for stimulating the various nodes in the circuits. The stimulation serves more to excite or force a state change on the nodes, than to generate meaningful data. Frequently this stimulus program may be merged with the products performance-verification program. The correct signatures are developed by simply exercising the various parts of a circuit that is known to be good and noting the results on the circuit diagram.

A second requirement is to break feedback paths within the circuit, either by using hardware switches, jumpers or connectors, or by disabling gates with software. This requirement is necessary to prevent a fault from being fed back around and disturbing all data nodes. When these two requirements are met, back tracing a fault to its source is a straight forward process of tracing faulty signatures.

In using signature analysis the procedure varies slightly, depending on whether the fault lies in the kernel (the minimum configuration of microprocessor and ROM necessary to run the simplest test program) or in the outlying circuitry.

If the fault is in the outlying circuitry (a keyboard or display scanner, input/output latch, etc.) the technician simply switches the circuit to the diagnostic mode. Then, guided by the manual, he uses the test instrument to trace faults back to their source. But what if the problem lies in the kernel, and even the ROM stimulus program will not run? Here, the microprocessor itself can provide a stimulus if its address counter is allowed to sequence through the address field. To do this it is only necessary to open the data/instruction bus and force the no-operation instruction onto it. This stimulus program checks out all the address lines and the individually enabled ROMs as well. All of these nodes are readily characterized with signatures.

Since signature analysis relies on the ability of an instrument to control itself in a synchronous manner, asynchronous circuits, like monostables direct-memory-access, dynamic memory, or interrupts, need to be carefully controlled. Generally, simple provisions in the hardware can be made to force them into a synchronous or disabled condition when that is required for a particular test.

In summary, HP expects the Signature Analyzer to have a significant impact on our own in-house service costs. True, there are some design costs to be accounted for in the new products utilizing signature analysis. However, in the long run, these costs will be more than offset by the serviceability of the instrument. And, as of today Signature Analysis is the first new and workable concept for servicing microprocessor based instruments.

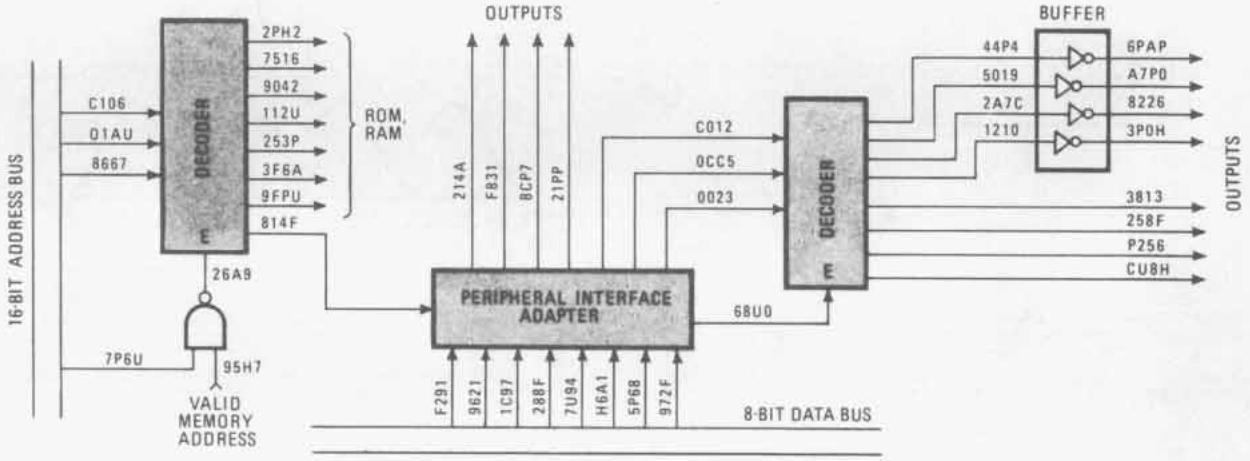


FIGURE 1. Example of Block Diagram with Signatures

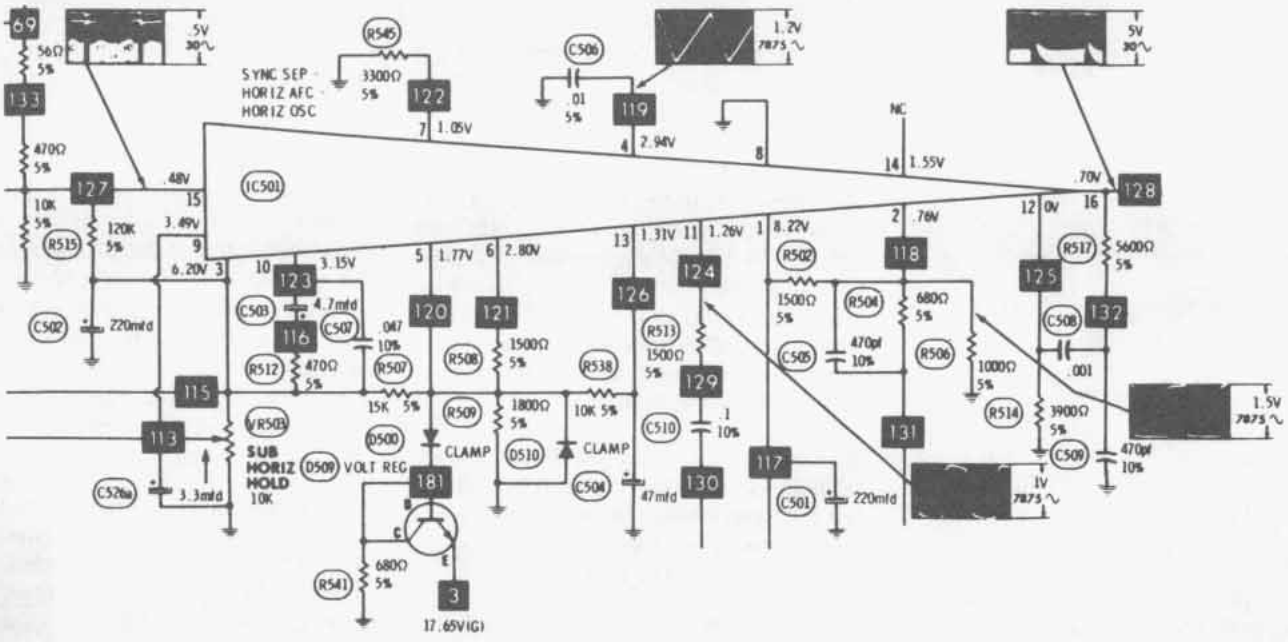


FIGURE 2. Example of Annotated Analog Schematic (Courtesy SAMS)

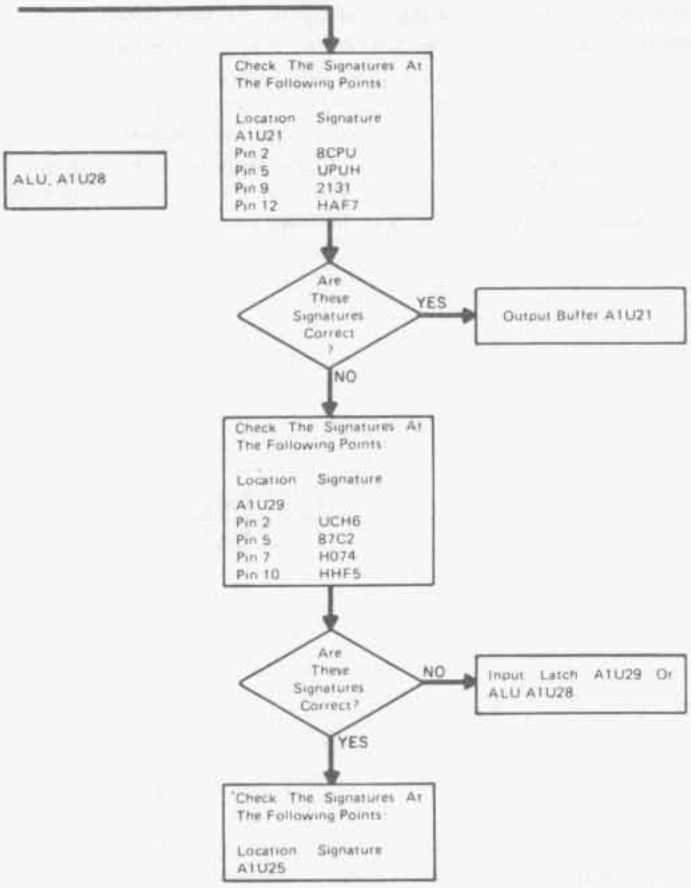
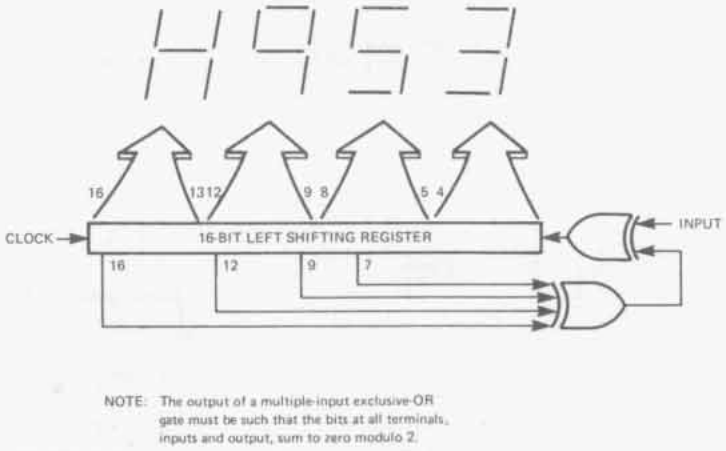


FIGURE 3. Example of Troubleshooting Flow Chart (from 3455 DVM manual)



NOTE: The output of a multiple-input exclusive-OR gate must be such that the bits at all terminals, inputs and output, sum to zero modulo 2.

FIGURE 4. Simplified Block Diagram of the Signature

ATTENTION 3476A/B MULTIMETER OWNERS

Two new Service Notes have been issued for your multimeter that show modifications to improve OHMS protection and operating performance.

Service Notes 3476A-3 and 3476B-2 describe a modification that may be desired for all 3476A's serials prior to 1619A05840 and 3476B's serials prior to 1617A05610. This modification increases the input voltage protection of the ohmmeter circuits from 30 volts rms (where the 32 milliamperes fuse, F2, now blows) to 150 volts rms. This modification should help in the case of accidental application of voltage between the volt–ohm input terminals and COM terminal when in the ohms function.

To determine if your 3476 has already been modified, examine A1R2. If A1R2 is a 5 kilohm resistor the modification has been made. Otherwise, make the changes as described in Table 1.

Service Notes 3476A-4 and 3476B-3 describe a modification to improve performance on 3476A's serials prior to 1619A05840 and 3476B's serials prior to 1617A05610. The 3476 sometimes exhibits the overload condition (five horizontal bars) with the instantaneous application of about 1000 volts dc or 700 volts rms. A gradual increase in voltage to these values will not cause an overload indication.

TABLE 1.

BOARD NUMBERS	COMPONENT DESIGNATOR	OLD PN	NEW PN
03476-66501 03476-66511	A1R2	0698-8748 1 KΩ, 5%, 2W	0811-0006 5 KΩ, 1%, 5W
03476-66501 03476-66511	A1R4	0757-0440 7.5 KΩ, 1%, 1/8W	0698-3152 3.48 KΩ, 1%, 1/8W

In the event a 3476A fails to respond to a step input, R51 which is in series with pin 6 of U1 should be changed from -hp- part number 0683-1035 (10 kilohm, 5%) to part number 0683-1025 (1 kilohm, 5%). General location of R51 is shown in Figure 1.

CUSTOMER SERVICE SEMINARS

Hewlett-Packard continually offers training to customers on a worldwide basis to help keep service skills current with HP's extensive product line. Seminars are provided throughout Europe and the United States in an effort to bring our training facilities closer to your area. For registration please use the form on page 15 of *Bench Briefs* or contact your Hewlett-Packard Sales and Service Office.

141T, 8552A/B, 8553B, 8554B, 8555A SPECTRUM ANALYZERS MAY 9-12, PARAMUS, NJ

COURSE CONTENT

LECTURE

I. Block diagram related to front panel controls. Optional viewing of video tape "141T/8552B/8553B Spectrum Analyzer Operation", 90030_607, 26 minutes.

II. Video tape, "141T/8552B/8554B Spectrum Analyzer Operation", 90030_646, 20 minutes

III. Overall block diagram and system description

IV. Detailed block diagram

V. Circuit descriptions
   - A. Input circuits
   - B. First, second and third mixers and IF stages
   - C. YIG drive circuits
   - D. 50 MHz amplifier
   - E. Marker generator
   - F. Phase-lock circuits

VI. Troubleshooting techniques ("bugged" instruments with typical failures)

VII. Repair cautions and mechanical tuning adjustments

LAB

I. Front panel familiarization

II. Change first mixer

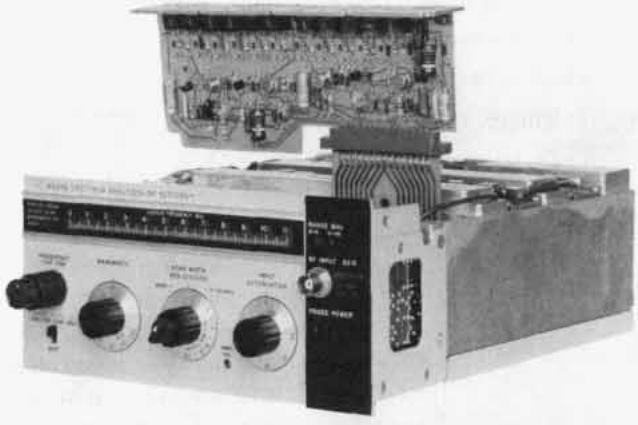
III. Set up YIG frequency

IV. Normal calibration

PREREQUISITES – None

PRESTUDY – Read Application text 150, "Spectrum Analysis . . . Spectrum Analyzer Basics"; View video tape "141T/8552B/8554B Spectrum Analyzer Operation", 90030_646, 20 minutes (Optional)

– Read Application text 136, "Understanding and Operating the 8555A Spectrum Analyzer and 8445B Automatic Preselector"; View video tapes "141T/8552B/8555A Spectrum Analyzer Operation", Part I, 90030_647, 28 minutes and Part II, 90030_697, 18 minutes (Optional)



3050B DATA ACQUISITION SYSTEM
JULY 11-14 (3-1/2 DAYS), LOVELAND, CO

COURSE CONTENT

LECTURE

I. 3495A Scanner
   - A. Operation
   - B. Theory of Operation
   - C. Troubleshooting

II. 3490A Multimeter
   - A. Operation
   - B. Guarding
   - C. Theory of Operation
   - D. Troubleshooting

III. Hewlett-Packard Interface Bus

IV. Calculator Control of HP-IB

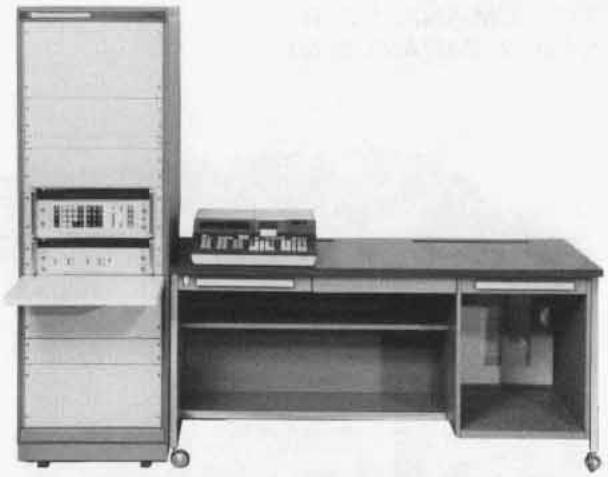
LAB

The lecture is given in a lab environment.

PREREQUISITES – Must be familiar with Sections I through V of the 3490A, 3495A, and 59405A Manuals. Must have read "Interface Bus User's Guide" for the appropriate calculator and "Condensed Description of the Hewlett-Packard Interface Bus".

PRESTUDY – 3595A, 3490A, 59405A Manuals, Interface Bus User's Guide, and Condensed Description of the Hewlett-Packard Interface Bus.

3040A NETWORK ANALYZER
JULY 18-20, LOVELAND, CO
AND
3042A NETWORK ANALYZER
JULY 18-22, LOVELAND, CO



NOTE: 3042A instruction same as 3040A plus two additional days (July 21-22)

COURSE CONTENT

LECTURE AND LAB

I. Introduction To Low Frequency Network Analysis

II. 3330B Synthesizer
   - A. Operation and Specifications
   - B. Theory of Operation
     1. Block Diagram of Amplitude Section
     2. Block Diagram of Frequency Section
     3. Reference Frequency Section
   - C. Unique Circuitry
     1. ÷N Loops
     2. Logarithmic Amplitude Control by Reference Frequency
   - D. Introduction to Algorithmic State Machines
     1. Basic ASM Concepts
     2. Functional Discussion of Controller Section
   - E. Repair and Calibration
   - F. Service Literature and Service Kits

III. 3570A Network Analyzer
   - A. Operation and Specifications
   - B. Theory of Operation
     1. Block Diagram of Amplitude Section
     2. Block Diagram of Digital Section
   - C. Calibration and Adjustments (Special Emphasis on Crystal Filter Adjustment)

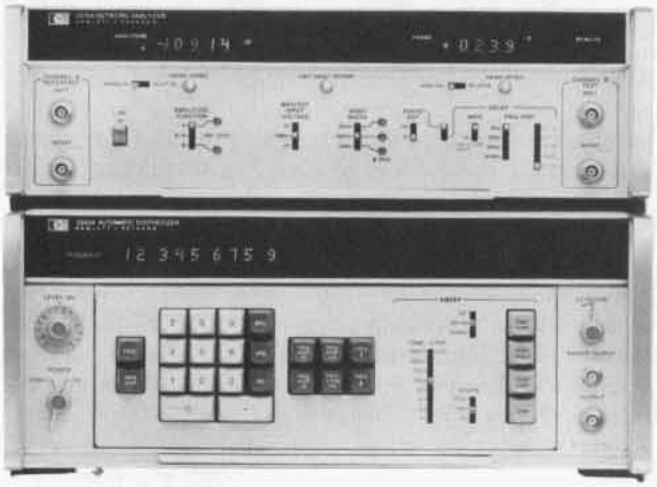
D. Troubleshooting
   1. Troubleshooting the Measurement Channels
   2. Troubleshooting the Digital Channels
E. Service Literature and Service Kits

IV. Hewlett-Packard Interface Bus
   A. Description
   B. Interfacing

V. 3042A System
   A. Basic System Concepts
   B. System Operation
   C. System Performance
   D. Controllers
   E. Programming
   F. Interfacing
   G. System Troubleshooting
   H. System Service Kits and Service Literature

PREREQUISITES – should have read the Interface Bus User's Guide for the appropriate calculator and the Condensed Description of the Hewlett-Packard Interface Bus. Must also be able to operate and program the appropriate calculator.

PRESTUDY – Interface Bus User's Guide and Condensed Description of Hewlett-Packard Interface Bus. Also 3330B and 3570A Manuals.



8640 AM/FM SIGNAL GENERATOR
8660 SYNTHESIZED SIGNAL GENERATOR
435/436 POWER METERS
8480 SENSOR AND 11683A CALIBRATOR
AUG 29-SEPT 2, PALO ALTO, CA

COURSE CONTENT

LECTURE

I. Introduction

II. Features and Model Options

III. Front Panel Features
   A. Video Tape
   B. Demonstration

IV. Theory
   A. Block Diagram
   B. Assembly Locations
   C. Schematic

LAB

I. Adjustments

II. Performance Tests

III. Troubleshooting

PREREQUISITES – Basic knowledge of digital logic circuits and general knowledge of electronics including operational amplifiers and phase lock circuits.

PRESTUDY – Review digital logic and block diagram information in 8640, 8660 and 435/436 manuals.

Read pages 1-48 in "Signal Generator Seminar" textbook.

View video tape 90030__566 (Optional).

5340A MICROWAVE FREQUENCY COUNTER
SEPT 1-2, PARAMUS, NJ

COURSE CONTENT

LECTURE

I. Overall Block Diagram

II. Numerical Examples of Frequency Measurements

III. Input Phase Lock Loop Circuit Description

IV. Transfer Phase Lock Loop Circuit Description

V. Instrument Flow Diagram and Algorithmic State Machine

VI. Options

LAB

The lecture is given in a lab environment. Attendees make voltage and waveshape measurements at different times during the lecture. A familiarization with adjustment procedures is also included.

PREREQUISITES – Basic knowledge of microwave measuring techniques

PRESTUDY – April 1973 HP Journal describing 5340A. "The Fundamentals of Electronic Frequency Counters", Application Note 172.

DIGITAL TROUBLESHOOTING TECHNIQUES

INTRODUCING MODERN DIGITAL TECHNOLOGY AND TROUBLESHOOTING TO THE ANALOG REPAIRMAN
JUNE 7 - 10

PACIFICA HOTEL
6161 Centinela Blvd.
Culver City (Los Angeles Area)
CA 90230
(213) 649-1776

FIRST DAY

- Analog vs. digital.
- IC Technology: DCTL, RTL, DTL, CTL, TTL, ECL, EECL, HTL, MOS, I^2L.
- Specialized tools and techniques to troubleshoot these technologies.
- Workshop – four hours of hands-on experiments with gates and troubleshooting tools.

SECOND DAY

- Logic Symbology.
- Positive/Negative logic notation.
- Understanding the implication of logic schematics.
- Implementation of logic gates: AND, OR, NOR, NAND, XOR, Wired-OR.
- Decoders and their uses.
- Comparators and their uses.
- Flip-flops: R-S, D, J-K (standard and master-slave).
- Workshop – four hours of hands-on experiments with decoders, comparators and flip-flops.
  Students will also have an opportunity to use modern tools to troubleshoot faults in a printed circuit assembly.

THIRD DAY

- Often encountered circuits containing flip-flops: Counters (BCD and binary, synchronous and ripple), dividers, shift registers, ring counters.
- Numbering systems including binary, BCD, octal and hexidecimal.
- Introduction to binary math including half and full adders.
- Workshop – four hours of hands-on time building and debugging counter circuits.

FOURTH DAY

- ROM'S/PROM (masked, E and UV).
- RAM'S: bipolar and MOS (static and dynamic).
- Typical failures and the troubleshooting difficulties encountered with ROM'S, PROM'S and RAM'S.
- Typical memory addressing techniques.
- Modern display technologies, their application and common failure modes.
- Introduction to the ROM controlled device with emphasis on methods used to fault isolate.
- Workshop – four hours of experiments leading to the building of a functioning strobed display device.

SAFETY-RELATED SERVICE NOTES

Service Notes from HP relating to personal safety and possible equipment damage are of vital importance. To make you more aware of these important notes, HP has recently modified the Safety Service Note format. The note is now printed on paper with a red border, and a "–S" suffix has been added to the note's number. In order to make you immediately aware of any potential safety problems, we are highlighting safety-related Service Notes here with a brief description of each problem. Also, in order to draw your attention to safety-related Service Notes on the Service Note order form at the rear of *Bench Briefs,* each appropriate number is highlighted by being printed in color.

463A AC Amplifier

Up to 210 volts ac may exist on the output terminals of the 463A with no input applied. Such a voltage on the 463A output terminals can be caused by:

- The amplification of noise in the environment
- A signal coupling between input and output through attached leads, and the subsequent amplification of this feedback signal
- A failure in the 463A.

Since the function of a high gain ac amplifier requires the amplification of low level ac signals to a high voltage level, the prevention of the conditions described above would severely degrade the performance of any high gain ac amplifier.

We therefore recommend that extreme caution be exercised when using a high gain ac amplifier such as the 463A.

740B DC Voltmeter

740B DC Voltmeters with serials 61000375 and below may have a defective range switch S1 that would put up to 1500 volts on the input terminals.

Examine the G wafer of the range switch. The absence of a blue wire attached to pin 17 on the front of the G wafer and the absence of a 10 ohm resistor between pins 7 and 15 on the front of the G wafer indicates that the range switch should be replaced.

The replacement switch is HP part number 00740-61907. Please refer to Service Note 740B-9-S for more information.

3459A Digital Voltmeter

Some 3459A Voltmeters have a potential shock hazard in that if the instrument is floated above ground, the "RATE" control shaft (and control knob set screw) is above ground potential. Use the following procedure to test your instrument for this potential shock hazard.

1. Turn the power switch off, disconnect all power cords and signal cables. Connect the ground strap between INPUT LOW and INPUT GUARD terminals (this tests both terminals at the same time).
2. Set an ohmmeter to the 1 kilohm range and connect one lead to the INPUT LOW or GUARD terminal.
3. Connect the other ohmmeter lead to the set screw on the front panel RATE control.
4. The ohmmeter should indicate infinity. If not, order the following parts and Service Note to modify the 3459A to conform to current safety standards.

Service Note 3459A-12

1 ea	14.5 mm round knob	0370-2551
1 ea	14.5 mm knob cap	0370-2553
1 ea	Warning label	7120-4082

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supplement to

BENCH BRIEFS SERVICE NOTE INDEX

NEED ANY SERVICE NOTES?

Here's the latest listing of Service Notes available for Hewlett-Packard products. To obtain information for instruments you own, remove the order form and mail it to the nearest HP distribution center.

463A PRECISION AC AMPLIFIER
463A-3A-S. All serials. Elimination of potential safety hazard. Supersedes 463A-3.

618C SHF SIGNAL GENERATOR
618C-12. Serial prefixes 1546A and below. Preferred replacement for Q1.

620B SHF SIGNAL GENERATOR
620B-14. Serial prefixes 1546A and below. Preferred replacement for Q1.

740B DC STANDARD/DIFFERENTIAL VOLTMETER
740B-9-S. Serial Number 61000375 and below. Elimination of potential safety hazard.

1220A OSCILLOSCOPE
1220A-25. All serials. Improved knobs.

1222A OSCILLOSCOPE
1222A-5. All serials. Improved knobs.

1310A DISPLAY
1310A-17/1311A-18. All serials. Power transformer part number error.

1311A DISPLAYS
1310A-17/1311A-18. All serials. Power transformer part number error.

1402A DUAL TRACE AMPLIFIER
1402A-10. All serials. Loss of alternate operation in some 14X series mainframes.

1740A OSCILLOSCOPE
1740A-5A. Serials 1533A and below. Modification to improve vertical amplifier balance and gain.
1740A-6A. Serials 1541A and above. Modification to improve vertical amplifier balance.
1740A-11A. Serials 1616A-01725 and below. Modification to eliminate short sweep problem.

1741A OSCILLOSCOPE
1741A-1. Serials 1624A00550 and below. Preferred replacement for A15R15 and A15R16 focus resistors.

3400A RMS VOLTMETER
3400A-9. All serials. Preferred range switch replacement.

3459A DIGITAL VOLTMETER
3459A-12. All serials. Revision to minimize shock potential.

3460A/B DIGITAL VOLTMETER
3460A-16B/3460B-11A. All serials. Elimination of a potential safety hazard. Supersedes 3460A-16A/3460B-11 (Dated 10/75-09), 3460A-16/3460B-6 (Dated 7/75-09). Does not supersede 3460B-6 dated Sept. 1967-9.

3476A/B DIGITAL MULTIMETER
3476A-3. Serials 1619A05840 and below. Modification to improve ohms protection.
3476A-4. Serials 1619A05840 and below. Modification to improve performance.
3476B-2. Serials 1617A05610 and below. Modification to improve ohms protection.
3476B-3. Serials 1617A05610 and below. Modification to improve performance.

3490A MULTIMETER
3490A-1C. All serials. Replacement of optical isolation assemblies.
3490A-9A. All serials. Preferred LED display replacement.
3490A-12A. All serials. Intermittent failures.

3495A SCANNER
3495A-1. All serials. Installation of low thermal relay assemblies connector guide.

3556A PSOPHOMETER
3556A-U-1003. Serials 1547U and below. New battery modification.

3570A NETWORK ANALYZER
3570A-2A. All serials. Recommended replacements for 03570-66555 log amplifier/ 03570-66556 output buffer boards and adjustment procedures.
3570A-3A. All serials. Replacement parts changes.
3570A-4A. All serials. Recommended replacements for 03570-66551 (50 ohms)/66558 (75 ohms) input amplifier and adjustment procedures.

3570A NETWORK ANALYZER
3570A-7A. Serials 1331A00386 to 1331A00670. Procedure to replace air capacitor.

3701A TRANSMITTER
3701Z-6. Serials 1119U-01176 and below. Preferred replacement for rectifier assy (A22).

3702B IF/BB RECEIVER
3702B-34A. Serials 1642U-01746 and below. Modification to prevent possibility of D.C. offset on I.F. display.

3702Z DEMODULATOR DISPLAY
3702Z-8. Serials 1119U-01176 and below. Preferred replacement for rectifier assy (A24).

3745A/B SELECTIVE LEVEL MEASURING SET
3745A/B-2. Serials 1645U and below. Modifications to prevent incorrect phase jitter readings in presence of noise.
3745A/B-4. Serials 1607U and below. Modification to improve performance.
3745A/B-6. Serials 1647U and below. Recommended modification to improve operation of +5.2V power supply.
3745A/B-7. All serials. Troubleshooting and adjustment procedures for XY driver assembly A601 03745-66001.

3761A ERROR DETECTOR
3761A-6. Serials 1707U-00306 and below. Modification to improve performance 150MB/S NRZ data input.

3770A AMPLITUDE/DELAY DISTORTION ANALYSER
3770A-30. All serials. Preferred replacement of A23R5.
3770A-31. All serials. Preferred replacement of A23C1 & C2.
3770A-32. Serials U-00430 and below. Modification to ensure sender measurement frequency = S.L.A. at switch-on.

3770B TELEPHONE LINE ANALYSER.
3770B-1. All serials. Preferred replacement of A23RT1.
3770B-2. Serials U-00116 and below. Improvement of 3dB check facility at low output levels.
3770B-3. Serials U-00126 and below. Preferred replacement of A21R36.
3770B-4. Serials U-00131 and below. Modification to improve noisy group delay performance at high temperature.
3770B-5. Serials U-00131 and below. Modifications to correct averaging time of RMS detector (WTD & +tone modes).
3770B-6. Serials between U-00131 and U-00151. Modification to prevent erratic display in noise + tone mode with input frequency ≃ 1kHz.
3770B-7. Serials U-00156 and below. Modification to prevent erroneous impulse noise count.

3780A PATTERN GENERATOR/ ERROR DETECTOR
3780A-12. Serials 1638U-00301 and below. Modification to improve the failure protection for the inverter driver circuits on the A30 power supply assembly.

3964A INSTRUMENTATION TAPE RECORDER
3964A-6/8864A-6/3968A-7/8868A-7. Serials 1702A and below. Improved power switch.

3968A INSTRUMENTATION TAPE RECORDER
3964A-6/8864A-6/3968A-7/8868A-7. Serials 1702A and below. Improved power switch.

5341A FREQUENCY COUNTER
5341A-2. All serials. Revision of adjustment procedures for A5 IF board and A4 prescaler board. Supersedes 5341A-1.

7200A/7201A/7202A GRAPHIC PLOTTER
7200A-16. All serials. Conversion kit for standard 7200A to EIA RS232C interface. Supersedes 7200A-7.
7200A-17/7201A-7/7202A-17/9125A/B-5. Serials 1620A and below. New chart hold (Autogrip) module.
7202A-16. All serials. Conversion kit for standard 7202A to EIA RS232C interface. Supersedes 7202A-6.
7203A-17/7210A-17/9862A-20. Serials 1620A and below. New chart hold (Autogrip) supply board.
7203A-17/7210A-17/9862A-20. Serials 1620A and below. New chart hold (Autogrip) supply board.

7402A OSCILLOGRAPHIC RECORDERS
7402A-6. All serials. Preferred replacements for ink valves/cartridges.
7402A-7. All serials. Motor/transmission/pulley part number history.

7404A OSCILLOGRAPHIC RECORDER
7404A-1. Serials 1610 and 1630. Ink cartridge replacement procedure.

8412A PHASE-MAGNITUDE DISPLAY
8412A-5. Serials 1625A02890 and below. Recommended replacement for bandwidth switch S1.

8505A NETWORK ANALYZER
8505A-2. Serials 1602A00111 thru 1610A00140. Modification to reduce 50 Hz line related variations on CRT trace.
8505A-3. Serials 1622A00185 and below. Recommended replacement for OP amp.

140T/141T DISPLAY SECTION SYSTEMS
8552B-10. All serials. Spectrum analyzer assembly instructions.
8552B-11. All serials. Simplified crystal bandwidth filter adjustment.

8690A SWEEP OSCILLATOR
8690A-16. All serials. A10 sweep generator improvement.

8690B SWEEP OSCILLATOR
8690B-13. Serials 1646A and below. A10 sweep generator improvement.

8864A INSTRUMENTATION TAPE RECORDER
3964A-6/8864A-6/3968A-7/8868A-7. Serials 1702A and below. Preferred replacement for the power switch.

8868A INSTRUMENTATION TAPE RECORDER
3964A-6/8864A-6/3968A-7/8868A-7. Serials 1702A and below. Preferred replacement for the power switch.

9125A/B GRAPHIC PLOTTERS
7200A-17/7201A-7/7202A-17/9125A/B-5. Serials 1620A and below. New chart hold (Autogrip) module.

9862A GRAPHIC PLOTTERS
7203A-17/7210A-17/9862A-20. Serials 1620A and below. New chart hold (Autogrip) supply board.

626XXJ SWITCHING MODULAR SUPPLY
626XXJ-3A. All serials. Troubleshooting switch failures.

86242C RF PLUG-IN
86242C-1A. All serials. YTO replacement kit. Supersedes 8624C-1.

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- ☐ 3770A-32
- ☐ 3770B-1
- ☐ 3770B-2
- ☐ 3770B-3
- ☐ 3770B-4
- ☐ 3770B-5
- ☐ 3770B-6
- ☐ 3770B-7
- ☐ 3780A-12
- ☐ 3964A-6/8864A-6/ 3968A-7/8868A-7
- ☐ 5341A-2
- ☐ 7200A-16
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- ☐ 7402A-6 7402A-7
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- ☐ 8505A-2
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- ☐ 8552B-11
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141 – 8552 – ☐ 8553 – May 9-12 8554 – 8555 –		$300/Student	Pete Johnson W 120 Century Road Paramus, NJ 07652 (201) 265-5000
☐ Digital Trouble-shooting – June 7-10		$300/Student	Jim Whitley 6305 Arizona Place Los Angeles, CA 90045
☐ 3050 – July 11-14		$300/Student	Tom Ely P. O. Box 301 815 Fourteenth St. Loveland, CO 80537 (303) 667-5000
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Upon receipt of your registration and check we will confirm your enrollment by returning all necessary prestudy material along with a list of nearby motel accommodations and reservation forms. Attendees are responsible for their own transportation, accommodations, and meals.

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