



**2440**

**20 GHz**

**MICROWAVE COUNTER**

**Operating Manual**

## 20 GHz MICROWAVE COUNTER

2440

Code nos. 52440-301C

-302R

-304K

-305A

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## PRELIMINARIES

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## HAZARD WARNING SYMBOLS

The following symbols appear on the equipment.

<i>Symbol</i>	<i>Type of hazard</i>	<i>Reference in manual</i>
△	Precision connector	Page iv and Chap. 2
△	Static sensitive device	Page iv
△	Maximum input - Channel A/B	Chap. 1, Page 3
△	Maximum input - Channel C	Chap. 1, Page 3

### 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.). New or amended material of technical importance introduced by the latest amendment is indicated by triangles positioned thus ▶.....◀ to show the extent of the change. When a chapter is reissued the triangles do not appear.

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 1. 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.

**CAUTION : STATIC SENSITIVE COMPONENTS**

Components identified with the symbol  on the circuit diagrams and/or parts lists are static sensitive devices. The presence of such devices is also indicated in the equipment by yellow discs, flags or labels bearing the same symbol. Certain handling precautions must be observed to prevent these components being permanently damaged by static charges or fast surges.

- (1) If a printed board containing static sensitive components (as indicated by a warning disc or flag) is removed, it must be temporarily stored in a conductive plastic bag.
- (2) If a static sensitive component is to be removed or replaced the following anti-static equipment must be used.

A work bench with an earthed conductive surface.

Metallic tools earthed either permanently or by repeated discharges.

A low-voltage earthed soldering iron.

An earthed wrist strap and a conductive earthed seat cover for the operator, whose outer clothing must not be of man-made fibre.

- (3) As a general precaution, avoid touching the leads of a static sensitive component. When handling a new one, leave it in its conducting mount until it is required for use.
- (4) If using a freezer aerosol in fault finding, take care not to spray programmable ICs as this may affect their contents.

**CAUTION : PRECISION CONNECTOR (on versions 52440-301C, -302R)**

The precision type N connector ( Channel C input) fitted to this instrument may be damaged by mating with general purpose type N connectors.

**CAUTION : LCD HANDLING**

When operating or servicing this equipment take care not to depress the front or rear faces of the display module as this may damage the liquid crystal display elements.

**WARNING : HANDLING HAZARDS**

This equipment is formed from metal pressings and although every endeavour has been made to remove sharp points and edges care should be taken, particularly when servicing the equipment, to avoid minor cuts.

**WARNING : TOXIC HAZARD**

Many of the electronic components used in this equipment employ resins and other chemicals which give off toxic fumes on incineration. Appropriate precautions should therefore be taken in the disposal of these items.

Chapter 1

## GENERAL INFORMATION

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Fig. 1 20 GHz Microwave Counter type 2440

## FEATURES

1. The 2440 is a frequency counter intended primarily for microwave use but offering continuous frequency measurement over the range 10 Hz to 20 GHz. Frequency cover is divided between three input channels A, B and C which accept 10 Hz to 100 MHz, 50 MHz to 600 MHz and 600 MHz to 20 GHz respectively. The instrument employs the principle of harmonic heterodyne frequency conversion under microprocessor control and has good sensitivity and dynamic range with short gate times and high resolution. This system also has wide f.m. tolerance and short signal acquisition times.
2. The measurement is displayed on nine 7-segment l.c.d. digits with annunciators giving the frequency units and other supporting information relating to the instrument's status. The accuracy of measurement is dependent only on the time base over most of the frequency range and depends on which of three alternative crystal oscillators has been installed. The crystal oscillator remains active independent of the front panel supply switch thereby maintaining temperature stability and accuracy.
3. Resolution is controlled by a group of keyswitches in decade steps from 0.1 Hz to 10 kHz with automatic positioning of the decimal point and indication of overflow. On input C, an immediate display of the overflow decades is available allowing all 12 digits to be seen. In the AUTO resolution mode, the gate time is automatically lengthened up to a maximum of 1 s in order to fill all 9 digits of display without overflow.
4. The rate at which the display is up-dated can be varied from 8 readings/s to 1 reading every 20 s by two keyswitches. Other major functions of the 2440 include an OFFSET mode in which the measured frequency may be added to or subtracted from the numerical offset entered into the instrument either via the keyboard or from a previous measurement. A low-pass filter can be introduced into the 'A' channel in order to reduce the noise bandwidth when low frequencies are to be measured. A range of automatic self test and diagnostic routines can be brought into action via the RESET key.
5. The GPIB interface unit permits full remote operation of all the functions (except the supply switch) via the General Purpose Interface Bus (GPIB).\*
6. A 12 bit digital to analogue converter module, available as an optional accessory, may be fitted in place of the GPIB unit. This provides an analogue voltage output of any three consecutive digits from the maximum of 12 decades of frequency data available within the instrument.
7. Other accessories provide a comprehensive range of servicing and operating aids.

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\*GPIB - Marconi Instruments General Purpose Interface Bus in accordance with IEEE Standard 488 - 1978 and IEC Publication 625-1.

## PERFORMANCE DATA

*Characteristic**Performance*8. Input

Three channels, switch selected covering the frequency range 10 Hz to 20 GHz.

*Input Channel A*

Frequency range :	10 Hz to 100 MHz direct count.
Sensitivity :	30 mV r.m.s. sine wave from 10 Hz to 10 MHz. 50 mV r.m.s. sine wave from 10 MHz to 50 MHz. 100 mV r.m.s. sine wave from 50 MHz to 100 MHz.
Maximum input :	250 V r.m.s. at 50 Hz decreasing by approx. $2.45 \times 10^{-6}$ V/Hz to 5 V r.m.s. at 100 MHz.
Input impedance :	Greater than 1 M $\Omega$ in parallel with less than 25 pF. AC coupled via 0.1 $\mu$ F.
Connector :	Type BNC female.
Input filter :	Switchable low pass filter reduces sensitivity above 5 kHz to improve noise immunity when measuring l.f. signals. Attenuation is at least 18 dB above 1 MHz.

*Input Channel B*

Frequency range :	50 MHz to 600 MHz direct count.
Sensitivity :	-20 dBm (50 MHz to 500 MHz). -15 dBm (500 MHz to 600 MHz).
Maximum input :	+13 dBm (1 V r.m.s. p.d. into 50 ohms).
Damage level :	+27 dBm (5 V r.m.s. p.d. into 50 ohms).
Input impedance :	50 $\Omega$ nominal.
Connector :	Type BNC female, AC coupled via 1 nF.
VSWR :	2 : 1 typical.

*Input Channel C*

Frequency range :	600 MHz to 20 GHz.
Sensitivity :	-25 dBm (600 MHz to 12 GHz). -20 dBm (12 GHz to 18 GHz). -15 dBm (18 GHz to 20 GHz).
Maximum input :	+3 dBm (600 MHz to 2 GHz). +5 dBm (2 GHz to 20 GHz).



*Characteristic**Performance*

Damage level :	+27 dBm.
Input impedance :	50 $\Omega$ nominal.
Connector :	Precision type N female.
VSWR :	2.5:1 typical (600 MHz to 18 GHz).
FM tolerance :	30 MHz p-p typical from 2 GHz to 20 GHz. For modulation frequencies up to 10 MHz.
AM tolerance :	Up to 40% modulation depth for signals within the sensitivity range.
Amplitude discrimination :	10 dB for two signals within 500 MHz. 20 dB for two signals >500 MHz over the band.
Acquisition time :	200 ms typical (600 MHz to 20 GHz).

9. Keyboard and displays

## Functions :

CHANNEL A/B OR C	Toggles between channels A & B or C.
RESOLUTION	Six buttons select resolution in decade steps from 0.1 Hz to 10 kHz.
AUTO	Autoranges resolution.
DISPLAY RATE	Increments/decrements display rate. Range from 8 reading/s to 1 reading every 20 s.
ON/OFF	Enables and disables offset frequency.
SET	Displays and/or selects offset frequency.
+/-	Adds or subtracts offset frequency.
LPF	Toggles between low-pass filter on and off.
RESET	Resets instrument and allows entry to internal self test modes.
LOCAL	Returns to front panel control (if GPIB in remote and not in local lockout).

Displays :	Nine digit liquid crystal display with annunciators to show frequency units, external frequency standards, overflows, offsets and remote GPIB operation. Decimal point is automatically selected and leading zeros are suppressed. The displays and LEDs may be checked using an internal self test.
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*Characteristic**Performance*

In channel C, digits that have caused an overflow may be revealed by pressing "C" again.

10. Accuracy

Basic accuracy :	$\pm 1$ count $\pm$ frequency standard error.
Frequency standard :	Internal 10 MHz crystal oscillator or external input automatically selected. Application of external signal overrides the internal oscillator. The EXT indicator shows when the external standard is in operation.
Residual stability :	$\pm \frac{(\text{Frequency in GHz})}{10}$ counts r.m.s.
External standard input	
Frequency :	1 MHz or 10 MHz sine wave or square wave.
Input level :	150 mV r.m.s. minimum up to 3 V r.m.s. maximum.
Input impedance :	10 k $\Omega$ (approx.) a.c. coupled.

11. Internal standard

Adjustment range : A control accessible through the rear panel allows adjustment of the internal standard to compensate for ageing.

## Stability

20 GHz Microwave Counter 2440A - version code no. 52440-301C and -304K with temperature compensated crystal oscillator.

Temperature :	Better than $\pm 1.5$ p.p.m. over the operating temperature range of 0 to 50°C.
Ageing rate :	Better than $\pm 1$ p.p.m. nominal per year after 1 month continuous use.

20 GHz Microwave Counter 2440A - version code no. 52440-302R and -305A fitted with oven controlled crystal oscillator.

Temperature :	Better than $\pm 0.1$ p.p.m. over the operating temperature range of 0 to 50°C.
Ageing rate :	Better than $\pm 1$ p.p.m. per year after 1 month continuous use.
Warm-up time :	Within 0.2 p.p.m. of final frequency within 10 min. from switch-on at 20°C ambient.

*Characteristic**Performance*

Auxiliary output : Internal 10 MHz standard available at 1 MHz or 10 MHz via rear panel BNC socket.

Level : Greater than 1 V p-p into 50  $\Omega$  (approximately 4 V p-p e.m.f.).

Impedance : Approximately 500  $\Omega$ .

▶ 12. External trigger mode

Enables counter to make one measurement when triggered by an external device. Also allows interface to appropriate sweeper for start, stop and marker frequency measurements.

External trigger input : TTL type low level or contact closure to ground. Pulse width to be greater than 30  $\mu$ s.

Sweep inhibit output : TTL type low level within 30  $\mu$ s of trigger input.

▶ 13. GPIB interface unit

A GPIB interface is fitted as standard. All functions except the supply switch are remotely programmable.

Capabilities : Complies with the following subsets as defined in IEEE 448 - 1978:-

SH1, AH1, T5, L4, SR1, RL1, PPO, DC1, DT1, CO and E1.

(Marconi Instruments General Purpose Interface Bus is in accordance with IEEE Standard 488 - 1978 and IEC Publication 625-1, first edition).

▶ 14. Digital to analogue converter module option

A digital to analogue (DAC) interface is available as an accessory for the user to fit. The DAC converts three consecutive digits from the display.

Level : -1 V to +1 V.

Resolution : 1 mV.

▶ 15. Power requirements

Voltage ranges : 105 V to 120 V  $\pm 10\%$ .  
(switchable) 210 V to 240 V

Frequency range : 50 Hz to 400 Hz  $\pm 10\%$ .

Consumption : 50 VA max.

▶ 16. Environmental

Rated range of use temperature : 0°C to +50°C.

Limit range of operation temperature : 0°C to +55°C.

*Characteristic**Performance*

Conditions of storage  
and transport :

Temperature : -40°C to +70°C.  
Humidity : Up to 90% relative humidity.  
Altitude : Up to 2500 m (pressurized freight at  
27 kPa differential, i.e. 3.9 lbf/in<sup>2</sup>).

17. Safety Complies with IEC 348.
18. Radio frequency interference This equipment conforms to the requirements of EEC Directive 76/889.
19. Dimensions and weight
- |          |  |
|----------|--|
| Height : | 108 mm (4.25 in).  |
| Width :  | 215 mm (8.5 in) without handle.<br>256 mm (10.1 in) with handle. |
| Depth :  | 338 mm (13.3 in).  |
| Weight : | 5.5 kg (12 lb).  |

## ACCESSORIES

20. Supplied

AC supply lead	43129-003W
Polythene cover	37490-435X
Operating Manual H 52440-900N, Vol. 1	46881-486G
GPIB instructions card	46881-551Y

21. Optional

GPIB lead assembly, 1 m, IEEE connectors	43129-189U
IEEE/IEC adapter block, IEEE male to IEC female	46883-408K
Digital to analogue converter module option	54414-001S
Front panel cover (stowage)	54124-022L
Extender card (processor)	46883-644C
Extender card	46883-645R
Flexible cable assembly 18 GHz, 500 mm, N male-N male	54351-022X
Flexible cable assembly 18 GHz, 500 mm, SMA male-SMA male	54351-023M
Adapter Precision co-ax N male-SMA female	54311-094M
Attenuator 10 dB, 5 W, type 6534/3	
Attenuator 20 dB, 5 W, type 6534/4	
Accessory box	46883-666S
Spanner tubular (service aid)	46883-726Y
Rack mounting kit - single unit	46883-638P
Rack mounting kit - double unit	46883-536P
Blank frame unit	46883-537X
Service Manual H 52440-900N, Vol. 2	46881-487V
GPIB Manual H 54811-010P	46881-365R

## ALTERNATIVE VERSIONS

22. The following alternative versions of the 2440 are available.

- |            |  |
|------------|--|
| 52440-301C | Standard version with temperature compensated crystal oscillator.  |
| 52440-302R | Standard version with oven controlled crystal oscillator.  |
| 52440-304K | Standard version with temperature compensated crystal oscillator and rear panel SMA entry for channel C. |
| 52440-305A | Standard version with oven controlled crystal oscillator and rear panel SMA entry for channel C.         |

Chapter 2

## INSTALLATION

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## UNPACKING AND REPACKING

1. Retain the container, packing materials and the packing instruction note (if included) in case it is necessary to reship the instrument.
2. If the instrument is to be returned for servicing attach a label indicating the service required, type or model number (on rear label), serial number and your return address. Pack the instrument in accordance with the general instructions below or with the more detailed information in the packing instruction note.
  - (1) Place a pad in the bottom of the container.
  - (2) Place pads in the front and rear ends of the container with the plywood load spreader(s) facing inwards.
  - (3) Put the polythene cover over the instrument and place it in the container with the front handles and rear projections (where applicable) against the plywood load spreaders.
  - (4) Place pads in the two sides of the container with cushioning facing inwards.
  - (5) Place the top pad in position.

- (6) Wrap the container in waterproof paper and secure with adhesive tape.
- (7) Mark the package FRAGILE to encourage careful handling.

Note...

If the original container or materials are not available, use a strong double-wall carton packed with a 7 to 10 cm layer of shock absorbing material around all sides of the instrument to hold it firmly. Protect the front panel controls with a plywood or cardboard load spreader; if the rear panel has guard plates or other projections a rear load spreader is also advisable.

## VENTILATION

3. If the 2440 is fitted with a plastic cover it should be removed before the instrument is connected to the a.c. mains supply. The instrument is air-cooled with fan assistance, air being drawn in through perforations at the front of the top and bottom covers. Air is ducted over the heat producing elements and is expelled by the fan through the rear panel grill. These air vents must not be obstructed while the instrument is in use.

## RACK MOUNTING ARRANGEMENTS

4. For rack mounting the 2440 counter alone, a single unit rack mounting kit 46883-638P is available. This contains a pair of side angle plates wide enough to allow the instrument to sit centrally within the 19 inch rack frame - see sketch Fig. 1.

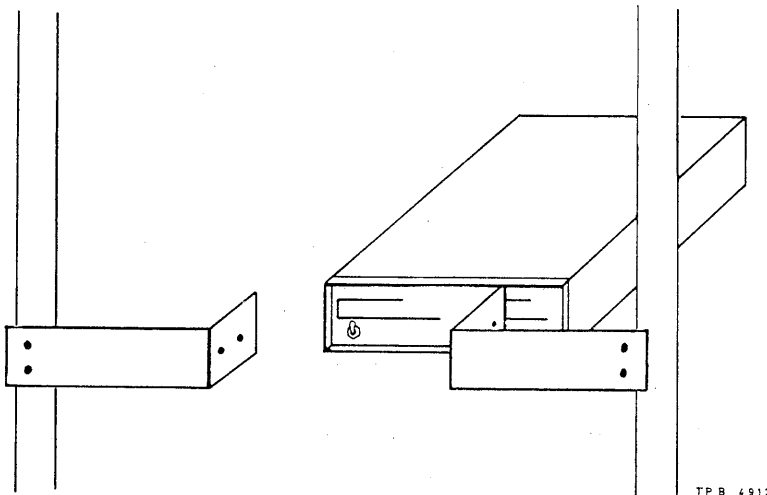
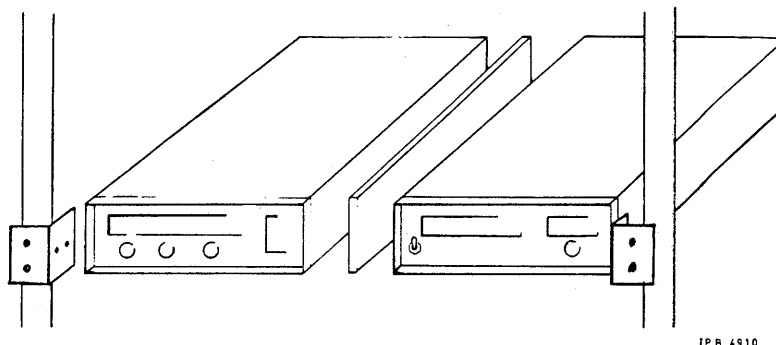


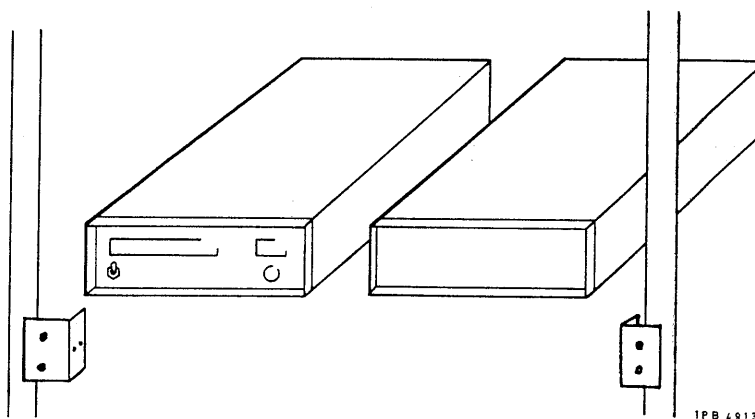
Fig. 1 Single unit rack mounting

5. For rack mounting the counter side by side with another instrument of the same construction, a double unit rack mounting kit 46883-536P is available. This kit contains fixings for joining the two instruments together and for attaching the twinned unit to the rack - see sketch Fig. 2.



*Fig. 2 Twinned unit rack mounting*

6. As an extension to the twinned approach, a blank frame unit 46883-537X is available. This enables earlier instruments having a wrap round case construction such as 2430A series counters or any other suitably sized equipment to be twinned with 2440 - see sketch Fig. 3.



*Fig. 3 2440 and blank frame unit rack mounting*

7. Alternatively if there is no immediate requirement to install a second unit, the blank front and rear panels supplied with the frame unit may be assembled to seal off the empty space.

8. For detailed information on kit parts, assembly etc., refer to the fitting instructions which are supplied with each rack mounting kit i.e.

code H 46883-638P for rack mounting kit - single unit,  
 code H 46883-536P for rack mounting kit - double unit,  
 (includes use of blank frame unit).



## CONNECTING TO SUPPLY

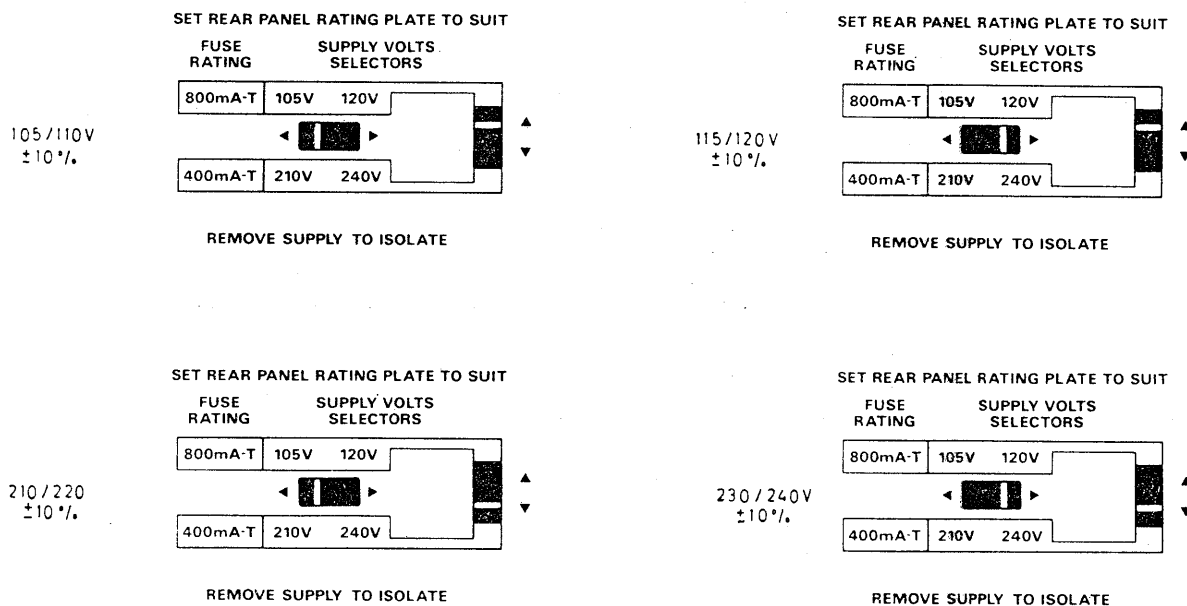
AC mains supply

9. The instrument will operate from a.c. supplies in the range 105 V to 120 V or 210 V to 240 V, at frequencies from 50 Hz to 400 Hz, a tolerance of  $\pm 10\%$  is allowable on both voltage and frequency ranges.

10. Before connecting the instrument to the mains supply check that the internal AC SUPPLY switches are correctly set for the a.c. supply available and that the fuses fitted are of the correct rating. The instrument is normally despatched with the 230 V to 240 V range selected as shown by the rating plate fixed to the rear panel. To check switch positions or to change them for another supply voltage, gain access by removing the top cover in the following way.

11. The cover is retained by the rear frame which is held in position by two screws through the rear feet. Withdraw these screws approximately 12 mm and pull back the rear frame to reveal the cover edge. Raise this edge and then lift the cover away from the chassis.

12. The two voltage range slider switches may be placed in one of four setting combinations as shown in Fig. 4.



1PB4938

Fig. 4 Supply voltage ranges : switch settings

13. Select the correct combination for the supply available. Now remove the screws securing the rating plate to the rear panel and replace the plate in the position that indicates the set voltage range. Refit the top cover, push forward the rear frame and tighten the screws through the rear feet.

14. Check that fuses of the correct rating are fitted as follows:-

800 mA (time lag) for the 105 to 120 V ranges  
or 400 mA (time lag) for the 210 to 240 V ranges.

The fuses are 20 mm x 5 mm cartridge type.

15. The free a.c. supply cable is fitted at one end with a female plug which mates with the a.c. connector at the rear of the instrument. When fitting a supply plug ensure that conductors are connected as follows:-

Earth - Green/yellow  
Neutral - Blue  
Live - Brown

When attaching the mains lead to a non-soldered plug it is recommended that the tinned ends of the lead are first cut off owing to the danger of cold flow resulting in intermittent connections.

#### Safety testing

16. Where safety tests on the mains input circuit are required, the following procedures can be applied. These comply with BS 4743 and IEC Publication 348. Tests are to be carried out as follows and in the order given, under ambient conditions, to ensure that mains input circuit components and wiring (including earthing) are safe.

(1) Earth lead continuity test from any part of the metal frame to the bared end of the flexible lead for the earth pin of the user's mains plug. Preferably a heavy current (about 25 A) should be applied for not more than 5 seconds.

Test limit : not greater than 0.5  $\Omega$ .

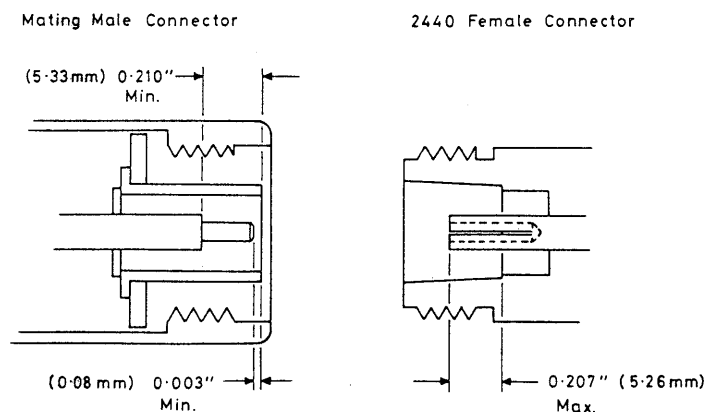
(2) 500 V d.c. insulation test from the mains circuit to earth.

Test limit : not less than 2 M $\Omega$ .

#### CONNECTING TO CHANNEL C INPUT (on versions 52440-301C and -302R)

17. Channel C input connector is a precision type N connector which may be damaged by mating with a general purpose type N connector. It must be mated with a precision type N connector conforming to the critical dimensions shown in Fig. 5.

Fig. 5  
Precision type N connector,  
critical dimensions



## CONNECTIONS TO GPIB INTERFACE UNIT

18. The GPIB unit is fitted in the rectangular cut-out in the rear panel. It is connected into circuit by mating the free socket with plug PLG on the processor board A8.
19. External connections are made via the 24-way connector mounted directly on the module and accessible at the rear panel. The GPIB address switch is mounted alongside this connector.
20. Connection to other equipment which has a 24-way bus connector to IEEE Standard 488 can be made with the GPIB lead assembly 43129-189U, available as an optional accessory. An IEEE-to-IEC adapter 46883-408K is also available for interfacing with systems using a 25-way bus connector to IEC Recommendation 625 - see Fig. 6.

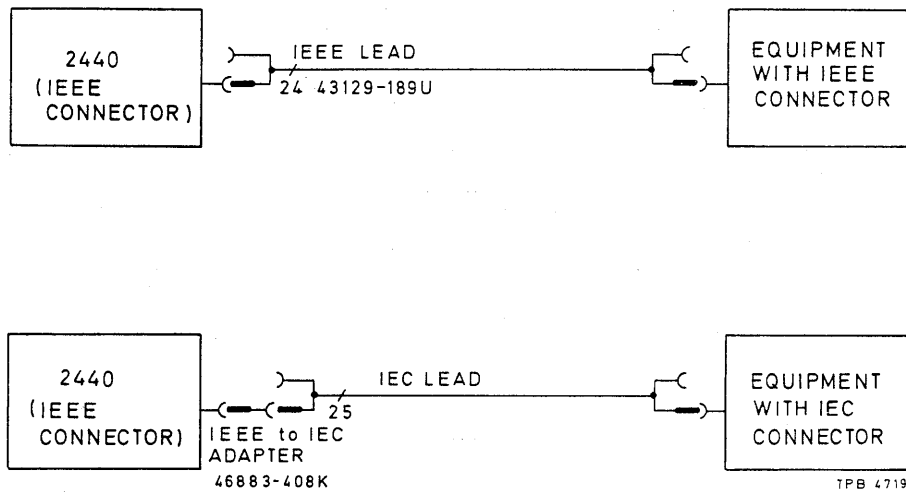


Fig. 6 GPIB interconnections

► FITTING THE DIGITAL TO ANALOGUE CONVERTER OPTION

21. The d-a converter unit fits in the rectangular cut-out in the 2440 rear panel which is normally occupied by the GPIB interface unit.
22. To fit the converter unit the instrument top cover, power supply sub-chassis and the GPIB unit must be removed.

Dismantle

*Top cover*

- (1) Release the two securing screws inserted through the rear feet and withdraw them approx. 12 mm.
- (2) Pull back the rear frame to reveal the cover edge. Raise this edge and lift off the cover away from the chassis.

*Power supply sub-chassis*

- (3) Remove and retain the four crossheaded screws which are arrowed on the top of the chassis and the two crossheaded screws holding the power supply chassis through the side rail.
- (4) Lift the power supply chassis out of the main chassis and lay at the side. Unplug the connecting cable from plug PLA on the motherboard A1.

*GPIB unit*

- (5) Unplug the ribbon cable from plug PLG on the processor board A8.
- (6) Remove and retain the two screws securing the unit to the rear panel. Carefully withdraw the GPIB unit and cable assembly through the cut-out and place to one side.

Assembly

- (7) Insert the converter unit and cable through the rear panel cut-out and secure with the two screws retained in (6).
- (8) Connect the unit into circuit by engaging the free socket with plug PLG on the processor board A8 and the free wire on to pin PLD on the motherboard A1.
- (9) Reconnect the power supply sub-chassis cable and plug and refit the chassis using the six screws retained in (3).
- (10) Refit the instrument top cover and tighten the two screws inserted through the rear feet.
- (11) Make external connections to the converter unit via the connector mounted directly on the unit and accessible at the rear panel.

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## PRINCIPLES OF OPERATION

1. Signal connection to the 2440 counter is made via one of three front panel sockets depending on the frequency of the signal. Local operation is accomplished by a 16 key pad on the front panel. Two keys are used to select the internal route to the appropriate measurement channel. Selected channel is indicated by an l.e.d.
2. The remaining keys are divided into three blocks - Resolution, Display Rate and Offset. Each key is labelled with its main function and a second function beneath. The second function applies only in the number entry mode which is controlled by the SET, LOCAL or RESET keys being pressed at the beginning of the operation.
3. The measured frequency is displayed on the 9 digit l.c.d. display unit with 5 annunciators providing information on the counter status e.g. display overflow, remote operation etc. In certain functions the display unit segments are used to write a message relating to the circuit conditions e.g.

LPFan or CLEAR.

4. Remote operation via a GPIB controller is enabled by the GPIB interface unit. With the optional d-a converter fitted in place of the GPIB unit, an analogue voltage output is made available at the rear panel.

## CONTROLS AND CONNECTORS

### Front panel (see Fig. 1)

5. (1) STANDBY/ON switch. In the STANDBY position the mains transformer and crystal oscillator (with its oven if fitted) remain active, thus ensuring that the oscillator working temperature and stability are maintained ready for normal operation.

ON powers up the instrument (and the ventilating fan) and starts normal operation.

- (2) SUPPLY indicator lamp. Remains illuminated so long as a mains supply is connected. It indicates that the supply transformer and crystal oscillator are active.

#### ⚠ CAUTION.

To de-energize instrument, disconnect or switch off the mains supply voltage.

- (3) Channel A input, via BNC connector.
- (4) Channel B input, via BNC connector.

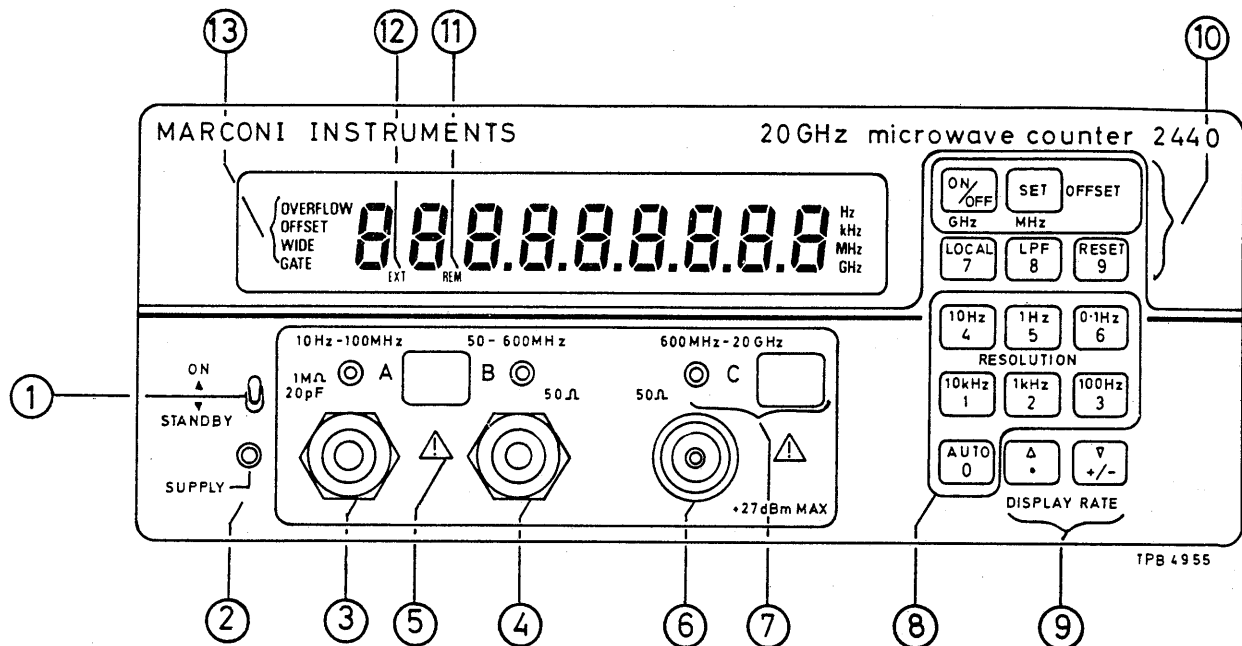


Fig. 1 Front panel controls and connectors

(5) Channel A/B input selector. The first operation of this push-button disconnects the input connection from channel C (power up status). Subsequent operations cause the connection to toggle between the Channel A and B connectors, the active connector being indicated by the illuminated state of the adjacent l.e.d.

(6) Channel C input, via precision type N connector.

(7) Channel C input selector. Operation of this push-button transfers the input connection to the channel C connector and causes the associated l.e.d. to light. Any subsequent operation of the switch will cause any overflowed digits to be displayed for as long as the button remains pressed.

(8) RESOLUTION keypad. These keyswitches select the resolution and units of the display. Numerical secondary markings on these and other keys relate to their use in the number entry mode. The **AUTO** key enters an auto-resolution mode which selects the longest gate time (up to a maximum of 1 second) that can be used without display overflow.

(9) DISPLAY RATE keypad. These keys introduce 2:1 increments (or decrements) in the dead time between measurements. Thus, the  $\Delta$  key repetitively halves the dead time (doubling the rate) and the  $\nabla$  key repetitively doubles the dead time (halving the rate). The alternative keyswitch markings relate to the decimal point and the sign of the arithmetic operation in OFFSET mode (toggles +/-).

(10) OFFSET MODE keypad. An OFFSET mode of operation is introduced by the **SET** key and a numerical entry is then made via the remaining keys using the secondary markings. A numerical entry is terminated by operation of **SET** for MHz, or of **ON/OFF** for GHz. Complete details OF OFFSET operating routines are given in the section headed 'Operating Procedure'.

**LOCAL** key is concerned with the GPIB interface unit or the digital to analogue converter option if fitted. With the GPIB unit fitted and the key held pressed, the display shows the current GPIB address. When the key is released the instrument reverts to LOCAL control. This is the only active keyswitch in REMOTE operation but even this may be disabled by 'LOCAL LOCKOUT' command sent over the bus by the controller.

With the d to a converter option fitted pressing **LOCAL** key displays the d.a.c. message with a prompt and the d to a converter function is entered. After pressing a numeric key to enter the function number, the display clears and normal operation is resumed.

**LPF** key toggles the low-pass filter on channel A in or out of circuit. If the key is held down the function will toggle on or off, its current state being indicated by the display message e.g. 'LPF on' or 'LPF off'. Although the filter is only introduced into channel A, the key remains effective whichever channel is in use and remains unchanged despite channel switching.

**RESET** key displays a 'reset' message and if no further action is taken the processor resets to its default state and restarts. If another key is pressed while the 'reset' message is displayed the TEST mode is entered, the actual test depending on which key was pressed. The selected TEST number or letter is displayed alongside the reset message. Details of the tests are given in the section headed 'Operating procedure'.

(11) REMOTE annunciator. Activated when the instrument has been correctly addressed via the GPIB. Only the supply switch and the **LOCAL** key remain active in REMOTE mode, (see description for this key in previous section (10)).

(12) EXTERNAL frequency standard annunciator. Activated when an external frequency standard within the specified limits is connected at the rear panel and over-rides the internal standard.

(13) Status annunciators.

OVERFLOW - Activated when one or more digits of the display have overflowed.

OFFSET - Activated when the 2440 is in OFFSET mode and the display reading is offset by a constant numerical quantity.



WIDE - Activated under power up or reset conditions but is not otherwise connected and has no functional significance.

GATE - Activated for the time period during which the signal is being counted.

Rear panel (see Fig. 2)

6. (1) STANDARD OUT BNC connector. Provides signal from internal standard for external use.
- (2) Changeover switch allowing either 1 MHz or 10 MHz signal deriving from the internal frequency standard to be routed to the STANDARD OUT BNC connector.
- (3) SET INTERNAL STANDARD. Hole in panel provides screwdriver access to multi-turn potentiometer. Adjustment enables internal frequency standard to be aligned against local reference.
- (4) STANDARD IN BNC connector. For connection to an external 1 MHz or 10 MHz standard frequency source. A source of appropriate level automatically over-rides the internal standard and causes the EXT annunciator to be displayed.
- (5) GPIB interface unit. Permits full remote operation of all functions (except the supply switch) via the General Purpose Interface Bus. Unit can be removed to accommodate the optional d-a converter unit.

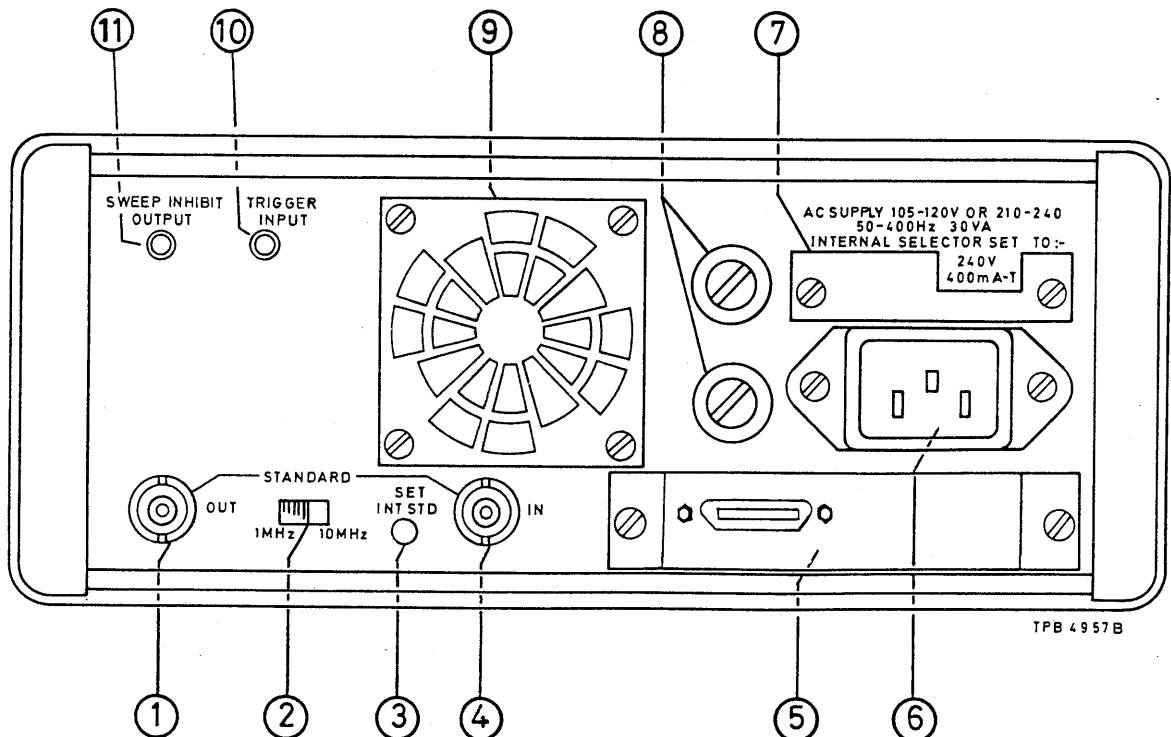


Fig. 2 Rear panel controls and connectors

(6) AC mains input connector. The a.c. supply is connected through this plug which mates with the connector fitted to the supply lead.

*CAUTION.*

Ensure that the internal supply switches are set to match the available supply before connecting. See Chap. 2 for details.

(7) Masking plate to display setting of internal supply switches. Plate may be fitted in one of 4 different positions to reveal only that nominal supply voltage to which the supply transformer has been adjusted.

(8) AC mains supply fuses. 400 mA (time lag) for 210 V to 240 V range and 800 mA (time lag) for 105 V to 120 V range.

(9) Fan ventilation outlet.

(10) EXT TRIG IN SMC connector. For connection to an external negative-going trigger pulse. This, when 2440 is in external trigger mode (Test mode B), triggers the counter to make one reading and then stop.

(11) SWEEP INH SMC connector. Provides an output inhibit signal to stop the sweep whilst the externally triggered reading is being made. Returns to high state after reading is completed.


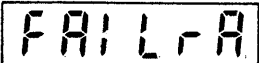
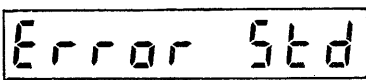
OPERATING PROCEDURE

7. An abbreviated set of keyboard instructions is shown in Table 1. These instructions are repeated on a self-adhesive label fixed to the inside rear cover, ready for the user to remove and mount at a convenient location. The full operating procedure is described in the following paragraphs.

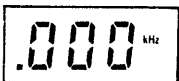
Power up status

8. The crystal oscillator frequency standard and the supply transformer become active as soon as a mains a.c. supply is connected to the mains input. The SUPPLY indicator lamp is illuminated to give confirmation of this STANDBY condition.

9. When the supply switch is moved to the ON position the main circuits become active and the processor automatically performs self check tests on the ROM, RAM and Real Time Clock. Should one of these tests fail then a message will be displayed as follows.

Test ROM		ROM failure
Test RAM		RAM failure
Test Real Time Clock		(a) 250 kHz Real Time Clock not running or (b) Ext input is not compatible with 1 MHz/10 MHz switch.

10. While these tests are running all the display l.c.d. segments (including all annunciators and decimal points) and l.e.d's are lit up. On satisfactory completion of the tests all instrument functions are set to the default or power up status as detailed in Table 2 and the counter commences the measurement routines. If there is no input connected then display will show



after auto-gating to 1 s, 1 Hz resolution.

TABLE 1 KEYBOARD INSTRUCTIONS (ABBREVIATED)

20 GHz MICROWAVE COUNTER 2440 - KEYBOARD INSTRUCTIONS	
SET CHANNEL	PRESS C <input type="checkbox"/> FOR CHANNEL C OR A <input type="checkbox"/> B TO TOGGLE BETWEEN CHANNELS A OR B.
SET RESOLUTION	PRESS KEYS <input type="checkbox"/> 10kHz TO <input type="checkbox"/> 0.1Hz TO SELECT DESIRED RESOLUTION. KEY <input type="checkbox"/> AUTO SELECTS LONGEST GATE - UP TO 1 SEC - WITH NO OVERFLOW.
DISPLAY OVERFLOW	PRESS C <input type="checkbox"/> . OVERFLOW DIGITS ARE DISPLAYED IN CHANNEL C ONLY.
SET DISPLAY RATE	PRESS AND HOLD <input type="checkbox"/> Δ TO INCREASE DISPLAY RATE OR <input type="checkbox"/> ∇ TO DECREASE DISPLAY RATE. THE RATE IS INDICATED IN Hz ON DISPLAY. (F = FASTEST)
SET FREQ. OFFSET	PRESS AND HOLD <input type="checkbox"/> SET THE OFFSET IS THEN DISPLAYED. RELEASE KEY THEN EITHER:- 1. PRESS <input type="checkbox"/> SET. THE COUNTER WILL ACCEPT THE PREVIOUS MEASUREMENT DISPLAY AS OFFSET. 2. KEY IN DESIRED OFFSET, TERMINATING WITH <input type="checkbox"/> MHz KEY OR <input type="checkbox"/> GHz KEY, AS APPROPRIATE. 3. PRESS <input type="checkbox"/> ON/OFF TO CLEAR THE OFFSET. 4. PRESS A <input type="checkbox"/> B OR C <input type="checkbox"/> TO EXIT OFFSET MODE.
OFFSET ON/OFF	PRESS <input type="checkbox"/> ON/OFF TO TURN OFFSET ON OR OFF.
LOW PASS FILTER (CHANNEL A ONLY)	PRESS <input type="checkbox"/> LPF AND HOLD TO TOGGLE FILTER ON OR OFF.
RESET	PRESS <input type="checkbox"/> RESET TO RESET COUNTER.
GPIB	PRESS & HOLD <input type="checkbox"/> LOCAL TO DISPLAY GPIB ADDRESS. THIS KEY ALSO RETURNS THE COUNTER TO LOCAL MODE FROM REMOTE OPERATION.
D TO A CONVERTER (IF FITTED)	TO SET D TO A CONVERTER, PRESS <input type="checkbox"/> LOCAL THEN A NUMBER KEY WHICH SELECTS THE LEAST SIGNIFICANT DIGIT OF THE THREE CONSECUTIVE DIGITS USED FOR A TO D CONVERSION. (KEY <input type="checkbox"/> AUTO = 0.10 Hz TO KEY <input type="checkbox"/> RESET = 0.10 GHz)

TABLE 2 DEFAULT/POWER UP STATUS

<i>Function</i>	<i>Status</i>
Input channel	C
OFFSET MODE	Off (offset data to 0)
TEST MODE	Off
RESOLUTION	Automatic
DISPLAY RATE	*
LOCAL/REMOTE	Local (SRQ enabled)

\*Dependent on auto-selected resolution i.e. if automatic mode selects a resolution of 1 kHz then the display rate will be 8 per second - the fastest possible for the selected resolution. Table 4 shows the range of display rates.

### Input

11. If the frequency of the signal to be measured is unknown and so cannot be related to a particular channel then it should be applied successively to each input until a reading is displayed.

#### *CAUTION.*

1. Take care that the signal level is within the limits specified for accurate measurement.
2. Have special regard for the level at which the onset of damage occurs - noting the different input impedances for each channel.

12. In normal use the characteristics of the signal will be known sufficiently well for the appropriate channel to be selected. Changing channels will cause the display to show zeros until the new gate has been completed. If 2440 is in OFFSET mode then changing channels will automatically cancel this mode but any entered offset data will be retained. If channel A or channel B is required, press the A/B selector button once or twice to light the appropriate channel l.e.d. indicator. Connection of the signal to the channel input concerned will then be followed by display of the measured frequency. No trigger controls are provided and accurate counting takes place at all frequencies for signals that fall within the dynamic range of the instrument.

### Resolution

#### *AUTO range*

13. In the AUTO mode the processor selects the longest gate time possible without incurring an overflow of the display up to a maximum gate length of 1 s. If the new resolution selected is greater than the old one, the display will immediately show the last data in the new format, but with the invalid digits showing a lower case '0' until the new gate has been completed.

#### *Manual range*

14. If faster cycling is required at the expense of resolution or if greater resolution is required at the expense of overflow, then individual gate times may be manually selected and held by pressing the appropriate RESOLUTION key. The frequency units and their corresponding decimal points have been allocated as shown in Table 3.

TABLE 3 RESOLUTION GATE TIMES

Range	Resolution	Gate time	Channel	
			A/B	C
0	AUTO			
1	10 kHz	100 $\mu$ s*	MHz	GHz
2	1 kHz	1 ms	MHz	GHz
3	100 Hz	10 ms	MHz	MHz
4	10 Hz	100 ms	MHz	MHz
5	1 Hz	1 s	kHz	kHz
6	0.1 Hz	10 s	Hz	Hz

\* This resolution still retains a 1 ms gate time but displays to a resolution of a 100  $\mu$ s gate.

15. An immediate display of overflow digits is available when already in channel C by keeping pressed the channel C selector button. Unless altered by the display rate keys the fastest rate for the resolution selected will be used.

#### Display rate

16. The interval between display up-datings is controlled by the two incremental keys  $\Delta$  and  $\nabla$  which will approximately double ( $\Delta$ ) or halve ( $\nabla$ ) the existing measurement display rate, within the limits of 8 readings/s to 1 reading every 20 s (8 Hz to 0.05 Hz). If the user selects a display rate that is incompatible with the current gate time (e.g. 8 readings/s on a 1 s gate) a default value will be used to give the fastest display rate possible on that particular resolution.

17. To change the rate, press one of the keys and the current rate will be indicated for one second in the rightmost digits of the display, see Table 4 for display rates. When the key is released, the rate will remain unchanged and the counter will return to normal working.

18. If the key is kept pressed the rates will be increased or decreased until either the end stop is reached or the key is released. Keeping the  $\Delta$  key held pressed until .F (fastest rate) is displayed and then releasing, causes the counter to take measurements as fast as the selected gate and software calculations will allow i.e. with no programmed dead time between measurements.

TABLE 4 DISPLAY RATES

Range	Indicated rate (Hz)	Display rate
0	F	Fastest possible
1	8	8/s
2	4	4/s
3	2	2/s
4	1	1/s
5	0.4	1/2.5 s
6	0.2	1/5 s
7	0.1	1/10 s
8	0.05	1/20 s

Offset mode operation

19. It is often convenient to measure frequency as a change or offset from a fixed value, or from a reference measurement made earlier. The following paragraphs describe how to use the OFFSET mode for these measurements and concludes with an example for each case.

20. To set current display as offset.

(1) To enter OFFSET mode press **SET**. Operation of this key also allows the OFFSET data to be changed. While the key is pressed the value of any current offset will be displayed. For first time operation this should be zero. Release the key and the display window will

show the prompt signal and a -ve sign.

0 . -

(2) To enter the currently displayed measurement as the reference, press and release **SET** again. All subsequent measurements will now appear as offsets from this reference i.e. Display = measured frequency minus reference frequency with OFFSET mode annunciator activated.

NOTE. If an offset reference has been entered and then a new input channel is selected, the OFFSET mode is automatically cancelled but the offset data remains intact. Entering the OFFSET mode again recalls the data.

21. If required, the reference may be added to the measured data by changing the reference sign. To display the sum press **SET**, **∇**/**+/-**, **SET**.

22. To return to a display of the difference, repeat this keyswitch operating sequence. As **∇**/**+/-** is pressed, a -ve reference sign will appear briefly in the display to confirm that subtraction is now being made. Each time this sequence is repeated the arithmetic operation toggles between addition and subtraction. Whenever the **SET** operation signals completion of a sign

change, the display **CURRENT** along with the new reference sign if -ve, will appear as indication that the current reference quantity is retained.

23. To enter numerical quantity as offset.

(1) Press **SET** to enter offset mode. Display will show offset mode and prompt.

0 . -

(2) Press the series of number keys, using **∆** for decimal point and **∇**/**+/-** for reference sign as required. Then press **SET** for value in MHz or **ON/OFF** if value is in GHz.

24. The display will echo the numbers as they are entered. Once the units have been entered, the instrument will revert to normal operation with the new offset value and the offset function activated. The -ve reference sign is the normal or default state and may be toggled by pressing **SET**,

**∇**/**+/-**, **SET**.

25. To clear current offset data press **SET** , **ON/OFF** . The message **CLEAR** will be displayed while the ON/OFF key is pressed and offset function is cancelled.

26. However if, while still in the offset number entry mode, it is realized that incorrect data has been entered, then pressing channel C selector will clear the offset buffer and restart the number entry mode. The display will show the offset mode and prompt **0.-** .

27. To enter or exit OFFSET mode.

Press **ON/OFF** . This key will toggle the instrument in and out of OFFSET mode operation with the reference quantity remaining unaltered. The current state is indicated by the OFFSET annunciator.

Note...

Operation of this key does not allow alteration of offset data. If any change in offset data is required it must be initiated by operation of **SET** key.

28. If the **SET** key is pressed ready to change the OFFSET data but instead the user changes the input channel, then the processor protects the existing OFFSET data by ignoring the **SET** key operation. The data remains intact and the OFFSET mode is cancelled. While the channel selector key is pressed the message **Ignored** will be displayed to indicate this condition.

#### *OFFSET mode default state*

29. All stored data entered during offset operation is volatile and reset to the default state when the instrument returns to the power up condition either from STANDBY or after an interruption of mains supply. That is with OFFSET reference set to zero, OFFSET mode set to off.

30. Example - setting current display as offset.

2440 in normal mode  
12.6 GHz input to channel C  
Resolution selected at 1 kHz

display **12.600000** GHz

Press **SET** , **SET** to set offset value at 12.6 GHz. If input frequency changes <1 kHz during this action

display **OFFSET** **.000000** GHz

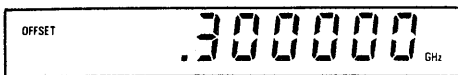
As input frequency drifts, numbers enter from right side. Change input frequency to 12.4 GHz


display 

Select AUTO resolution (maximum resolution now 10 Hz). If short term stability better than 10 Hz ( $<1$  in  $10^{-9}$ )

display 

In practice there will be fluctuations in one or more of the least significant digits. Change input frequency to 12.9 GHz


display 


Press  RESOLUTION

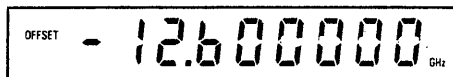
display 


Resolution 1 Hz

Note that +ve sign is implied by absence of the -ve sign.

Press  RESOLUTION

Press and hold  . While key is pressed offset value


display 

Press  to change offset reference sign to +ve.


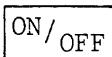
Press and hold  . While key is pressed

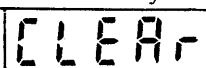
message display  indicates offset quantity not changed.

Measured input signal of 12.6 GHz is added to offset value of 12.6 GHz

display 

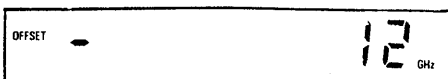
31. Example-setting numerical quantity as offset.

Press  .  
Press and hold  . While key is pressed

message display  indicates that existing offset data

has been cleared. Press  ,  ,  then

Press and hold  . While key is pressed

display 



This indicates new offset reference of 12 GHz with the default -ve sign. When the **ON/OFF** key is released display will change to display the result of the subtraction of 12 GHz from the current measurement.

Press **SET** , **∇** , **SET** to change reference sign to +ve and add offset to current measurement as described in previous example.

#### Test mode operation

32. Operation of **RESET** key followed by a number or function key enables the user to introduce various test and diagnostic routines to aid in fault finding. Test mode numbers and use of routines are described in the Service Manual, Vol. 2.

33. Press **RESET** , then while 'reset' is displayed select the appropriate TEST number or function key. This will be echoed on the display i.e.

**RESET 7**

The display will clear and commence test mode 7.

34. particular tests may be of interest to the operator and are as follows:-

(1) Test Mode 0 - Power up reset.

Press **RESET** , **AUTO** . Resets the instrument to its power up state and is equivalent to turning the supply off and on.

(2) Test Mode 7 - Display device test.

Press **RESET** , **LOCAL** . Causes all the display l.c.d. segments (including all annunciators and decimal points) and l.e.d's to be displayed and remain displayed until exit. Exit by pressing either channel selector key. The test verifies the proper functioning of the display and drive components.

(3) Test Mode 8 - Current software issue and date.

Press **RESET** , **LPF** . Display shows the issue number and date of the software contained in the instrument.

for example **02.24.11.83**

Issue 2 24th Nov. 1983

Press either channel key to exit.

(4) Test Mode B - External trigger mode.

Press **RESET** , press channel C selector button. Display shows

**trig on**

then clears.

External negative-going pulse triggers counter to make one measurement then stop.

Repeating the above procedure will toggle the external trigger mode to the off condition.

## GPIB CONTROL

35. The GPIB interface unit, provided as a standard fitting, allows the instrument to be remotely controlled via the standard IEEE 488 (or IEC 625) bus to the extent defined by the interface functions.

SH1 AH1 T5 L4 SR1 RL1 DC1 DT1 CO PPO EI

These are briefly described below. For detailed information on this subject see 'The GPIB Manual' which is available as an optional accessory.

### SH1 : Source handshake (complete capability)

The source handshake sequences the transmission of each data byte from the instrument over the bus data lines. The sequence is initiated when the function becomes active, and the purpose of the function is to synchronize the rate at which bytes become available to the rate at which accepting devices on the bus can receive the data.

### AH1 : Acceptor handshake (complete capability)

The acceptor handshake sequences the reading of the data byte from the bus data lines.

### T5 : Talker function

The talker function provides the 2440 with the ability to send device dependent messages over the bus to other devices. The ability of any device to talk exists only when it has been addressed as a talker.

### L4 : Listener function (no listen only function)

The listener function provides a device with the ability to receive device dependent messages over the bus. The capability only exists where the device is addressed to listen via the bus by the controller.

### SR1 : Service request function (complete capability)

The service request function gives the 2440 the capability to inform the controller when it requires attention.

### RL1 : Remote/local function (complete capability)

The remote/local function allows the 2440 to be controlled either by the local front panel keys or by device dependent messages over the bus.

### DC1 : Device clear function (complete capability)

Device clear is a general reset and may be given to all devices in the system simultaneously (DCL).

### DT1 : Device trigger function (complete capability)

Device trigger function allows the synchronization of the start of two or more devices tasks irrespective of their particular programming codes.

C0 : Controller function (no capability)

PPO : Parallel poll function (no capability)

E1 : Open collector drivers

The GPIB drivers fitted to 2440 have open collector, rather than tri-state outputs.

36. The instrument may be addressed in one of two modes :

Talk and listen,  
Talk only.

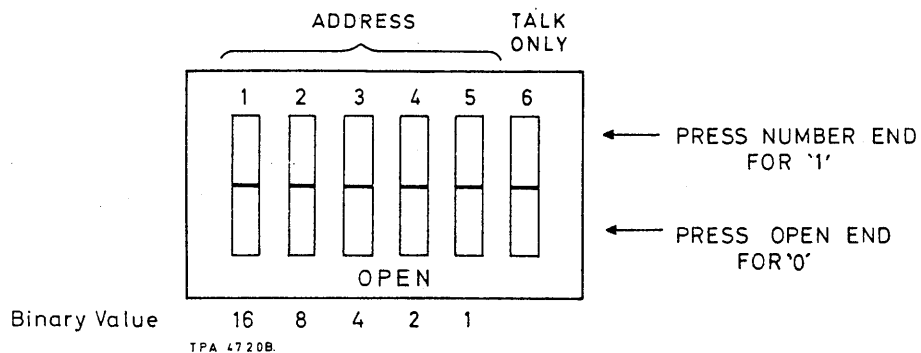
When addressed to listen it will respond to Data, Trigger (GET), Clear (SDC), and Go to Local (GTL) messages.

When addressed to talk it will send Data and Status Byte messages.

Whether addressed or not it will respond to the Clear (DCL), Local Lockout (LLO), Go to Local (GTL) and Interface Clear (IFC) messages and will send Service Request (SRQ) messages.

#### Setting the GPIB address

37. The instruments talk and listen addresses can be selected by the address switch, illustrated in Fig. 3. This is positioned on the GPIB unit alongside the connector and is accessible at the rear panel.



*Fig. 3 GPIB address rocker switch*

For talk and listen mode press open end of talk only switch and select any address from binary 00000 to 11111 (0 to 31 decimal).

For talk only mode press number end of talk only switch and select any address from binary 00000 to 11111 (0 to 31 decimal).

38. The GPIB address, along with an indication if the instrument is in the 'talk only' mode, may be read on the front panel display by pressing LOCAL

e.g. GPIB 066.0

The instrument will revert to Local control unless 'Local Lockout' command has been sent over the bus by the controller, in which case this key will not respond.

39. When the address is set for talk only mode, frequency data will start to be output on the bus as soon as it becomes available. When set to talk and listen mode, instrument will only respond to commands prefixed by the address set on the address switch (0 to 31).

#### Remote operation

40. On receipt of the Remote Enable (REN) message from the GPIB the instrument switches to remote operation and the REM annunciator on the front panel comes on. No instrument settings are changed but all front panel keys except LOCAL are disabled and their functions come under GPIB control.

41. Unless inhibited by the Local Lockout (LLO) message the instrumentation can be returned to local control by pressing the LOCAL key or by receipt of a Go to Local (GTL), Interface Clear (IFC) or Not Remote Enable (REN L) message.

42. On receiving 'Device Clear' DCL, the instrument will ignore any more interrupts until it has completed its power-up sequence. Hence a delay of at least 2 seconds should be inserted before sending any more bus commands.

43. After 'T' trigger command has been received there must be a delay of at least 9 ms plus acquisition time (typically 200 ms) plus selected gate time before the instruments output buffer is read, or zero data will be read. It is strongly recommended that the serial poll status byte should be used, in which case simply wait until the SRQ bit (bit 7) is set or the BUSY bit (bit 5) is reset before reading data.

44. After sending a command, the output buffer may still contain data collected by the previous command status. This must first be cleared by reading the buffer before the new data becomes available. Trigger commands will initialize the buffer and place the instrument into single shot mode. The output buffer in normal operation will contain the last reading taken i.e. if the reading before has not been read out over the bus, the new reading will overwrite it in the buffer.

#### GPIB program codes

45. All valid GPIB program codes are listed in Table 5. These include equivalents for all front panel keys (except LOCAL) with additional codes for special operating modes.

46. The instrument will ignore any spaces, commas or semi-colons in the program string. A total of 31 ASCII command characters can be handled at any one time. Any more characters are simply ignored and the command sequence automatically terminated. If more than 31 command characters are needed, they should be sent as two, or more separate strings.

TABLE 5 GPIB PROGRAM CODES

Function	Program code	Description
INPUT CHANNEL	A	Selects channel A.
	B	Selects channel B.
	C	Selects channel C.
RESOLUTION	Rn	Changes resolution (n = 0 to 6 as in Table 3) and sets Display rate to default status.
DISPLAY RATE	Dn	Changes reading rate (n = 0 to 8 as in Table 4). Must follow resolution code Rn.
OFFSET value	On...n	Sets offset value with up to 12 characters depending on selected resolution, -ve sign and decimal point. +ve sign is implied by absence of -ve sign. Code is terminated by G (GHz), M (MHz) or K (kHz). If unterminated will assume Hz. Must be followed by F1 to become active.
OFFSET mode	Fn	Sets offset function (n=1 for ON, 0 for OFF).
LPF	Ln	Sets low-pass filter (n = 1 for ON, 0 for OFF).
TEST	Xn	Selects test mode (n = 0 to 9 see para. 32).
SINGLE SHOT	Sn	Sets single shot and waits for trigger (n = 1 for ON, 0 for OFF or external trigger, n = 2).
TRIGGER	T	Sets single shot mode and executes one measurement cycle. On completion a service request (SRQ) message is normally sent to indicate that data is ready.
SRQ INHIBIT	Qn	Enables instrument to free run without raising service requests whenever data becomes available (n = 1 for ON, 0 for OFF). Note the 'data ready' bit of the status byte may still be read to indicate that data is ready without asserting SRQ.

Typical program string

47. When the instrument has been addressed to listen as part of the routine GPIB protocol, it can be set to the required operating conditions by a string of program codes terminated by a Line Feed (LF) (usually accompanied by End or Identify EOI) as shown in Fig. 4. In this and subsequent examples the symbol '^' indicates a space.

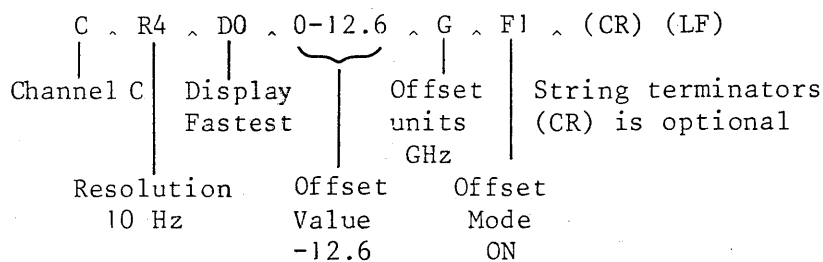


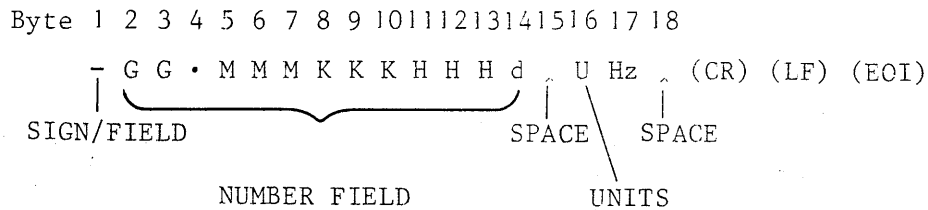
Fig. 4 Typical program string

48. In this example spaces are inserted between each program code for clarity but are not essential. Commas (,) or semi-colons (;) may also be used. The codes can be programmed in any order except for Display (Dn) which must follow Resolution (Rn) as shown in example.

49. For subsequent program strings only the altered codes need be sent followed by (LF).

#### Remote output data format

50. Frequency data is output to the GPIB as a string of ASCII characters in an 18 byte format followed by Carriage Return (CR) and Line Feed (LF) with End or Identify (EOI) as in Fig. 5.



*Fig. 5 Output data string*

51. Leading and trailing zeros in the number field are replaced with spaces. Spaces are also used to represent the default status for the sign and units field. In this way the 18 byte format is maintained irrespective of gate time or resolution selected. The decimal point position mimics that of the front panel display. Table 6 lists the output data parameters in byte number order.

#### Service request (SRQ) message

52. A service request message is raised at the end of every valid measurement when output data is ready or when an invalid GPIB program code is received, (unless SRQ INHIBIT command is active).

TABLE 6 OUTPUT DATA PARAMETERS

Byte No.	Name	Purpose
1 ±	Sign field	Indicates the sign of the number field. ^ = positive (default status) - = negative
2 to 14 GG.MMM KKKHHH d	Number field	Contains the numerical information with 1 byte reserved for the decimal point. Valid characters are 0 to 9 and ^. Leading and trailing zeros replaced with ^.
15 and 18 ^	Compulsory spaces	To assist intelligibility and act as delimiters between the number and units field and the units Hz and end of string.
16 U	Units field	Identifies the units of measurement G = GHz M = MHz K = kHz ^ = Hz (default status)
17 Hz	Hz units	Identifies the units of measurement.
	Carriage Return (CR)	For correct formatting of printed copy
	Line Feed (LF)	Used as the string terminator and sent with (EOI) End or Identify.

Status byte

53. A status byte is prepared following receipt of Serial Poll Enable (SPE) or when 2440 raises SRQ. This consists of 8 bits, each of which is set true under the conditions shown in Fig. 6 and is sent to the controller when 2440 is addressed as a talker.

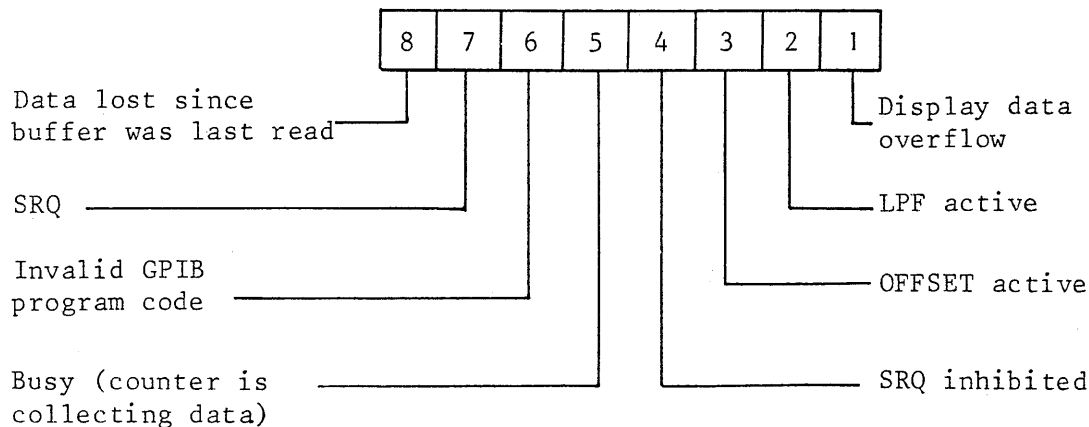
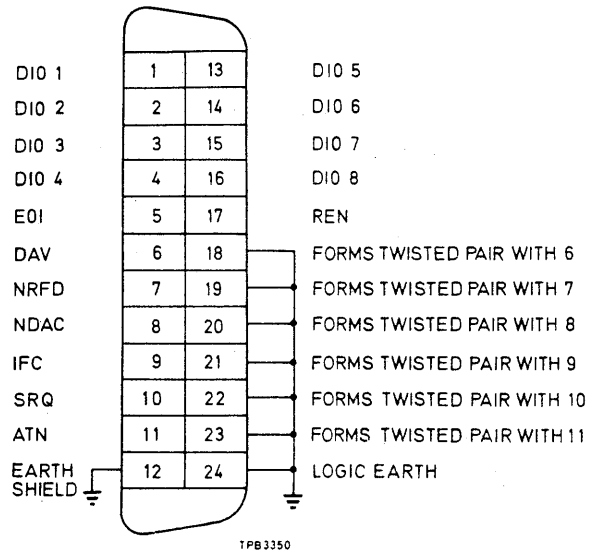


Fig. 6 Status byte

GPIB connector contact assignments

54. The contact assignment of the GPIB cable connector and the device connector is as shown in Fig. 7 below.



*Fig. 7 GPIB connector contact assignments*

GPIB instructions card

55. For easy reference by the operator, the GPIB instructions are repeated on a separate card which is supplied with each operating manual.



## DIGITAL TO ANALOGUE CONVERTER OPERATION

56. On power-up the d-a converter module is automatically enabled and set to convert 3 digits of frequency data as detailed in Table 7, key 9.

57. Selection of other digits for conversion is carried out by pressing LOCAL key. The display will show the d.a.c. message and a prompt i.e.

**dAc.**

and wait for a single numeric key operation to select the required 3 consecutive digits from the 12 decades of frequency data available. Allocation of digits to key numbers is shown in Table 7.

TABLE 7 CONVERTER DIGIT SELECTION

Key	Selects digits (DDD)			
	GHz	MHz	kHz	Hz
0	---	.---	---	.-- D D . D
1	---	.---	.---	. D D D . --
2	---	.---	---	. D . D D -- . --
3	---	.---	.---	. D D . D --- . --
4	---	.---	.---	. D D D . --- . --
5	---	.---	.---	. D . D D -- . --- . --
6	---	.---	.---	. D D . D --- . --- . --
7	---	.---	.---	. D D D . --- . --- . --
8	---	.---	.---	. D . D D -- . --- . --- . --
9*	D D . D	---	.---	. --- . --- . --

\* Default status

Note...

Allocation is on an absolute basis and is unaffected by any particular choice made via a RESOLUTION key for inclusion in the 9 available display digits. So for example - with a display resolution of 1 kHz it would not be sensible to choose DAC 0 or DAC 1 as the selected digits would always be zero.

58. After echoing the selected key number on the display, the counter will return to normal working ready to provide an analogue output voltage when an input signal is connected. Output voltage range is -1 V to +1 V, echoing the sign of the display.

Chapter 4-1

## BRIEF TECHNICAL DESCRIPTION

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## INTRODUCTION

1. The following summary is an outline circuit description of 2440 and is intended to be read in conjunction with the simplified block diagram, Fig. 1. Detailed circuit descriptions and diagrams are given in Chap. 4-2 of the Service Manual.

## SUMMARY

Inputs

2. Signal handling and measurement over the frequency range 10 Hz to 20 GHz is accomplished in 3 input channels A, B and C operating under microprocessor control. Channels A and B have direct counting functions while channel C input frequency is derived from a number of processor controlled measurements.

Channel A (10 Hz to 100 MHz)

3. The low frequency counter unit for channel A incorporates a selectable low-pass filter input, AGC control and a 20 dB amplifier. The amplified signal is selected and gated under processor control and then counted by a 10 decade counter. Keyboard operation toggles the low-pass filter in/out.

4. The gate and counter are also used in channel C operation during which the processor selects the required input.

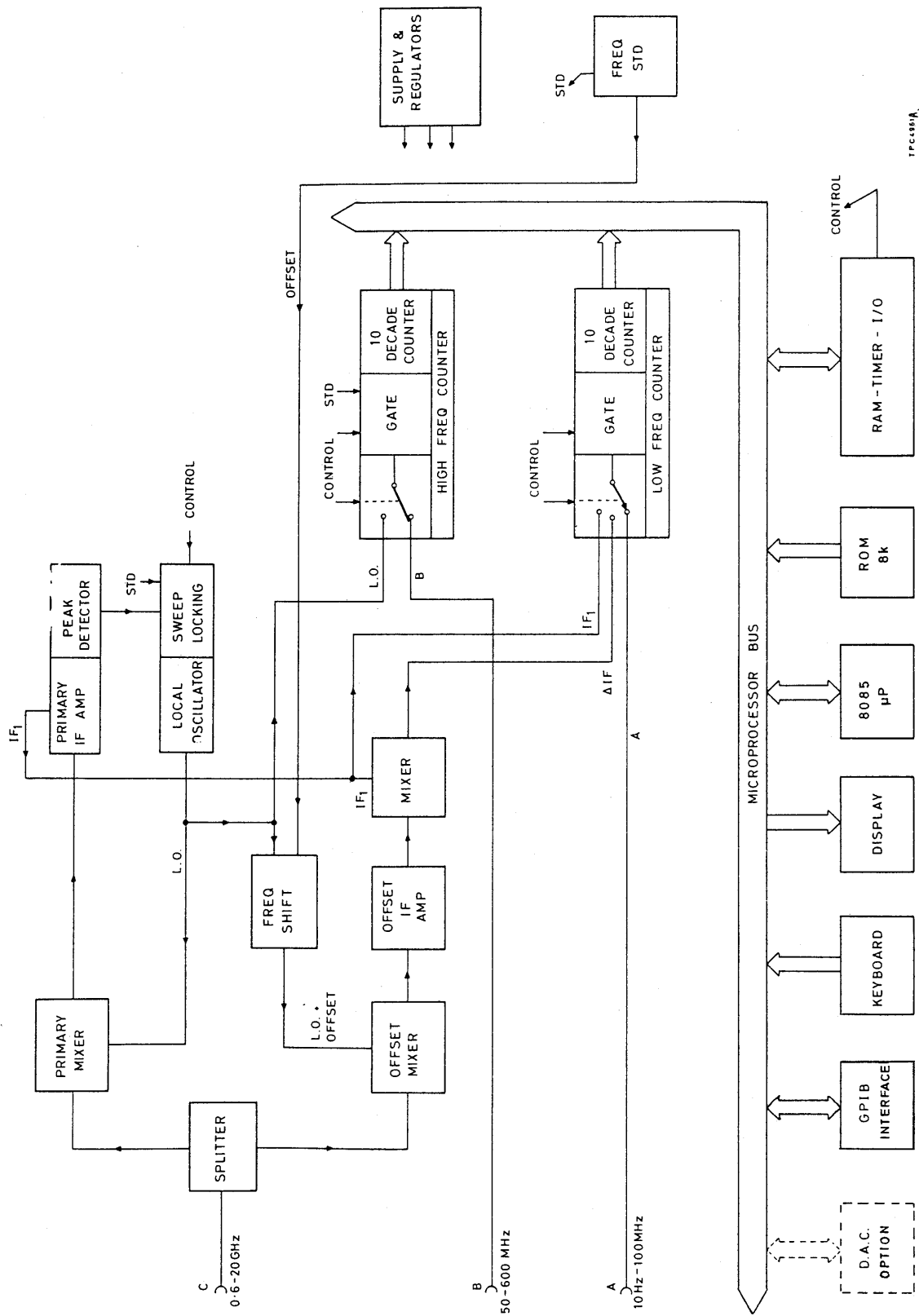


Fig. 1 2440 : Simplified block diagram

Channel B (50 MHz to 600 MHz)

5. The high frequency counter unit for channel B also incorporates an AGC input control circuit and 20 dB amplifier. Processor control operates the input selection circuit and the gate. The gate is retimed from the 1 MHz internal frequency standard and the amplified signal counted by a 10 decade counter.

6. The alternative input to the gate and counter is selected by the processor when measuring channel C input frequency.

Channel C (600 MHz to 20 GHz)

7. Channel C employs the harmonic heterodyne conversion technique with a small offset on the oscillator frequency to enable computation of the harmonic number.

8. The input is split into two signal paths, both of which immediately down-convert the microwave signal to produce two i.f.'s in the 20 to 100 MHz range using identical sampling type mixers.

9. The primary mixer is driven by a local oscillator in the 300 to 400 MHz range and harmonics are generated within the mixer to beat with the input signal and produce a primary i.f. ( $IF_1$ ). Under control of the microprocessor the local oscillator is swept over its full frequency range which allows the primary i.f. system to 'look at' the complete r.f. input spectrum.

10. A peak detecting a.g.c. system sets the i.f. gain such that only the largest amplitude input signal will be recognized. A dedicated counter detects an i.f. in the centre of the i.f. pass band and stops the local oscillator sweep. Control is then passed to a complex phase-locked loop which locks the local oscillator to the system time base and determines whether the upper or lower sideband has been acquired.

11. The locked local oscillator frequency is shifted by a small amount and fed to the offset mixer. This results in a slightly different i.f. frequency which is mixed with the primary i.f. to produce a third i.f. ( $\Delta IF$ ). This frequency is a measure of the harmonic number.

12. By measuring this third i.f. ( $\Delta IF$ ) and the primary i.f. ( $IF_1$ ) in the LF counter and the local oscillator frequency (LO) in the HF counter, the input signal frequency can be calculated by the microprocessor.

Microprocessor control

13. An 8085A microprocessor based controller directs routines concerned with system and function control, accepts instructions from the keyboard, interprets and directs them as necessary, carries out calculations and controls the display.

14. The microprocessor controller also allows full remote operation of the instrument via the GPIB interface unit and the GPIB bus. With the aid of a converter unit fitted the microprocessor directs the keyboard selected digits of internal frequency data to the unit for conversion.

Power supply

15. The supply circuits become active as soon as an a.c. mains supply is connected to the instrument.

16. Three d.c. supply voltages are provided by transformer fed conventional full wave rectifier circuits each with their own series regulator circuit. The voltages are +10.5 V, +5 V and -5 V. 2440 is powered up by application of the +10.5 V supply through the ON position of the ON/STANDBY switch. In the STANDBY position the +10.5 V supply to the standard 10 MHz crystal oscillator is maintained to ensure temperature stability.

