tft Powermeter System 6460S, Wattmeter Absorption CT 596 and Wattmeter Set 6460N

(including tft Powermeter 6460/1)

Manual part no. 46881-686N
Print code: H-12/88

CONTENTS

PRELIMINARIES

CHAPTERS

Note...

Each page bears the date of the original issue or the code number and date of the latest amendment (Am. 1, Am. 2 etc.).

Any changes subsequent to the latest amendment state of the manual are included on inserted sheets coded C1, C2 etc.

NOTES AND CAUTIONS

ELECTRICAL SAFETY PRECAUTIONS

This equipment is protected in accordance with IEC Safety Class I. It has been designed and tested according to IEC Publication 348, 'Safety Requirements for Electronic Measuring Apparatus', and has been supplied in a safe condition. The following precautions must be observed by the user to ensure safe operation and to retain the equipment in a safe condition.

Defects and abnormal stresses

Whenever it is likely that protection has been impaired, for example as a result of damage caused by severe conditions of transport or storage, the equipment shall be made inoperative and be secured against any unintended operation.

Removal of covers

Removal of the covers is likely to expose live parts although reasonable precautions have been taken in the design of the equipment to shield such parts. The equipment shall be disconnected from the supply before carrying out any adjustment, replacement or maintenance and repair during which the equipment shall be opened. If any adjustment, maintenance or repair under voltage is inevitable it shall only be carried out by a skilled person who is aware of the hazard involved.

Note that capacitors inside the equipment may still be charged when the equipment has been disconnected from the supply. Before carrying out any work inside the equipment, capacitors connected to high voltage points should be discharged; to discharge mains filter capacitors, if fitted, short together the L (live) and N (neutral) pins of the mains plug.

Mains plug

The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action shall not be negated by the use of an extension lead without protective conductor. Any interruption of the protective conductor inside or outside the equipment is likely to make the equipment dangerous.

Fuses

Note that there is a supply fuse in both the live and neutral wires of the supply lead. If only one of these fuses should rupture, certain parts of the equipment could remain at supply potential.

To provide protection against breakdown of the supply lead, its connectors, and filter where fitted, an external supply fuse (e.g. fitted in the connecting plug) should be used in the live lead. The fuse should have a continuous rating not exceeding 6 A.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of mended fuses and the short-circuiting of fuse holders shall be avoided.

Chapter 1

GENERAL INFORMATION

CONTENTS

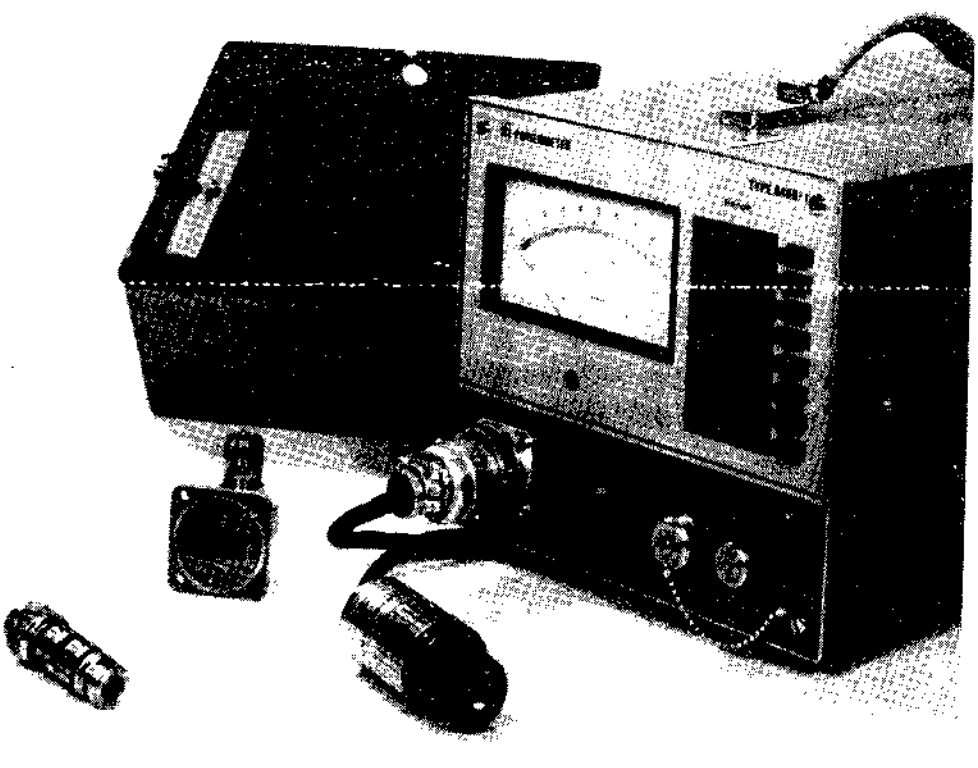

Fig. 1 tft powermeter system showing type 6460/1 with front cover, power head, 20 dB attenuator and coaxial-to-waveguide transformer

INTRODUCTION

1. Powermeter System 6460S, Wattmeter Absorption CT596 and Wattmeter Set 6625-99-541-6389 comprise three specific collections of instruments and accessories, as detailed below, selected and tested for military applications. These equipments measure power in the range 300 nW to 1 W in a frequency range of 10 MHz to 18 GHz and meet the environmental requirements of Joint-Services Specification REMC/20/FR (Iss. 6) Cat. III.

2. They are based on the tft Powermeter 6460/1 which, in conjunction with a series of tft ®* Power Heads, can provide a total measuring range of 30 nW to 3 W from 10 MHz to 40 GHz.

COMPOSITION OF EQUIPMENT

3. The three equipments in this range comprise the following items as indicated by asterisks under the appropriate column heading.

	Nato ref. no.	*Equipment* 6460S	CT596	6625-99-541-6389
(1) Powermeter type 6460/1 complete with storage covers	6625-99-637-9583	*	*	*
(including mains lead, 3 m long, part no. 2400-035	6625-99-637-9586)	*	*	*
(2) tft Power Head type 6440N	6625-99-637-9584		*	*
(3) tft Power Head	6625-99-643-8693	*		
(4) 20 dB Attenuator type 6534/4	5905-99-520-8780	*	*	*
(5) Coaxial-to-waveguide Transformer type 6237/1, 12.4 to 18 GHz	5985-99-637-9587	*		*
(6) Coaxial-to-waveguide Transformer type 6237/3, 8 to 12.4 GHz	5985-99-637-9585		*	
(7) Battery Pack part no. 2200-186 ...	6140-99-649-4905	*		*

4. Apart from the above differences in composition the three equipments have detailed differences in performance as shown on pages 3 and 4.

FEATURES

5. Type 6460/1 Powermeter in conjunction with the 6420 and 6440 series of tft Power Heads, is a highly accurate instrument which measures radio frequency power over an extremely wide frequency and power range. It measures and indicates the average power absorbed by the power head in use, and accepts amplitude and frequency modulated, pulsed and c.w. signals. Tables 1 and 2 list tft power head characteristics.

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* *Thin film thermoelectric device made under licence from General Microwave Corp., USA.*

6. The powermeter features automatic scales selection, which ensures that only the scale corresponding to the sensitivity of the power head in use is activated. Other features include a switch which enables the selection of either normal or fast amplifier response time, output terminals for measurement systems using external recorders or digital voltmeters and two paralleled input connectors which permit power head connections at the front or rear of the 6460/1.

7. An internal 50 MHz r.f. calibrator is fitted. This produces three preset power levels of 1 mW, 10 mW or 100 mW depending on the power rating of the power head being used. The calibrator automatically supplies the correct output to power head.

8. The 6460/1 is suitable for use in a wide variety of applications, including portable and field use (when used with the optional rechargeable battery pack) fixed stations and laboratory bench set-ups. Since all tft power heads will operate with the 6460/1 a single instrument with different power heads can be applied to a wide variety of measurement applications. The type 963R Junction Box, which permits simultaneous connection of up to five power heads, facilitates many applications. Junction boxes can be cascaded to permit operation of an even greater number of power heads.

9. By using the proper rack adapter the 6460/1 can be rapidly rack-mounted by itself, with any other MI Sanders unit packaged in this half-rack configuration or with 198 mm (7 25/32 in) wide half-rack units of other manufacturers.

SPECIFICATION

10. Frequency range

Type 6460S & CT596 and 6625-99-541-6389 :	10 MHz to 18 GHz.
Type 6460/1 :	10 MHz to 40 GHz depending on tft power head in use.

11. Power range

Type 6460S & CT596 and 6625-99-541-6389 :	0.3 μW to 10 mW (−35 dBm to +10 dBm) in 1-3-10 range steps.
	With 20 dB Attenuator 6534/4, range is extended to 1 W (+30 dBm).
Type 6460/1 :	0.03 μW to 3 W (−45 dBm to +35 dBm), depending on tft power head in use, in 1-3-10 range steps.
Accuracy :	±1.5% of f.s.d. on all ranges from 0°C to $+55^{\circ}$C.
Noise and drift :	Less than 1% of f.s.d. on lowest range, and correspondingly less on higher ranges, (except for the highest sensitivity position where it may rise to 2% peak) at constant ambient temperature.

Temperature coefficient :	Less than 0.1% per °C using any tft power head.
Response time :	100 ms approx. or less than 1 s.
Recorder output :	Proportional to indicated power.
	On 1-10-100 ranges: Output at full-scale is -1 V ±0.5% of f.s.d. or adjustable from 0 to -1 V.
	On 3-30-300 ranges:
	Output at full-scale is -0.3 V ±0.5% of f.s.d. or adjustable from 0 to -0.3 V.
	Output impedance : 100 Ω.
12. <u>RF calibrator</u> :	Internal 50 MHz oscillator with type N female connector on front panel. Power level corresponding to tft power head automatically preset.
Power output :	1 mW, 10 mW or 100 mW depending on tft power head connected to powermeter.
	Power level factory set to ±0.7%; traceable to national standards.
Temperature coefficient:	±0.1%/°C worst case (0 to 55°C); +0.05%/°C typical.
13. Input connectors:	Two provided, one on front panel and one at the rear.
14. Meter :	115 mm (4½ in) mirror scale, taut-band suspension.
15. Power requirement :	115/230 V a.c. ±10%, 50 to 400 Hz, 5 W. Mains connector to CEE 22 (BS 4491).
16. <u>Dimensions and weight</u>	
Type 6460S and CT596 and 6625-99-541-6389 :	Height: 200 mm (8 in) Width : 222 mm (8¾ in) Depth : 358 mm (14 in) over controls 480 mm (18 7/8 in) with covers Weight: 8.3 kg (18 lb) Battery : 1.3 kg (2¾ lb)
Type 6460/1 :	Height : 185 mm (7¼ in) Width : 200 mm (8 in) Depth : 350 mm (13¾ in) Weight : 4 kg (9 lb)

ACCESSORIES

Code no.

17. Supplied accessories

Mains lead, 3 m (10 ft) long 2400-035

18. Optional accessories

DC Calibrator type 305B - Provides all required calibration voltages for type 6460/1.

Rechargeable Battery Pack 2200-186 - Permits portable or field use of type 6460/1. Provides up to 12 hours operation.

Junction Box type 936R - Each permits operation of up to five tft power heads with one type 6460/1. They can be cascaded.

Rack Adapter (19 in) 3850-001 - Permits rack mounting of the type 6460/1 by itself, or with any other MI unit packaged in the half-rack configuration.

tft POWER HEAD CHARACTERISTICS

19. Powermeter System 6460S uses Power Head 6440N only. The CT596 uses the 6440N/1 only; this head is identical to the 6440N except for its connecting cable which has a low temperature (-40°C) operating capability.

20. Powermeter 6460/1 can use any of the power heads listed, but only the 6440N and N/1 will fit in the storage compartments of the powermeter systems.

TABLE 1 6440 SERIES OF tft POWER HEADS

The Type 6440 Series are coaxial thermoelectric Power Heads with coaxial connectors in type N, ultra precision APC7 and miniature SMA. These Power Heads extend the operating frequencies to 18 GHz

Type	Freq. Range (GHz)	Average Power Range(1) From	To	Max peak pulse power at +25°C	Max. Energy Per Pulse at +25°C W - μsec.	Pulse Duration at +25°C μs (max)	Max. VSWR	Field Replacement tft element	RF Connector
6440	0·01–18	0·3μW −35dBm	10mW +10dBm	1W	5	5	1·5:1 from 0·01 to 0·015 GHz 1·35:1 from 0·015 to 10 GHz 1·6:1 from 10 to 18 GHz	TL–4A	SMA-male
6440N	0·01–18								Type N male(2)
6440P	0·01–18								APC–7

Temperature Coefficient: Less than 0·1% per deg. C. when used with any tft Powermeter

Dimensions:
6440 2·66"L × 1·28" Dia. (67,6 × 32,5 mm) (3)
6440N 3·42"L × 1·28" Dia. (86,9 × 32,5 mm) (3)
6440P 3·23"L × 1·28" Dia. (82,0 × 32,5 mm) (3)
Nett Weight: Approx. 3 oz. (85 g)

(1) For MI Sanders Powermeter Type 6555 the lower power limit is increased by 20dB and Type 6550B the lower power limit is increased by 10dB. Overload Rating 300% While the heads will take overloads for short periods of time, extended periods of operation at overload levels may result in permanent change in the element characteristics or even burn out. Maximum care should be exercised to avoid such an occurrence

(2) Precision type N 50 Ω male to MIL-C-39012

(3) Maximum, including r.f. connector but excluding cable and multi-pin connector.

TABLE 2 6420 SERIES OF tft POWER HEADS

in coaxial and waveguide.

Type	Freq. Range (GHz)	Average Power Range From	Average Power Range To	Max. Peak Pulse Power	Max. Energy Per Pulse W – μsec	Pulse Duration μS(max)	Max. VSWR	Field Replacement tft Element	Connector
6420		0·3μW –35dBm	10mW +10dBm	3W	34	11		TL-0A	Precision Type N
6421	0·01–12·4	3μW –25dBm	100mW +20dBm	30W	180	6	100MHz to 1GHz 1·1:1 10MHz to 5GHz 1·25:1 (I)	TL-1A	50Ω male to
6422		0·03μW –45dBm	1mW 0dBm	0·3W	2	7	5GHz to 12·4GHz 1·4:1 (II)	TL-2A	MIL-C-39012
6423		0·3mW –5dBm	3W +35dBm	60W	500	8		TL-3	
6423/5	0·01-2·0	0·3mW –5dBm	3W +35dBm	60W	500	8	100MHz to 1GHz 1·1:1 10MHz to 2GHz 1·3:1	TL-3	Spinner 7/16, 50Ω
6425	8·2-12·4			2·5W	25	10	1·5	TL-XO-A	R100,WR90 UG39/U
6426	12·4-18·0			2·5W	25	10	1·5	TL-UO-A	R140 WR62 UG419/U
6427	18·0-26·5	0·3μW –35dBm	10mW +10dBm	1·6W	10	6	1·5	TL-KO-A	R220,WR42 UG595/U
6428	26·5-40·0			1·6W	10	6	1·65	TL-AO-A	R320 WR28, UG599/U

(I) Except in the range 10MHz to 15MHz where VSWR may rise to 1·75:1

(II) Except 6423 where VSWR from 11 to 12·4 GHz may rise to 1·7:1

Nett Weights 6420, 6421, 6422: 1lb 2oz 505g
6423 2lb 2oz 975 g
6423/5 2lb 3oz 1kg
6425, 6426, 6427, 6428 1lb 10oz 800g

Chapter 2

INSTALLATION

CONTENTS

GENERAL PRECAUTIONS

1. With the exception of those in para. 4, there are no special precautions to be observed when installing or using a 6460/1 Powermeter and tft power heads other than the normal good practices associated with accurate measurement procedures, and the use and handling of microwave components. In particular, the following precautions must be observed.

(1) The flange or connector of the tft power head should be handled with care to avoid scratching or marring the surfaces and connecting parts, and should be covered with a protective cap when not in use to prevent accumulations that can affect performance.

(2) The power ratings of the tft power heads should never be exceeded since permanent damage to the tft element may result. Although the power ratings are conservatively applied, the margin of safety should not be deliberately narrowed.

2. If it is desired to use a recorder to obtain a plot of power output versus time, or to connect a digital voltmeter to the amplifier output for increased accuracy, use the OUTPUT connectors. For details, see Chap. 3, para. 6.

RACK MOUNTING

3. If it is desired to rack-mount the 6460/1, use an MI Sanders Rack Adapter type 3850-001, which can be used to mount any one or two half-rack configuration units. Some half-rack units of other manufacturers can be mounted with a 6460/1 or the type 6460/1 can be mounted into some rack adapters of other manufacturers. It is suggested that the MI Sanders factory be contacted regarding the use of other manufacturers' equipment in conjunction with MI Sanders rack adapter.

AC MAINS SUPPLIES

4. If a.c. mains power is to be used check the position of the MAINS voltage selector on the rear panel. The instrument is normally dispatched set for a nominal mains input of 230 V. To change to the nominal 115 V setting remove the locking plate, reset the switch, reverse the plate and refit.

5. The two mains fuses are 160 mA slow-blow types for either value of mains input voltage.

6. Connect a 3-pin supply plug to the free end of the mains supply cable observing the correct colour coding:-

Earth	Green/yellow
Neutral	- Blue
Live	- Brown

Chapter 3

OPERATION

CONTENTS

PREPARATION FOR USE

1. Before using the instrument carry out the following preliminary steps. (The front and rear panel controls, connectors and indicators are identified and described in Figs. 1 and 2.)

(1) If a.c. mains power is to be used, first check the setting of the MAINS voltage selector (see Chap. 2). Make connection to the power source and depress the mains power ON button. The associated indicator lamp should glow.

(2) If battery power is to be used, check the battery condition using the BAT CHK button, and depress the BAT ON button. The 6460/1 can be operated for about 12 hours on a fully charged battery, and the charging cycle is about 16 hours for a complete charge. Refer to the manufacturer's literature for complete battery data.

(3) Connect the tft power head to either the front or rear INPUT connector.

(4) Allow a warm-up period of about 5 minutes for circuit stabilization.

OPERATING PROCEDURE

2. To make a measurement proceed as follows:-

(1) Depress the lowest RANGE button and zero the meter using the ZERO control.

(2) Depress the highest RANGE button. Adjust the % EFF control on the power head to 100%. Then connect the power head to the CAL output connector. Switch to CAL ON at the rear panel.

(3) Adjust the CAL ADJ control to make the meter read full-scale. The powermeter and power head sensitivity are now calibrated.

(4) Switch to CAL OFF at the rear panel when on battery operation.

(5) Determine the effective efficiency from the graph mounted on the power head and set the % EFF control on the power head to the value obtained.

(6) Depress the desired RANGE button, connect the power head to the source of r.f. power to be measured and read the power on the meter. (If the power to be measured is not approximately known, use the least sensitive power head available, depress the upper RANGE button and, after application of r.f. power, reduce the power range and/or change power heads as required.)

(7) To turn off, depress the mains power OFF button. This step applies equally to instruments using battery power or a.c. mains power.

MULTI-POINT TESTING

3. Since the tft power heads are r.f. power-to-d.c. voltage transducers, it is possible to successively connect a number of different power heads to a 6460/1 thereby enabling measurement of power at different points in an r.f. network, without readjustment of the powermeter. There is no danger of upsetting the network characteristics under these conditions, since the power heads retain their matched characteristics, even when not connected to the powermeter.

4. To facilitate the use of a number of power heads, a five-input junction box, type 963R, is available. Switching is performed by a front-panel mounted low-noise rotary switch. By cascading junction box units, a larger number of power heads can be used in conjunction with one 6460/1. (Remotely Programmable Junction Box type 963R-4 is available to special order.)

CONTROLS AND CONNECTORS

5. Front panel

(1) RANGE. An eight-position push-button switch which permits selection of the desired operating power range. Fifteen different ranges in four overlapping scales are available, and the scale corresponding to the sensitivity of the tft power head in use is automatically activated. The overlay markings are given in both watts and dBm, and are full-scale values. Only those markings corresponding to the scale in use and the manually selected range are illuminated.

(2) METER ZERO. This potentiometer is used to electrically zero the instrument. Once set, it need not be adjusted when changing ranges.

(3) CALIBRATOR. A calibrated 50 MHz r.f. output is provided at this connector at levels matched to the tft power head connected to INPUT (4).

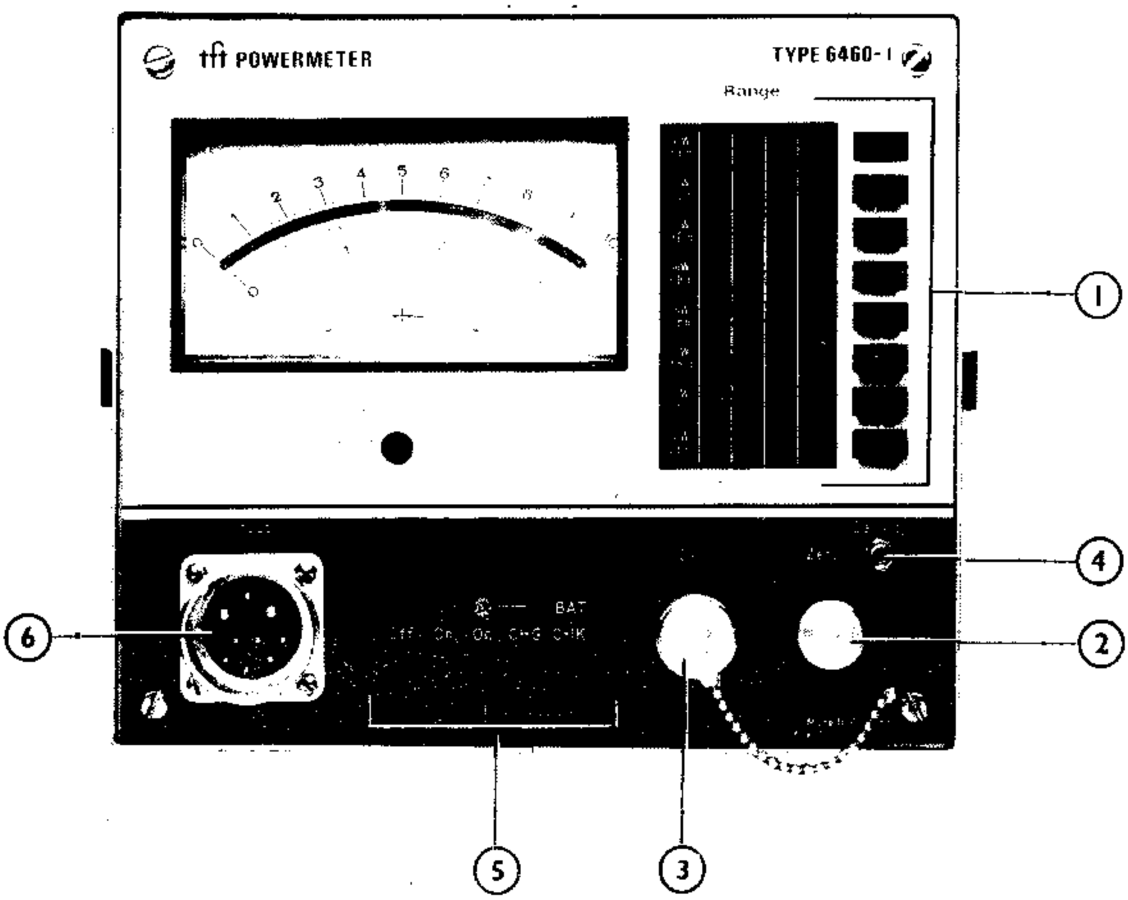


Fig. 1 Front panel

(4) CAL ADJUST. This potentiometer is used to set the calibration of any tft power head and powermeter combination. The control should be adjusted to produce a meter indication of 10 when the power head is connected to the CAL socket.

(5) POWER. A five-position push-button switch which energizes the 6460/1 using either a.c. mains power (ON button) or optional battery power (BAT ON button). It also permits the condition of the batteries to be checked (BAT CHK button), and permits the batteries to be charged (BAT CHG button). When in the mains ON position, a trickle charge is applied to the batteries, and when in the BAT CHG position, the a.c. mains power is completely diverted for battery charging purposes. The associated indicator lamp will glow only when one of these two buttons is depressed.

(6) INPUT. This ten-pin connector provides all inter-connections with the tft power head in use. An identical connector, wired in parallel, is located at the rear of the 6460/1. Either may be used.

6. Rear panel

(1) 115 V - 230 V MAINS. This switch permits the application of either 115 V or 230 V a.c. power. Ensure that the switch position is properly set prior to the application of power to avoid equipment damage. If replacement of either the live or the neutral FUSE becomes necessary, ensure that the replacement conforms with the description given in Chap. 6.

(2) OUTPUT. This pair of terminals provides either a calibrated analogue output of the measured r.f. power (1 V d.c. full-scale) for digital voltmeter use, or an adjustable d.c. output (0 to -1 V full-scale) for recorder use.

(3) OUTPUT ADJUST. This potentiometer controls the voltage available at the OUTPUT terminals. When set to its fully clockwise position and with a full-scale indication on the 10 meter scale, a -1 V d.c. calibrated analogue voltage is provided at the OUTPUT terminals. (A -0.3 V d.c. calibrated analogue voltage is provided with a full-scale indication on the 3 meter scale.) When the control is not in the fully clockwise position, an adjustable linear 0 to -1 V d.c. voltage proportional to the measured r.f. power is provided at the OUTPUT terminals.

(4) RESPONSE. This switch controls the amplifier response time (and noise level). When in the NORM position, the response time of the amplifier will be less than 1 s, and in the FAST position, about 100 ms. (Note, however, that the noise will also increase when in the FAST position, particularly in the lower ranges.)

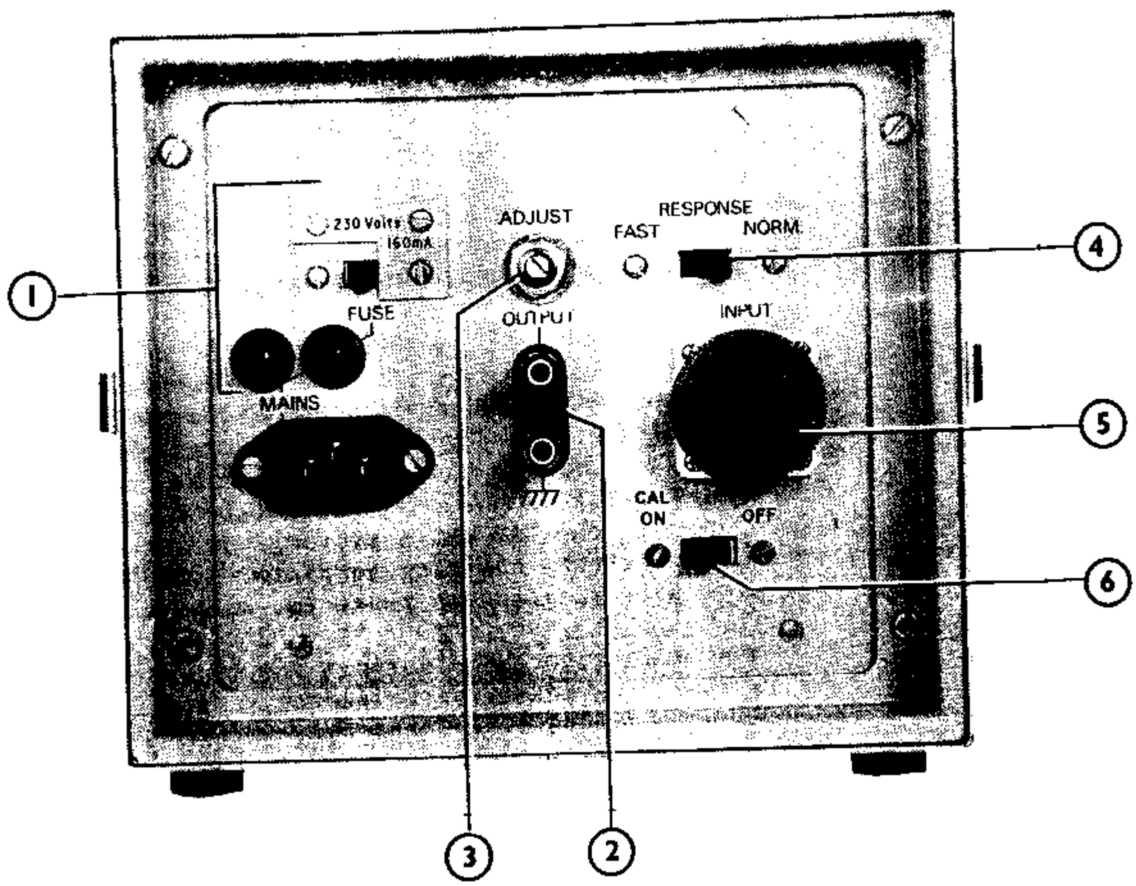


Fig. 2 Rear panel

(5) INPUT. This connector is wired in parallel with the INPUT connector on the front panel. Either may be used for interconnection with the tft power head in use.

(6) CAL ON/OFF. This switch controls the power supply to internal 50 MHz calibrator and should be switched off when not in use.

POWER MEASUREMENT ACCURACY

7. A number of factors affect the overall accuracy of power measurement. The major sources of uncertainty are mismatch, r.f. losses and instrumentation error.

Mismatch uncertainty

8. In practical measurement situations, both the source and the power head have a v.s.w.r. and the source is rarely matched to the power head unless a stub tuner is used. This mismatch loss depends both on the source and power head v.s.w.r. The impedance that the source sees is a function of the actual power head impedance, the electrical length of the line and its characteristic impedance, Z. Generally, neither the source or the power head have the specified nominal impedance, and the actual impedances are known only as reflection coefficients, or v.s.w.r., which lack phase information. As a result the power delivered is known only as lying somewhere between two limits. This uncertainty increases with increasing v.s.w.r. and is the main reason why designers strive to reduce the v.s.w.r. of microwave power measuring instruments.

9. Limits of mismatch loss can be determined from the mismatch limits graphs, included in each tft power head handbook.

RF losses

10. Any power that enters the power head, but is not dissipated in the tft load, can be considered as an r.f. loss. This may be in the walls of a waveguide mount, the centre conductor of a coaxial head, the capacitor dielectric, or due to radiation or poor electrical connection within the head. The effective efficiency data provided with each tft head permits compensation for these r.f. losses.

Instrumentation accuracy

11. This is the ability of the power meter to accurately measure and interpret the information available at the power head output. In specifying the accuracy of a powermeter, the instrumentation error is the figure generally given. For the 6460/1 the instrumentation error is ±1.5% of f.s.d.

Effective efficiency

12. As previously stated an exact correction for mismatch error cannot be applied, since it depends on both the power head and source v.s.w.r. However, the efficiency errors, due to r.f. losses in power head and d.c.-to-microwave conversion efficiency variation with frequency, can be corrected unambiguously.

13. The 'effective efficiency' correction factors, at various frequencies, are marked on the power head and the control on the head should be set to the value given. Powermeter 6460/1 will then automatically correct for and eliminate this efficiency error.

Chapter 4

TECHNICAL DESCRIPTION

CONTENTS

FUNCTIONAL DESCRIPTION

1. The type 6460/1 is basically a d.c. amplifier with the atributes of very low noise, high gain and high gain stability, with a self-contained meter to indicate its output signal. Because of the extremely low d.c. signals involved (less than 1.5 µV full-scale on the most sensitive range), a chopper-carrier system is employed to avoid drift.

2. Fig. 1 is a block diagram of the overall unit. The d.c. input signal from the tft power head is applied to the modulator. The square wave output signal of the modulator is stepped up by the input transformer and applied to the low-noise pre-amplifier. The square wave signal is amplified in this circuit and coupled to the filter amplifier, where much of the noise and other spurious signals are filtered out.

3. The resulting sine wave signal is then amplified and coupled to the phase splitter. This circuit provides the phase splitting action required to provide the demodulator input. The full-wave demodulator, which is synchronously driven with the modulator, recovers the input d.c. signal at a greatly amplified level.

4. The output of the demodulator is applied to the integrating amplifier. This circuit provides additional signal gain, and also reduces the amplifier bandwidth to the degree required consistent with the selected response time (and noise level). The output of the integrating amplifier is coupled back to the modulator and input transformer circuit through a RANGE switch network. This feedback path provides a high degree of degeneration and, thus, gain stability, and at the same time provides a means of accurate control of the overall amplifier gain.

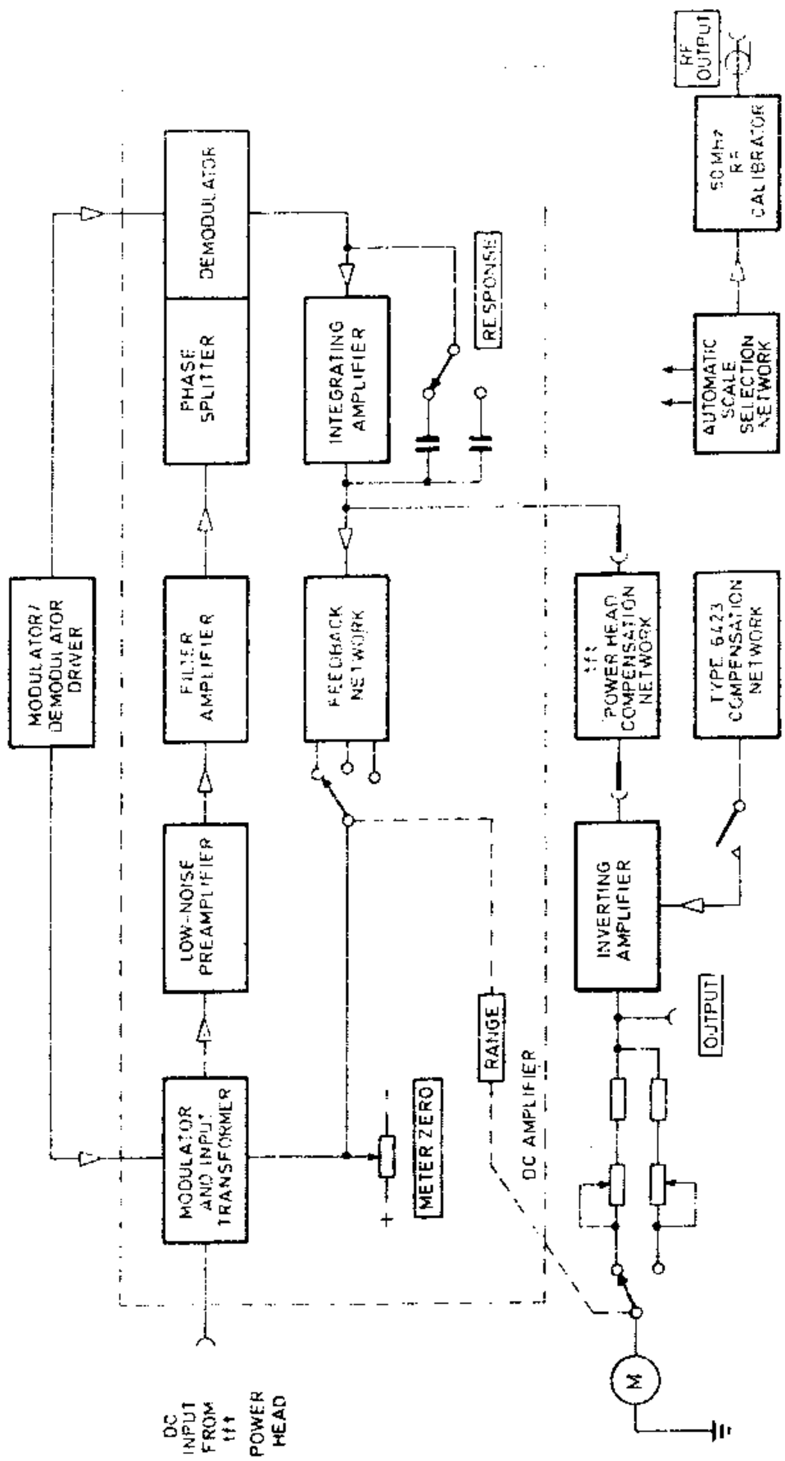


Fig. 1   Block diagram of tft Powermeter 6460/1

5. The output of the integrating amplifier is also applied to the compensation network in the power head, where compensation is made for the sensitivity of the power head, and for its inefficiency at the frequency of the signal under measurement. The return from the power head compensation network is applied to the inverting amplifier, and the output of this circuit drives the front-panel meter through a second RANGE switch network. The output of the inverting amplifier is also made available at the recorder/digital voltmeter OUTPUT terminal.

6. Two identical 8 V regulated power supplies are included in the 6460/1. One provides a positive output, and the other a negative. In addition, provisions are contained for mounting an optional rechargeable battery pack to power the unit.

7. The r.f. calibrator provides three precision power levels of 1 mW, 10 mW and 100 mW at a frequency of 50 MHz. These power levels are programmed automatically depending on which power head is connected. If no power head is connected then the 1 mW output level is produced by the calibrator.

8. Automatic scale selection is provided in the 6460/1. The operation of this network is controlled by the various interlock combinations associated with pins 4, 5 and 6 of the power head connector.

9. The modulator/demodulator drive circuit is a conventional free-running multivibrator which provides the required 110 Hz signal.

CIRCUIT DESCRIPTION

DC amplifier

10. Modulator and input transformer. The input signal to the 6460/1 is applied to the moving arm of modulator G1-A, which is one half of a mechanical chopper. The d.c. amplifier feedback signal and the d.c. offset voltage from the meter ZERO control R23 are applied to the centre-tap of the primary of input transformer T1. Therefore, the difference between the input and feedback/d.c. offset signals is alternately applied to each half of the transformer primary, producing a full-wave signal (square wave). The signal is stepped up in the transformer and applied to the low-noise pre-amplifier.

11. To eliminate thermal e.m.f's in the input circuit, copper leads are employed throughout, and all connections are soldered with low-thermal e.m.f. solder. The modulator and input transformer also employ copper leads, and the transformer is carefully shielded to minimize hum pick-up. The input connector employs special pins for the signal lines.

12. Low-noise pre-amplifier. The square wave signal from the modulator and input transformer is amplified in the VT1 and AR2 stages, and coupled to the filter amplifier. The gain of the AR2 stage is controlled by resistor R12, R14, R16 or R18, and is determined by the RANGE switch setting.

13. Filter amplifier. The square wave signal from the low-noise pre-amplifier is amplified in the AR3 stage, which is an active band-pass amplifier/filter network centred at 110 Hz. Fine tuning for the stage is provided by means of potentiometer R39. The resulting 110 Hz filtered sine wave signal is then coupled to the phase splitter and demodulator.

14. Phase splitter and demodulator. The signal from the filter amplifier is applied to the VT2 stage, which, together with the VT3 stage, drives the demodulator. The full-wave demodulator is synchronously driven with the modulator at a 110 Hz rate. Therefore, much of the non-synchronous noise and spurious signals present in the carrier are eliminated.

15. Integrating amplifier. The output of the demodulator is applied to the AR4 stage which, together with VT4 and feedback resistor R57, and by virtue of the feedback capacitor (C32 or C33), forms an integrating amplifier. The integrating amplifier stage feedback capacitor determines the bandwidth of the d.c. amplifier, and is controlled by the setting of the RESPONSE switch S2. When in the NORM position, the response time of the 6460/1 is less than 1 s and the noise is less than ±1% peak-to-peak of full-scale on the most sensitive range. When the RESPONSE switch is set to FAST, the response time decreases to approximately 100 ms, but the noise may increase above the ±1% specification, particularly in the lower ranges.

16. Feedback network. The integrating amplifier d.c. output provides the feedback signal around the entire d.c. amplifier. The magnitude of the feedback signal and, therefore, the d.c. amplifier gain is determined by the ratio of the sum of resistors R11, R13, R15 and R17 (changed by the RANGE switch setting), and the value of resistor R26.

17. The presence of spurious d.c. signals at the input to the d.c. amplifier must be anticipated because of thermal e.m.f's as well as any slight unbalance that may be present in the power head. Accordingly, to correct for these offset signals, a small adjustable d.c. voltage is introduced with the feedback signal. This voltage is derived from the positive and negative power supplies and is controlled by the setting of the meter ZERO potentiometer R23.

18. tft power head compensation network. The integrating amplifier d.c. output is also applied to the power head compensation network, where compensations for the sensitivity and efficiency variations of the power head are made. Since both the absolute sensitivity and efficiency of all power heads differ, the 6460/1 gain must be varied with each power head employed. This is accomplished by the calibration potentiometer in the power head, which is adjusted as part of the calibration procedure for the power head, and by the efficiency potentiometer, also located in the power head, which is adjusted by the operator to compensate for the power head inefficiency at the particular frequency of the r.f. signal under measurement. This permits the 6460/1 to be used, without adjustment, with any tft power head.

19. Inverting amplifier. The compensated return from the power head is amplified and inverted in the AR1 stage. Potentiometer R1 is a d.c. offset adjustment for the stage. The output of AR1, which is an analogue voltage varying from 0 to -1 V as a function of the measured r.f. power level, is applied to the meter M1 and the OUTPUT terminal SK4. Full-scale meter adjustments are provided by means of potentiometers R19 (for readings on the 3 scale) and R21 (for readings on the 10 scale). The signal level at the OUTPUT terminal can be conveniently adjusted for recorder use by means of the ADJUST potentiometer R25, or alternatively, can be maintained at a -1 V full-scale level for d.v.m. use or calibration purposes by rotating the ADJUST potentiometer fully clockwise. The meter is diode protected against overload damage by CR50, 51 and 52.

Power supplies

20. Two identical regulated 8 V power supplies are included in the 6460/1. One provides a positive output and the other a negative. The positive supply consists of VT9 and VR1, and associated components. The full-wave rectified output of CR6 and CR7, at about 18 V, is applied to current booster stage VT9 when the mains power ON button is depressed. The output of the VT9 stage is applied to the voltage regulator stage VR1, and the regulated 8 V output of this stage is made available to the 6460/1 as required. The negative power supply consists of VT10 and VR2, and associated components. The full-wave rectified output of diodes CR8 and CR9 is similarly applied to this power supply through the mains power switch.

21. The 18 V rectified outputs of CR6/CR7 and CR8/CR9 are made available through the power switch to the (optional) batteries. When the main supply ON button is depressed, the batteries receive a trickle charge by means of resistors R80 and R82, and when the BAT CHG button is depressed, the batteries receive a full charge by means of resistors R81 and R83. The condition of the batteries can easily be checked by means of the BAT CHK button, which places the batteries in series, with each other, the meter, and limiting resistor R79.

22. Resistor R97 simulates the loading of the powermeter circuits. Diodes CR53 and 54 prevent unwanted battery discharge if the mains ON switch is not cancelled when the mains supply is removed from the instrument.

Control and compensation

23. Automatic scale selection network. This network consists of transistors VT11 to VT13 (corresponding to the series 6422, 6420, 6421 and 6440 tft Power Heads, respectively), transistor VT14 (corresponding to the type 6423 tft Power Head), emitter-follower VT15, and associated circuitry. Transistors VT11, VT12 and VT13 are normally biased 'on', thereby establishing a potential at their collectors which is essentially at ground level. When a series 6422, 6420, 6421 or 6440 tft Power Head is connected to the type 6460/1 two of the three interlock pins (4, 5 and 6) are grounded, since the corresponding pins are grounded in the power head. These grounded pins bias the associated two transistors 'off'. Since the collectors of the three transistors are connected to the corresponding rows of indicator lamps (vertical), only that row of lamps which corresponds to the appropriate power head remains activated (by means of the ground potential). When a RANGE button is depressed, a positive potential is applied to the row of indicator lamps corresponding to the selected range (horizontal), and therefore, only the single lamp corresponding to both the selected range and scale will go on since it is the only one which receives both the ground and positive potentials.

24. Transistor VT14 is normally biased 'off' when a series 6422, 6421, 6420 or 6440 tft Power Head is connected due to the clamping action of two grounded diodes CR13, CR14 and/or CR15. When a type 6423, which has no grounded interlock pins, is connected to the 6460/1 transistor VT14 will be biased 'on' since none of the diodes is grounded. This establishes the activating ground potential at the collector of VT14, and therefore, on indicator lamps DS26 to DS32.

25. This also establishes a negative potential at the base and emitter of VT15, which, in turn, clamps the bases of VT11, VT12 and VT13 at a negative potential, thereby biasing them 'off'. This removes the activating ground potential from the other three scales and ensures that only the scale corresponding to the

type 6423 remains activated. (Note that if no power head is connected to the type 6460/1 none of the interlock pins is grounded, and the display is identical to that of the type 6423.)

26. Modulator/demodulator driver. This circuit is an astable multivibrator. The values of resistors R66, R67 and R68 and capacitors C39 and C42 establish operation at about 110 Hz. The variable resistors R68 permit the exact setting of the operating frequency to 110 Hz. The output of the multivibrator is applied directly to the chopper energizing coil.

27. Type 6423 compensation network. This network consists of diode CR5, relay K1 and resistor R45. When a type 6423 is connected to the type 6460/1 and the 3 W RANGE button is depressed, relay K1 is energized, and the compensation network reduces the gain of amplifier AR1. The circuit parameters are such that compensation for the non-linearity of the type 6423 results.

RF calibrator

28. The r.f. calibrator provides three precision power levels of 1 mW, 10 mW and 100 mW at a frequency of 50 MHz. These power levels are programmed automatically depending on which power head is connected. If no power head is connected then the 1 mW output level is produced by the calibrator. The basic schematic of the calibrator, consisting of five main blocks, is shown in Fig. 2.

29. The action of the circuit is such that the input voltage to the 50 Ω source resistor is maintained at a constant level, regardless of load (i.e. a change in detailed output causes the comparator to increase or decrease the oscillator output to maintain the detected level constant). This then constitutes a zero source impedance.

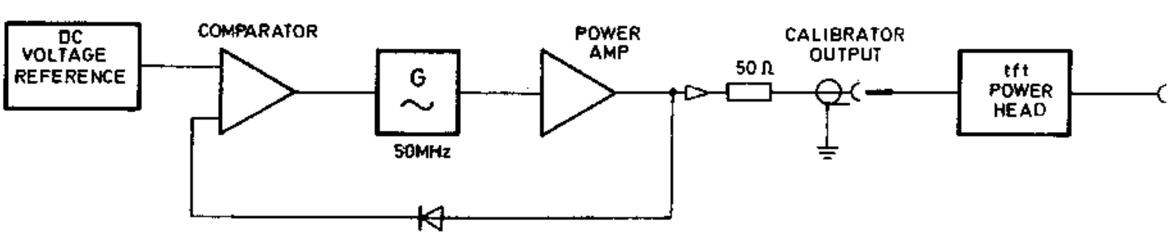


Fig. 2 Block diagram of r.f. calibrator

30. DC reference. This forms the basic power reference for the calibrator and therefore has a very low temperature coefficient and ageing rate.

31. Comparator. This has a very large open loop gain to maintain both input and detected outputs equal. The loop may be considered as a servo system with the reference as input and 100% feedback applied from output detector back to comparator input. The bandwidth of the comparator is kept low to avoid spurious oscillations (i.e. amplitude jitter or modulation).

32. Oscillator. This is a 50 MHz L-C oscillator. Long term amplitude stability is not important here as any change is divided down by the loop gain of the control loop.

33. Power amplifier. This is a class A amplifier that can deliver 200 mW into a 100 Ω load (i.e. power head + 50 Ω series resistor). Any change in gain or amplitude is again divided down by the overall loop gain.

34. Detector. This, in effect, is an a.c./d.c. converter converting 50 MHz a.c. into a d.c. control voltage. As any change in detector efficiency with time or temperature causes a direct change in power output, this device is carefully selected.

35. Detailed circuit description. The calibrator consists of a Colpitts oscillator, TR1 and associated components, feeding into power amplifier TR2. In operation the output from TR2 is peak detected via D6 and applied to the operational amplifier IC2. Here it is compared with a preset voltage from one of the two potential divider chains. This amplified difference voltage is then used to control the current through the series diodes D4 and D5. This, in turn, varies their dynamic resistance and causes the output of the oscillator TR1 to vary in sympathy.

36. Because of the very high gain of IC2, the detected output of TR2 and hence power level, is kept at substantially the same level relative to the derived d.c. level. Thus power into the 51 Ω source, in series with a load (powermeter tft head), is kept substantially constant.

37. Temperature effects are minimized by incorporation of D3 on 1 mW range to offset the change in detector efficiency of detector diode D6 with temperature. Diode D6 is, in fact, overdriven by the series l.c. circuit L3, 4 and C15, 14, thus tending to swamp the changes in detector efficiency of D6 with temperature. This obviates the need for D3 as compensation on the 10 mW and 100 mW ranges. Both 10 mW and 100 mW share the same reference chain, the 100 mW range being obtained by dividing down the output of D6.

Chapter 5

MAINTENANCE

CONTENTS

INTRODUCTION

1. Standard readily available components are used in the manufacture of MI Sanders instruments whenever possible. Such parts can usually be obtained from a local supplier. Special or modified parts, as determined by an entry in the last column of the Table of Replaceable Parts in Chap. 6, are available from MI Sanders.

REMOVAL OF CASE

2. To gain access to the interior of a 6460/1 remove the a.c. mains lead and the four screws at the rear of the unit, and carefully remove case covers.

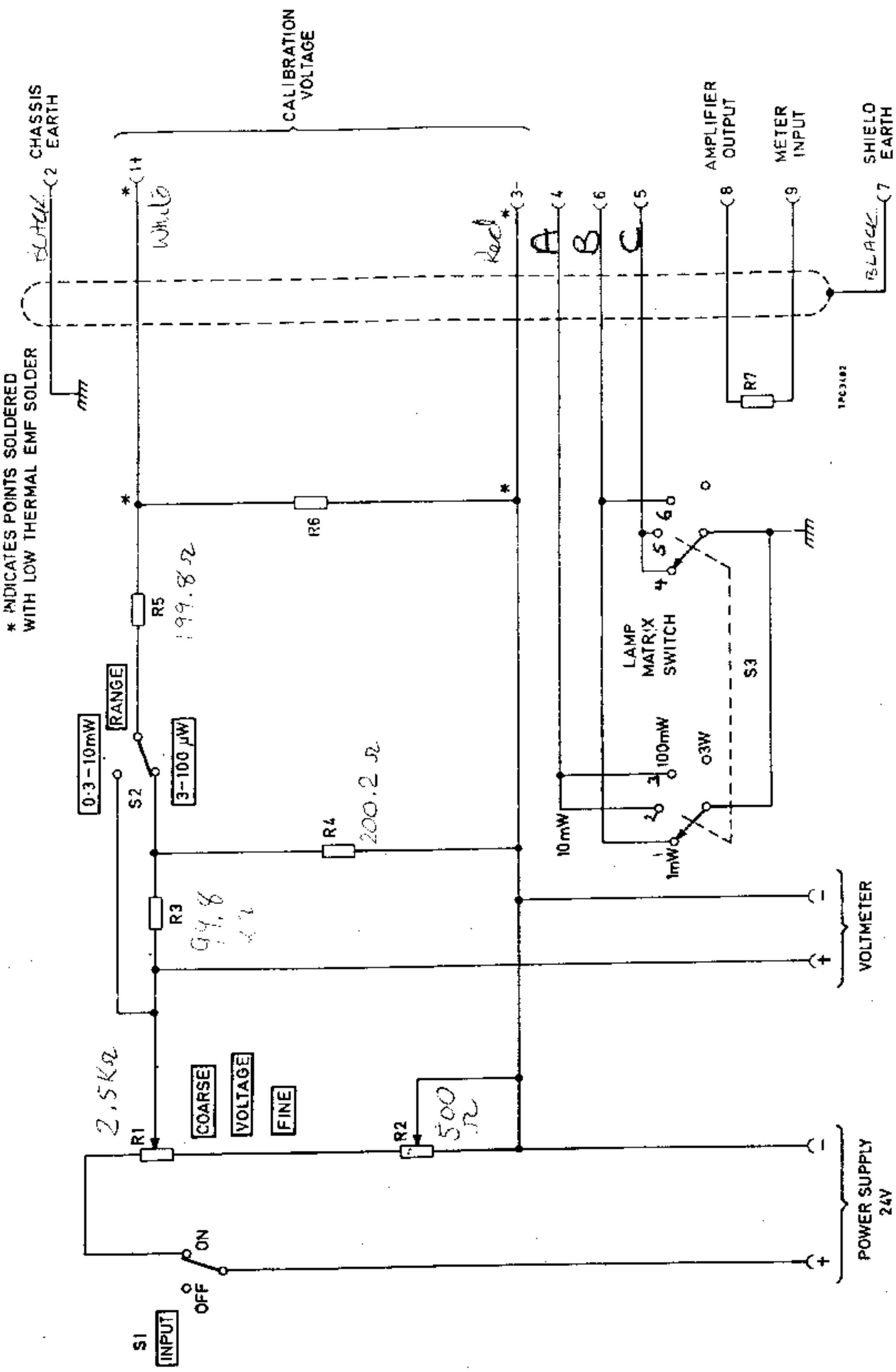


Fig. 1 Calibration test jig (d.c. calibrator) circuit diagram

TEST EQUIPMENT REQUIRED

3. Use the test equipment listed in Table 1 or equivalents for the test and calibration procedures. In addition, to facilitate the performance of the procedures, a d.c. calibrator is required. For this purpose the use of an MI Sanders type 305B DC Calibrator, or the jig shown in Fig. 1 is recommended. If the jig is constructed, use the components listed in Table 2 or equivalents.

Note...

When making tests to verify that the instrument meets its stated performance limits allowance must always be made for the uncertainty of the test equipment used.

CAUTION...

(1) DO NOT MAKE RESISTANCE CHECKS ON INPUT TRANSFORMER T1.

(2) All circuits use either transistors or integrated circuits. Do not make resistance checks using the lower ohmmeter ranges.

(3) Because of the very low d.c. voltages involved, repair of the type 6460/1 must be conducted with special care. All connections to the input circuit must be made with only copper leads, and all solder connections must be made with low-thermal solder using a soldering iron which has been employed with only that type of solder, a length of which is furnished with each 6460/1.

TABLE 1 TEST EQUIPMENT REQUIRED

Description	*Manufacturer*	*Model*
Oscilloscope, general purpose		
DC voltmeter	Marconi Instruments	TF 2606
Electronic counter	Marconi Instruments	TF 2430
Multimeter	SEI	Selectest
Variable auto-transformer	Variac	
Calibrator powermeter (standardized against National Standard)	Rhode & Schwartz	NRS

TABLE 2 CALIBRATION TEST JIG (DC CALIBRATOR) COMPONENTS

Circuit ref.	*Description*
P1	Connector; MI Sanders part no. 3850-043
R1	Resistor, variable WW, 25000 Ω, 2 W, 10 turn
R2	Resistor, variable, 500 Ω ±3%, 1.5 W, 5 turn
R3	Resistor, fixed, WW, 99.8 kΩ ±0.025%, 750 mW
R4	Resistor, fixed, WW, 200.2 Ω ±0.025%, 750 mW
R5	Resistor, fixed, WW, 199.8 kΩ ±0.025%, 750 mW
R6	Resistor, fixed, WW, 200 Ω ±0.025%, 750 mW (To be wound of Evanohm wire with enamelled copper leads. All internal connections to be made with low thermal solder).
R7	Resistor, fixed, WW, 100 Ω ±0.05%, 750 mW
S1	Switch, toggle, s.p.s.t.
S2	Switch, toggle s.p.s.t.
S3	Switch, rotary, 2-pole, 4 W (break before make)

PERFORMANCE TESTS

4. Before applying a.c. power, depress the mains OFF button, and make co tinuity checks to ensure that neither the live or netural sides of the mai lead are connected to the instrument chassis.

(1) Mechanically zero the meter, if necessary, and connect the varia auto-transformer (Variac) to a source of 115 V/230 V, 50 to 400 Hz po

(2) Set the type 6460/1 115 V/230 V MAINS switch to 230 V and the RESPONSE switch to NORM. Connect the 6460/1 to the variable auto-transformer and set the mains voltage to 240 V using the a.c. voltmet

(3) Connect the d.c. calibrator (or test jig - see para. 3) to either INPUT connector and set the calibrator controls as follows :

RANGE switch : 0.3 to 10 mW
INPUT switch : OFF

It is important that this remains connected during the following tests

(4) Depress the mains ON button. The associated indicator lamp shou go on. Allow a five-minute warm-up period before proceeding.

Sensitivity selection logic test

5. To check the operation of the RANGE switching proceed as follows :

(1) Depress the 3 W RANGE button and verify that the appropriate indicator lamp goes on.

(2) Sequentially depress the 1 W to 3 mW RANGE buttons and verify that the appropriate indicator lamps go on.

Power supply tests

6. +8 V power supply regulation tests

(1) Adjust the mains voltage to 220 V.

(2) Using the d.c. voltmeter, verify that the voltage between TP4(+) and ground is between 7.5 and 8.4 V.

(3) Adjust the line voltage to 260 V, and verify that the d.c. voltmete indicates between 7.5 and 8.4 V.

(4) If the unit under test has a charged type 2200-186 Battery Pack installed, depress the BAT ON button and verify that the d.c. voltmeter indicates between 7.5 and 8.4 V. Depress the mains ON button.

7. -8 V power supply regulation tests

(1) Connect the d.c. voltmeter between TP3(-) and ground, and verify that it indicates between -7.5 and -8.4 V.

(2) Adjust the line voltage to 220 V, and verify that the d.c. voltmeter indicates between -7.5 and -8.4 V.

(3) If the unit under test has a charged type 2200-186 Battery Pack installed, repeat above check with battery.

8. Power supply ripple tests

(1) Using the oscilloscope, verify that the peak-to-peak ripple between TP4 and ground does not exceed 10 mV.

(2) Repeat operation at TP3.

Carrier frequency tests and adjustments

9. Chopper drive frequency tests

(1) Adjust the mains voltage to 240 V.

(2) Using the electronic counter, verify that the period of the chopper drive signal between TP2 and ground is 9 ms. If not, adjust R69 to obtain the proper frequency. Remove the electronic counter.

10. Filter adjustment

(1) Depress the mains OFF button and remove integrated circuit AR4 from its socket.

(2) Connect the oscilloscope between TP1 and ground.

(3) Depress the mains ON button and adjust potentiometer R39 for a symmetrical, negative-going, full-wave rectified sine wave (as shown on circuit). Depress the OFF button and replace AR4. Depress the ON button.

Meter calibration

11. DC zero adjustment

(1) Connect the d.c. voltmeter to the OUTPUT connectors.

(2) Rotate the OUTPUT ADJUST control fully clockwise.

(3) Depress the upper RANGE button (no indicator lamp should go on) and adjust potentiometer R1 for a 0 ±0.3 mV indication on the d.c. voltmeter.

(4) Depress the .01 W RANGE button and adjust the meter ZERO control for a 0 ±5 mV indication on the d.c. voltmeter.

(5) Continue to repeat above steps until no additional adjustments are required.

12. Meter sensitivity calibration

(1) Depress the upper RANGE button.

(2) On the d.c. calibrator (or test jig - see para. 3), set the INPUT switch to ON and adjust the VOLTAGE controls to obtain an indication on the d.c. voltmeter of -1.000 V.

(3) Adjust potentiometer R21 for an indication of 10 on the 10 scale of the 6460/1 meter.

(4) Adjust the VOLTAGE controls on the d.c. calibrator for an indication on the d.c. voltmeter of -300 mV.

(5) Depress the 3 W RANGE button.

(6) Adjust the VOLTAGE controls on the d.c. calibrator for an indication of -316.2 mV.

(7) Adjust potentiometer R19 for an indication of 10 on the 10 scale of the 6460/1 meter.

Range accuracy tests

13. To check the calibration on each range proceed as follows.

(1) Depress the upper RANGE button.

(2) Connect the d.c. voltmeter to the VOLTMETER terminals of the d.c. calibrator (or test jig - see para. 3) and adjust the VOLTAGE controls for an indication on the d.c. voltmeter of 4.312 V ±0.010 V.

(3) Adjust the CAL control to produce full-scale deflection on the 6460/1 meter.

(4) Adjust the d.c. calibrator controls in accordance with the tabulation given below. At each range setting, recheck the 6460/1 zero. Then adjust the d.c. calibrator VOLTAGE controls for an indication of 10 on the 10 scale of the 6460/1 meter. Verify that the d.c. voltmeter indication for each setting is within the limits, indicated in the third column.

Note...

The internal r.f. calibrator should be switched off during this test

RANGE button depressed	Calibrator RANGE switch setting	Limits (V) From	Limits (V) To
3 W*	0.3- 10 mW	1.330	1.386
1 W	0.3- 10 mW	0.4280	0.4344
.3 W	0.3- 10 mW	0.1352	0.1375
.1 W	3 -100 mW	21.39	21.75
.03 W	3 -100 mW	6.767	6.875
.01 W	3 -100 mW	2.114	2.157
3 mW	3 -100 mW	0.6710	0.6985

*Adjust the d.c. calibrator VOLTAGE controls for an indication of 3 on the 3 scale on the front-panel meter for this step only.

Noise test

14. To check the indicated noise level proceed as follows.

(1) Set the d.c. calibrator INPUT switch to OFF. Ensure that the 3 mW RANGE button on the type 6460/1 is depressed. Set the RESPONSE switch to NORMAL.

(2) Adjust the meter ZERO control for an indication of 5 on the 10 scale of the type 6460/1 meter. Verify that the noise as seen on the meter is less than 2% of full-scale (one small division peak-to-peak).

Zero carry-over test

15. To check the meter zero indication proceed as follows.

(1) Adjust the meter ZERO control for an indication of 0 on the type 6460/1 meter.

(2) Sequentially depress each of the remaining RANGE buttons and verify that the type 6460/1 meter indicates 0 at all positions.

Response time test

16. To check the action of the RESPONSE switch proceed as follows.

(1) Connect the oscilloscope to the OUTPUT terminals.

(2) Depress the 3 mW RANGE button.

(3) On the d.c. calibrator set the INPUT switch to ON and adjust the VOLTAGE controls for an indication of 10 on the 10 scale of the type 6460/1 meter.

(4) Set the oscilloscope sensitivity and sweep rate to 0.1 V/cm and 0.5 s/cm respectively.

(5) Set the d.c. calibrator INPUT switch to OFF and adjust the meter ZERO control for a 0 indication on the type 6460/1 meter.

(6) While observing the oscilloscope, set the d.c. calibrator INPUT switch to ON and verify that the rise time (10% to 90%) of the waveform is between 0.5 and 1.5 s.

(7) Set the RESPONSE switch to FAST and repeat test.

(8) The rise time should be between 50 and 150 ms. Set the RESPONSE switch to NORM.

Output adjust test

17. To check the operation of the ADJUST OUTPUT control proceed as follows.

(1) Depress the upper RANGE button.

(2) On the d.c. calibrator, set the range switch to 0.3 - 10 mW and adjust the VOLTAGE controls for an indication of 10 on the 10 scale of the 6460/1 meter.

(3) Rotate the ADJUST OUTPUT control counter-clockwise and verify that the indication on the oscilloscope varies from -1 V to 0.

Lamp matrix test

18. To check the operation of the RANGE lamps proceed as follows.

(1) Depress the upper RANGE button and set the LAMP MATRIX switch on the d.c. calibrator to 1 mW. Check that the 1 mW (DS2) lamp is illuminated.

(2) Sequentially depress all RANGE buttons and check that all lamps are functional in the 1 mW column (DS2-DS9).

(3) Repeat step (2) for the 10 mW, 100 mW and 3 W columns respectively.

RF calibrator calibration

19. This calibrator check should, for optimum accuracy, be carried out at 20°C.

(1) Connect the d.c. calibrator (or test jig - see para.3) to the powermeter and use it to simulate the connection of 1 mW, 10 mW, 100 mW and 3 W rft power heads by using the range scale control (LAMP MATRIX switch).

(2) Connect the calorimetric powermeter (with best absolute accuracy available and 100 mW power measurement capability) to the CAL output socket. Select the top range on 6460/1 and using the range scale control switch in the 3 W range. The calorimetric powermeter should indicate 100 mW ±0.7% (± uncertainty of the calorimetric powermeter).

(3) If the indication is outside this tolerance adjust R2 on the 6460/1 internal r.f. calibrator box.

(4) Repeat this procedure on the 10 mW range (adjust R14) and the 1 mW range (adjust R17).

(5) The logic switching of the various power levels is produced by applying the following logic levels to the pin connectors A, B or C on the r.f. calibrator box. (Logic '0' = short circuit to 0 V; logic '1' = open circuit.)

Output	*For head connected*	*Input 'A'*	*Input 'B'*	*Input 'C'*
1 mW	None	1	1	1
1 mW	1 mW	1	0	1
10 mW	10 mW	0	1	0
100 mW	100 mW	0	0	1
100 mW	3 W	0	0	1

Chapter 6

REPLACEABLE PARTS

CONTENTS

INTRODUCTION

1. Components are listed in alphanumerical order of circuit reference and the following abbreviations are used.

c.f.	:	carbon film
Comm	:	common part available from a number of manufacturers
d.p.d.t.	:	double-pole double-throw
m.f.	:	metal film
s.p.d.t.	:	single-pole double-throw
ww	:	wirewound
†	:	value selected in calibration

ORDERING

2. When ordering parts, please address your order to

Marconi Instruments Ltd.,
Sanders Division,
Gunnels Wood Road,
Stevenage,
Hertfordshire,

and indicate the following for each component :

(1) Type and serial number of instrument.

(2) Circuit reference.

(3) Description, manufacturer and part number.

COMPONENTS

3. Powermeter

Circuit ref.	*Description*	*Total used*	*Manufacturer*	*Part No.*
AR1-4	Amplifier, IC; type 741C Minidip	4	Comm.	
BT1,2	Battery, rechargeable (optional)	1	Ml Sanders	2200-186
CR1-4	Semiconductor diode; type 1N4148	39	Comm.	
CR5	Semiconductor diode; 1N5390	1	Fairchild or equiv.	
CR6-12	Semiconductor diode; 1N4004 or equiv.	10	Comm.	
CR13-55	Same as CR1			
CR49	Not used			
CR50-52	Same as CR6			
CR53-54	Same as CR1			
C1	Capacitor, fixed, ceramic, 0.1µF,30V	4	Comm.	
C2	Not used			
C3	Not used			
C4	Capacitor, fixed, ceramic, 0.01µF,100V	10	Comm.	
C5	Not used			
C6	Same as C4			
C7	Capacitor, fixed, tantalum, 68µF,15V,20%	1	ITT or equiv.	Tag 68/15
C8	Same as C1			
C9	Capacitor, fixed, tantalum 150µF,6V,20%	1	ITT or equiv.	Tag 150/6
C10	Not used			
C11	Capacitor, fixed, tantalum, 22µF,10V,10%	2	ITT or equiv.	Tap 22K10
C12	Capacitor, fixed, tantalum, 47µF,10V,20%	1	ITT or equiv.	Tag 47/6
C13	Same as C4			
C14	Same as C4			
C15	Not used			
C16	Not used			
C17	Same as C4			
C18	Same as C4			
C19	Capacitor, fixed, mylar, 0.1µF,10%,250V	2	WIMA MKS or equiv.	
C20	Not used			

Circuit ref.	Description	Total used	Manufacturer	Part No.
C21	Same as C19			
C22	Not used			
C23	Not used			
C24	Same as C4			
C25	Not used			
C26	Same as C11			
C27	Same as C4			
C28	Capacitor, fixed, mylar, 1µF, ±10%, 100V	2	WIMA TFM or equiv.	
C29	Same as C28			
C30	Not used			
C31	Capacitor, fixed, ceramic 0.047µF, 30V	1	Comm.	
C32	Capacitor, fixed, tantalum, 1µF, ±10%, 35V	1	ITT or equiv.	TAA 1K35A
C33	Capacitor, fixed, tantalum, 33µF, ±10%, 10V	1	ITT or equiv.	TAA 33K10B
C34	Same as C4			
C35	Not used			
C36	Not used			
C37	Not used			
C38	Same as C4			
C39	Capacitor, fixed, tantalum, 4.7µF, 35V, 10%	2	ITT or equiv.	TAA 4-7K35B
C40	Not used			
C41	Not used			
C42	Same as C39			
C43	Capacitor, fixed, electrolytic, 470µF, 25V	1	Mullard, Erie or equiv.	108-16471 21102-100-0471-0T-0250
C44	Capacitor, fixed, electrolytic, 1000µF, 40V	2	Mullard or equiv.	071-17102
C45	Not used			
C46	Same as C44			
C47	Not used			
C48	Not used			
C49	Capacitor, fixed, ceramic, 0.001µF, 500V	2	Comm.	
C50	Same as C1			
C51	Same as C50			

Circuit ref.	Description	Total used	Manufacturer	Part No.
C52	Same as C14			
C53	Capacitor, fixed, tantalum, 33µF,10V,20%	1	ITT	TAG 33/10
DS1	Neon indicator, clear	1	Arcolectric	SL41WL
DS2-32	Lamp, incandescent	32	Oshino or Chicago min	OL6006BP CM7-7382
F1	Fuse, 160mA	2	Comm.	
C1	Chopper, electronic	1	MI	3850-040F
K1	Relay	1	ERC or equiv.	MEP1-1MA/G3-9V
M1	Meter	1	MI	3888-011
PL1 & 2	Connector, socket, electrical	2	MI	3878-009
PL3	Appliance inlet, mains electrical, IEC type 320	1	MI	3850-034
	AC cord set, moulded, 3 core, 6 A, 250V, CEE22	1	MI	2400-035
R1	Resistor, variable cermet, 10kΩ,±20%	1	Bourns	3339H
R2	Not used			
R3	Resistor, fixed, film, 681Ω,±1%,1/8W	1	Comm.	
R4	Resistor, fixed, wirewound, 2kΩ,+0.05%	1	Mann Compnts.	AX175
R5	Resistor, fixed, wirewound, 1kΩ,+0.05%	1	Mann Compnts.	AX175
R6	Resistor, variable cermet, 100Ω,±20%	1	Bourns	3006-Y-1-101Z
R7	Not used			
R8	Resistor, fixed, film 47kΩ,±1%,1/8W	3	Comm.	
R9	Same as R8			
R10	Resistor, fixed, film 301Ω,±1%,1/8W	1	Comm.	
R11	Resistor, fixed, film 2.317kΩ,+0.1%,1/8W	1	Comm.	
R12	Resistor, fixed, m.f., 100kΩ,±2%,1/4W	6		24773-321L
R13	Resistor, fixed, film, 20.94kΩ,±0.1%,1/8W	1	Comm.	
R14	Resistor, fixed, m.f., 10kΩ,±2%,1/4W	2		24773-297M
R15	Resistor, fixed, film, 209.4kΩ,+0.1%,1/8W	1	Comm.	
R16	Resistor, fixed, m.f., 1kΩ,±2%,1/4W	1		24773-273A
R17	Resistor, fixed, film 2.094MΩ,±0.1%,½W	1	Comm.	
R18	Resistor, fixed, m.f., 100Ω,±2%,1/4W	2		24773-249J
R19	Resistor, variable cermet, 50Ω,+20%	1	Bourns or equiv.	3006P

Circuit ref.	Description	Total used	Manufacturer	Part No.
R20	Resistor, fixed, film 220Ω,±1%,1/8W	1	Comm	
R21	Resistor, variable cermet, 200Ω,±20%	1	Bourns or equiv.	3006P
R22	Resistor, fixed, film 909Ω,±1%,1/8W	1	Comm.	
R23	Resistor, variable 25kΩ	1	MI Sanders	3850-031
R24	Resistor, fixed, ww, 82Ω,±0.05%	1	Mann Compnts.	AX175
R25	Resistor, variable ww, 1kΩ,±20%,1W	1	Reliance MW or equiv.	
R26	Resistor, fixed, 10Ω	1	MI Sanders	3850-035
R27	Resistor, fixed, m.f., 16kΩ,±2%,1/4W	1		24773-302X
R28	Same as R8			
R29	Resistor, fixed, Film, 249kΩ,±1%,1/8W	1	Comm.	
R30	Not used			
R31	Same as R12			
R32	Same as R12			
R33	Not used			
R34	Resistor, fixed, m.f., 220kΩ,±2%,1/4W	1		24773-329T
R35	Resistor, fixed, ww, 68Ω,±20%,3W	1	Welwyn	W21,CGS C3
R36	Not used			
R37	Resistor, fixed, m.f., 470kΩ,±2%,1/4W	1		24773-337R
R38	Resistor, fixed, film, 3.16kΩ,±1%,1/8W	1	Comm.	
R39	Resistor, variable cermet, 500Ω,±20%	1	Bourns	3329H
R40	Resistor, fixed, film, 1/8W Select value at test	1	Comm.	
R41	Same as R12			
R42	Resistor, fixed, film, 634kΩ,±1%,1/8W	1	Comm.	
R43	Not used			
R44	Not used			
R45	Resistor, fixed, film, 1/8W Select value at test	1	Comm.	
R46	Resistor, fixed, m.f., 68kΩ,±2%,1/4W	1		24773-317N
R47	Resistor, fixed, m.f., 24kΩ,±2%,1/4W	1		24773-306B
R48	Resistor, fixed, m.f., 4.7kΩ,±2%,1/4W	4		24773-289W
R49	Same as R48			
R50	Resistor, fixed, m.f., 47kΩ,±2%,1/4W	3		24773-313H
R51	Resistor, fixed, m.f., 3.3kΩ,±2%,1/4W	1		24773-285F
R52	Resistor, fixed, m.f., 3.9kΩ,±2%,1/4W	6		24773-287V
R53	Same as R50			

Circuit ref.	*Description*	*Total used*	*Manufacturer*	*Part No.*
R54	Same as R12			
R55	Same as R14			
R56	Same as R50			
R57	Resistor, fixed, m.f., 4.7MΩ,±2%,1/4W	1		24321-881F
R58	Resistor, fixed, m.f., 68kΩ,±2%,1/4W	1		24773-317X
R59	Not used			
R60	Resistor, fixed, m.f., 150Ω, ±2%,1/4W	1		24773-253F
R61	Resistor, fixed, m.f., 8.2kΩ, ±2%,1/4W	1		24773-295P
R62	Resistor, fixed, m.f., 51Ω, ±2%,1/4W	1		24773-242Z
R63	Resistor, fixed, m.f., 200Ω, ±2%,1/4W	1		24773-256S
R64	Same as R18			
R65	Same as R48			
R66	Resistor, fixed, film, 1.3kΩ,±1%,1/8W	2		
R67	Same as R66			
R68	Same as R48			
R69	Resistor, variable cermet, 200Ω,±20%	1	Bourns	3329H
R70	Resistor, fixed, m.f., 56Ω, ±2%,1/4W	2		24773-243H
R71	Resistor, fixed, m.f., 20Ω, ±2%,1/4W	1		24773-232X
R72	Resistor, fixed, m.f.,1.2 Ω, ±2%,1/4W	2		24773-203R
R73	Resistor, fixed, m.f., 3.3Ω, ±2%,1/4W			24773-213U
R74 †	Resistor, fixed, film, 1kΩ,±1%,1/8W	2	Comm.	
R75	Same as R70			
R76	Resistor, fixed, film, 8.45kΩ,±1%,1/8W	2	Comm.	
R77	Same as R74			
R78	Same as R76			
R79	Resistor, fixed, m.f., 43kΩ, ±2%,1/4W	1		24773-312Z
R80	Resistor, fixed, m.f., 1.5kΩ,±2%,1/4W	2		24773-277U
R81	Same as R62	2	Comm.	
R82	Same as R80			
R83	Same as R81			
R85	Resistor, fixed, ww., 68Ω,±5%,1.5W	1	Paignton	MV1A
R86	Resistor, fixed, m.f., 2kΩ,±2%,1/4W	4		24773-280U
R87	Same as R52			
R88	Same as R86			
R89	Same as R52			

Circuit ref.	Description	Total used	Manufacturer	Part No.
R90	Same as R86			
R91	Same as R52			
R92	Same as R52			
R93	Same as R86			
R94	Same as R52			
R95	Resistor, fixed, m.f., 6.2kΩ,±2%,1/4W	1		24773-292W
R96	Resistor, fixed, m.f., 750Ω,±2%,1/4W	1		24773-270R
R97	Resistor, fixed, c.f., 220Ω,±5%,2W	1	Comm.	
R98	Resistor, fixed, m.f., select at test, 1/4W	1	Comm.	
R99	Resistor, fixed, m.f., select at test, 1/4W	1	Comm.	
S1	Switch, pushbutton, 8 station	1	MI	3850-038
S2	Switch, d.p.c.o.	1	MI	23467-161W
S3	Switch, d.p.c.o.	1	MI	23467-161W
S4	Switch, pushbutton, 5 station	1	MI	3878-033
S5	Switch, d.p.c.o.	1	MI	23467-161W
SK4	Binding post assembly, BLK & RED	1	Belling Lee or equiv.	L1568/1
T1	Transformer, a.f.	1	MI	3850-030
T2	Transformer, power step-down	1	MI	3850-046
VT1-3	Transistor 2N5138 or PN 4250	7	Comm.	
VT4	Transistor 2N5133 or 2N2222	1	Comm.	
VT5-8	Same as VT1			
VT9,10	Transistor BD132	2	Comm.	
VT11-17	Transistor 2N5135 or PN 5135-05	7	Comm.	
VR1,2	Voltage regulator, IC; 723C DIL	2	Fairchild or equiv.	

4. RF calibrator

Circuit ref.	Description	Total used	Manufacturer	Part No.
C1	Capacitor, fixed, ceramic, 0.01μF,100V	10	Comm.	
C2	Capacitor, fixed, polystyrene, 0.001μF,125V,2%	2	Comm.	

Circuit ref.	Description	Total used	Manufacturer	Part No.
C3	As C1			
C4	As C1			
C5	As C1			
C6	Capacitor, fixed, polystyrene, 150pF,2%	1	Comm.	
C7	Capacitor, fixed, polystyrene, 15pF,±1pF	2	Comm.	
C8	Capacitor, air spaced trimmer,3-11.5pF	1	MI	26816-236
C9	As C16			
C10	As C2			
C11	As C1			
C12	As C1			
C13	Capacitor, fixed, polystyrene,22pF,±1pF	1	Comm.	
C14	Capacitor, fixed, mica, 56pF,±1pF	1	Comm.	
C15	Capacitor, fixed, mica, 27pF,±1pF	1	Comm.	
C16	Capacitor, fixed, ceramic, 0.001μF	4	Comm.	
C17	As C16			
C18	As C1			
C19	As C1			
C20	As C1			
C21	As C1			
C22	As C16			
C23	As C7			
D1	Semiconductor diode HG1005	2	BAT 85	
D2	Diode, Zener, BZX79 C5V1	1	MI	28371-401V
D3	Diode, Schottky, HP5082-2800	2	HP	
D4	Diode, 1N4148	1	Comm.	
D5	Diode, 1S920	1	MI	28336-138T
D6	As D3			
D7	As D1			
IC1	Integrated circuit 7400N	1	Comm.	
IC2	Op.amp. N5556	1	MI	28461-311
R1	Resistor, fixed, m.f., 120Ω,2%,1/8W	1	Comm.	
R2	Resistor, variable, cermet, 50kΩ,10%	1	MI	25748-509C
R3	Resistor, fixed, m.f., 33kΩ,2%,1/8W	3	Comm.	

Circuit ref.	Description	Total used	Manufacturer	Part No.
R4	As R3			
R5	Resistor, fixed, m.f., 680Ω,2%,1/8W	1	Comm.	
R6	Resistor, fixed m.f., 6.8kΩ,2%,1/8W	2	Comm.	
R7	Resistor, fixed, m.f., 1.8kΩ,2%,1/8W	1	Comm.	
R8	Resistor, fixed, m.f., 68Ω,2%,1/8W	1	Comm.	
R9	Resistor, fixed, m.f., 2.7kΩ,2%,1/8W	1	Comm.	
R10	Resistor, fixed, m.f., 470Ω,2%,1/8W	1	Comm.	
R11	Resistor, fixed, m.f., 33Ω,2%,1/8W	1	Comm.	
R12	Resistor, fixed, m.f., 51Ω,2%,1/8W	1	Comm.	
R13	Resistor, fixed, m.f., 2kΩ, 2%,1/8W	1	Comm.	
R14	Resistor, variable, cermet, 1kΩ,10%	2	MI Sanders	25748-504D
R15	As R6			
R16	Resistor, fixed, m.f., 6.2kΩ,2%,1/8W	1	Comm.	
R17	As R14			
R18	Resistor, fixed, m.f., 1.5kΩ,2%,1/8W	1	Comm.	
R19	As R3			
R20	Resistor, fixed, m.f., 220Ω,2%,1/8W	1	Comm.	
R21	Resistor, fixed, m.f., 1.2kΩ,2%,1/8W	1	Comm.	
R22	Resistor, fixed, m.f., 12Ω,2%,1/8W	2	Comm.	
R23	As R22			
RLA	Reed relay	2	Clare	PRME 15005AB
RLB	As RLA			
TR1	Transistor BC107B	1	Comm.	
TR2	Transistor BFW16A	1	Comm.	

Chapter 7

SERVICING DIAGRAMS

CONTENTS

CIRCUIT NOTES

(1) PL1 and PL2 are front and rear panel input connectors and are connected in parallel.

(2) DO NOT MAKE RESISTANCE CHECKS ON TRANSFORMER T1.

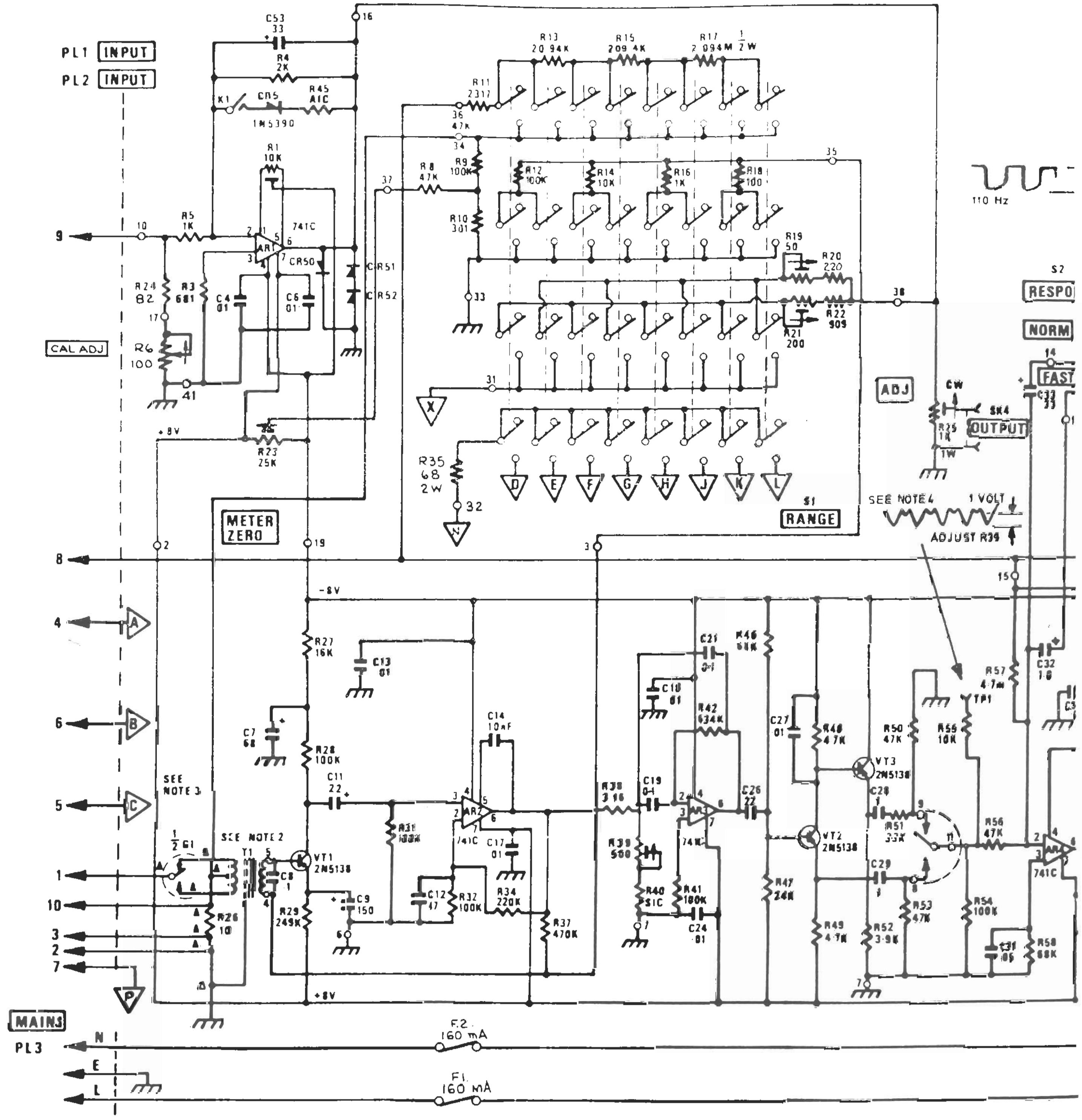
(3) Junctions marked Λ utilize low thermal solder.

(4) Waveform observed when AR4 is removed and top RANGE button is depressed.

(5) Circuit positions marked ▷ and with identical letters are interconnected.

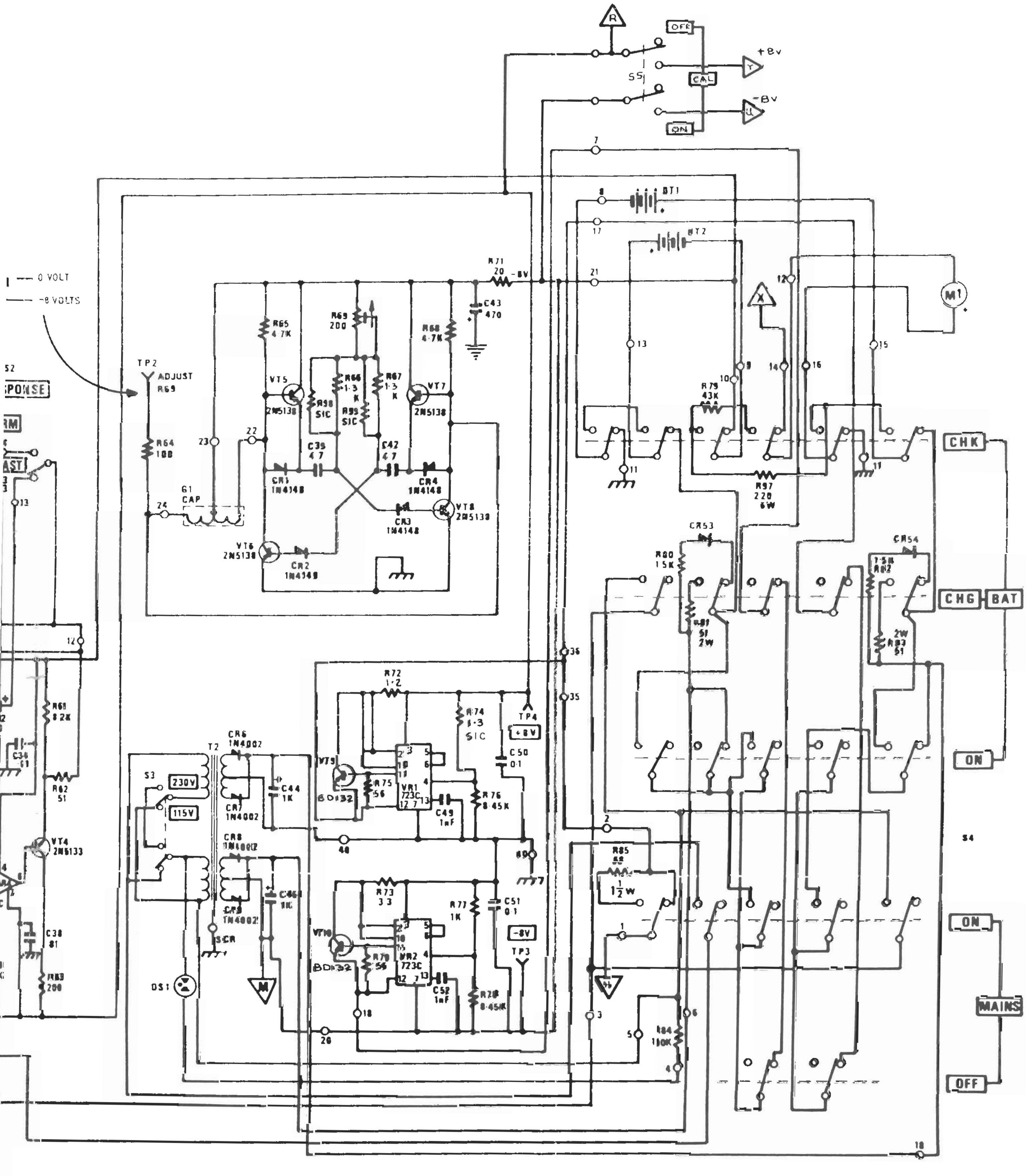
(6) Unless otherwise specified:-

Resistances are given in ohms and are rated 1/8 W unless shown on circuit diagram. Capacitances are given in microfarads.

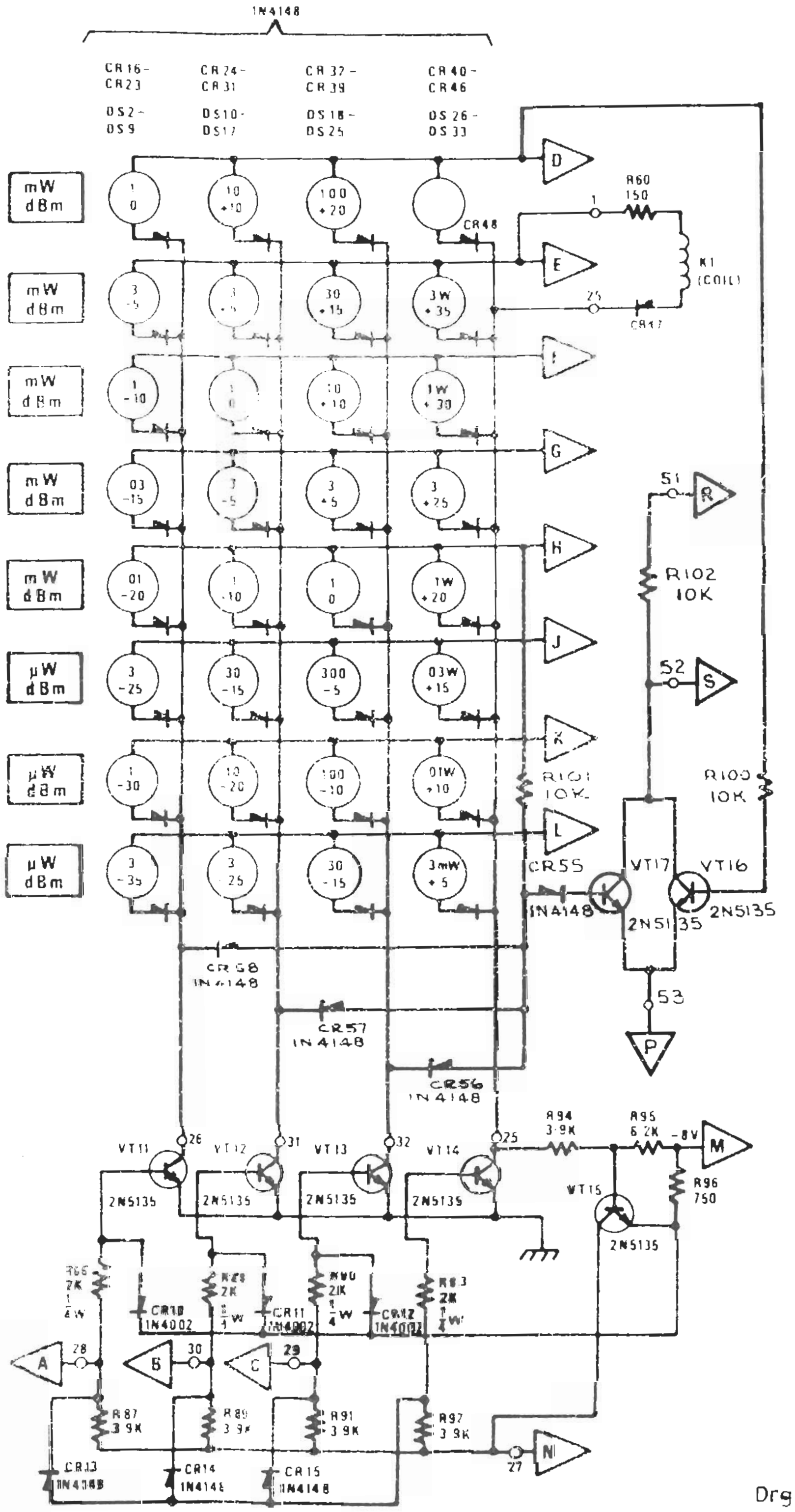


Drg. No. S3878/900 Sheet 1 Iss. 2

Fig. 1



60/1 circuit diagram



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meter range switching circuit diagram

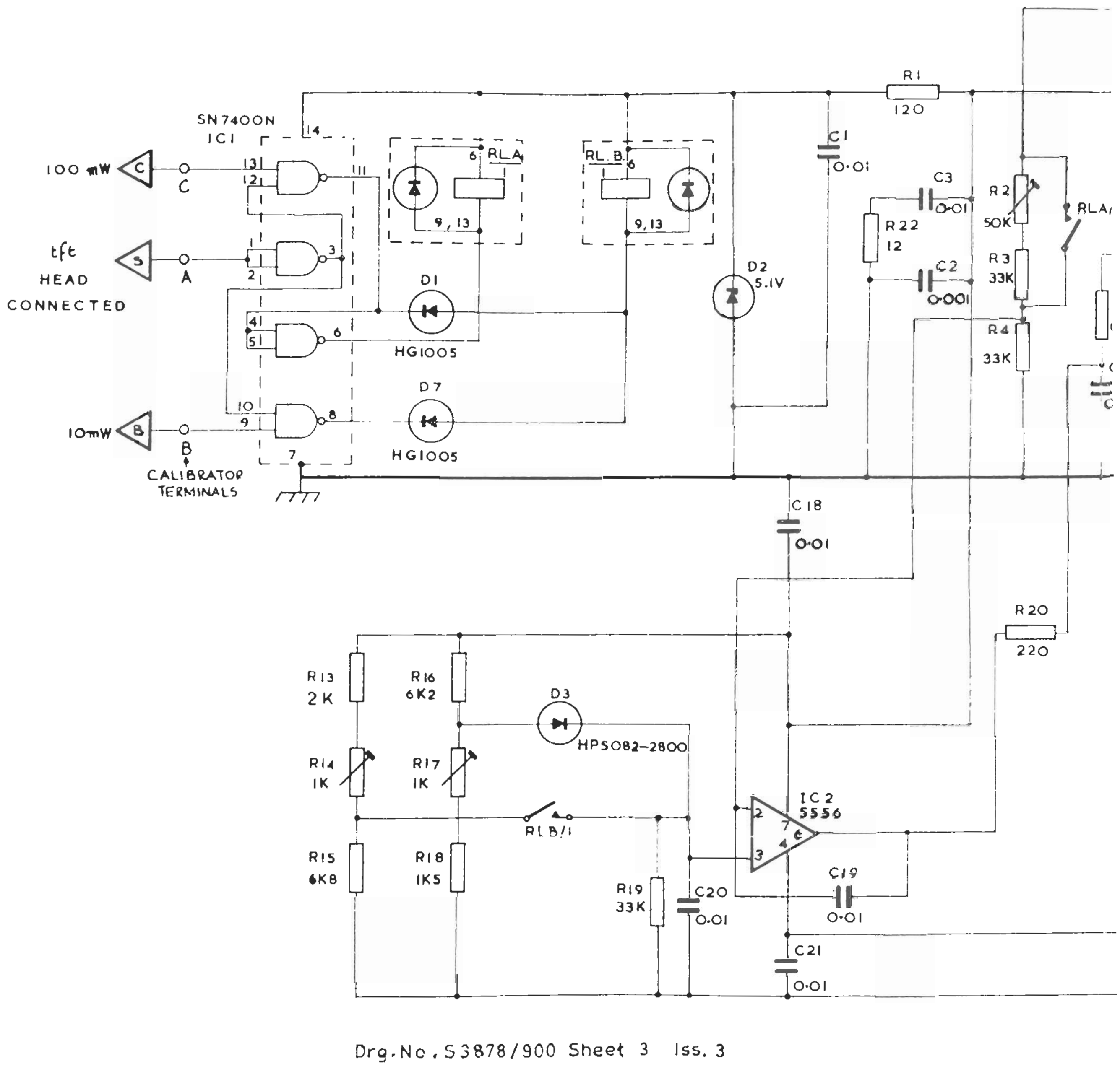

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Fig. 3 RF calibrator

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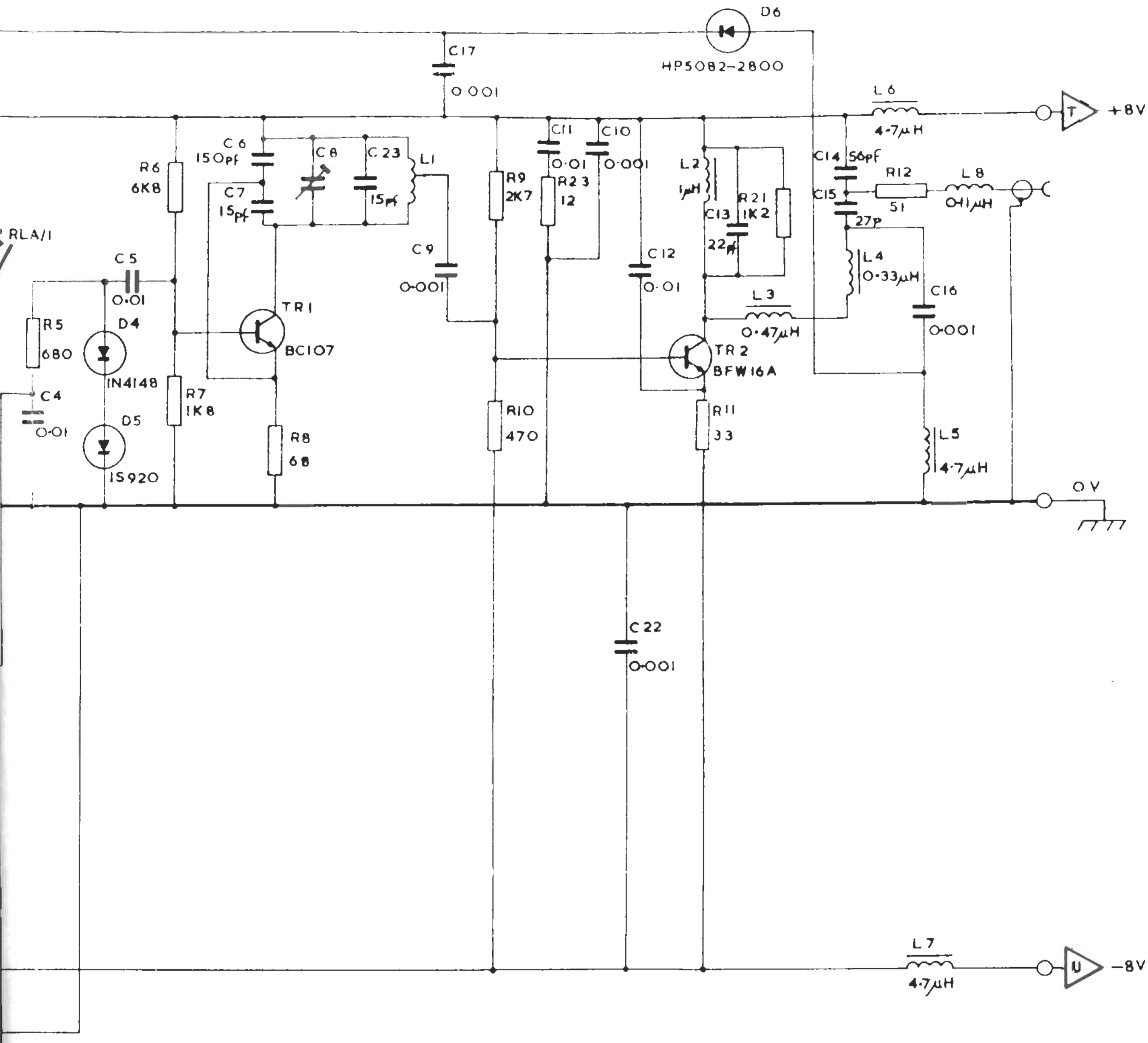


tor circuit diagram

Marconi
Instruments

6440 series

tft POWER HEADS

Chapter 1

General information

1.1 GENERAL DESCRIPTION

The Type 6440 Series of tft (R)* Power Heads, in conjunction with the compatible Power Meter, are designed to measure mean r.f. power from –35dBm to +10dBm (0.3μW to 10mW) at frequencies from 10MHz to 18GHz (22GHz with the Type 6440).

R.F. connectors in Type N or SMA with 50 ohm impedance are available – see Table 1.

These tft Power Heads are compatible with the Power Meters Types 6460, 6550B and 6555.

The Calibration Factor and Effective Efficiency data is given on a label attached to each tft Power Head.

* Thin film thermoelectric

Chapter 2

Operation

2.1 OPERATING INFORMATION

To place the tft Power Head into use, first connect it to a tft powermeter and zero the instrument to balance out residual thermal emf's. (The detailed operating procedures for the Type 6460, 6555 and 6550B are given in the Operating and Service Manuals supplied with those instruments.) If correction for Effective Efficiency or Calibration Factor is desired, transfer the correction from the appropriate graph attached to each tft Head to the control at the rear of the mount. The tft Power Head should then be connected to the r.f. system under test and the mean power will be indicated on the tft Powermeter.

2.2 OPERATING INSTRUCTIONS

The operating instructions for the tft Power Heads applies to the maximum allowable RF input power.

The absolute maximum RF signal level that may be coupled to the 6440 Series tft Power Heads is given in Table 1.

TABLE 1

6440 SERIES TFT POWER HEADS

The 6440 Series are thermoelectric Power Heads with coaxial connectors in Type N and miniature SMA. These Power Heads extend the operating frequency to 18GHz in coaxial line. 6440N/1 is intended for use with Powermeter System 6460S and differs from 6440N only in its type of connecting cable.

SPECIFICATIONS

Type	Freq. Range (GHz)	Average Power Range (1) From	To	Max. peak pulse power at $+25^\circ$C	Max. Energy Per Pulse at $+25^\circ$C W – µ sec	Pulse Duration at $+25^\circ$C µs (max)	Max. dc voltage	Max. VSWR	Field Replacement tft element	RF Connector
6440	0.01–22(2)									SMA-male
6440N and –N/1	0.01–18	0.3µW –35dBm	10mW +10dBm	1W	5	5	10	1.5:1 from 0.01 to 0.015GHz 1.35:1 from 0.015 to 10GHz 1.6:1 from 10 to 22GHz(2)	TL–4A	Type N male(4)

R.F. Impedance: 50Ω nominal

Temperature Coefficient: Less than 0.1% per deg. C. when used with any tft Powermeter

Dimensions: 6440, 2.66" L x 1.28" Dia. (67,6 x 32,5 mm)(3)
6440N, 3.42" L x 1.28" Dia. (86,9 x 32,5 mm)(3)

Weight: Approx. 3 oz. (35,1 gm)

(1) For Powermeter Type 6555 the lower power limit is increased by 20dB and Type 6550B the lower power limit is increased by 10dB

(2) Upper Frequency limit for 6440N is 18GHz. Standard 6440 has upper frequency limit of 18GHz with operation up to 22GHz available to special order.

(3) Maximum, including r.f. connector but excluding cable and multi pin connector.

(4) Precision type N 50Ω male to MIL–C–39012

Figure 1 expresses the absolute maximum energy input in graphical form.

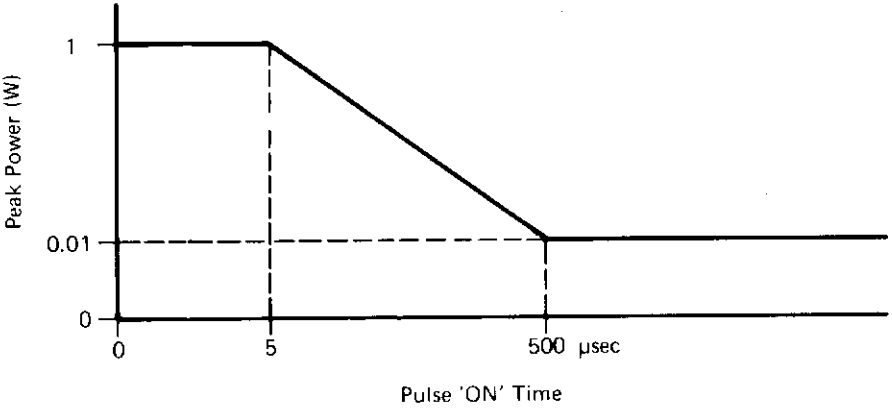


Figure 1 Allowable Energy Input to 6440 Series Power Head

2.3 CAUTION

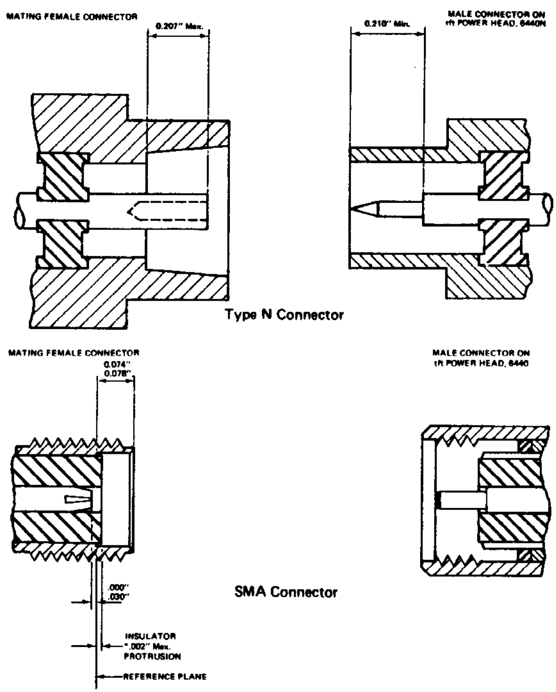
While the tft Power Heads will take overloads of up to 300% for short periods, the levels given in table 1 should not be exceeded or damage may result.

2.4 RF INPUT CONNECTORS

The input connectors on the tft Power Heads are precision connectors produced to Mil-C-39012 or IEEE Standard. When assembled with mating connectors to the dimensions shown in Figure 2, the optimum impedance match is achieved.

Chapter 2

Operation



Interface Dimensions to Mil-C-39012
for Optimum Performance

Figure 2

Chapter 3

Technical description

3.1 PRINCIPLES OF OPERATIONS

The tft Power Heads incorporate a thin film metallic load, which acts as a well-matched 50 ohm termination and absorbs the incident r.f. power. The load contains thermoelectric junctions which absorb the r.f. power and generate a proportional d.c. voltage. The d.c. output is coupled to the power meter amplifier and displayed as true mean power.

3.2 SOURCES OF ERROR

There are two primary sources of error that are common to most power measuring devices. These are best described by the terms mismatch and efficiency errors.

3.2.1 Mismatch errors

The ideal power sensing device would be completely reflectionless, absorbing all the power that is incident upon it. Although all models of coaxial tft Power Heads are very well matched over an extremely broad band of frequencies, there may still be a significant amount of power reflected at some frequencies.

In order to account exactly for the mismatch error, one must know the complex impedances of both generator and load. In most circumstances, it is not convenient to measure these quantities. Nevertheless, with a knowledge of the magnitude of these two quantities, it is possible to establish an upper limit on this error with the use of the following equation:

$$\text{Mismatch error} = \frac{(1 - |\Gamma_g|^2)(1 - |\Gamma_L|^2)}{(1 \pm |\Gamma_g \Gamma_L|)^2}$$

where Γ_g = the generator reflection coefficient.

Γ_L = the load reflection coefficient, and

$$\Gamma = \frac{VSWR-1}{VSWR+1}$$

Figure 3 is a graph of the limits of mismatch error as a function of generator and load VSWR.

3.2.2 Efficiency errors

Although the usual definitions of mount efficiency as applied to barretters and thermistors do not apply to tft Power Heads, since these devices do not depend directly upon substitution power to effect a measurement, an equivalent error exists which is a result of the frequency dependent response of the unit. As described below, calibration of the tft Power Heads can be performed at audio frequencies and this is one of the factory procedures employed.

Technical description

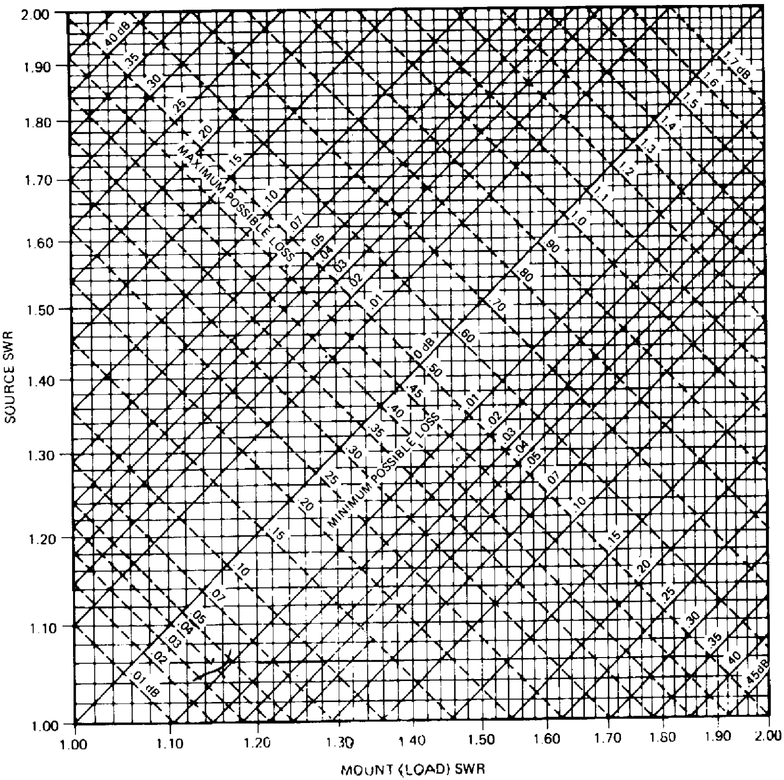


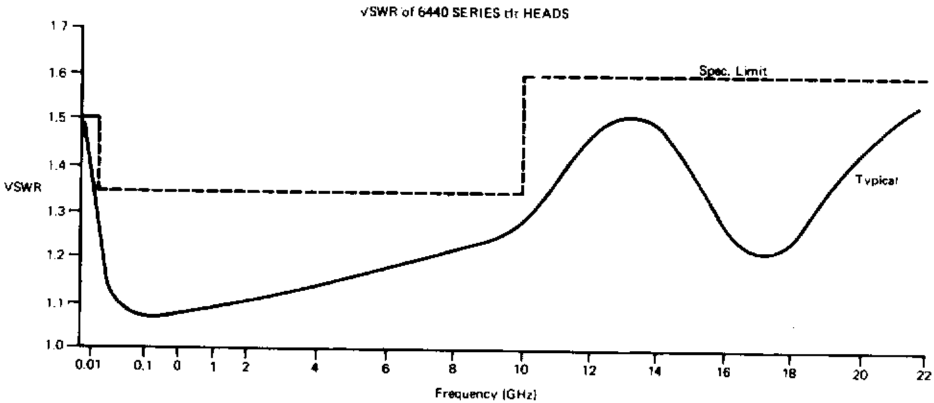
Figure 3 Mismatch Loss Limits

Chapter 3

Technical description

Ideally the Joule heating effect of the audio power used in calibration and the r.f. power to be measured should be the same, giving rise to the same thermo-electric emf, in practice, some of the r.f. power absorbed by the mount is lost in the metallic conductors, dielectric supports of the mount, the r.f. bypass capacitors and contacts of the tft element. This error is corrected by the Effective Efficiency factor (i).

Every tft Power Head is individually calibrated using standards traceable to the most accurate available, and which have British Calibration Service (BCS) approval.



Chapter 3

Technical description

A calibrated control on the tft Head permits for correction of its variation in efficiency with frequency. This efficiency is essentially 100% up to 2GHz and a calibration chart on the tft Head gives correction in terms of EFFECTIVE EFFICIENCY(i) and also CALIBRATION FACTOR(ii) at higher frequencies. With the CAL. FACTOR correction, the powermeter and tft Power Head will, when used with a 50 ohm matched generator, measure power corrected for all errors and mismatch uncertainties, except those resulting from the uncertainty of the basic Standard and its transfer. With the EFF.EFF.correction, the powermeter, when used with a conjugate match generator, will similarly eliminate all major losses and uncertainties.

(i) EFFECTIVE EFFICIENCY is the ratio of audio reference power to r.f. power dissipated within the tft Head for the same dc output voltage.

(ii) CALIBRATION FACTOR is the ratio of audio reference power to r.f. power incident on the tft Head for the same dc output voltage.

Chapter 4

Maintenance

4.1 GENERAL MAINTENANCE

Except for replacement of tft elements, maintenance should not be required for tft Power Heads.

Field Servicing of the microwave assembly section (Male connector assembly and lower housing, see diag. fig. 4) is not possible and if any part of this becomes defective, the unit should be returned to the factory.

4.2 FAULT FINDING

The information given below is intended to help isolate a problem to a particular part of the tft Head.

4.2.1 Powermeter will not zero

With the tft Power Head connected to a Powermeter, but without r.f. input to Power Head, the Powermeter cannot be zeroed with relevant Powermeter control, proceed as follows:-

(a) Remove Power Head cable from Powermeter. With suitable multimeter check tft element.

tft element check

(b) Verify that the resistance between pins 1 and 3 on P1 is approximately 200 ohms. DO NOT USE R ÷ 100 OHMMETER RANGE

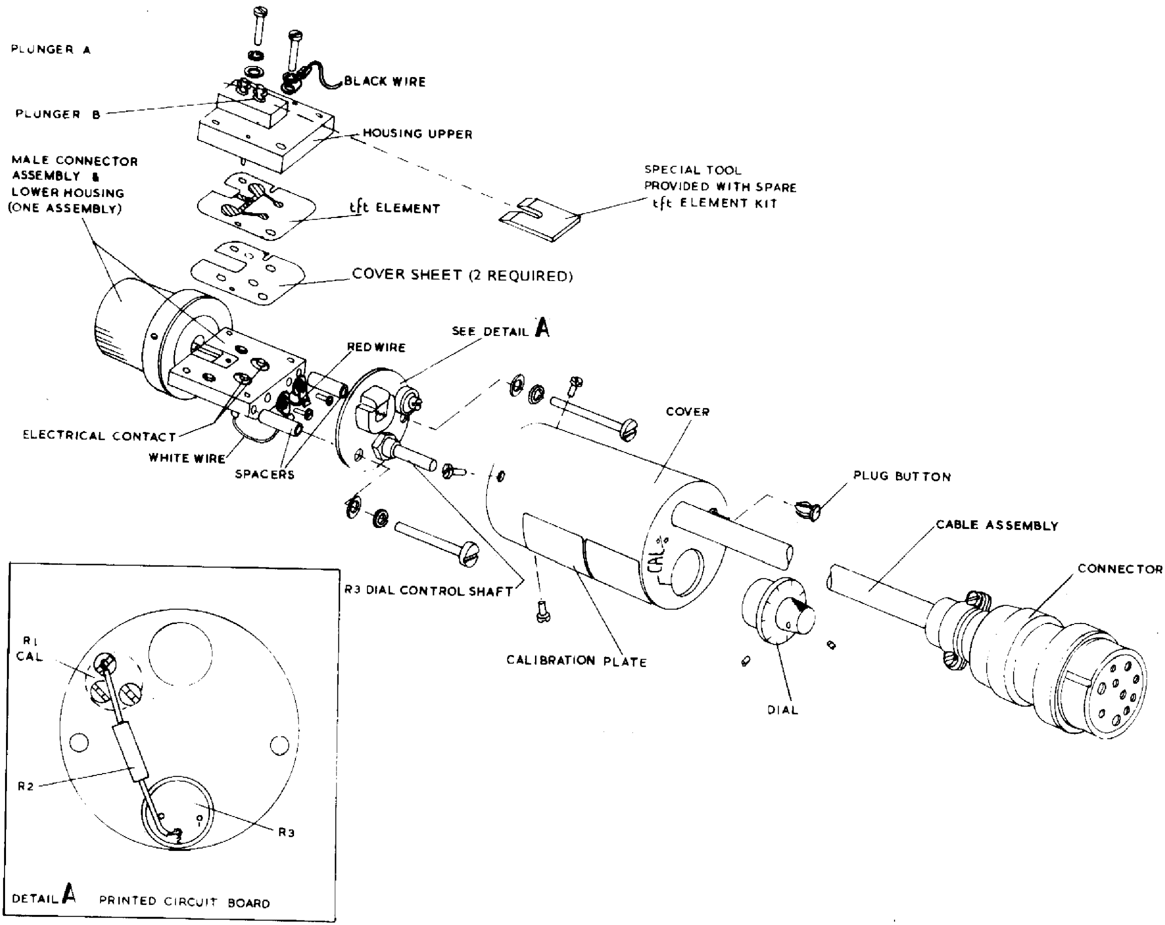

PLUNGER A
BLACK WIRE
PLUNGER B
HOUSING UPPER
MALE CONNECTOR
ASSEMBLY &
LOWER HOUSING
(ONE ASSEMBLY)
SPECIAL TOOL
PROVIDED WITH SPARE
tft ELEMENT KIT
tft ELEMENT
COVER SHEET (2 REQUIRED)
SEE DETAIL A
RED WIRE
COVER
ELECTRICAL CONTACT
WHITE WIRE
SPACERS
PLUG BUTTON
CABLE ASSEMBLY
CONNECTOR
CAL
R3 DIAL CONTROL SHAFT
R1
CAL
CALIBRATION PLATE
DIAL
R2
R3
DETAIL A PRINTED CIRCUIT BOARD

Figure 4

Maintenance

(c) If resistance is in excess of 250 ohms element should be replaced, see Section 4.3.

Isolation Check

(d) Using R x 100 scale verify that an open circuit exists between pins 1 and 2, and between 3 and 2 on Plug P1.

(e) If resistance is not infinite check tft element assembly. See section 4.3.2.

If all the above checks show the tft Power Head to be working to specification then the tft element is satisfactory and the fault may be in the other circuits of the Power Head. Proceed to checks 4.2.2.

4.2.2 Powermeter will not indicate power

If the tft Power Head has been satisfactorily checked to tests 4.2.1 and the Powermeter indication still remains at zero, even if r.f. power is applied to the Head, or is erratic, then proceed as follows:-

(a) Remove Power Head cable from Powermeter. Using suitable multimeter (ohms R x 1 range)

Feedback resistance check

(b) Using multimeter check that resistance between Pins 8 and 9 on plug P1 is between 30 and 200 ohms.
If the measured resistance lies outside this range the dc components inside the tft Power Head are defective. To isolate the specific component continue as below.

(c) Vary Eff.Eff/.Cal.Factor control on Power Head. The measured resistance should vary correspondingly.

(d) The angular rotation of Eff.Eff./Cal.Factor control should not exceed 270 degrees of arc. If the control can be rotated continuously in one direction and the resistance reading is erratic the variable resistor R3 (see Circuit fig. 6) is defective and should be replaced.

RF input assembly check

(e) Measure input capacitance at r.f. connector by measuring between centre conductor and connector outer diameter. This measurement can be made with any suitable capacitance bridge. Input capacitor when measured should be greater than 200 picofarads. If a lower capacitance is measured then the r.f. input assembly is defective and the complete tft Power Head should be returned to Marconi Instruments Limited.

4.3 tft POWER HEAD SERVICING

4.3.1 Factory repair facility

To obtain a factory replacement of tft elements for your tft Head, please return units to:

Marconi Instruments Limited,
Service Division (Microwave),
PO Box 10,
Six Hills Way,
Stevenage,
Herts SG1 2AU
England.

4.3.2 Field replacement of tft element

As the tft elements used in the tft Power Heads are field replaceable, a spare parts kit can be supplied for servicing carried out by users.

When spare tft elements are required for field replacement they should be ordered in accordance with the following:-

Type No. tft Power Head	Type No. tft Power Head
6440	TL-4A
6440N	TL-4A

tft element replacement procedure

Proceed as follows for field replacement of TL-4A elements. The use of the special tool (U-Jig) furnished with each replacement element is required.

1. Loosen setscrew and remove dial from dial shaft (See diagram, fig.4)
2. Remove the three screws which secure the enclosure to the Power Head assembly. Slip the enclosure along the cable away from the power head assembly.
3. Hold the U-jig bevel side up and slide it between the two snap rings of Plunger A and B and the Housing upper.

Maintenance

4. Loosen each screw fixing housing upper to lower housing one turn.

5. Then remove screw (without black wire attached) lockwasher and flatwasher.

6. Then remove other screw, lockwasher and earth tag with black wire.

7. Carefully lift the upper housing straight away from the lower housing.

8. Remove the cover sheets and element from the guide pins on the upper housing.

9. Clean the mounting surfaces of the upper and lower housing with a soft pipe cleaner using acetone or another residue-free cleaning agent. Donotallow the cleaning agent to make contact with the two plastic pins in the upper housing, or the two bellows, stripline or cavity area near the stripline in the lower housing. After cleaning, inspect the two surfaces to verify that all foreign particles have been removed.

10. Clean the replacement tft element with a dry soft pipe cleaner to remove all dust and lint. Do not clean with any cleaning agent. The tft element should be carefully handled with tweezers, ensuring that the tweezers do not touch the film area of the element.

11. Carefully install replacement element (with cover sheet on both sides) over guide pins on upper housing, aligning the two larger holes in the element with the two mounting holes in the upper housing, and aligning the cut-out in the element with the corresponding cut-out in the upper housing.

12. Clean the replacement cover sheet with acetone. Dry it thoroughly before installation.

13. Install a new cover sheet over the element. Do not use the old cover sheet.

14. Carefully align the upper housing guide pins with the corresponding holes in lower housing and bring the blocks together.

15. Install first screw, lockwasher and flatwasher, and second screw, lockwasher and earth tag with black wire. Ensure that the flat surface of the flatwasher faces the upper housing. Tighten both screws one turn at a time until the two blocks are firmly secured.

16. Remove the U-Jig and check for proper element installation by verifying that the resistance between pins 1 and 3 on the multipin connector P1 is nominally 200 ohms. Use the R x 100 scale. Then check that an open circuit appears between pins 1 and 2, and between 3 and 2. Use the R x 100 scale. If not, there may be a foreign particle in the Power Head. If this occurs, the mount should be disassembled, cleaned as described above, and reassembled.

17. If the above checks show that the tft element has been correctly replaced, refit the enclosure over the Power Head assembly, and secure.

18. Rotate the dial control shaft fully clockwise, set the dial to read 100%, and secure.

19. Perform the recalibration procedures described below.

4.4 CALIBRATION

To recalibrate the tft Power Head as part of a periodic calibration programme, it is acceptable to use either of the two following procedures.

4.4.1 Audio Calibration

If this procedure is employed, frequency of between 400 and 1000Hz is best so that mount efficiency errors can be ignored.

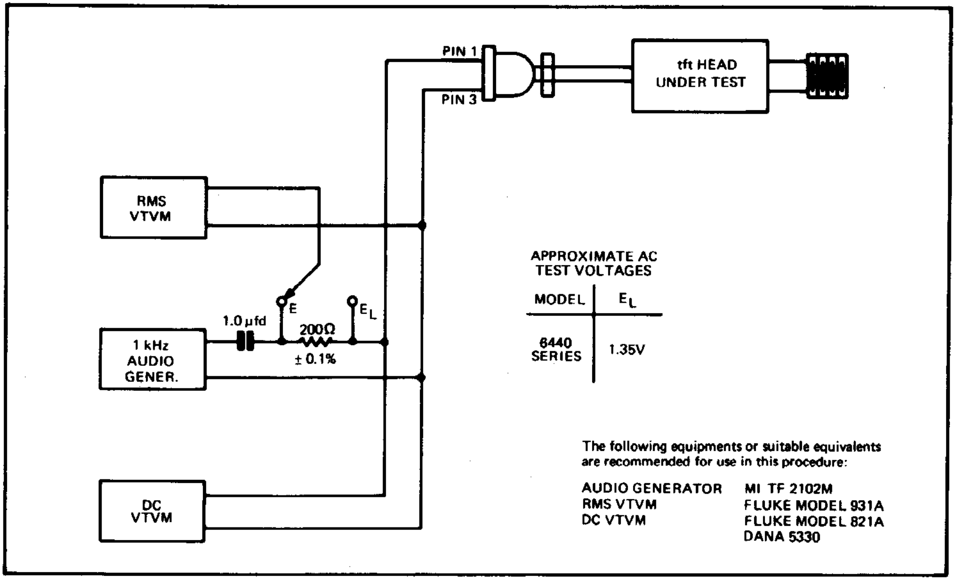


Figure 5 Test Set-Up for Audio Calibration

(a) Connect the tft Power Head as shown in figure 5. Be sure to observe proper ground connections to avoid spurious ground loops. To check for this, prior to connecting the tft Power Head, observe the d.c. voltmeter as the a.c. generator output is varied. There should be no reading under these conditions. Disconnect the d.c. voltmeter and observe that there is no change in the a.c. voltmeter reading.

(b) Adjust the output of the 1KHz generator to the voltage indicated Fig.5 (approximately 10% below the maximum rated power of the head). Measure the rms audio input voltages (E and E_L) and the d.c. output voltage E_{dc} and comput the sensitivity (S) as follows:

$$S = \frac{E_{DC}}{\dfrac{(E - E_L)}{200}\left[E_L\right]} \qquad \text{EQUATION (1)}$$

Compute the required value for the calibration resistance from the formula

$$R = 971\left[0.478S - 0.103\right]$$

Connect a precision resistance bridge between pins 8 and 9 of P1 and adjust R3 to produce the desired resistance.

Maintenance

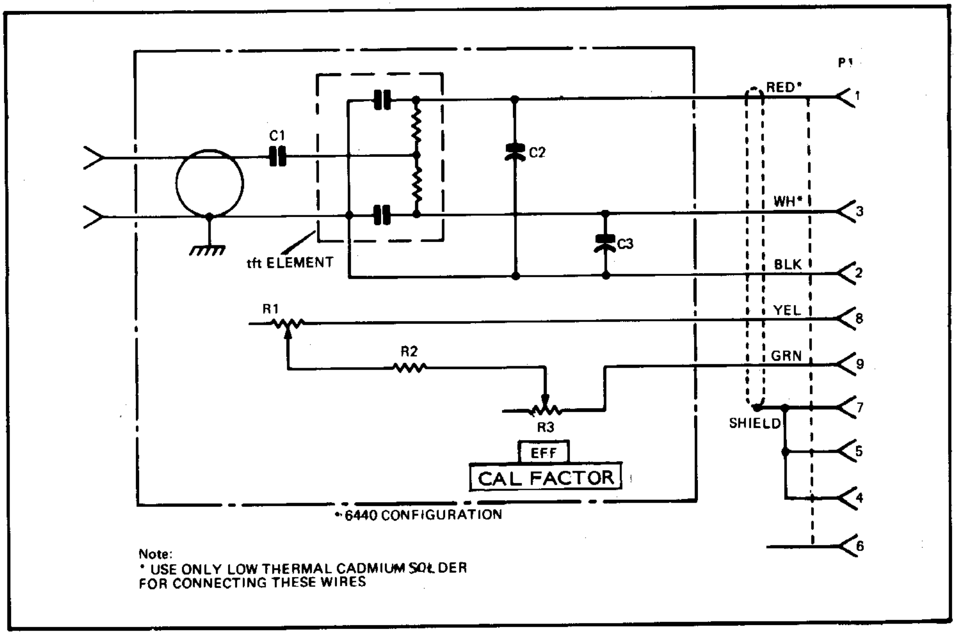


Figure 6 Circuit Diagram for Type 6440 Series

4.4.2 R.F. Calibration

With an r.f. standard, a known level of power from a well-matched source (VSWR less than 1.02) should be established. A level, close to the maximum rating of the tft Power Head, is best to minimize drift and noise. The VSWR of the tft Power Head should be measured at the calibration frequency and the return loss computed. With the tft Power Head connected to the tft Power meter (e.g. 6460) and the efficiency control set to 100% apply the r.f. signal and adjust the the calibration potentiometers R1 (see figure 6.) to produce the desired reading including correction for the return loss. The calibration potentiometer is available at the rear of the Power Head housing by removing the metal plug.

4.4.3 Efficiency Determination

For recalibration when replacing tft elements, the mount should first be tested in accordance with the audio calibration procedure described above. RF Effective Efficiency can then be determined by measurement against r.f. standards and the new efficiency factor marked on a new calibration plate and attached to the mount.

4.4.4 Calibration with Extension Cables

When using tft POWER HEADS in conjunction with extension cable assemblies, such as types W967, W970 and W972, it is necessary to compensate for the resistance of the extension cable assemblies. Towards this end, it is acceptable to use any of the methods given below. (If the total length of the extension cable assemblies does not exceed ten feet, then the resistance can be ignored).

(a) Perform either the 4.4.1 or the 4.4.2 procedures described in this Instruction Manual, with the extension cable assemblies attached to the tft Power Head.

(b) Perform the described audio calibration procedures and change the calibration formula in equation (1) as necessary from R = ( ) to R = ( ) –X; where X= the resistance of the cable assemblies at 1 ohm per 20 feet.

(c) Perform the described r.f. calibration procedures and adjust the CAL potentiometer X ohms lower (See (b) above) than the value to which it would normally be adjusted. Make this adjustment at the conclusion of the described procedures.

4.5 ACCESSORIES AVAILABLE

TOOL KIT PART No. 3850 TK–1 is essential for repairing any of the tft Power Heads.

The Tool Kit consists of :-

(a) Assy. Jig

(b) Screwdriver

(c) Tweezers

(d) Allen Key

Replaceable parts

Ref. Sym.	Description	Part Number	Mfr.	Quantity used per tft Power Head
	tft Element Kit	TL-4A	MI	1
	Cable Sp. elect.	3853/119 (or 3881/102 for 6440N/1)	MI	2 Metres
	Dial.	3881/006	MI	1
C1, C2, C3	Capacitor (part of microwave assy.)	–	MI	
P1	Conn. Plug Elec.	3853/120	MI	1
R1	Res. Var. WW 100Ω	3329P-1-101	Bourns	1
R2	Res. Fxd. Film 39.2Ω ±2% 1/8W 100ppm		Comm.	1
R3	Res. Var. WW	3853/012	MI	1

Comm. – Common part available from a number of manufacturers.
MI – Marconi Instruments Ltd.