TECHNICAL MANUAL

OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT, AND GENERAL SUPPORT MAINTENANCE MANUAL FOR

MODULATION METER ME-505A/U (MARCONI INSTRUMENTS, MODEL 2305) (NSN 6625-01-154-4844)

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CHANGE

No. 1

HEADQUARTERS
DEPARTMENT OF THE APRMY
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OPERATORIS, ORGANIZATIONAL, DIRECT SUPPORT
AND GENERAL SUPPORT MAINTENANCE MANUAL

MODULATION METER, ME-505A/U
(MARCONI INSTRUMENTS MODEL 2305)
(NSN 6625-01-154-4844)

TM 11-6625-3146-14, 26 December 1985, is changed as follows:

1. Insert print date of 26 December 1985, on the front cover of the manual.
2. Remove old pages and insert new pages as indicated below. New or changed material is indicated by a vertical bar in the margin of the page. Added or revised illustrations are indicated by a vertical bar adjacent to the identification number.

Remove	Insert
i through iv	i through iv
1-3 and 1-4	1-3 and 1-4
1-11 through 1-16	1-11 through 1-16
2-1 and 2-2	2-1 and 2-2
3-1 and 3-2	3-1 and 3-2
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4-7 and 4-8	4-7 and 4-8
4-11 and 4-12	4-11 and 4-12
4-31 through 4-44	4-31 through 4-44
4-47 through 4-52	4-47 through 4-52
5-3 through 5-6	5-3 through 5-6
None	5-6.1/(5-6.2 blank)
5-17 and 5-18	5-17/(5-18 blank)
5-43 and 5-44	5-43 and 5-44
B-5 through B-8	B-5 through B-8
None	Figure FO-25

3. File this change sheet in front of the publication for reference purposes.

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The Adjutant General

DISTRIBUTION:
To be distributed in accordance with DA Form 12-36 literature requirements for ME-505/U.

5 SAFETY STEPS TO FOLLOW IF SOMEONE IS THE VICTIM OF ELECTRICAL SHOCK

1. DO NOT TRY TO PULL OR GRAB THE INDIVIDUAL
2. IF POSSIBLE, TURN OFF THE ELECTRICAL POWER
3. IF YOU CANNOT TURN OFF THE ELECTRICAL POWER, PULL, PUSH OR LIFT THE PERSON TO SAFETY USING A DRY WOODEN POLE OR A DRY ROPE OR SOME OTHER INSULATING MATERIAL
4. SEND FOR HELP AS SOON AS POSSIBLE
5. AFTER THE INJURED PERSON IS FREE OF CONTACT WITH THE SOURCE OF ELECTRICAL SHOCK, MOVE THE PERSON A SHORT DISTANCE AWAY AND IMMEDIATELY START ARTIFICIAL RESUSCITATION

WARNING

HIGH VOLTAGE is used in the operation of this equipment. DEATH ON CONTACT may result if personnel fail to observe safety precautions. Know the areas in this equipment containing high voltage. Be careful not to come in contact with the high voltage connections during operation of this equipment.
Do not be misled by the term "Low Voltage." Potentials as low as 25 volts may cause death under adverse conditions.

WARNING

FLAMMABLE SOLVENTS are used in the maintenance of this equipment. Adequate ventilation should be provided while using isopropyl alcohol. Prolonged breathing of the vapor should be avoided. The solvent is not to be used near heat, sparks, or open flames; it is highly flammable. Since isopropyl alcohol dissolves natural oils, prolonged contact with skin should be avoided. When necessary, use gloves which are solvent-resistant. If the solvent is taken internally, consult a physician immediately.

WARNING

COMPRESSED AIR is used in the maintenance of this equipment. When used for cleaning, the compressed' air source must limit nozzle pressure to no more than 29 pounds per square inch (PSIG). Goggles must be worn when cleaning with compressed air.

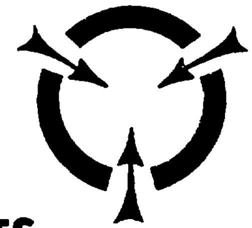
WARNING

Adequate ventilation should be provided while using TRICHLOROTRIFLUOROETHANE. Prolonged breathing of vapor should be avoided. The solvent should not be used near heat or open flame; the products of decomposition are toxic and irritating. Since TRICHLOROTRIFLUOROETHANE dissolves natural oils, prolonged contact with skin should be avoided. When necessary, use gloves which the solvent cannot penetrate. If the solvent is taken internally, consult a physician immediately.

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.

CAUTION



THIS EQUIPMENT CONTAINS PARTS AND ASSEMBLIES SENSITIVE TO DAMAGE BY ELECTROSTATIC DISCHARGE (ESD). USE ESD PRECAUTIONARY PROCEDURES WHEN TOUCHING, REMOVING OR INSERTING PRINTED CIRCUIT BOARDS.

ESD
CLASS 1
NOTE

The symbol for static sensitive devices in military inventory is as depicted in the caution block above. The symbol used in this authenticated manual is

GENERAL HANDLING PROCEDURES FOR ESDS ITEMS

- USE WRIST GROUND STRAPS OR MANUAL GROUNDING PROCEDURES
- KEEP ESDS ITEMS IN PROTECTIVE COVERING WHEN NOT IN USE
- GROUND ALL ELECTRICAL TOOLS AND TEST EQUIPMENT
- PERIODICALLY CHECK CONTINUITY AND RESISTANCE OF GROUNDING SYSTEM
- USE ONLY METALIZED SOLDER SUCKERS
- HANDLE ESDS ITEMS ONLY IN PROTECTED AREAS

MANUAL GROUNDING PROCEDURES

- MAKE CERTAIN EQUIPMENT IS POWERED DOWN
- TOUCH GROUND PRIOR TO REMOVING ESDS ITEMS
- TOUCH PACKAGE OF REPLACEMENTS ESDS ITEM TO GROUND BEFORE OPENING
- TOUCH GROUND PRIOR TO INSERTING REPLACEMENT ESDS ITEMS

ESD PROTECTIVE PACKAGING AND LABELING

- INTIMATE COVERING OF ANTISTATIC MATERIAL WITH AN OUTER WRAP OF EITHER TYPE 1 ALUMINIZED MATERIAL OR CONDUCTIVE PLASTIC FILM - OR -HYBRID LAMINATED BAGS HAVING AN INTERIOR OF ANTISTATIC MATERIAL WITH AN OUTER METALIZED LAYER
- LABEL WITH SENSITIVE ELECTRONIC SYMBOL AND CAUTION NOTE

CAUTION

Devices such as CMOS, NMOS, MNOS, VMOS, HMOS, thin-film resistors PMOS, and MOSFET used in many equipments can be damaged by static voltages present in most repair facilities. Most of the components contain internal gate protection circuits that are partially effective, but sound maintenance practice and the cost of equipment failure in time and money dictate careful handling of all electrostatic sensitive components.
The following precautions should be observed when handling all electrostatic sensitive components and units containing such components.

CAUTION

Failure to observe all of these precautions can cause permanent damage to the electrostatic sensitive device. This damage can cause the device to fail immediately or at a later date when exposed to an adverse environment.

STEP
1 Turn off and/or disconnect all power and signal sources and loads used with the unit.

STEP
2 Place the unit on grounded conductive work surfaces.

STEP
3 Ground the repair operator using a conductive wrist strap or other device using a 1-M series resistor to protect the operator.

STEP
4 Ground any tools (including soldering equipment) that will contact the unit. Contact with the operator's hand provides a sufficient ground for tools that are otherwise electrically isolated.

STEP
5 All electrostatic sensitive replacement components are shipped in conductive foam or tubes and must be stored in the original shipping container until installed.

STEP
6 When these devices and assemblies are removed from the unit, they should be placed on the conductive work surface or in conductive containers.

STEP
7 When not being worked on wrap disconnected circuit boards in aluminum foil or in plastic bags that have been coated or impregnated with a conductive material.

STEP
8 Do not handle these devices unnecessarily or remove from their packages until actually used or tested.

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.

Main 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. Before fitting a non-soldered plug to the mains lead, cut off the tinned ends of the mains lead. Otherwise cold flowing of the solder could cause intermittent connections.

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.

TECHNICAL MANUAL **TM 11-6625-3146-14**

NO. 11-6625-3146-14

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, 26 December 1985

OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT, AND GENERAL SUPPORT MAINTENANCE MANUAL MODULATION METER ME- 50 5A/U (MARCONI INSTRUMENTS MODEL 2305) (NSN 6625-01-154-4844)

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistakes or if you know a way to improve the procedure, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual direct to: Commander, US Army Communications-Electronics Command and Fort Monmouth, ATTN: AMSEL-ME-MP, Fort Monmouth, New Jersey 07703-5000.

In either case, a reply will be furnished direct to you.

This manual is an authentication of the manufacturer's literature which, through usage, has been found to cover the data required to operate this equipment. Since the manual was not prepared in accordance with military specifications and AR 310-3, the format has not been structured to consider levels of maintenance.

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LIST OF ILLUSTRATIONS Continued

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CHAPTER 1
INTRODUCTION

Section I. GENERAL

1-1. Scope.

a. This manual describes Modulation Meter ME-505A/U, (fig. 1-1), hereinafter referred to as 2305 and provides operation and maintenance instructions.

b. Appendix A contains a list of references applicable to this equipment.
Appendix B contains the maintenance allocation chart (MAC) Organizational and General Support maintenance repair parts and special tools are listed in TM 11-6625-3146-24P.

1-2. Consolidated Index of Army Publications and Blank Forms.

Refer to the latest issue of DA Pam 310-1 to determine whether there are new editions, changes or additional publications pertaining to this equipment.

1-3. Maintenance Forms, Records, and Reports.

a. Reports of Maintenance and Unsatisfactory Equipment. Department of the Army forms and procedures used for equipment maintenance will be those prescribed by DA Pam 738-750 as contained in Maintenance Management Update.

b. Report of Packaging and Handling Deficiencies. Fill out and forward SF 364 Report of Discrepancy (ROD) as prescribed in AR 735-11-2/DLAR 4140.55/ NAVMATINST 4355.73A/AFR 400-54/MCO 4430.3F.

c. Discrepancy in Shipment Report (DISREP) (SF 361). Fill out and forward Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 55 -38/NAVSUPINST 4610.33C/AFR 75-18/MCO P4610.19D and DLAR 4500.15.

1-4. Reporting of Equipment Improvement Recommendations (EIR).

If your Modulation Meter ME-505A/U needs improvement let us know. Send us an EIR. Let us know why you do not like the design. Put it on an SF 361 (Quality Deficiency Report). Mail it to Commander, US Army Communications Electronics Command and Fort Monmouth, ATTN: AMSEL-ME-MP, Fort Monmouth New Jersey 07703-5007. We'll send you a reply.

1-5. Administrative Storage.

Administrative storage of equipment issued to and used by Army activities will have preventative maintenance performed in accordance with the PMCS instructions before storing. When removing equipment from administrative storage the PMCS should be performed to assure operational readiness.

1-6. Destruction of Army electronics materiel to prevent enemy use shall be in accordance with TM 750-244-2.

Section II. DESCRIPIION AND DATA

1. 2305 is a high performance, microprocessor controlled, modulation meter with a comprehensive specification covering the carrier frequency range 500 kHz to 2 GHz.

2. Operation may be either local or remote. Local control is obtained via functionally grouped key switches which form the front panel controls and which direct all the instrument functions except those of SUPPLY ON and LF LEVEL.

3. Indication of measured quantities is provided by two l.c.d. 7-segment digital displays : frequency - either of the carrier or of the modulating tone - appears in the 8-digit left-hand display, modulation - in % a.m., kHz or radians deviation - appears in the 4 digit right-hand display.

4. The microprocessor allows maximum flexibility in arranging and controlling the circuit functions and permits remote operation via the GPIB* when the instrument is fitted with the GPIB interface optional accessory. The 2305 is thus as well suited for stand-alone manual operation as for incorporation in automatic systems with programmed operation and makes few demands on operator skill.

Fig. 1-1. 500 kHz to 2 GHz Modulation Meter 2305 ME-505A/U

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* GPIB - Marconi Instruments General Purpose Interface Bus in accordance with IEEE Standard 488 - 1978, IEC Publication 625-1 1979 and BS 6146.

5. In its simplest method of operation, the 2305 provides both automatic tuning and control of the ranging circuits, although tuning may be controlled directly by keypad entry of numerical data, and individual ranges may be retained by the use of keyboard second functions if necessary. A HOLD ON/OFF key permits all ranges and functions to be locked in their present states.

6. In both forms of tuning, the local oscillator frequency retains the same sense relationship with signal frequency needed to ensure that positive frequency and phase excursions are always presented as P+.

7. In the CARRIER ERROR mode the instrument will measure small frequency drifts or offsets by continuously subtracting a stored reference value from instantaneous measurements of the carrier. The reference value can be either a numerical entry made via the keypad or a particular instantaneous measurement transferred to store by operation of the CARRIER ERROR key. Two other frequency measurement modes provide for the display of either carrier or modulating frequency.

8. When necessary, an external 10 MHz standard may be used in place of the internal reference which forms the basis for local oscillator frequency synthesis and for frequency measurement. It is also possible to provide for direct substitution of the local oscillator signal by a source of external origin. The changeover in both cases being effected by second function keying.

9. Modulation is normally measured as peak excursions of either the amplitude, frequency or phase of the carrier signal and a choice of detector modes enables the peaks of each polarity either to be measured separately or for their average to be calculated and presented as IF. Two additional detector modes offer (1) an averaging detector, and (2) a PEAK HOLD function. The averaging mode (NOISE AVG) is useful when noise is to be measured, and the quantity displayed when in this mode is of the peak value of a sine wave having the same average value. In PEAK HOLD, successive peak samples are examined and store and display are up-dated each time the previous largest sample is exceeded.
The PEAK HOLD mode is useful for logging transients and other aspects of modulator system performance under operational conditions. In the a.m. mode, peaks are always measured as P+ and troughs as P-.

10. The 2305 will tune and measure automatically without loss of accuracy on signal levels between-18 dBm and +30 dBm. The sensitivity increases considerably towards the bottom end of the frequency range and a substantial further increase can be obtained by reverting to manual tuning. Input protection is provided above the permitted maximum of +30 dBm. Deep amplitude modulation may reduce the signal level during troughs to a point that is insufficient to ensure proper functioning of the internal frequency counter and auto-tuning may be adversely affected. The effect is only likely to occur with a.m. greater than 90% and, if it happens, the a.m. depth should be temporarily reduced to allow auto-tuning to complete.

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t Keyboard second functions - A range of operating modes exceeding 50 in number which greatly extend the instrument's use for special purposes including fault diagnosis. The second functions are in 4 groups ranging from those which are directly accessible, through three further groups requiring preliminary unlocking codes of graded complexity.

11. Frequency deviation can be measured up to a maximum of 500 kHz for modulation frequencies up to 275 kHz. The accuracy attainable varies with modulation frequency and approaches +0.5% at I kHz.

12. Phase deviation can be measured to a maximum of 500 radians up to I kHz modulation frequency. Above this frequency the maximum measurable deviation decreases at 6 dB per octave.

13. Amplitude modulation up to 95% can be measured with accuracy approaching 1%, depending on modulation depth and frequency, up to a maximum modulation frequency of 50 kHz. Useful indications are given for depths up to 99.9%.

14. Measurements of all three types of modulation can be related to any reference level and expressed as dB. The reference quantity may be entered numerically via the keypad or may be a measurement selected from a series and transferred to store by a single key stroke.

15. The post detector bandwidth may be shaped by any one of five built-in filters which cover the varied requirements of mobile radio, broadcasting, telemetry etc. There is also a choice of 3 de-emphasis time constants which may be introduced into the audio output signal in f.m. mode. They may also be introduced into the measurement system by a keyboard second function.
External filters may be introduced into the measurement circuit in addition to and independently of any internal selection.

16. Standards of amplitude and frequency modulation are generated within the instrument for calibration purposes. The 2305 automatically runs a selfcheck routine against these standards after each switch-on and displays pass/ fail data. 2305 measurements can be recalibrated against these standards at any time by operation of the CAL key.

17. For systems use or production tests, up to 10 sets of control settings may be stored in non-volatile memory for subsequent recall and use.

18. In its POWER function, the 2305 will normally display the power entering the input terminal in dBm or watts. The measurement is based on peak voltage detection and will indicate peak power on amplitude modulated signals. The range may be extended upward by added external attenuation and a flexible system of power calibration with optional display in watts or dBm can be introduced by second functions.

19. Two major optional accessories extend the instrument's capabilities.

(1) The GPIB option enables all the main controls and measurements to be operated and monitored remotely under program control.
(2) The Distortion/Weighting Filter option provides single key stroke noise and distortion measurement and contains two standard psophometric weighting networks which may be introduced into the measurement channel.

> The measurement performance of the 2305 can be changed by the user to meet special operational needs by keyboard second functions which have their status stored in nonvolatile memory. If you are not certain of the state in which the instrument has been left by previous users, you should obtain a second function status display according to the procedure described on page 3-15, before attempting any measurements.

PERFORMANCE DATA

Characteristic	Performance
RF INPUT	
20. Carrier frequency range	500 kHz - 2 GHz. Acquisition time on AUTO TUNE is, typically, 500 ms.
21. Carrier frequency indication	8 digit 1.c.d. Resolution: 10 Hz below 1 GHz, 100 Hz above 1 GHz, 10 Hz at all frequencies in CARRIER ERROR function.
22. Signal input	
Minimum requirements :	-25 dBm (13 mV) 500 kHz to 1 GHz. -18 dBm (28 mV) 1 GHz to 2 GHz.
Maximum input :	Permitted maximum, 1 W (+30 dBm). Overload trip provides protection against overloads up to 25 W.
Input connector :	Type N female. 50 Ω nominal.
FREQUENCY MODULATION	
23. Maximum deviation :	(1) Carrier frequencies up to 5.5 MHz. 50 kHz peak deviation at modulation frequencies from 30 Hz to 15 kHz. (2) Carrier frequencies above 5.5 MHz. 500 kHz peak deviation at modulation frequencies from 30 Hz to 275 kHz.
Range selection :	Selection is automatic for best resolution.
Display :	4 digit l.c.d., in kHz.•
Accuracy : (for carriers >5.5 MHz)	After calibration using internal calibrator: +0.5% of reading ±1 digit at I kHz modulation frequency measured with 50 Hz to 15 kHz filter selected for deviations above 5 kHz and ±1% of reading ± digit below 5 kHz deviation. Frequency response relative to I kHz : ±0.5% for modulation frequencies from 20 Hz to 20 kHz measured with 10 Hz to 300 kHz filter selected, +0.5%, -1% for modulation frequencies from 20 Hz to 50 kHz, +0.5%, -5% for modulation frequencies from 20 Hz to 275 kHz.

* Note. For all three types of modu-a-tion measurement, as the quantity dlation measurement, as the quantity displayed increases from 5000 to 6000, the least significant digit will become a fixed zero whatever position the decimal point may happen to be in. The process rever-ses as the quantity falls. Wherever accuracy statements relating to modulation include the qualifica-tion '± N digits', the digits re-ferred to are the least significant of the active digits i.e. XXXN or XXN- as the case may be.

Characteristic	Performance
	Note: Where necessary, allowance must be made for peak residual noise which will contribute to peak readings.
AM rejection :	Typically, 50% a.m. at 1 kHz will produce an indicated 40 Hz deviation with the 300 Hz to 3.4 kHz filter selected.
Residual f.m. noise : (300 Hz to 3.4 kHz bandwidth)	*Carrier frequency* / *FM noise (r.m.s. values)* 500kHz - 50MHz 1.4 Hz 50MHz - 500MHz 15 Hz 500MHz - 1GHz 30 Hz 1GHz - 2GHz 60 Hz 500MHz typically 8 Hz Typical performance with external low noise 28 MHz to 56 MHz local oscillator: Below 120 MHz 0.5 Hz 500 MHz 2 Hz 1 GHz 4 Hz
PHASE MODULATION	
24. Carrier frequency range :	5.5 MHz to 2 GHz, usable down to 0.5 MHz.
Maximum deviation :	500 radians for modulation frequencies up to 1 kHz. Decreasing at 6 dB/ octave above 1 kHz.
Range selection :	Ranges automatically selected for best resolution.
Accuracy :	After calibration using internal calibrator : ±2% of reading ±3 least significant changing digits at 1 kHz modulation frequency. Frequency response relative to I kHz : ±2% +3 least significant changing digits from 300 Hz to 4 kHz. Note. Where necessary, allowance must be made for peak residual noise which will contribute to peak readings. Improved accuracy in the measurement of phase modulation may be obtained for single tone modulation by using the FM

Characteristic	Performance
POWER MEASUREMENT	
26. Range :	10 mW to 1 W (+10 dBm to +30 dBm).
Accuracy :	+1 dB at 800 MHz. Frequency response +1 dB from 500 kHz to 1500 MHz, usable up to 2 GHz. Input v.s.w.r. : <2.00 from 500 kHz to 1500 MHz.
Display :	Display may be in dBm or W as selected by keyboard second function.
27. Frequency display	Front panel keys enable the following frequencies to be displayed on an 8 digit l.c.d.
CARRIER	
CARRIER ERROR :	Frequency difference between measured carrier frequency and frequency refe-rence in store.
MODULATION	
Resolution	
CARRIER :	10 Hz below 1 GHz, 100 Hz above I GHz.
CARRIER ERROR :	All carrier frequencies : 10 Hz.
MODULATION :	0.1 Hz up to 5 kHz, 10 Hz above 5 kHz.
Accuracy : (all modes)	±1 count ± error in standard
Frequency standard :	Front panel indicator shows when external standard is selected.
28. Internal frequency standard	
Frequency change with temperature :	<±0.1 p.p.m. over the range 0 to 40°C.
Warm-up time :	Within 0.5 p.p.m. of final frequency within 5 min from switch-on at 20°C ambient.

Characteristic	Performance
POWER MEASUREMENT	
26. Range :	10 mW to 1 W (+10 dBm to +30 dBm).
Accuracy :	±1 dB at 800 MHz. Frequency response +1 dB from 500 kHz to 1500 MHz, usable up to 2 GHz.
Input v.s.w.r.:	<2.00 from 500 kHz to 1500 MHz.
Display :	Display may be in dBm or W as selected by keyboard second function.
27. <u>Frequency display</u>	Front panel keys enable the following frequencies to be displayed on an 8 digit 1.c.d.
CARRIER	
CARRIER ERROR :	Frequency difference between measured carrier frequency and frequency refe-rence in store.
MODULATION	
Resolution	
CARRIER :	10 Hz below I GHz, 100 Hz above I GHz.
CARRIER ERROR :	All carrier frequencies : 10 Hz.
MODULATION :	0.1 Hz up to 5 kHz, 10 Hz above 5 kHz.
Accuracy : (all modes)	±1 count ± frequency standard error.
Frequency standard :	Front panel indicator shows when external standard is selected.
28. <u>Internal frequency standard</u>	
Frequency change with temperature:	<±0.1 p.p.m. over the range 0 to 40°C. Better than 3 parts in 109 per day. Better than 1 part in 107 per month. Better than 1 part in 106 per year.
Ageing rate :	Better than 3 parts in 109 per day. Better than 1 part in 107 per month. Better than 1 part in 106 per year.
Warm-up time :	Within 0.5 p.p.m. of final frequency within 5 min. from switch-on at 200C ambient.

	Characteristic	Performance	
29.	Modulation display	In accordance with the function selected, a 4 digit 1.c.d. will show the following :	
		AM -	% modulation depth.
		FM -	kHz deviation.
		ϕM -	radians deviation.
		POWER -	W or dBm as selected.
		Relative (REL) -	dB.
30.	Detector modes	The following may be selected :	
		Average of P+ and P- J	P-P 2
		Positive peak	P+
		Negative peak	P-
		Noise averaging (calibrated as peak of equivalent sine wave)	NOISE AVG.
31.	Display modes	The following may be selected :	
		Absolute -	absolute values of modu- (ABS) lation are displayed.
		Relative- (REL)	measured modulation is displayed as a ratio in dB to a reference quantity entered and stored in the instrument.
		Peak hold - (PK HOLD)	holds and displays the maximum peak occurring in period of observation. In power measurement, measures peak power.
32.	Modulation bandwidths	Five post detector filter bandwidths may be selected from the front panel	
		10 Hz to 300 kHz	for wide band f.m. measurements.
		30 Hz to 50 kHz	flat within 0.1 dB.
		65 Hz to 250 Hz	
		50 Hz to 15 kHz	nominal
		300 Hz to 3.4 kHz	-3 dB bandwidths

	Characteristic	Performance
33.	<u>De-emphasis</u>	Three de-emphasis time constants may be selected from the front panel : 50 µs, 75 µs, 750 µs. De-emphasis may be introduced into the 1.f. output circuit and relative measurements only and does not affect absolute measurements.
34.	<u>Outputs (front panel)</u>	
	IF :	As carrier frequency for input carriers up to 1.5 MHz. 250 kHz nominal for carrier frequencies from 1.5 MHz to 5.5 MHz. 1.5 MHz for carrier frequencies above 5.5 MHz. 100 mV r.m.s. nominal into 50 R.
	LF :	Demodulated, filtered and de-emphasized signal is available at BNC socket. LF LEVEL control adjusts level from 0 to at least 3 V r.m.s. into 600 Q for f.m. deviations >500 Hz, a.m. >0.5% and ϕ.m. >1.5 rad. at 1 kHz.
35.	<u>Distortion</u>	
	FM :	For modulation frequencies up to 20 kHz, <0.15%THD (Total Harmonic Distortion) for deviation up to 100 kHz. <0.5% THD for deviation up to 500 kHz. <1%THD for modulation frequencies up to 100 kHz.
	AM :	<0.3% THD for modulation depths up to 95% at I kHz modulation frequency and <1% THD for modulation depths up to 95% and modulation frequencies up to 50 kHz.
	Stereo separation :	Better than 50 dB at 1 kHz (typically 54 dB above 100 Hz).

Characteristic	Performance
36. Store/Recall	The RCL/STO key used with the numeric keypad allows up to 10 instrument settings to be stored in non-volatile memory for later recall.
37. Rear panel connections	
(1) External filter :	An external l.f. filter may be connected via a standard stereo jack into the modulation amplifier. Source impedance is low and load impedance is high.
(2) External local oscillator input :	An external local oscillator may be connected via a BNC socket and can be switched into circuit in place of the internal oscillator by keyboard action. Frequency range 28 MHz to 56 MHz to cover input signals from 26.5 MHz to 2 GHz. Input level, 100 mV to I V into 50 52.
(3) Internal frequency standard output :	10 MHz output from internal standard available at BNC socket. Output level at least 100 mV into 50 Ω.
(4) External frequency standard input :	10 MHz external standard input via BNC socket. 1 V r.m.s. sine wave into a nominal 100 Ω.
38. Keyboard second functions	Group PO (unprotected) and PI (first level protected) are concerned with extensions and modifications in operating technique and their use is described in Chapter 3 of this volume. The second and third levels of protection - groups P2 and P3 - control access to basic calibration data stored in the instrument and their description and use is covered in the Service Manual which is available as an optional extra.

	Characteristic	Performance
39.	GPIB operation	A GPIB interface is available as an optional accessory which may be supplied fitted, with the instrument, or may be subsequently fitted by the user without the need for special skills or equipment. All controls except for SUPPLY and LF LEVEL are remotely programmable. Second functions are all programmable, and protected levels can be accessed via the bus directly without prior insertion of the locking code. The interface complies with the following subsets as defined in IEEE 488 - 1978, IEC 615-1 1979 and BS 6146 : SH1, AH1, T6, TEO, L4, LEO, SR1, RL1, PPO, DC1, CO, E1 - see optional accessories para. 48, page 1-13.
40.	<u>Psophometer weighting/distortion measurement</u>	Incorporation of the optional kit 46883-527G enables the full potential of the 2305 to be realized and the keys controlling weighting (WTG) and distortion measurement (DIST SINAD) to become operational. The kit comprises an assembled circuit board with fitting instructions and may be retro-fitted by a user if fitting was not requested prior to despatch of the 2305.

Distortion measurement

Measurement frequencies:	300 Hz, 500 Hz, 1 kHz, automatically tuned over ±5%.
Fundamental rejection :	greater than 65 dB.
Distortion measurement range:	0.1 to 100%.
SINAD measurement range :	0 to 60 dB.
Measurement accuracy :	±1 dB.

Weighting filters

CCITT filter :	Frequency response conforms to CCITT recommendation P53.
CCIR filter :	Frequency response conforms to CCIR recommendation 468-2.

Characteristic		Performance
ENVIRONMENTAL		
41.	Rated range of use	0 to 55°C.
42.	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^2).
43.	Safety	Complies with IEC 348.
44.	Radio frequency interference	Conforms to the requirements of EEC directive 76/889.
45.	Power requirements	AC mains, switchable voltage ranges: 105 to 110 V 115 to 120 V ±10% 210 to 220 V 230 to 240 V 45 to 440 Hz, 70 VA.
46.	Weight and dimensions	
	Height :	152 mm (6 in).
	Width :	425 mm (16.7 in).
	Depth :	535 mm (21 in).
	Weight :	13.5 kg (29.7 lb).

ACCESSORIES

47. Supplied accessories

	Code no.
Plastic cover	37490-180L
AC supply lead	43123-076Y
Operating manual	46881-431P
Jack plug (Con. Tel. Male 3 Free Black A)	23421-620H

48. Optional accessories.
Not acquired with instruments under JAN designation ME-505A/U.

PRINCIPLES OF MEASUREMENT

49. Most modulation measurement is likely to be carried out using steady single tone signals so that the tests can be well defined. For observations on operational systems, the 2305 makes available an i.f. analogue of the input signal that is within the frequency range of most oscilloscopes (IF OUTPUT) and the demodulated tone (LF OUTPUT). The PEAK HOLD function can be used in dynamic measurements to store the largest measurable modulation peak occurring during any period of observation.

Amplitude modulation

50. Amplitude changes are commonly viewed on oscilloscopes because of their unique property for allowing the immediate recognition of fault conditions.
Such observations sometimes extend into measurements and it is well to understand that there may be aspects of the signal that will cause inevitable differences between measurements of a.m. signals made on modulation meters and those made on oscilloscopes. In the following paragraphs the reasons for this are examined in more detail.

51. A typical a.m. signal is shown in Fig. 1-2. In this signal the peaks of modulation are equally spaced about the zero level of the modulating waveform and, consequently, are also symmetrical about the mean - or unmodulated level of the carrier. With such a signal the 2305 should produce the same reading on both P+ and P- and therefore also on '. Any signal may, however, include distortion of the carrier component depending on the nature of the source and whether or not any tuning or filtering at carrier frequency has been given. Harmonics of the carrier will be much reduced by the 2305 which will therefore measure modulation on the fundamental component of the carrier (as displayed in the FREQUENCY window) and this sometimes differs from the amount present on the signal with carrier distortion present. The reason for this is not immediately evident but it is more likely that an oscilloscope will pass some distortion of the carrier than will a tuned modulation meter. Differences can often be detected in these circumstances between successive oscilloscope measurements, based on AM - made with P - T made with and without initial harmonic filtering. Differences will also arise
P + T'
if the modulation is asymmetrical.

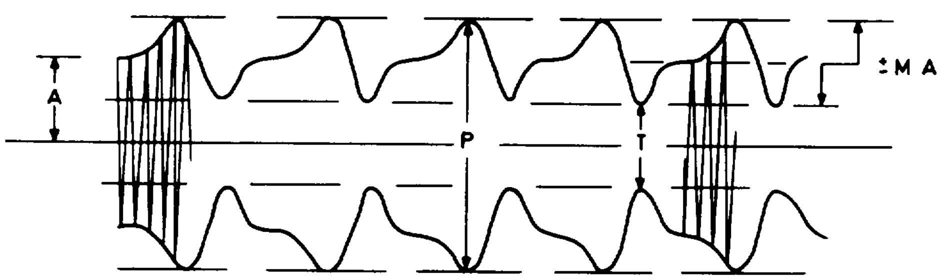


Fig. 1-2. Typical full a.m. signal symmetrical modulation.

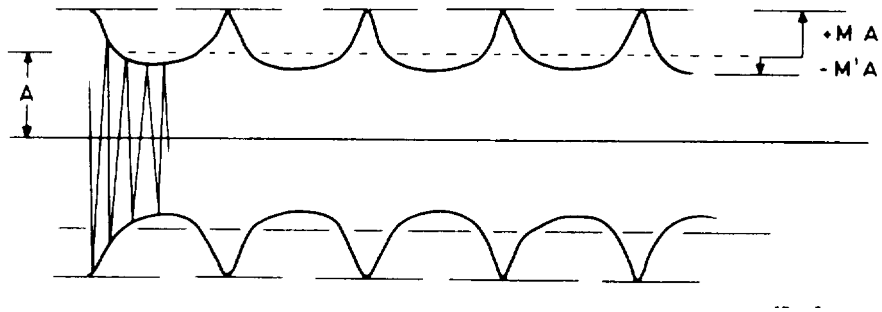


Fig. 1-3. Asymmetrical modulation.

52. The example of a.m. shown in Fig. 1-3 exhibits gross asymmetry and carrier minima and maxima are very unequally disposed about the mean, unmodulated, level. On such signals the 2305 will measure the quantities M and M[1] shown in the figure, when P+ and P- are requested, or, their average for P-P 2 The oscilloscope observer, however, has no reliable way of detecting P-T where the mean level lies and the usual formula employed of a.m. = p + T will P-P not, in general, yield the same result as a 2305 measurement of . This can be readily verified by a numerical evaluation of asymmetrical modulation using both formulae. The example shown in Fig. 1-3 is somewhat extreme, but asymmetry of a few percent of this kind can frustrate an attempt to get agreement between the two measurement methods to within 1%. Any decision as to which measurement is correct requires attention to the definition of the measurement taking the distortion into account.

Non-conventional a.m.

53. The term 'amplitude modulation' is sometimes used in connection with signals for which the measurements made by instruments employing the principles of the 2305 are inappropriate. One example is a signal taken from a modulation system in which carrier or sideband suppression has been carried out and to which the normal conventions cannot apply. Another example is the application of the term to the square wave modulation produced by switching modulators in microwave signal sources. The specification for carrier suppression achieved during the 'off' part of the cycle in such modulators is, typically, well in excess of 46 dB (corresponding to 99% a.m.) and so cannot be verified by a modulation meter.

AM calibrator

54. The internal a.m. calibrator uses a resistive attenuator pad which is introduced into an i.f. signal deriving from the local oscillator when required. The pad is switched in and out by high impedance FET switches driven from a 1 kHz signal that is precisely square. The attenuation of nominally is introduced gives a very stable 1 khz a.m. dependent only on the stability of the resistors in the pad.

Frequency modulation

55. Frequency deviations are translated from the signal frequency to the i.f. The i.f. deviations are then linearly demodulated into a voltage having the frequency of the modulating tone and an amplitude proportional to the deviation. This voltage is then amplified and detected by the same circuits that are used for a.m., the overall gain being sufficiently stable for the metering circuit to be directly calibrated in frequency deviation. The calibration is ultimately referred to the internal frequency standard via the f.m. calibrator in which the local oscillator synthesizer is switched between two pairs of frequencies so simulating two levels of deviation.

Bessel zero calibration technique

56. A well-known method of producing calibrated f.m. signals utilizes the predictable ratios of deviation to modulation signal frequencies at which the carrier or certain sideband signal components disappear. The method is prone to error if the modulating signal is at all distorted or if there is any spurious a.m. present. For these and other reasons this calibration method has been largely superseded by more modern techniques of f.m. synthesis and should be regarded with suspicion if it appears to conflict with the internal calibrator in the 2305.

Phase modulation

57. Phase and frequency modulation are related by the expression ϕ- = fd, where - is the carrier phase deviation in radians arising from a modulating tone of frequency fm, causing carrier deviation fd. A detector of frequency modulation can therefore be turned into a phase demodulator by causing its output to vary as T i.e. to roll off at 6 dB/octave. This technique of phase demodulation is used in the 2305 and in other comparable instruments.
The permissible full-scale maxima for ϕ.m. cannot, though, be as independent of modulating frequency as in f.m. and a.m. The fixing of a low modulation frequency requirement of 500 radians full-scale defines the corresponding maximum modulation frequency (at which 500 kHz frequency deviation is reached) at I kHz. For modulation frequencies above I kHz the permissible range maxima must decrease at 6 dB per octave. Below I kHz the demodulator gain rises at 6 dB/octave to maintain the 500 rad full-scale maximum until 300 Hz is reached at which point the cut-off frequency of a high-pass filter defines the practical limit for low frequencies. This performance reflects the normal limitations inherent in the design of phase modulated systems and is no disadvantage in practice.

CHAPTER 2
SERVICE UPON RECEIPT AND INSTALLATION

Section I. SERVICE UPON RECEIPT

MOUNTING ARRANGEMENTS

1. Excessive temperatures may affect the instrument's performance; therefore, completely remove the plastic cover, if one is supplied over the case, and avoid standing the instrument on or close to other equipment that is hot.

CONNECTING TO SUPPLY

2. Before connecting the instrument to the a.c. supply check the position of the two voltage selector switches on the rear panel. A locking plate fixes both switches into one of four possible combinations and only the selected voltage range is displayed when the locking plate is fixed to the back panel. The instrument is normally dispatched with the switches se6lected to 230/240 V. To select a different voltage range remove the locking plate and re-position the switches to the required range as shown in Fig.2-lbelow and refit the locking plate into its alternative position.

Note...

The a.c. supply fuse may also have to be changed. An indication of the correct fuse rating is given with each displayed voltage range:

i.e.	1 A-T (1 A time lag)	105 V 120 V +10%
	0.5 A-T (0.5 A time lag)	210 V 240 V +10%

The fuses are 20 mm x 5 mm cartridge type.

3. 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

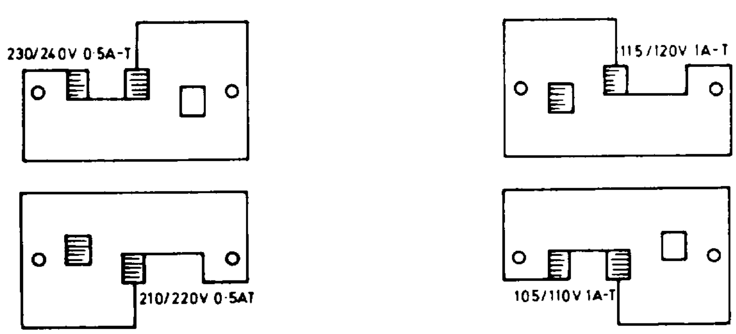


Fig. 2-1. Voltage ranges (alternative switch and locking plate positions)

SAFETY TESTING

4. Where safety tests on the a.c. supply 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 a.c. supply 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 a.c. supply plug. Preferably a heavy current (about 25 A) should be applied for not more than 5 seconds. Test limit : not greater than 0.5 n.

(2) 500 V d.c. insulation test from the a.c. supply circuit to earth. Test limit : not less than 2 MO.

GPIB INTERFACE

5. The GPIB interface is an optional accessory and can easily be fitted by the user as follows:

(1) Remove and discard the rectangular cover plate from the left-hand side of the rear panel.

(2) Withdraw the interconnecting lead from inside the instrument and connect this to the GPIB assembly.

(3) Using the four retaining screws provided, secure the GPIB assembly to the rear panel where four pre-positioned captive nuts are fitted. The interface is now ready for GPIB operation.

Section II. INSTALLATION

RACK MOUNTING

6. The instrument may be mounted in a standard 19 inch rack using the kit 46883-506M (not procured by Army). Fitting instructions are as follows:

(1) Remove both top and bottom outer covers, detach and discard front and rear feet on bottom cover.

(2) Detach and discard side trim infills, countersunk screws and screw cups.

(3) Remove the front panel assembly and lay face down protecting the l.c.d's.

(4) If it is required to bring the r.f. input in via the rear panel, carry out steps (5) to (8) otherwise go to step (9).

(5) Remove the r.f. input coaxial socket from the front panel and transfer it to the blanked-off position on the rear panel (see Figs. 3-2 and 3-3, pages 3-3 and 3-5 for precise locations). It is not necessary to remove either of the two coaxial terminals from the r.f. lead in this process. Note that the lead is doubled back on itself for the full depth of the instrument before returning to the miniature bulkhead connector on the r.f. box immediately behind the front panel.

(6) Unscrew the miniature connector and remove the type N r.f. input socket from the front panel by undoing the securing nut. Release the cable from its securing cleats and withdraw it completely from the instrument.

(7) Remove the blanking off grommet from the hole in the rear panel and put it in place of the connector in the front panel. Remove the type N securing nut and washer from the lead by passing them over the miniature connector. Feed the lead back into the instrument by passing the miniature connector through the hole in the rear panel. Replace the washer and nut on the lead by passing them over the miniature connector. Feed the lead fully through the rear panel and assemble the type N connector to the panel.

(8) The lead should be routed down through the recess in the edge of the bulkhead below the new input position. It can then be led diagonally across the base of the power supply, secured in place with a piece of adhesive tape, and returned to the original run of cleats along the bottom of the left-hand side panel and reconnected to the input bulkhead connector on the r.f. box.

(9) Fit the rack brackets in the recesses of the side trims or of the panel handles if these are to be retained, using the 16 mm M4 pan head screws and washers and discarding the plastic trim infills. Finally, refit top and bottom covers.

FRONT PANEL HANDLES

7. Front handles are supplied only as optional accessories, fitting instructions are as Follows:

(1) Remove the side trim infills and side trims. Discard the side trims but retain the screws and washers for re-use.

(2) Fit the panel handles using the screws and washers previously used to secure the side trims. Ensure that all 4 screws are engaged before any are tightened.

(3) Refit the side trim infills using the existing screws and washers.

EXTERNAL FILTER

8. The connections are shown in Fig. 2-2. The source impedance is low a few ohms and the input impedance is 100 kΩ.

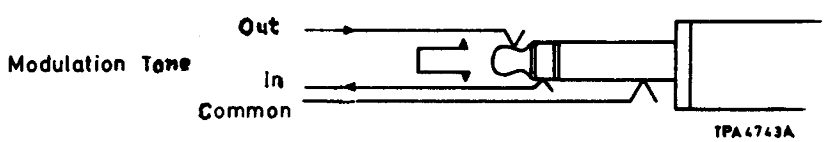


Fig. 2-2. Connection to external filter jack.

CHAPTER 3
OPERATING INSTRUCTIONS

1. The 2305 is operated locally by functionally grouped keyswitches on the front panel. With the exception of the purely numerical keys on the data keypad which are used for the entry of numerical data, keyswitches have associated lights which by their 'on' state signal that the function controlled by a particular key is active. Dual function keys have dual lights which change over the on state as the controlled functions toggle with successive finger pressures.

2. The operational state of the instrument is indicated by the 'key active' lights together with any display annunciators which may be activated and by the display itself which may be of measured data or, possibly, one of a number of error codes indicating an irregularity of some sort. The simplest of these is the row of 8 dashes in the frequency window shown in Fig 3-1 which indicates that the auto-tuning process has not yet produced an acceptable i.f. signal and this is the normal condition for an instrument which has been switched on without a signal connected. It is allocated the error code number 50 but this is the only error code not displayed in numerical form. The standard form of error display utilizes the two central digits in the frequency display. The two display windows are shown in full detail in Fig. 3-4 and Fig. 3-5.

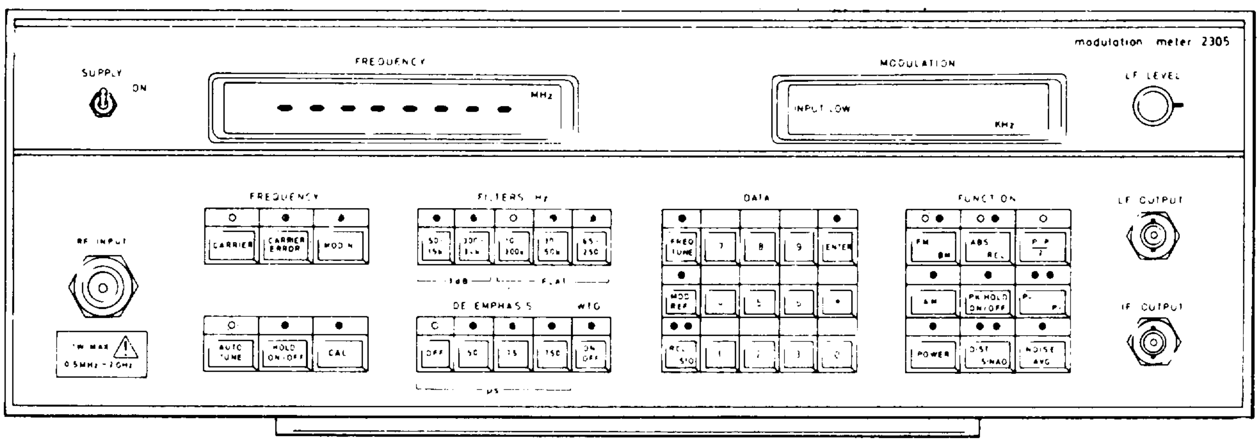


Fig.3-1. 2305 controls shown in standard power up status

> The measurement performance of the 2305 can be changed by the user to meet special operational needs by keyboard second functions which have their status stored in nonvolatile memory. If you are not certain of the state in which the instrument has been left by previous users, you should obtain a second function status display according to the procedure described in para. 36, page 3-14 before attempting any measurements.

<u>Keyswitch functions</u>

3. Keyswitch operation is aided by the following considerations.

(1) Keys which control major functions are colored orange or green.

(2) Other function keys having a more subordinate role are coloured grey.

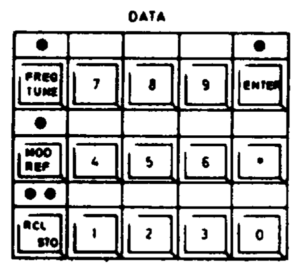
(3) Data entry keys forming the keypad are black with the exception of the ENTER key which is, uniquely, blue for ease of identification.

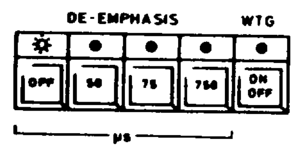
(4) Dual function keys will toggle from one function to the other on successive operations but will only cancel when a key controlling an associated alternative function is operated.

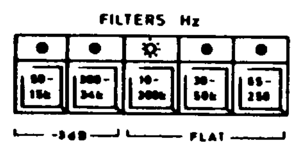
(5) Those single function keys which are marked ON/OFF will toggle between the two states on successive finger pressures but all others remain active once pressed until a key controlling an alternative function is operated.

(6) Keypad data entry is initiated by the operation of one of the three left-hand director keys. When actuated, FREQ TUNE will cancel the AUTO TUNE function and the MOD REF. key will pre-empt the REL (relative) function on the ABS REL key.

(7) An OFF key is provided with the DE-EMPHASIS selectors which is equivalent to zero de-emphasis. A continuous indication of the main bandwidth state is given by the key active light in the FILTERS group of keys. The maximum bandwidth of 10 Hz to 300 kHz is selected as part of the power-up status following switch on. Selection of any other filter requires separate independent choice and action and is unrelated to all other functions apart from that of phase modulation, Φm., which requires special filtering. When Φ .m. is selected DE-EMPHASIS and FILTERS selections are cancelled, the key active light reverts to the OFF key in the DE-EMPHASIS group and is extinguished on the FILTERS key.







(8) In the event of a mistake occurring during keypad data entry, the keypad register can be cleared by a second operation of the appropriate director key and the sequence can then begin again.

(9) If an illegal command is made, as would happen if a frequency outside the instrument's range was entered, an error code will show in the FREQUENCY display. Error codes also appear if an incoming signal has properties that lie beyond the scope of the instrument or of a range that

has been held in operation. Error code displays remain, blocking normal operation, until the source of the error is corrected. The occasional brief display of error codes during normal use while transient conditions settle down should be ignored.

4. The only controls which are intended for local manual operation and which cannot be operated remotely via the GPIB are

SUPPLY ON } front
LF LEVEL } panel

STD FREQ ADJ ; rear panel access.

CONTROLS AND CONNECTORS

Coaxial connectors

5. There are two BNC female connectors on both the front and rear panels (items 20 and 21 and items 3 and 4 respectively). The only other coaxial connector is a 50 A type N female, RF INPUT, which is normally mounted on the front panel (item 2) but which can be transferred to the rear panel and placed in the blanked-off position (item 2) when it is required to rack-mount the instrument

Rear panel connections

6. The 50 400 Hz 70 VA a.c. supply receptacle plug (item 6) accepts the a.c. supply input cable supplied with the instrument (code no. 43129-071D). The AUDIO IN-OUT socket (item 5) accepts a standard stereo headphone jack plug, supplied. When the GPIB optional accessory is fitted the receptacle accepts the standard IEEE 488 connector.

Front panel controls

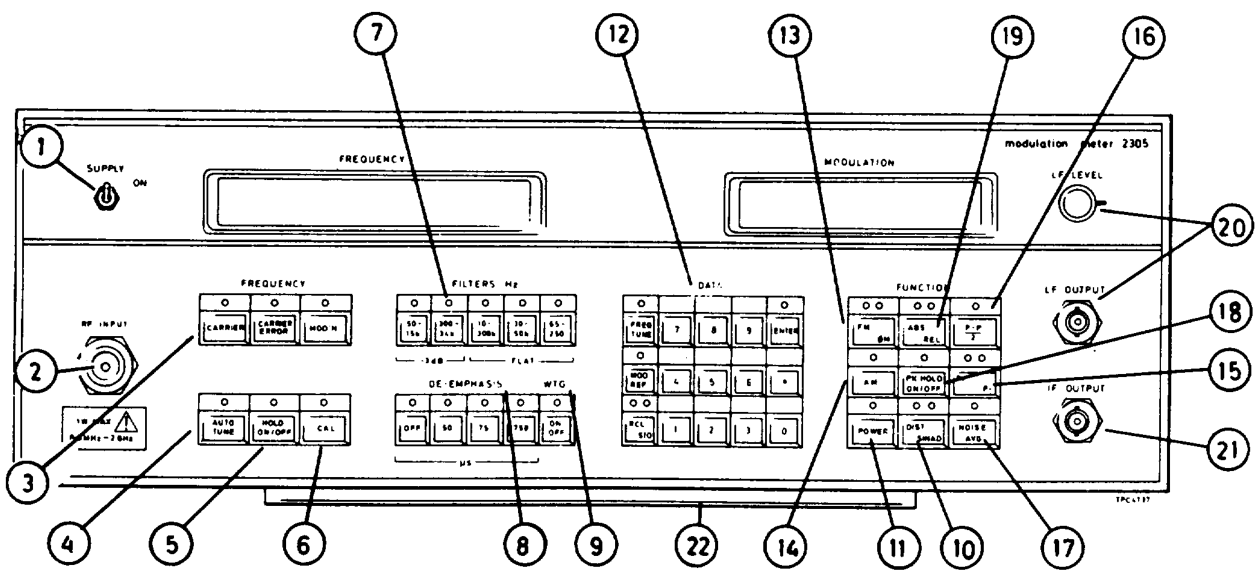


Fig. 3-2. Front panel controls and connectors 3-3

7. (1) SUPPLY switch : sole means of connecting the a.c. supply to the instrument circuits.

(2) RF INPUT : point of entry for the measurement signal.

(3) FREQUENCY keys : allow the FREQUENCY display to be used for three separate frequency measurements. CARRIER : frequency of input signal carrier. CARRIER ERROR : frequency difference between instantaneous measurement of signal carrier and a stored value. MODN : frequency of modulation tone (modulation rate).

(4) AUTO-TUNE : causes instrument to sweep through its tuning range and to lock-on to the largest signal detected.

(5) HOLD ON/OFF : enables all measurement functions to be frozen in their current states.

(6) CAL : causes calibration of the modulation measuring circuits to be realigned to the internal a.m. and f.m. standards and sets the signal detection threshold for optimum sensitivity.

(7) FILTERS : give choice of pass band characteristic.

(8) DE-EMPHASIS : gives choice of 4 f.m. de-emphasis time constants (including zero).

(9) WTG ON/OFF : when DIST SINAD option is fitted, enables whichever of the CCIR, CCITT weighting circuits has been installed by second function action to be introduced by a single stroke of this key.

(10) DIST SINAD : introduces the optional accessory and presents the distortion of the modulation tone in either form. This key is inoperative if the option is not installed.

(11) POWER : causes power content of input signal to be displayed in units selected by second function. Measurements may be referred to the input side of externally mounted power attenuators.

(12) DATA keypad : provides for the entry of numerical data for tuning or reference purposes. ENTER key terminates entry in normal use but precedes two digit number entries for second function operations. When the ENTER key is operated first, its key active light remains ON to indicate that entries are for second functions. Up to 10 sets of control settings may be stored and recalled via RCL/STO in normal operation. In second function mode this key is used to terminate data entry and return to normal mode.

(13) FM Φ M : gives choice of angle modulation type for main function, f.m. in kHz, Φ .m. in radians.

(14) AM : selects a.m. as main function (%).

(15) P+, P- : gives choice of peak or trough measurement.

(16) $\frac{P\text{-}P}{2}$: causes average of P+ and P- to be displayed.

(17) NOISE AVG : changes from peak responding to average responding modulation measurement. Calibration is the peak value of equivalent sine wave.

(18) PK HOLD, ON/OFF : stores, and holds in display, the largest value appearing during any period of measurement while the key is active.

(19) ABS REL : enables modulation functions to be carried out as an absolute or relative measurement.

(20) LF OUTPUT : filtered, weighted, demodulated signal fully controllable by LF LEVEL control. The index mark corresponds to the overload point and the onset of distortion for signals giving indications approaching the nominal range full scales of 1.5, 5.0, 15 etc.

(21) IF OUTPUT : a buffered output at low impedance.

(22) PULL-OUT CARD : gives summary of operating instructions and error codes which may occur in normal operation.

Rear panel features

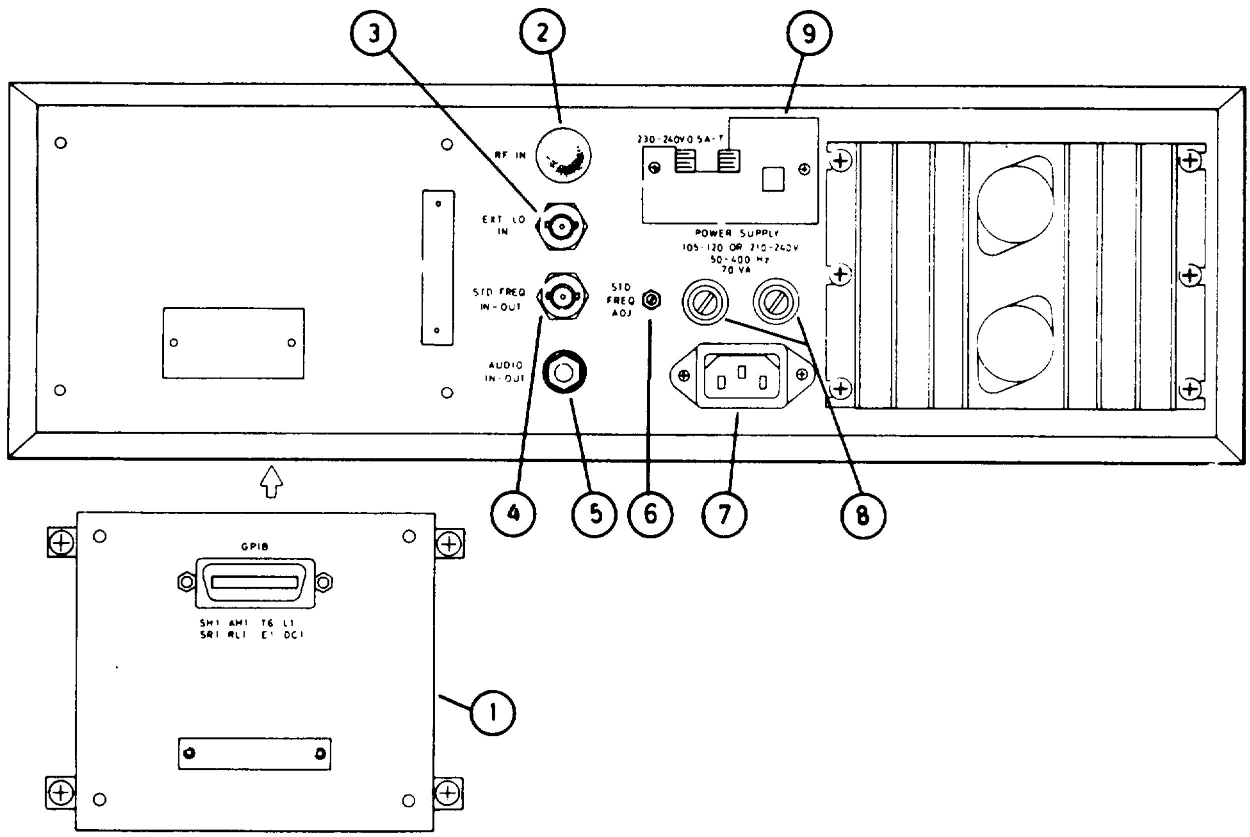
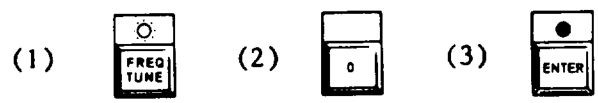


Fig.3-3. Rear panel controls and connectors

8. (1) REMOTE CONTROL GPIB INTERFACE, optional accessory.

(2) Optional position for r.f. input connection.

(3) EXT. LO IN : connection point for external local oscillator. EXT. LO is switched in by the data pad entry sequence :



(4) STD. FREQ IN-OUT : buffered output point for internal 10 MHz standard when this is in use. Entry point for external standard when switched in by second function keying.

(5) AUDIO IN-OUT : enables an external filter to be inserted into the audio signal path without disturbance to the internal filters.

(6) STD FREQ ADJ : screwdriver slot adjuster enables standard frequency to be varied over a range of about ±5 p.p.m. to align with an external standard.

(7) Standard receptacle for mains connector.

(8) Mains supply fuses.

(9) Mains supply voltage adjusting switches and locking plate see page 2-1, para. 4.

<u>LCD annunciators</u>

9. Annunciators associated with the numerical l.c.d's are activated as necessary to give supporting information with respect to the units of measurement and the functional state of the instrument as shown :

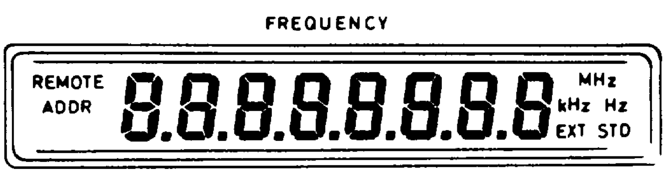


Fig. 3-4. Frequency display

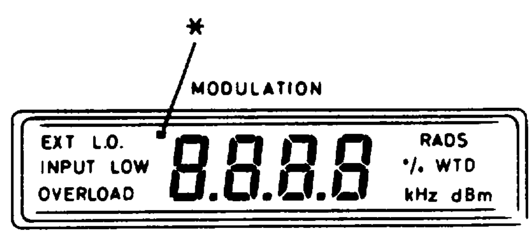


Fig.3-5. Modulation and power display

* This small elevated 'point' preceding the numbers is activated when SRQ is requested under GPIB operation.

(1) Annunciators, FREQUENCY display.

REMOTE : Instrument has been switched to remote operation following receipt of a command from the bus controller.

ADDR : Instrument has been correctly addressed and is ready for data.

EXT. STD. : Instrument has been switched to accept an external standard frequency signal.

(2) Annunciators, MODULATION display.

EXT. LO. : Instrument has been switched to accept an external local oscillator. The frequency display now shows the i.f.

INPUT LOW } : Signal input outside the instrument's
OVERLOAD } : dynamic range.

WTD : CCIR or CCITT weighting circuit has been introduced. If the SINAD option is not installed, the WEIGHTING key and the annunciator are both inoperative.

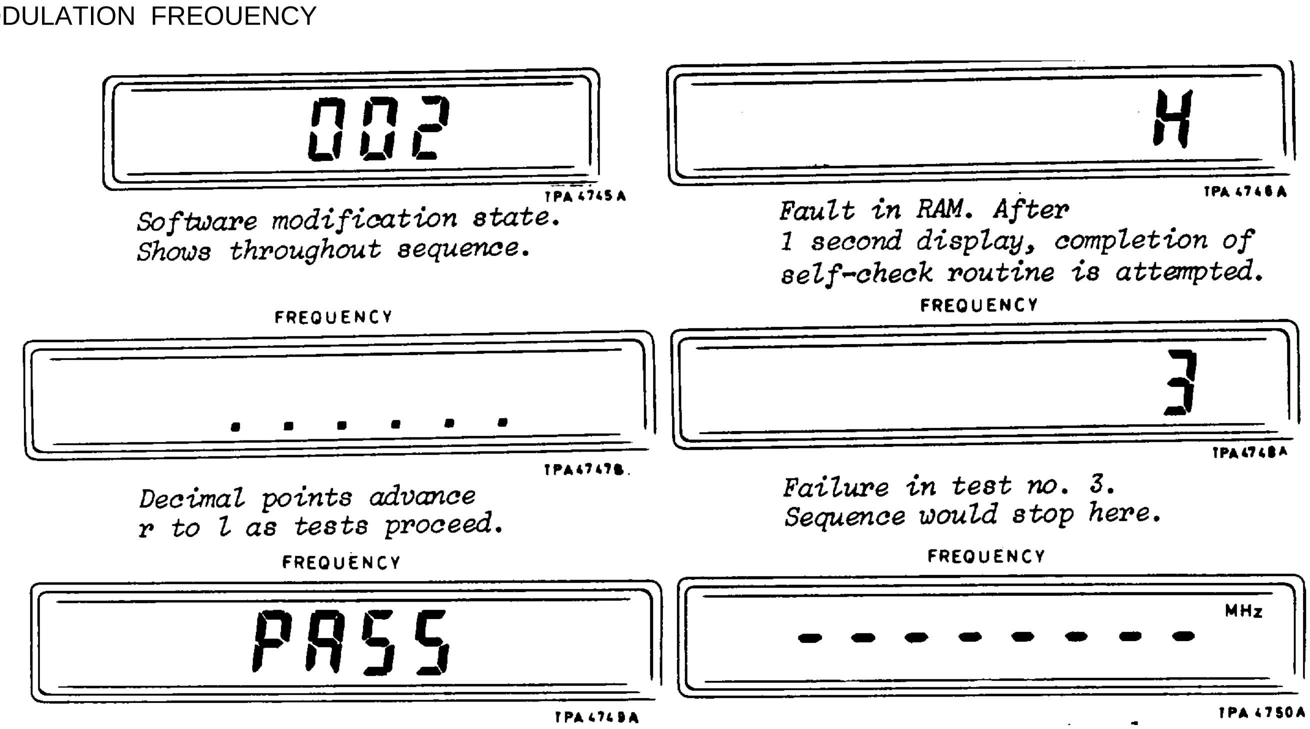
dBm, %, RADS, kHz : Units of measurement.

PREPARATION FOR USE

10. After the 2305 has been properly installed with connection made to a suitable mains supply, switch on. The instrument will now enter a series of self checks and its progress will be monitored on the FREQUENCY display in the way shown in Fig. 3-6. A fault appearing during memory checks will result in a brief display of a letter H (RAM fault) or P (PROM fault). Such a fault would probably also appear as an operating malfunction and as such would impede progress in the six sets of measurements which now begin on the analogue measuring circuits and are monitored by the gradual advance of the decimal points across the display. When all six sets are complete, nine derived test results are calculated in sequence and each result is compared with a result stored from the same test when made at time of manufacture. A test is failed if the current result differs by more than 5% from the stored reference and will cause the sequence to stop at that point with a display of the test number concerned. If all tests are satisfactory the 2305 will display PASS and then move into its power-up status. This may be the standard power-up status of the instrument as supplied, or it may be any set of operating conditions introduced by both first and second keyboard functions and entered into STORE 0. 'Standard' power-up status confers the following control settings which are considered to be those most commonly required :

FREQUENCY display	-	CARRIER
AUTO-TUNE	-	ON
FILTERS	-	10 Hz to 300 kHz (maximum bandwidth)
DE-EMPHASIS	-	OFF
FUNCTION	-	ABS., FM, $\frac{\text{P-P}}{2}$

Whether the 2305 powers-up to the standard status or to a special set of operating conditions is determined by the state of second function 24. This may be found from the second function status display described in para. 36 (01) on page 3-14. For standard power-up status (2305 as supplied) second function 24 will have status 0 and for power-up to store 0 it will have status 1.



Self check success.
Display held for 1 second.

Power-up status entered.
Signal search proceeding.

Fig. 3-6. Normal and possible fault condition displays occurring during power-up sequence

11. The row of 8 dashes that appears across the FREQUENCY display at this stage is an indication that the 2305 is actively searching in the AUTO-TUNE mode but has not yet found a signal. It is also listed under ERROR CODE 50.

12. The PASS indication shows that there has been no abnormal deterioration in the measurement circuits which should not and cannot be calibrated out by operation of the CAL key. Until the next operation of the CAL key, measurements continue on the basis of the recalibration data acquired at the last operation regardless of the number of switch-on sequencies that may have occurred between. If a test is failed during self-check, normal operating conditions may be obtained by entering AUTO-TUNE unless the circuit failure concerned has been catastrophic. The level of uncertainty in any measurements made with the 2305 in this state will, however, be undefined.

13. The 3-digit number 001, 002 etc. which also appears in the MODULATION window during the self-check routine is an indication of the software modification state built into the instrument.

OPERATING PROCEDURES

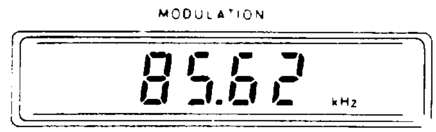
14. When, following switch-on, the 2305 enters the standard power-up status and a signal within its dynamic range is connected to the RF INPUT, the 2305 will tune to the signal and display the carrier frequency and any frequency modulation present. The INPUT LOW annunciator will go out. The 2305 can follow drifts in signal carrier frequency up to rates of tens of kHz per second, the limit being dependent on the carrier frequency. If the maximum rate is exceeded as might happen, for example, if a signal generator frequency range was changed, it is possible for the 2305 to be prevented from entering a complete new auto-tuning cycle by an apparent signal acquisition which is, in fact, spurious. The condition is accompanied, typically, by a frequency display that is noisy or grossly in error and by over-ranging in f.m. measurements. To be safe re-enter AUTO-TUNE after changing frequency.

Modulation measurement

15. (1) Select AM, FM or OM as required. The MODULATION display will autorange as required for maximum resolution. If it is necessary to override the auto-ranging action in order to retain a particular range, it may be done via Second function 36, see page 3-18.

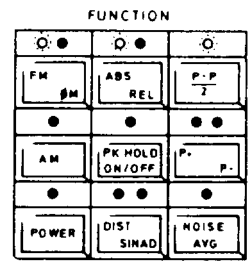
(2) Select ABS for absolute measurement in:
% AM,
or kHz deviation FM.

or radians Φ M.



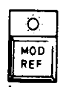
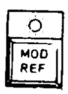
(3) Select $\frac{\text{P-P}}{2}$ and note the reading. If any modulation asymmetry is suspected it may be measured by operating P+ and P- alternately.

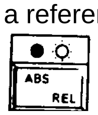
(4) Select an alternative FILTER if required.



Relative modulation

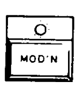
16. (1) To relate measurements to a pre-determined figure e.g. 25 kHz deviation or 80% a.m. :

Enter MOD REF on the keypad  This action will also activate the REL function if not already carried out. Then follow with the numbers of the reference quantity and  In the event of a mistake when making a keypad entry, press  and start again. When AM is selected, the numbers are automatically interpreted as % AM. Similarly, for FM and Φ M, the unit quantities are known from the FUNCTION that has been selected. The modulation measured will now be displayed in dB relative to the quantity entered. In relative modulation, the signal measured may be shaped by de-emphasis or by the weighting filters if required.

(2) To measure changes in modulation relative to a reference measurement. The 2305 will be in the ABS mode. When the reference measurement is made, press  This measurement will then automatically transfer J to store and all subsequent modulation will be expressed as dB referred to this quantity.

Note.
A combination of deep a.m. and high modulation frequency may cause difficulty in auto-tuning. Should this occur, reduce the modulation briefly or increase the signal until tuning is achieved.

Modulation frequency measurement

17. Press the  FREQUENCY key. The FREQUENCY display will auto-range to give the appropriate resolution.

Display ranging

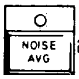
18. The FREQUENCY display makes use of all 8 digits when in CARRIER mode, for frequencies down to 100 MHz. Resolution is, accordingly, 100 Hz for carrier frequencies of I GHz and above and 10 Hz below. Below 100 MHz

resolution stays fixed at 10 Hz with suppression of leading zeros. In CARRIER ERROR mode, resolution is 10 Hz at all frequencies. In MODN mode, resolution is 0.1 Hz below 5 kHz and 10 Hz above. The MODULATION display makes use of all four digits independently of the position of the decimal marker, which moves in response to changes in modulation as required by the fixed units kHz, % or rads, until the displayed quantity 5000 is exceeded. Before the quantity 6000 is reached the least significant digit becomes a fixed zero leaving 3 useful digits up to the full-scale display of 9990.

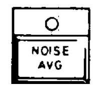
Noise averaging

19. With the 2305 measuring a modulated signal, turn off the modulation. The least significant digit of the MODULATION display will now be fluctuating in a random manner as the instrument measures the spurious, residual modulation.

This is likely to be a larger quantity with an f.m. source than with a.m.

Press 

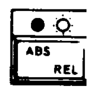
and notice the reduction in fluctuation. Use this key when making signal to noise, relative, measurements. Note that the NOISE AVG calibration is of the peak value of the equivalent sine wave so that both noise and modulation measurements are reduced to quantities of the same kind.

20. This fact may be verified by using a test signal with good quality sinusoidal modulation. When 

and 

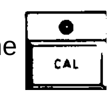
are operated alternately there will be no significant difference in indicated modulation although the detectors will be average and peak responding respectively.

Correction for noise

21. A noise measurement can be converted to a relative quantity by pressing 

when the 2305 is measuring the total of signal plus noise. If the modulation is now turned off leaving only the noise component, the 2305 will measure this and display it as dB down. If the quantity is too large to be neglected it may be applied as a correction by subtracting the noise fraction from the modulation measurement. As both the measured quantities are peak values, they combine arithmetically.

Use of CAL (calibration) key

21a. The 2305 may be put into its recalibration routine at any time by operation of the 

key. The instrument will first carry out the self-check routine and only after satisfactory completion of the nine circuit tests will changes be entered into the 'last user calibration' data if any are needed to ensure correct measurement of the internal standards. The 2305 then reverts to its original status. The effect of CAL key operation can be restricted solely to the self-check function if it is required to remove the recalibration capability from operator control. This requires access to second function 40 and the procedure is described on Page 5.6.1. The 2305 is supplied with the recalibration action asserted and its use is necessary in order to obtain the full specified performance. CAL key operation may need to be more frequent when environmental changes occur or when it is necessary to use the 2305 immediately following switch-on. Practical experience in any one set of circumstances having regard to the time available-for recalibration and the size of the changes introduced, will probably dictate the frequency of use.

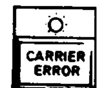
Input overload protection : trip and reset

22. Normal ranging within the 2305 will enable the measuring circuits to accommodate inputs up to 1 W (+30 dBm). Above this level, the OVERLOAD annunciator will light up and at 2 W (+33 dBm) the input protection will introduce an open circuit at the input terminal. The instrument will enter an error mode (07) and will cause the active light on the POWER function key to flash regularly. To reset the instrument, first remove the overload and press the POWER key once.

Manual frequency tuning

23. The non-automatic tuning mode may be required if several signals of comparable strength are present. Select (1) 

on the keypad followed by the numerical frequency data in MHz and (2) 

The AUTO-TUNE key will have cancelled. The FREQUENCY display will be of the measured signal frequency as before, provided that the numerical entry is close enough to the signal frequency for the i.f. to be within the pass band. Press 

to display ERROR directly any difference between the measured and the entered frequencies. So long as the signal components remain within the pass band of the i.f. amplifier the CARRIER ERROR mode will monitor drift in the carrier frequency and the modulation measurement circuits will function.

Use of External local oscillator

24. An external low-noise local oscillator within the range 28 to 56 MHz may be substituted for the internal oscillator. Connect the oscillator to the appropriate BNC socket on the rear panel. The input impedance is 50 Φ and a terminal voltage of between 100 mV and 1V is required.

The MODULATION display will now show EXT LO, the FREQUENCY display will be of the i.f., the Auto-tune process is inhibited and the input signal and external local oscillator are both connected to the sampling gate mixer. The external local oscillator frequency should produce an i.f. of 1.5 MHz ±150 kHz for input signals within the frequency range of 28 MHz to 2 GHz. In order to retain the normal polarity sense in demodulation (positive frequency modulation excursions are measured in the P+ mode) the local oscillator frequency should be chosen from within the permissible range as that which satisfies the relationship.

$$\text{Local oscillator frequency} = \frac{\text{signal frequency} + 1.5\text{ MHz}}{N}$$

with the smallest possible integral number for N. As there are 36 possible integers for signal frequencies of 2 GHz, falling to 10 for inputs of 560 MHz, it is only signal frequencies in the low hundreds of MHz and below that will require local oscillator frequencies to be substantially more than 10% below the 56 MHz upper limit. It is assumed that, for this particular measurement refinement to be worthwhile, the external local oscillator in question will be based on specially ground quartz crystals and that the possibility of obtaining a valid i.f. display by exciting a spurious response with a variable frequency oscillator does not arise. The displayed i.f. may be allowed to depart from the nominal 1.5 MHz by as much as ±150 kHz without incurring the risk of an increase in measurement uncertainty.

Distortion measurement and psophometric weighting (requires incorporation of options kit 46883-527G)

25. To include a psophometric weighting network in the measurement circuit, press WTG 

Either the CCITT or CCIR network will now be introduced depending on which has been pre-selected for first function entry by operation of first level protected second function 25. Guidance in this operation is given in a later section devoted to second functions, starting at para. 30. If the options kit has not been installed, error code 06 will be displayed. Weighting is only introduced into relative and distortion measurements. The action of the weighting network or any other filter selected is, however, always present in the LF output signal.

26. To measure distortion, first ensure that the test signal has single tone modulation within ±5% of one of the three standard frequencies 300 Hz, 500 Hz or 1 kHz. As soon as the signal is tuned and the desired level of modulation is displayed, operate 

or 

depending on which form of measurement is wanted. If the modulation frequency is within acceptable limits, fundamental rejection will take place and the distortion factor or SINAD will be calculated and displayed, distortion factor in percent and SINAD in dB.

27. The measurements are based on the usual relationships :

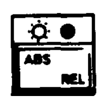
$$\text{Distortion factor} = \frac{\text{Distortion products + noise}}{\text{Signal + distortion + noise}} \times 100\ \%$$

where noise is understood to include all components apart from signal and harmonic distortion, and

$$\text{SINAD} = 20 \log \frac{1}{\text{Distortion factor}}\ \text{dB}$$

If the error code 59 is displayed, the circuit has failed to produce a frequency notch and the modulation tone should be adjusted to bring its frequency closer to the nominal value.

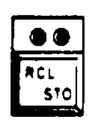
28. The 2305 average detector is automatically selected for distortion measurement and, in most practical measurement situations, introduces insignificant error in approximating to the r.m.s. response that is theoretically required. The minimum fundamental rejection of 65 dB is compatible with a 0.1% total harmonic distortion measurement and the overall accuracy specification of ±1 dB.

29. If the modulation frequency is changed to another standard tone when in DIST/SINAD function, it will be necessary to leave and re-enter the function by operating another function key, say 

followed by 

again in order to be certain of obtaining a notch at the new frequency.

Store and recall of control settings

30. To store the 2305's current set of operating conditions, operate 

 (one of store nos.0-9). These conditions may now be reproduced at any 'Required future time by recalling the same store number 

 (store no)

when the 2305 will be returned to the same state of operation that it had when the particular store was entered. The data stored therefore includes all keyboard functions, all numerical reference data entered and any 'storable' second functions which may have been introduced. Each time a store is entered existing data is overwritten by the new entry.

KEYBOARD SECOND FUNCTIONS

31. Second functions are identified by two digit numbers. Numbers from 01 to 52 are allotted although several are spare. The group allocation is as follows :

01 to 15	Unprotected access (group P0)
16 to 39	First level protected (group P1)
40 to 45	Second level protected (group P2)
46 to 52	Third level protected (group P3)

32. To introduce a second function, use the two digit number preceded by the ENTER key. Prior use of the ENTER key in this way causes its active light to come on to indicate the existence of the second function mode. To leave a second function, press any normal function key or use ENTER again.

33. After entry, the second function appears as a 2-digit number in the modulation display. The frequency display may show any of four possible responses :

(1) No response, i.e. the second function does not exist or is locked.

(2) Display goes blank and is awaiting the entry of data.

(3) It shows the current value of some variable, this may be one or more digits with or without decimal points or other symbols such as , or 'A'.

(4) It displays a changing 4-digit number which represents an internal voltage.

<u>Data entry</u>

34. Once accessed most second functions require a data entry which may be simply a 0 or a I or more as in function 02 GPIB address, which is a 2-digit decimal number. On access, the current state of the data is shown on the right-hand side of the frequency display. When new data is entered and is accepted as being in the correct format, it will appear in the left-hand side.

Operate 

to store the new data which will then transfer to the righthand side of the frequency display, displacing any earlier entries. If the 2305 is in local control, this display will last for 1 second after which the active light on the ENTER key will go out, and the 2305 will return to normal operation. When in REMOTE mode there is no pause for display.

<u>Data volatility</u>

35. In groups P0 and P1, some second functions have their related data stored in volatile memory so that each switch-on finds these functions in their nonasserted state. The important exceptions are functions covering such items as GPIB address, source of frequency standard, SRQ mask etc. which are stored in non-volatile memory. In a number of cases, data which would normally be volatile may, optionally, be entered into one of the instrument's stores (0-9) together with all the related control settings. Functions belonging to these

groups are identified as 'non-volatile' and 'storable' respectively in the list which follows.

SECOND FUNCTIONS 01 TO 15 (GROUP PO, UNPROTECTED)

36. These functions, which may be entered directly without unlocking are as follows.

01 Second function status

In this function, the status of those second functions that are important to the basic operation of the instrument is shown using both the frequency and modulation windows to display the digits concerned, thus :

G G.S C.D.P **W.I.B.M u**

where the digits represent the following.

				Second function	*Protection*
GG	(00 to 30)	= GPIB address	-	02	None
S	(0/1)	= SRQ enable	-	19	First level
C	(0/1)*	= Calibrate mode	-	40	Second level
D	(0/1)	= Power-up mode	-	24	First level
P	(0 to 3)	= Protection state	-	-	
W	(0/1)	= Weighting filter	-	25	First level
I	(0/1)	= ILS filter	-	28	First level
B	(0/1)	= 30 kHz B/W	-	27	First level
M	(0 to 4)	= Power measurement offset	-	30	First level
Annunciator u					
W		Power units watts	-	29	First level
dBm		Power units dBm	-	29	First level

The second function status display for the 2305 'as supplied' will appear as:

Fig. 3-7. Function status display.

02 GPIB address (non-volatile)

Any number from 00 to 30 will be accepted. If the GPIB option is not fitted, a double dash will appear instead of the 02 code when this function is entered.

03 GPIB option : auxiliary output (possible future development)

Enables a 8 bit number to be stored in the 2305 for transmission via an auxiliary output on the GPIB accessory. Enter 8 x 0/1. The auxiliary output is intended for the control of simple apparatus not having full GPIB interface capability.

* *The function of the CAL key may be re-allocated via Second function 40 to perform either the full recalibration process or the self-check routine as introduced automatically during power-up. Instruments are supplied with Second function 40 asserted and the CAL key assigned to the recalibrate mode.*

Unprotected second functions contd.

SE04 Select external frequency standard (non-volatile)

Enter 0 for internal, 1 for external. When re-entering this function in order to return to internal, it is necessary to operate the keying sequence slowly if the external source has already been removed.

SF05 Display mixer level

Displays a 4-digit number in the right-hand side of the frequency window being the output from the volts/frequency converter with the mixer level detector connected. The number is not readily calibratable but is useful in fault diagnosis.

SF06 Display 1F level

As function 05, but with the IF level detector substituted.

SF07 Display demodulated audio (pre-filter)

As function 05, but with substitution of the detector monitoring the output of the 1.f. amplifier (A9) prior to filtering on the A10 board.

SF08 (followed by a selection digit) Voltmeter input

Selection digit	*Voltmeter input*
0	Peak -ve
1	Peak +ve
2	Averaging detector
3	RF power detector
4	IF level detector
5	Zero reference
6	Mixer level detector
7	Demodulated audio

As function 05, but with the other voltmeter inputs not so far included. Note that when the instrument bases a measurement on any of the volt/frequency conversions, it first supplies a zero voltage input to the converter and notes the magnitude of the offset. This offset is displayed on input 5. The quantities available for display on function 08 are not corrected for this offset but those on functions 05, 06 and 07 are.

SF09 Synthesizer/counter self check

This function exercises the synthesizer control logic and checks the adjustment of the oscillator coils. Any failure in this test would result in the 2305 entering error code 13. The number 13 would then be transmitted via the bus if the 2305 was asked to 'Talk Error' but the only display in the FREQUENCY window would be of a two-digit number representing the particular test in which failure had occurred.

SF10 FM calibrator wide deviation

This signal will be present at the i.f. output socket on a 1.59375 MHz carrier.

SF11 FM calibrator narrow deviation

This signal will be present at the i.f. output socket on a 1.50 MHz carrier.

<u>12 AM calibrator</u>

The a.m. calibration signal will appear at the i.f. output socket on a 1.50 MHz carrier. Each time this function is entered, the calibrator signal appears for 10 seconds after which the 2305 reverts to normal operation.

Second functions 13 to 15 inclusive are spare.

SECOND FUNCTIONS 16 TO 39 (GROUP P1, 1ST LEVEL PROTECTED)

37. Second functions 16 to 18 inclusive are spare.

<u>To unlock the first level of protection</u>

Press and release (1) [ENTER] (2) [0] Press [0] again then [CARRIER] ng both keys down until a 1 shows in the frequency display. This takes about 5 seconds. To leave the unlocking mode press [ENTER] again or almost any other function key. The protected second function may now be entered in the same way as an unprotected function. Protection is automatically restored by a supply switch operation or, alternatively, by pressing (1) [ENTER] (2) [0] (3) [0] in) and (4) [ENTER] again or another function key.

<u>19 SRQ enable</u>

To enable the SRQ, enter l; to disable the SRQ, enter 0. Disabling will remove any pending SRQ.

<u>20,21,22,23 SRQ mask 1, 2, 3, 4</u> (non-volatile)

Allows any number of error conditions to be masked off from asserting an SRQ. To generate a mask, enter 0 or 1 as necessary (0 = unmasked, 1 = masked) according to the following scheme.

Error number

Second function 20	:	00*	01	02	03	04	05	06	07
Second function 21	:	08	09	10	11	12	13	14	15
Second function 22	:	48	49	50	51	52	53	54	55
Second function 23	:	56	57	58	59	60	61	62	63

The 0/1 digits enter the FREQUENCY display from the right and the mask is generated by placing a 1 in the same position in a row as the error number to be masked. Unmasked errors attract a O.

<u>24 Power-up mode</u> (non-volatile)

Allows the 2305 to power-up to a particular batch of control settings entered in store 0 instead of the standard power-up status. To default to the standard status enter 0; to recall 0, enter 1.

<u>25 Select weighting filter</u> (non-volatile)

To select the filter introduced by the WTG ON/OFF key, enter 0 for CCITT, I for CCIR.

---

* *The number 00 is not an error code but is allocated to the 'Ready SRQ'. If 00 is masked, Ready SRQ will not be transmitted*

First level protected second functions contd.

SF25 Select weighting filter (non-volatile)

To select the filter introduced by the WTG ON/OFF key, enter 0 for CCITT, 1 for CCIR.

SF26 Measure with de-emphasis

To introduce the de-emphasis time constants into the measurement circuit, enter 0 for off, 1 for on.

Note

This special requirement should be introduced with care as the de-emphasis will affect all modulation measurements and there is nothing on the front panel to indicate that the introduction has been made. As the function is volatile it will clear to the normal mode as soon as the 2305 is switched off.

SF27 Force 30 kHz bandwidth (storable)

This function causes a 30 kHz low-pass filter that is normally automatically switched out of use when input signal frequencies are above 5.5 MHz, to remain effective for all signals. This enables some channel separation to be carried out within the 2305 as, for example, when high frequency digital information might wind back the ranging in the l.f. amplifier and cause a low frequency voice channel to be lost. The 'forced' bandwidth precedes the l.f. amplifier whereas the panel controlled filters follow it. Enter 0 for 30 kHz off, 1 for 30 kHz in.

SF28 ILS filter (storable)

This function selects the 15 kHz low-pass filter separately from and without any accompanying high-pass section. This provides sufficient high frequency bandwidth for the a.m. ILS signal without admitting an excessive amount of noise. Its special merit is the absence of dispersive effects at the low modulation frequencies employed which would be caused by inclusion of a highpass section. Enter I for on, 0 for off. For AM, select AM and the 10-300 k filter, for FM or to change from AM to FM, select FM and the 50-15 k filter. When the 0-15 k ILS filter has successfully been selected, the l.e.d's in the 50-15 k and 10-300 k filter keys will light simultaneously. Note that when the state of second function 28 is returned to 0, the filter will remain active, with both l.e.d's on, until an alternative filter is selected.

SF29 Power units (non-volatile)

Input power may be displayed either as watts or dBm. Enter 0 for dBm, I for watts.

SF30 Power offset modes (storable)

Enter 0 for no offset, 1 - 4 for offset modes as below :

SF31 Enter value (in dB) of added external attenuator (mode 1). (non-volatile)

SF32 Enter power ref. 1 (mode 2). (non-volatile)

SF33 Enter power ref. 2 (mode 3). (non-volatile)

SF34 Enter power ref. 3 (mode 4). (non-volatile)

Mode 1 allows calibration of the extended power range to be derived from a calibration of the external power attenuator.

Modes 2-4 allow calibration of the extended power range to be derived at three standard power levels which can be supplied to the 2305 input with the known values entered for each mode.

Data entered for these modes is all non-volatile. More detailed guidance in the use of power offsets comes in the next section, beginning at para. 42.

<u>35 Set input attenuator setting</u> (storable)

Enter 5 for setting 0 dB, 4 for 10 dB, 3 for 20 dB etc. to 0 for 50 dB. Any number greater than 5 restores automatic operation.

<u>36 Set switchable gain range setting</u> (storable)

Enter 0 to 5 for settings 0 dB, 10 dB etc. to 50 dB. Any number greater than 5 restores automatic operation.

<u>37 Set options board gain setting</u> (storable)

Enter 0, 1 or 2 for settings 0 dB, 10 dB or 20 dB gain. Any number greater than 2 restores automatic operation.

<u>38 Set options board notch selection</u> (storable)

Enter setting 0 to 3 for setting required.	0 - No notch, 1 - 300 Hz notch, 2 - 500 Hz notch, 3 - 1 kHz notch.

Any number greater than 3 restores automatic operation.

<u>39 Restore second functions 35, 36, 37 and 38 to automatic operation</u>

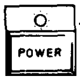
When this function is entered, the four setting functions are simultaneously restored to automatic operation.

When any of these second functions is entered, the setting digit corresponding to the, range selected at that time in the element concerned will be displayed in the FREQUENCY window. The digit will be accompanied by one of the following letters as appropriate:

A - automatic mode
H - held mode
P - set mode

38. Second functions <u>40</u> to <u>49</u> comprise the groups P2 and P3 which relate to the 2305's fundamental calibration and which have higher levels of protection. Details concerning their use are given in Chapter 5.

Power measurement

39. Power entering the RF INPUT terminal of the 2305 that is within the range 10 mW to 1 W (+10 dBm to +30 dBm) may be measured by operating 

The measured quantity will then be displayed in the MODULATION window as a 4 digit number in a single fixed measurement range of 1 W or +30 dBm full scale. Whether the units of measurement are watts or dBm depends on the state of second function 29 which is non-volatile and has to be re-entered if a change of state is required. The discrimination represented by the least significant digit in the display is 1 mW or 0.01 dBm respectively.

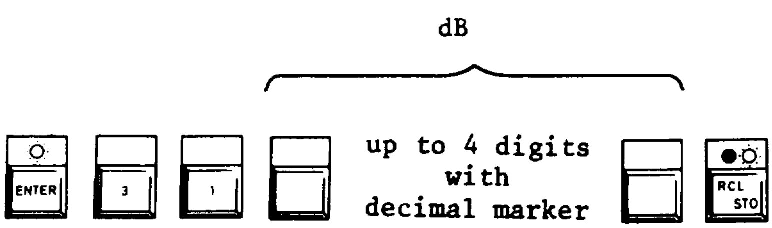
40. If an accidental power overload occurs, the input protection relay will trip open to protect the instrument. The tripped state is indicated in 3 ways. The light on the POWER key will flash, the INPUT OVERLOAD annunciator is active and error code 07 shows in the FREQUENCY window. When the overload has been removed, the relay may be reset by a further operation of the POWER key which will also return the alarm indicators to their normal state.

41. If an external power attenuator is connected to the input of the 2305 in order to increase the, upper limit of signal power that may be accepted from a source,-it is possible to enter calibration data into the instrument so that an r.f. power measurement can be referred to the attenuator input with direct indication given of the power entering that terminal. The calibration is entered as a measured value for the external attenuator (second function 31) or as the value in watts of a standard power input to the attenuator. Up to 3 such power calibrations may be stored, via second functions 32, 33 or 34, so enabling particularly good accuracy to be associated with r.f. level in 3 individual sets of test conditions. The method is entitled 'Power offset mode' and requires the use of second functions within the first level of protection which must be unlocked before entries can be made.

Use of power offset mode

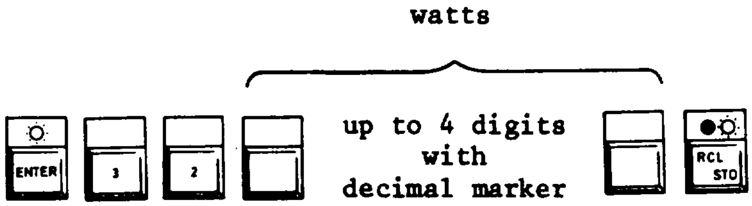
42. To enter power offset data, unlock the first level of protection and proceed as follows :

(1) Entry of external attenuator value (second function 31). Operate keyswitch sequence :



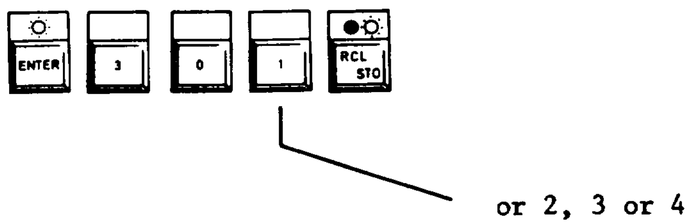
The upper limit for attenuation is 50.00 dB.

(2) Entry of standard power level (second functions 32, 33 and 34) Operate keyswitch sequence



The upper power limit is 999.9 watts.

(3) Register choice of offset mode 1, 2, 3 or 4 with offset mode selector (second function 30). Operate keyswitch sequence :

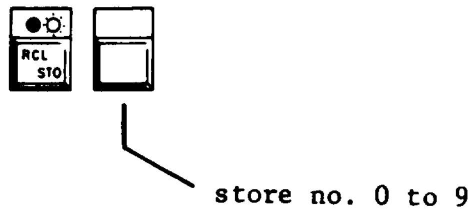


43. The offsets themselves will be in non-volatile memory, but the choice of mode selected for introduction by second function 30 will be volatile. It may be stored, along with other data relating to operating status, in any of the 10 main instrument stores for subsequent recall as a test routine needed for use over an indefinite period. If not stored, the offset will lapse to mode 0 (no offset) when the 2305 is switched off. To retain the offset mode in non-volatile memory :

(1) Verify that the choice of offset mode is correct by entering either of second functions 01 (second function status) or 30 (offset mode). Then leave second function mode.

(2) Set the instrument up to receive and measure the unknown signal with the calibrated external attenuator in position. If the POWER mode is entered the 2305 will now incorporate the selected offset either as dB or as a level correction based on the standard level used in second function 32, 33 or 34 and will display the signal power level. Note that the display units may be either watts or dBm even though the calibration power levels must be entered in watts.

(3) Operate



All the operating conditions then current will be entered in the selected, non-volatile store including the selected power offset. Any of the other stored offsets may be introduced in similar fashion, together with whatever additional control settings might be required, and entered in an empty instrument store. Note that offset storage does not require the 2305 to be necessarily in the POWER FUNCTION in this process.

44. Calibration of offset modes 2, 3 and 4 is entered in watts but is converted by the microprocessor into an equivalent attenuation in dB linking the two power levels (1) into the external attenuator and (2) as measured in the 2305. In this way the offset mode calculation carried out in each successive measurement is the same for these three modes as for mode 1. If any of second functions 32, 33 or 34 is re-entered after calibration has been assigned, the figures appearing in the right-hand four digits of the FREQUENCY display will be of this calculated equivalent attenuation.

ERROR CODES

45. An error code is a two digit number which appears centrally in the FREQUENCY display. It should not be confused with the single digit codes (I to 9) which appear on the right-hand side of the display during the self-check procedure if a fault is found in any of the measurement circuits. See also para. 10 and Fig.36 in this chapter. For control purposes errors are divided into two groups according to origin. Errors which arise from an operator's mistake or from a condition in the 2305 are coded 01 to 47. Errors created by a condition of the signal, e.g. frequency out of instrument's range, are given numbers greater than 47. A total of 25 error codes have so far been created.

46. Once an error occurs, further measurement stops until it is cleared. An operator induced error is cleared by the introduction of another function. An error due to an incompatibility in the signal clears as soon as the incompatibility is removed.

47. While the error state persists, GPIB strings are not updated and are preceded by the letter E. If the SRQ is not disabled (second function 19) and the particular error code is not masked, SRQ is asserted for errors coded 47 or less. Signal induced errors (codes greater than 47) do not give rise to an SRQ unless the 2305 is asked to talk frequency or modulation while the error persists.

Error code number	*Description*
01	Entered data outside limits.
02	Key pressed conflicts with modulation type e.g. de-emphasis with a.m.
03	PEAK HOLD not allowed. (PEAK HOLD is permitted only on ABS measurements).
04	Measurement instruction cannot be changed while HOLD is ON.
05	Illegal numerical entry (e.g. FREQ TUNE or MOD. REF. were not pressed first).
06	Option not fitted.
07	RF input protection tripped. To clear, remove overload and press the POWER function key.
08	Counter error (usually due to external standard being selected but not connected).
09	Unrecognized GPIB character pair.
10	System error - very unlikely - arises from software or hardware fault.
11	Bus error.
12	Calibration tolerance exceeded.
13	Synthesizer/counter self check error.

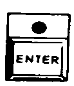
Error code number	*Description*
48 49	Unallocated.
50	No signal applied in AUTO TUNE mode. Displayed as _ _ _ _ _ _ _ _ _ _ _ _ _ _
51	Mixer overdriven, e.g. if input attenuator has been held at too low a setting using second function 35.
52	Applied signal carrier frequency appears to be outside range.
53	IF level too high. Automatic operation has been over-ridden.
54	IF level too low. May come on briefly during normal auto-tuning.

Error code number	*Description*
55	Modulation over range.
56	Small i.f. error.
57	Large i.f. error. IF errors can be caused by signal drift or, in manual operation, by a revised entry in tuning. A small error (56) will be corrected in automatic mode by slight readjustment. A large error will cause the AUTO TUNE cycle to start over again if this mode is operative.
58	Power display over-range. Occurs when the ranging capability is exceeded. (999.9 W in external attenuator mode.)
59	Cannot select notch. When using Distortion/Weighting Filter, signal frequency is not within ± 5% of any of the three design frequencies.
60	Options board over-range. When gain setting is held high by second function intervention.
61	Voltmeter over-range. Could be on any voltmeter function. It may arise from a circuit malfunction including, possibly, the voltmeter itself.

GENERAL PURPOSE INTERFACE BUS (GPIB) FUNCTIONS

48. The GPIB interface, offered as an optional accessory, allows the instrument to be coupled to a controller. The essential purpose of the GPIB functions is described below. Further information on the general features and applications of the GPIB system can be obtained from the separate GPIB manual offered as an optional accessory.

49. The 2305 has both talker and listener capabilities. One address is used for both talking and listening and is set via the front panel or via the GPIB using a second function. The instrument can request service (assert SRQ) in certain conditions under the control of an SRQ mask which is set by second function entries.

50. Once addressed via the GPIB, the keyboard is locked out to guard against accidental disruption. Local control can be recovered by operating 

unless Local Lockout has been asserted by the controller.

<u>SR1 : Source handshake</u> (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.

T6 : Talker function (no talk only function)

The talker function provides the 2305 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 2305 the capability to inform the controller when it requires attention.

RL1: Remote/local function (complete capability)

The remote/local function allows the 2305 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). 2305 resets to the power-up mode, that is

Function	- ABS, FM, $\frac{P\text{-}P}{2}$
Auto-tune	- ON
Filters	- 10 Hz to 300 kHz
De-emphasis	- OFF
Frequency display	- CARRIER

E1 : Open collector drivers

The GPIB drivers fitted to 2305 have open collector, rather than tristate, outputs.

List of 2305 GPIB commands

51. Instructions and data are sent to the 2305 in ASCII format. Instructions take the form of two-character alphanumeric pairs; data is normal ASCII figures and minus sign, plus '.' for decimal marker. When a command is followed by a numerical data string as required, for example, by FT and MR, the string must be terminated in a similar way to that which would be required for a keypad entry, only in this case any of the following punctuation marks should be used : comma, semicolon, <carriage return>, or <line feed>. These may also be used to separate instruction strings, in which case they are ignored. Most of the instructions correspond exactly to front-panel keys; where this would be inconvenient, extra codes are included.

Code	*Meaning*	*Code*	*Meaning*
CF	carrier freq.	PM	phase mod.
CE	carrier error	FM	FM
MF	mod. frequency	AM	AM
AT	autotune	PR	power
H1	hold on	PA	peak-peak/2
H0	hold off	PN	peak negative
CL	calibrate	PP	peak positive
F0	filter 50Hz - 15kHz	AV	noise average
F1	filter 300Hz - 3.4kHz	AB	absolute
F2	filter 10Hz - 300kHz	RL	relative
F3	filter 30Hz - 50kHz	DS	distortion
F4	filter 65Hz - 250Hz	SN	sinad
D0	de-emphasis off	P1	peak hold on
D1	de-emphasis 50Os	P0	peak hold off
D2	de-emphasis 75Vs	W0	weighting off
D3	de-emphasis 750ps	WI	weighting on
FT	freqtune	TF	talk frequency
MR	mod. reference	TE	talk error
RC	recall	TM	talk modulation
ST	store	SF	second function
RS	reset overload trip		

Talking function

52. When addressed to talk, the 2305 has three possible responses :

TF talk frequency (carrier or modulation)
TM talk modulation (kHz, rad or %)
TE talk error (two digits)

Note...

From software version 009 (appearing in the MODULATION window during the self-check routine), it is essential to send TF, TM or TE before each data string is requested.

The prefix 'E' is sent when the instrument is in error mode.

Comrnand	*Response*
TE	E NN 2 digit error code

The talk command is sent while the 2305 is still in listening mode and before it is addressed to talk.

Service requests (SRQ)

53. When the 2305 service request function is enabled (via Second function 19), attention may be requested for two reasons, first because the instrument has entered an error mode and secondly because of the need to signal to the controller that a status change has been completed and the 2305 is ready for fresh instructions the 'READY' SRQ.

54. In response to a serial poll, the 2305 will transmit the status byte

b7	b6	b5	b4	b3	b2	b1	b0
0	rsv	abnormal	d4	d3	d2	d1	d0

where b7 : is always 0
b6 : rsv is set for all SRQ
b5 : abnormal, I for ERROR SRQ, 0 for READY SRQ

b0 to b4 indicate the error number, thus :

for error no. b4 = 0
01 to 15 } b0 to b3 hold error no. in binary

for error no. b4 - 1
16 to 48 } b0 to b5 hold error no. in binary

While the 2305 requests service, the small blob at the top left of the lefthand digit in the modulation display is activated. During this time the 2305 will not handshake any new information over the bus : after the delay the response will continue as normal whether the SRQ has been serviced or not.

SRQ mask

55. If a selective SRQ response is required it is possible to mask off any particular set of error codes chosen via second functions 20 to 23 and to inhibit the SRQ from being generated should the 2305 enter any of these error states. The READY SRQ can be suppressed in the same way. Note that any SRQ mask is stored in non-volatile memory indefinitely but that the state of second function 19 is volatile and will need to be re-asserted after each switch-on if any SRQ response is required.

Clear and switch on

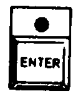
57. SDC and DCL clear 2305 to the following state:-

AUTO-TUNE	- ON
FREQUENCY display -	- CARRIER
FILTERS	- 10 Hz to 300 kHz
DE-EMPHASIS	- OFF
FUNCTION	- ABS, FM, $\frac{\text{P-P}}{2}$

Notes...

(1) Int/Ext frequency standard selection is unaffected by the SDC and DCL commands.

(2) The instrument stores are not changed, switching on clears, the 2305 to the same status as SD or DCL or to the control settings in store 0.

(3) To revert from GPIB to front panel control, press the 

key.

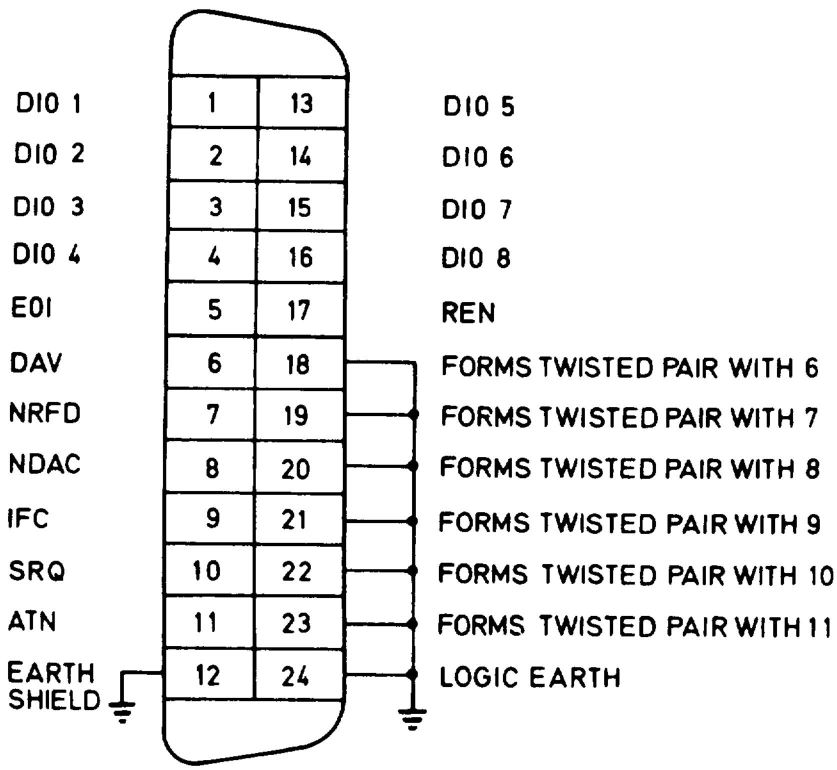


Fig.3-8. GPIB connector contact assignments

EXTENDED APPLICATION

LF signal measurements

1. Although the primary application of the 2305 is in the measurement of modulated r. f. signals, the low frequency measurement circuits in the instrument can usefully be accessed for measurements on low frequency signals such as those originating, for example, in the output stages of receivers. Entry to the l. f. stages is via the rear panel jack socket normally intended for the insertion of external special filters. Reference to Fig.2-2 in Chap. 2 and FO-1 will show that if the jack tip connection is ignored, a signal connected between the ring and the sleeve of the jack will be substituted for the internal demodulated signal. Most of the functions of the DATA and FUNCTION keys are still available so that both absolute and relative level measurements can be made including signal to noise ratio. Voltage measurements may be peak or average responding and, if the Distortion/Weighting filter option kit is fitted, the measurements may be weighted and extended to include distortion if required. The signal frequency can be displayed in the FREQUENCY window.

2. Practical details. A jack plug is supplied with the instrument and a suggested method of connection is shown in Fig.3-9. If frequent reversion to standard operation is required, as would be the case if l. f. signal measurements formed part of an automatically controlled sequence, the jack plug may be left inserted and the changeover effected by relay contacts as shown. Alternatively, if only occasional use is likely, the switch contacts and the tip wiring can be omitted and the jack inserted manually as required. Any wiring left permanently connected to the 2305 signal path must introduce as little stray capacitance as possible as the l. f. bandwidth may otherwise be reduced.

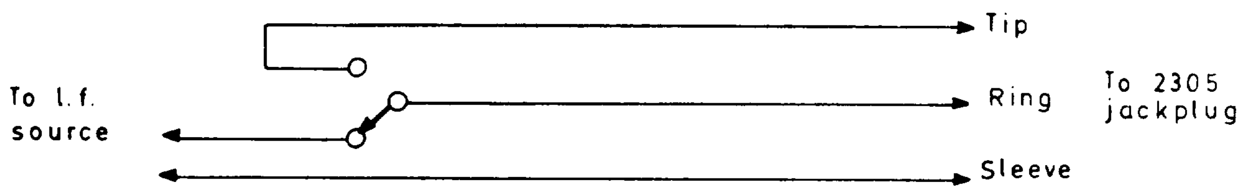


Fig. 3-9. External connections to enable the introduction of l.f. Signals into 2305

3. The 2305 requires a 3 V signal at this point to produce full-scale on the voltmeter. The voltmeter can be made direct reading on a '5' full-scale range by the addition of a simple calibration network of the kind shown in Fig.3-10 between the source and the jack connections.

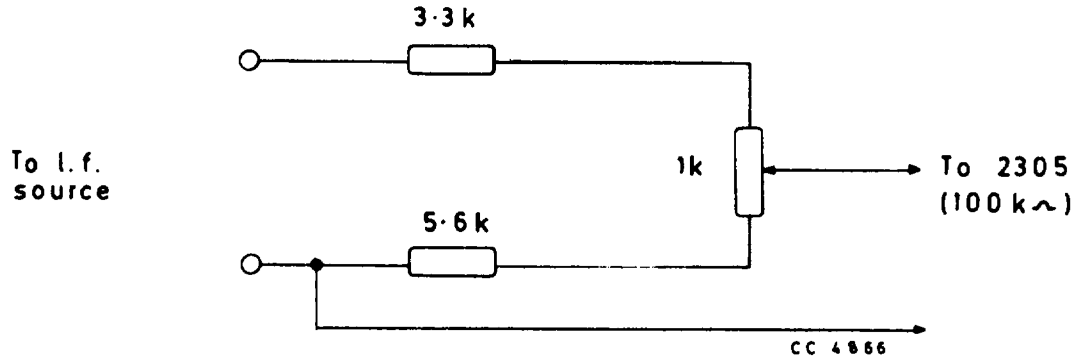
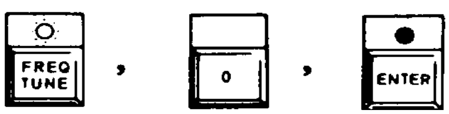


Fig.3-10. Calibration network to give 5 V full-scale

4. <u>Operation.</u>

(1) Select FM.
In the absence of an r. f. signal input, the 2305 displays are blanked and the l. f. stages are inhibited. The following keyswitch (or equivalent GPIB command) sequence is therefore required before measurements can begin.

(2) With the external circuit disconnected, press in turn



in order to inhibit autotuning.

This is a precaution which ensures total freedom from disturbance to the l. f. operation.

(3) Press in turn,

This introduces the narrow deviation calibration signal causing the 2305 to act as if a signal was present and switch the voltmeter to the 50.00 kHz full-scale range. The frequency displayed in the MODULATION window will only approximate to the 31.25 kHz deviation standard as the filter and de-emphasis circuits will not be switched to their calibration state.

5. Introduce the l. f. signal. A number will now be displayed on the 50.00 kHz range. If a standard 5 V signal is available, it may be connected via the calibration network which can then be adjusted for a precise 50.00 kHz indication. Signal limiting will start to occur at 20% over-range but all four digits will remain active in this method of use. The 2305 circuit is d. c.-coupled at the point of access and precautions must be taken to ensure that the total applied signal cannot exceed the limits of +15 V with respect to the common (ground) terminal. If a calibration network is not inserted, the basic voltmeter accuracy will give an indication within +5% of (5 x input voltage). The linearity is, typically, ±0.1% of full-scale on - and +0.25% of full-scale on NOISE AVG.
6. The keys shown in the keyboard illustration of Fig 3-llretain their functions and may be used with external l.f. signal measurements. In particular, all the detector modes are available and reference quantities may be entered for relative measurements.

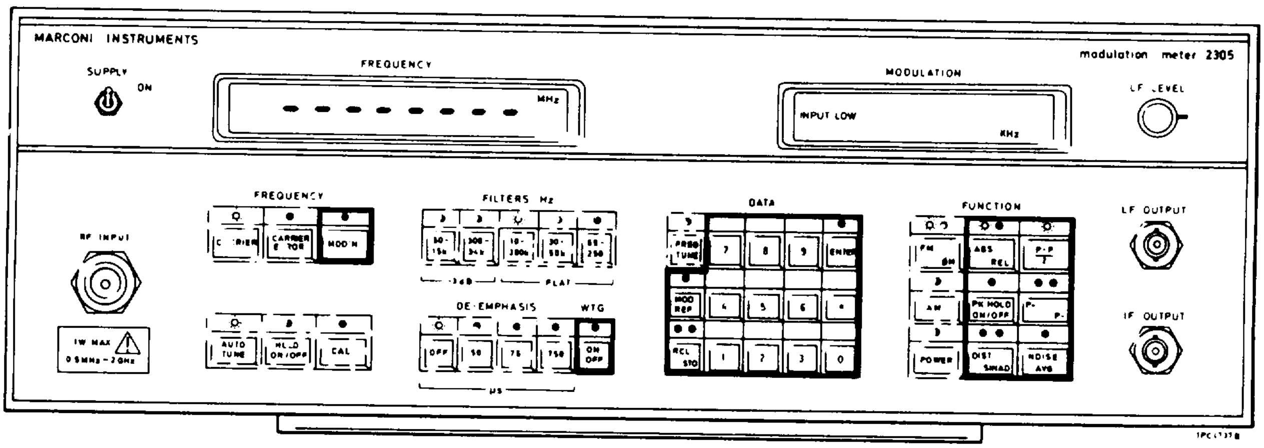


Fig.3-11. Keys still useful when measuring external l. f. signals

A fully controllable replica of the measurement signal will be available at LF OUTPUT.

CHAPTER 4

FUNCTIONING OF EQUIPMENT

Section I. BRIEF TECHNICAL DESCRIPTION

CONSTRUCTION

1. The instrument's component parts may be considered, conveniently, as forming three main groups.

(1)The front panel assembly. This is made up from the keyboard and the display which are directly controlled by the microprocessor.

(2)The rear panel assembly. This comprises the power supply and a card guide. The guide contains the circuit boards for the microprocessor and memories, the counter and voltmeter.

(3)The RF box. This is compartmented and contains most of the analogue signal processing circuits. The circuits are set up and interconnected in response to digital instructions which are latched onto a separate internal bus system so freeing the RF box from the risk of interference which would follow from direct interaction with the microprocessor. The construction may be seen in figure 4-1.

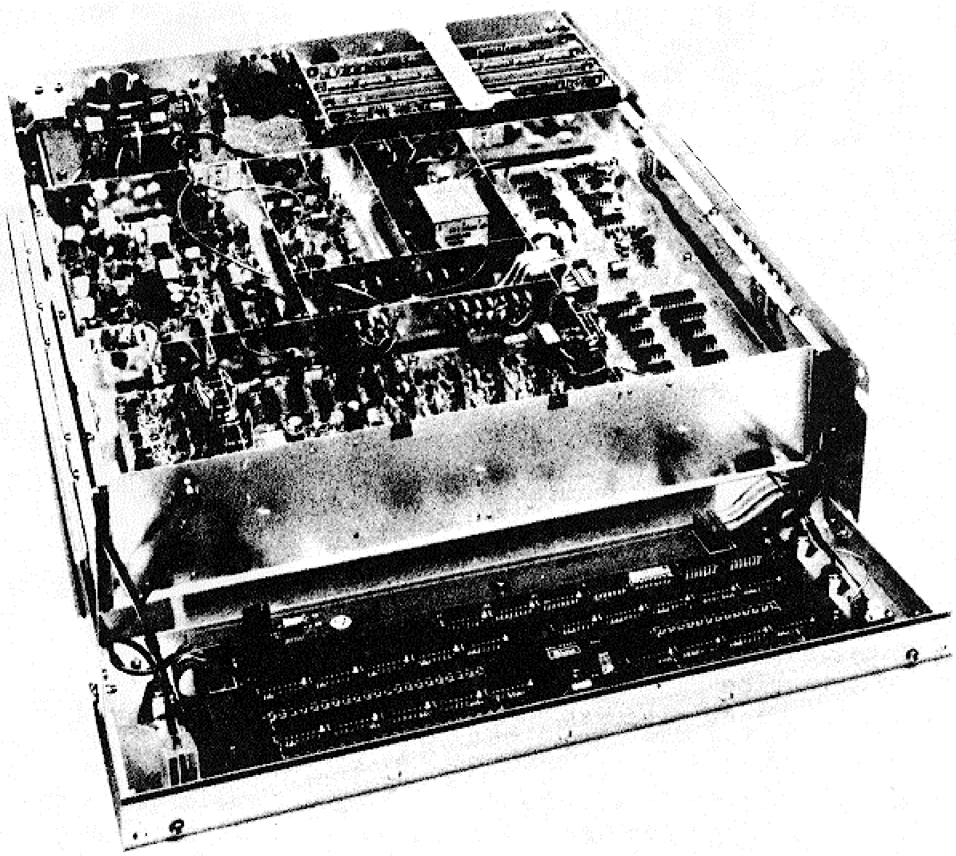


Figure 4-1. Internal view of 2305 with front panel folded down.

DESIGN OUTLINE

2. The instrument is a low gain superheterodyne amplifier with a synthesizer local oscillator and two separate mixers, a double-balanced ring bridge for signal frequencies below 56 MHz and a sampling gate mixer for frequencies from 56 MHz to 2 GHz. Signals of 1.5 MHz and below pass directly into the i. f.
amplifier.

Input circuit arrangement

3. Reference should be made to the instrument block diagram, FO-1.The signal for measurement passes to the input attenuator via a coaxial line relay which isolates the input when it is overloaded. The attenuator has three switchable pads, two of 14 dB and one of 7 dB, which are introduced in 7 dB steps. A diode detector connected immediately after the input protection circuit serves the dual purpose of metering the input power level and, when necessary, of triggering the overload detector circuit. The overload detector shares a circuit board with the l.o. voltage controlled oscillator. When tripped, it causes the INPUT OVERLOADED annunciator in the modulation display to light up and opens the protection relay. The relay can then only be reset by the microprocessor following intervention via the keyboard or GPIB.

4. With no input signal present, the input attenuator is set automatically to zero dB. When a signal appears at the attenuator output, it is detected by the wideband mixer level detector and attenuation will be introduced as required to bring the mixer input within the designed dynamic range. The Instrument will then, if not switched to manual over-ride, begin its autotuning routine.

Auto-tuning process

5. In the first stage of auto-tuning , the sampling gate is used as the frequency changer with the local oscillator executing a two-stage search programme designed to produce an i.f. within the range 3 MHz to 11 MHz. A special circuit branching off the main i.f. channel is tuned to receive this band of frequencies and the appearance of a signal here above a standardized threshold causes a level detector to be triggered and information to be passed to the microprocessor that an i.f. exists which is within the frequency range of the internal counter frequency meter. Once the microprocessor receives this 'i.f. present' signal, it causes the signal frequency to be precisely measured and, by noting the effect on the i.f. of a small increment in the local oscillator frequency, it calculates which harmonic of the local oscillator is effective in producing the i.f. The microprocessor then has enough information to calculate the exact input signal frequency and it causes this to be displayed in the FREQUENCY window. It also changes the instructions to the local oscillator and, if necessary, to the binary divider as well so as to produce an i.f. of 1.5 MHz and to ensure that the correct mixer is used.

6. A failure to detect an i.f. signal after this part of the autotune programme has been completed will be interpreted by the microprocessor as meaning that the input signal is 17 MHz or less and it will then cause the signal to bypass the mixers and pass directly to the i.f. After its frequency measurement has been interpreted by the microprocessor the signal will be routed to the balanced mixer if above 1.5 MHz and allowed to pass directly to the i.f.
if less.

7. A continued failure to detect an i.f. while the mixer level detector continues to detect an input, will result in the display of error code 52 - frequency out of range.

8. The double-balanced mixer is introduced for signal frequencies below 56 MHz where the rejection contributed by the mixer to the local oscillator and signal frequencies is needed to assist in the proper separation of the i.f. Further assistance is given by the reduction in i.f. from 1.5 MHz to 250 kHz that is made when input signals of less than 5.5 MHz are used. All filter switching and signal routeing is carried out by local latching and control in response to data transmitted over the internal bus.

Local oscillator

9. The l.o. is phase-locked to the required frequency in a loop including the digital phase detector, the programmable divider and a 10 kHz reference frequency. For l.o. frequencies below the bottom limit of the v.c.o. range of 28 to 56 MHz, the binary divider stage is activated so as to reduce the frequency in the required ratio. For signal frequencies above 56 MHz, the sampling gate mixer is used and the l.o. produces a very short sampling pulse at a rate near to a sub-harmonic of the input signal frequency.

10 MHz internal reference oscillator

10. The internal oscillator is in a standard oven-controlled enclosure. A sample output appears at the external STD. FREQ. IN-OUT terminal on the rear panel when the instrument is switched to the internal standard and a rear panel-mounted potentiometer enables a fine frequency control to be achieved. An alternative, external, reference may be employed and is switched in by a keyboard second function. The STD. FREQ. IN-OUT terminal then becomes an input terminal.

AM detection

11. The a.m. detector operates with a mean level a.l.c. loop which ensures that peak amplitude excursions of the signal are always measured in relation to the same constant mean value and are therefore proportional to the percentage a.m. The time constants of the a.l.c. loop are switched by the microprocessor in accordance with the lowest modulation frequencies in use so that settling and measurement times are kept to the minimum. Information on the modulation frequency range is deduced from the user's choice of l.f. filter.

Internal calibrator

12. For self-calibration purposes the l.o. output is routed to the i.f. circuit. When f.m. calibration is called for, it is produced by modifying the instructions to the programmable divider at a I kHz rate. A separate high speed sampling phase detector is used with a 100 kHz reference within the phase-locked loop so that the loop may settle with sufficient speed. The l.o. is switched between either 47 MHz and 49 MHz (I MHz deviation) or between 46 MHz and 56 MHz (5 MHz deviation). After these frequencies are divided by 25 in the binary divider, the resulting calibration is at deviations of 31.25 kHz and 156.25 kHz.

13. For a.m. calibration, the l.o. is set to 1.5 MHz and its output is routed via a resistive T-pad giving a nominal +5 voltage ratio. This pad is switched in and out by a bottoming transistor producing nominally 67% a.m. that is dependent almost solely on the properties of the resistors. The precise value of the a.m. is determined during factory calibration and is stored in the instrument's non-volatile memory.

FM detection

14. The f.m. detector is supplied via a separate branch of the i.f. amplification system and is designed as a balanced circuit so as to optimize rejection of any residual a.m. that might be present. The detector uses the charge pump principle.

Low frequency circuits

15. The audio signals from the modulation detectors, which are related by their amplitude to the amount of modulation, pass into the 50 dB ranging l.f. amplifier and from there to the filter board which contains the switchable filter elements and f.m. de-emphasis circuits all of which are accessed from the keyboard for the appropriate functions. The 6 dB/octave h.f. roll-off characteristic which is introduced automatically when phase modulation is selected, is produced by circuit elements on the filter board. The 2-circuit jack located on the rear panel enables an external filter to be introduced into the audio path at this point.

16. The LF Filter board contains a patching link in its output stage that enables the options board to be connected there, if required. The LF OUTPUT signal originates here so that a signal taken from this outlet will have been conditioned by any filtering and de-emphasis introduced, either internally or externally, and by any function selected on the options board - if fitted.

17. The signal conditioning circuits are normalized to a single mid-band gain level so that the LF OUTPUT mid-band signal level is dependent only on modulation depth but is shaped by the chosen characteristic at other frequencies. The measurement signal, in normal operation, is taken to the voltmeter board without passing through de-emphasis. It is voltage detected, then given analogue to digital conversion and display.

Metering detectors

18. The peak detector operates on positive peaks only but is preceded by a switchable, inverting non-inverting stage which enables either polarity to be measured. When the function is chosen, the microprocessor requests peak measurements of each polarity to be made in turn, then stores the results and calculates the mean value for display. The average detector ensures accurate averaging by converting the l.f. signal into a current source which feeds into leaky capacitor reservoirs. This is followed by an active low-pass filter which completes the averaging process with the longest time constant compatible with an acceptable measurement time.

Voltmeter

19. Analogue to digital conversion is carried out as voltage to frequency with frequency then being measured in the internal counter frequency meter and displayed. The converter employs a v.c.o. in a nulling phase-locked loop in which the v.c.o. drives a source of precise, unidirectional pulses. These pulses are supplied to one input of a resistive summing network and the voltage selected for measurement is connected to another. As the summing point is also the nulling point, the v.c.o. frequency is constrained to follow the unknown voltage with accurate proportionality.

20. The voltmeter is also used for the digitization of a range of quantities which are not displayed as part of normal measurement but which are either used by the microprocessor as a part of the control of the automatic processes or which may be accessed for display only as keyboard second functions as aids to fault diagnosis. It is switched between these and any of the normal modulation measurement quantities by on-board switching controlled by local latch/ decoders in response to signals on the internal bus.

21. The voltmeter board also contains a multiplying circuit which increases modulation frequencies below 6 kHz by a factor of x100 before passing them to the counter for modulation frequency measurement. This improves the resolution imposed by the 100 ms gate time from 10 Hz to 0.1 Hz and gives the required discrimination at low modulation frequencies without the need to extend gate (and measurement) times or to introduce the complexity of period measurement. The x100 multiplier includes a v.c.o. with a +100 stage in a phaselocked loop. The phase-detector output to the v.c.o., being proportional to frequency, is also used outside the loop with a trigger stage to switch the multiplier in and out as the modulation frequency rises respectively from below to above 6 kHz.

Frequency counter and microprocessor

22. The counter is based on a l.s.i. custom c.m.o.s. chip with three external scalers which effectively increase the speed of the c.m.o.s. chip. Only two gate times are used 10 ms and 100 ms. The counter is completely automatic and measures any of 3 signals as directed by the microprocessor. These are : the IF, the demodulated LF signal and the output from the voltmeter voltage to frequency converter.

23. The microprocessor system occupies two boards, one containing the CPU and program memory and the other the I/O ports and EAROM.

24. The microprocessor (type 8085A) is run at about 3 MHz from an oscillator on the board. Up to 7 x 4 kbyte EPROMs of program memory can be accommodated on the board.

25. The interfacing between the instrument data buses, the EAROM and the microprocessor is carried out by two 8155 RAM I/O devices. A -30 V supply for the EAROM is generated by a d.c. d.c. converter on the board.

Power supply

26. The 3 supplies for +5 V and +15 V are entirely conventional. A +5 V line to the microprocessor is separately decoupled at the output connector. The mains transformer is a standard item and one secondary winding is not used on the 2305. The consumption is approximately 70 VA.

Section II. DETAILED TECHNICAL DESCRIPTION

MECHANICAL DESIGN PRINCIPLES

1. The construction of the instrument can be seen from the photograph in Fig. 4-2 which shows a view with the upper covers removed and the front panel hinged downwards. The construction is arranged to suit the functional requirements and falls into four main assemblies which are given the letter designation shown in Fig. 4-2 and which are described below.

Assembly A,.	the front panel with keyboard and display boards.
Assembly B,.	the r.f. box, which is compartmented on each side of a horizontal dividing bulkhead. The r.f. box contains most of the analogue circuits.
Assembly C,.	the mother board and four daughter boards containing the microprocessor and other digital circuits.
Assembly D,.	the power supply.

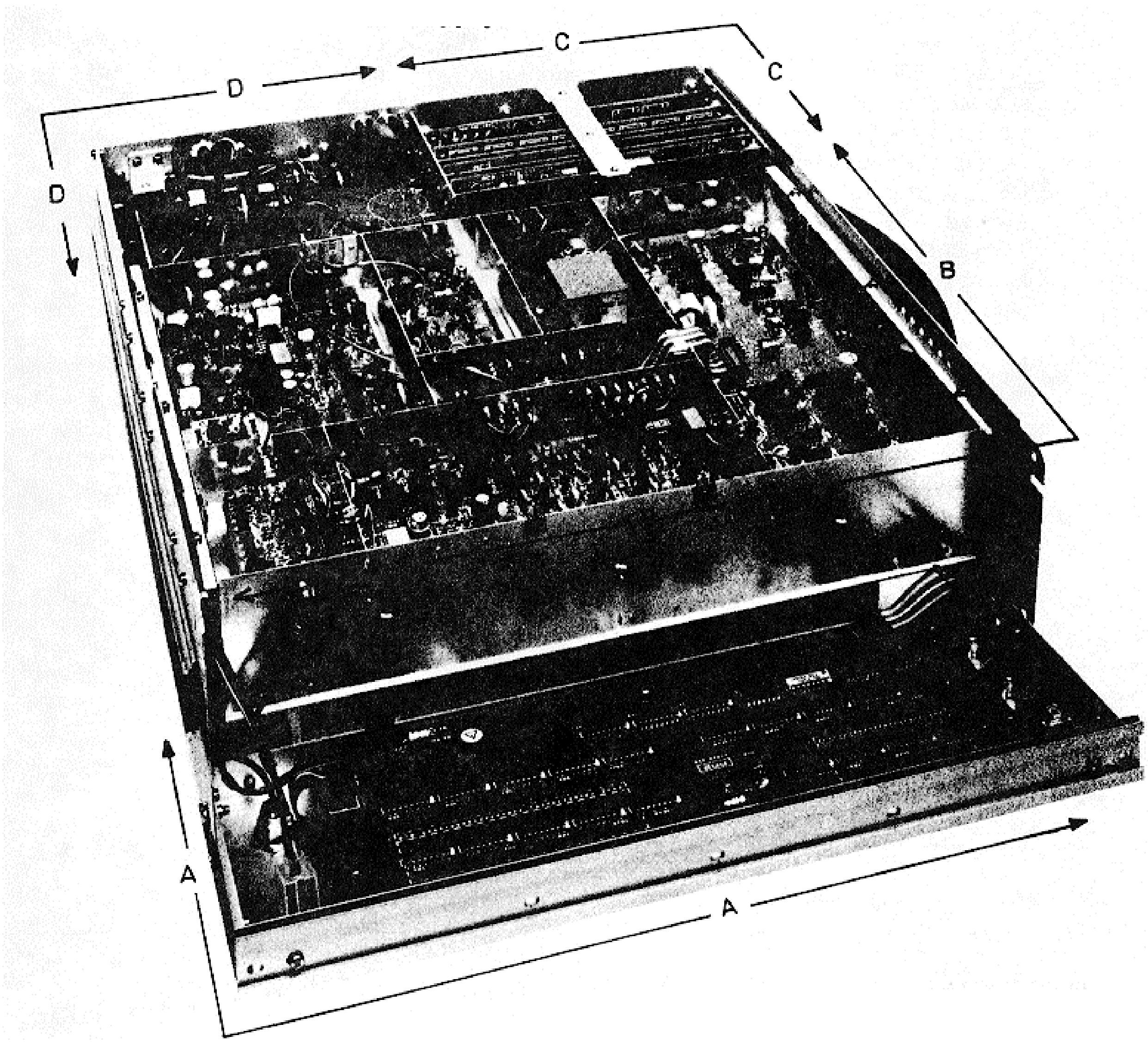


Fig.4-2. Functional assemblies Virtue showing interior with assemblies A-D identified

2. The various circuit boards making up each functional assembly are numbered 1, 2, 3 etc. and all assemblies have the prefix A giving, for example, board AAI the keyboard and boards ABI, AB2 to ABI1 in the r.f. box. Any further sub-division is assigned a letter suffix, as in AB2A the sampling gate mixer which is a board sub-assembly mounted onto the main mixer board AB2 and is the only example of this level of sub-division in the instrument. The assembly letter E is used for the optional Distortion/Weighting filter and the letter Z denotes the complete instrument. The zero suffix is customarily reserved for the interconnection diagram at the assembly level concerned so that ABO and AZO are the r.f. box and main frame interconnection diagrams respectively. The system is a convenient shorthand for use in technical description and forms the framework for the numbering of component circuit references.

Accessibility for servicing

3. The 2305 design allows good accessibility to the active circuit elements. With very few exceptions, the electrical components are assembled onto circuit boards, each board being associated with a particular circuit function. The boards are readily detachable as all interconnections are made by plug and socket combination there being no permanent links.

4. The outer cover is made in two halves with the split made centrally along each side. Each half is retained by two screws on the rear panel which pull the cover up against lipped sections on the framework. The retaining screws are accessible through the rear panel protective feet once the central plastic plugs are removed.

5. After removal of the outer cover, access is possible to the rear panel components, to the power supply and to the digital circuit boards AC2 to AC5. The front panel may be hinged down very simply to give access to the panel circuits. Remove the two screws on each side which retain the trim pieces and slacken the other two screws which are then uncovered. Hinge down. If further access is required, detach the slackened screws and the panel will come free.

6. Access to the main analogue circuits can be obtained by removing one or both of the upper and lower r.f. box covers as necessary. The key to board location and functions is given in FO-2 together with the indentities and positions of board mounted plugs and sockets. After removing the power supply regulator board AD] access is gained to the mains transformer, the rectifiers and components associated with the supply mains, as shown in Fig.4-3.

ELECTRICAL DESIGN PRINCIPLES

7. The overall block diagram in foldout 1 may be extended to throw clear of the text for ease of reference if required. The 2305 is a low gain superheterodyne receiver with nominal i.f's of 1.5 MHz and 250 kHz. It has two frequency changer systems with a double-balanced mixer for signals below 56 MHz and a sampling gate mixer for signals above that frequency. The local oscillator is a synthesizer so that tuning can be digitally controlled with a stability deriving from a high quality, single frequency reference oscillator.

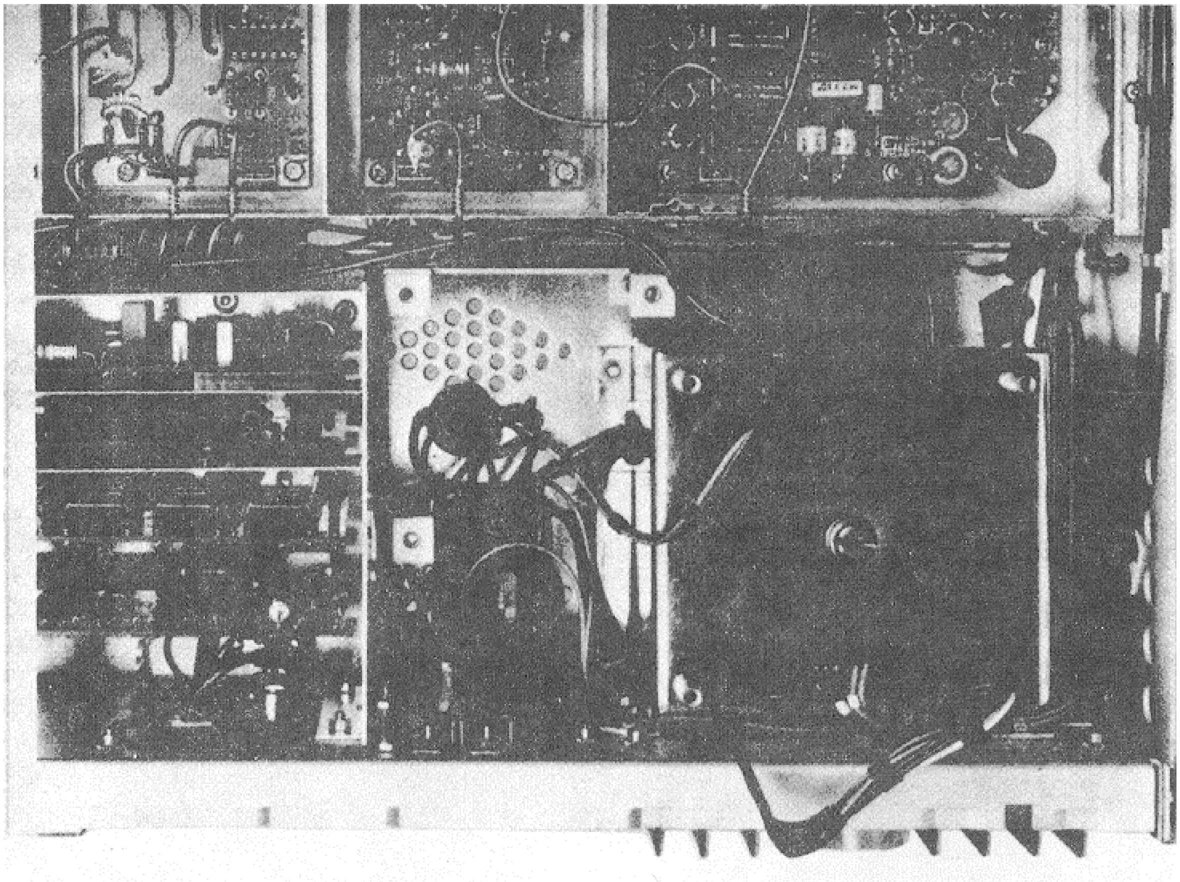


Fig. 4-3. Mains components with ADI board removed (Rear lefthand corner, top view)

8. The modulation is transferred from the input signal to the i.f. which 'is accurately mean level-controlled to a fixed value. The i.f. signal is demodulated to produce l.f. signals that are accurate models of the modulation; a.m. via an envelope detector and f.m. via a charge-pump discriminator. The l.f. signals are amplified in a range-switching amplifier before passing through the selected band-pass filter and the Distortion/Weighting filter accessory if this is fitted. At this stage phase modulation is extracted from the demodulated f.m. by use of a special filter which causes the l.f. signal amplitude to fall off with increasing modulating frequency at 6 dB per octave.

9. Modulation is measured by peak detection of the l.f. signal and is digitized by conversion from voltage to frequency. An alternative average responding detector is available. The measurement is completed when the frequency analogue is measured by a frequency counter and displayed. The counter performs this function for a number of voltage measurements which have been digitized in this way and also measures the i.f. and l.f. signal frequencies when directed.

10. The circuits involved in signal processing and measurement are controlled by the microprocessor by means of a 16 line internal data bus. The voltmeter, counter and display boards have a high degree of interaction with the processor and are therefore grouped separately outside the r.f. box with a separate bus. The main internal bus is relatively quiet by comparison and the separation of control activities in this way reduces the possibility of crosstalk. For remote operation, all the 2305 functions can be controlled by signals on an external bus system which gain access to the microprocessor via the optional GPIB interface module.

Bus conventions

11. In the circuit and block diagrams, the highly interactive bus is labeler IB and the related control lines D0, D1, A0, A1 etc. appear without prefix. The quiet (r.f. box) bus is labeled IBB and its related control lines carry the prefix 'B' e.g. BD0, BA1 etc. After decoding and latching the latch number is substituted for the bus prefix and lines are shown as L2DO, L3D3 etc. All r.f. box control requirements except for those of the programmable divider on AB4 are decoded and latched on board ABII by latches 0 to 3 and 6 to 13 inclusive. Latches 4 and 5 which cover the needs of the programmable divider are located on AB4. Decoding and latching for the interactive units AC2 and AC3 is carried out within the units themselves.

SUB-ASSEMBLY DETAILS

AA1 keyboard assembly
Circuit diagram : Foldout 2.

12. Use of the keyboard is controlled by the microprocessor which recognizes key operation, stores the history of a keying sequence and controls the associated key active lights so as to indicate the operational state of the instrument.

13. Control is via 8 data lines (D7 to DO), 3 address lines (AO to A2) and one valid line (VALID 2). The address lines are decoded in ICI and the decoded output line is taken low when VALID 2 goes low. All the other outputs remain high. A valid ADDRESS 0 enables the 8 keyboard buffers (IC8) to put data onto the data bus. A valid ADDRESS 1 latches D4 to DO into the five row latches (IC7) for the keyboard matrix. The keyboard columns are pulled high by the resistor network R7. If no key is pressed and the keyboard output is read (ADDRESS 0), all data lines will be high. If a low is latched into a row and a key is pressed in that row, the associated columns will be pulled low and will take one input to the multiple input NAND gate IC9 low and the output (KEYBOARD INTERRUPT) high. A key that is on a row latched high can have no effect.

14. When the KEYBOARD INTERRUPT line goes high, the normal microprocessor routine is interrupted and a new routine is initiated in which each row is taken low in turn with the other rows held high. Meanwhile the keyboard column output is scanned and the coordinates of the key concerned are obtained when coincidence between a low row and a high data line is detected. In normal keyboard operation this process is completed comfortably within the time lapsing between cessation of key contact bounce and key release and is followed by restoration to the normal state with all rows latched low.

By limiting the involvement of the microprocessor to a few milliseconds each time a key is pressed, a considerable economy in processor time is made over that which would be required if the keyboard had to be scanned continuously.
15. The 34 indicator LED's are driven by IC2 to IC6. Each of IC2 to IC5 latches all 8 data lines when addressed (on 2, 3, 4 or 5) and controls 8 LED's (latch high LED off, latch low LED on). The other two LED's are controlled by IC6 which, accordingly, only latches two lines, DO and D1 (address 6).

TABLE 1. CONTROL DATA, KEYING

Column Row	*D0*	*D1*	*D2*	*D3*	*D4*	*D5*	*D6*	*D7*
DO	CARRIER	CAL	65-250	WTG ON/OFF	4	9	0	PEAK HOLD
D1	CARRIER ERROR	50-15K	OFF	FREQ. TUNE	1	6	FM/PM	DIST/ SINAD
D2	MOD'N	300-3.4K	50is	MOD. REF.	8	3	AM	(P-P)/2
D3	AUTO-TUNE	10-300K	75is	RCL/ STO	5	ENTER	POWER	P+/P-
D4	PK. HOLD ON/OFF	30-50K	750ps	7	2	DECIMAL MARKER	ABS/ REL	NOISE AVG

<u>AA2 display assembly</u>
Circuit diagram : Foldout 3.

16. The AA2 is controlled from the microprocessor by 8 data lines (D7 to DO), 4 address lines (A3 to AO) and a valid line (VALID 3). Data lines, valid lines and address lines are also routed to the keyboard AAI via PLAA. The data and address lines are buffered by ICI and IC2. The addresses are decoded by IC15 and IC16 which form a 1 of 11 decoder controlled by IC13. If A3 is low when VALID 3 goes low, IC15 will be enabled and one output, depending on the states of A2 and AO, will go high. All other outputs remain low. If A3 is high when VALID 3 goes low, IC6 will be enabled. When VALID 3 is high, both decoders are disabled. The decoded addresses enable the latches in the LCD drivers IC3 to ICII, IC14 and IC18 to IC26.

17. The LCD's are driven by square waves switching between +5 and -3 V which are produced by the LCD drivers from a TTL square wave originating at about 48 Hz in ICI7. When a particular driver is addressed it will excite the necessary segments as required by the decoded data lines by supplying those segments and their backplane in antiphase. This applies the full available 8 V p-p as an alternating voltage to those parts of the display that it is required to make visible. Electrodes of segments or symbols which are to remain non-visible are supplied with an identical (in-phase) voltage to the back plane electrode. Each display has one common back plane electrode, that for XI is driven from a section of IC18 and that for X2 from a section of IC26.

TABLE 2. CONTROL DATA, KEY ACTIVE LIGHTS

Address = A6L2		Address = A6L5	
Data line	Key LED operated	Data line	Key LED operated
DO	CARRIER	DO	POWER
D1	CARRIER ERROR	DI	ABSOLUTE
D2	MOD’N	D2	RELATIVE
D3	AUTO TUNE	D3	PEAK HOLD
D4	HOLD ON/OFF	D4	DISTORTION
D5	CALIBRATE	D5	SINAD
D6	50-15K	D6	(P-P)/2
D7	300-3.4K	D7	PEAK +
	Address = A6L3	Address = A6L6	
DO	10-300K	DO	PEAK -
DI	30-50K	D1	NOISE AVERAGING
D2	65-250		
D3	OFF (DE-EMPHASIS)		
D4	50us		
D5	75-ps		
D6	750us		
D7	WEIGHTING FILTER		
CCIR/CCITT			
Address = A6L4			
DO	FREQUENCY TUNE		
DI	MODULATION REFERENCE		
D2	RECALL		
D3	STORE		
D4	ENTER		
D5	FM		
D6	PHASE MOD.		
D7	AM		

18. Two types of LCD driver are used : the 4056 is a latched 7-segment decoder and is used to drive the digits in the frequency display (IC4 to ICil) and in the modulation display (IC20 to IC23). Two decoder-drivers are latched at one address, one taking data from D7 to D4 and the other from D3 to DO. The other driver type, the 4054, provides 4 latched drives and is used in accordance with the following.

	Frequency display	*Modulation display*
Decimal points	IC14	IC26
	IC18	
Annunciators	IC3	IC19
	IC12	IC25

TABLE 3. CONTROL DATA, DISPLAY

Information type	*Address*	*Information in BCD*		
Frequency	A7LO	D0-3	LSD	
		D4-7	LSD+I	
	A7LI	DO-3	LSD+2	
		D4-7	LSD+3	D7 and D3
	A7L2	DO-3	LSD+4	are MSB's
		D4-7	LSD+5	
	A7L3	DO-3	LSD+6	
		D4-7	MSD	
Modulation	A7L4	DO-3	LSD+I	
		D4-7	LSD	
	A7L5	DO-3	MSD	
		D4-7	LSD+2	
		Information		
Decimal point (DP)				
Frequency	A7L6	DO	Not used	
		DI	DP ON LHS OF LSD	
		D2	DP ON LHS OF LSD+I	
		D3	DP ON LHS OF LSD+2	
		D4	DP ON LHS OF LSD+3	
		D5	DP ON LHS OF LSD+4	
		D6	DP ON LHS OF LSD+5	
		D7	DP ON RHS OF MSD	
Modulation	A7L7	DO	Not used	
		DI	DP ON LHS OF LSD	
		D2	DP ON LHS OF LSD+I	
		D3	DP ON RHS OF MSD	
Annunciators				
(Frequency display)	A7L8	DO	REMOTE	
		DI	ADDR	
		D2	Not used	
		D3	MHz	
		D4	kHz	
		D5	Hz	
		D6	EXT	
Annunciators	A7L8	D7	Elevated 'point' on LHS	
(Modulation	A7L9	DO	EXT L.O.	
display)		D1	INPUT	
		D2	LOW	
		D3	OVERLOAD	
	A7LIO	DO	k	
		DI	Hz	
		D2	%	
		D3	RAD	
		D4	dB	
		D5	m	
		D6	W	
		D7	TD	

ABI Input attenuator board
Circuit diagram : Foldout 5.

19. The attenuator contains three switchable pads, two of 14 dB and one of 7 dB, which are introduced under control of the microprocessor in increments of 7 dB up to the maximum of 35 dB. The impedance is 50 Q. The pads are switched by TO 5 can relays RLB, RLC and RLD which by changeover action select either a pad or a direct link. The relays are controlled via the drive transistors TRI, TR2 and TR3 which are protected from transient damage by diodes D5, D6 and D7 and are switched by negative true logic on PLBC deriving from the latches board ABII in accordance with the scheme shown in Table 4.

TABLE 4. CONTROL DATA, INPUT ATTENUATOR

Line	*D0*	*D1*	*D2*	*Pads Contributing (dB)*			*Overall attenuation*
PLBC Pin	*9*	*10*	*11*	*RLB*	*RLC*	*RLD*	*dB*
	H	H	H	0	0	0	0
	H	H	L	0	0	7	7
	L	H	H	14	0	0	14
	L	H	L	14	0	7	21
	L	L	H	14	14	0	28
	L	L	L	14	14	7	35

20. Resistors R20 and R21 introduce a fixed additional nominal 2 dB immediately after the switched elements and provide a residual insertion loss in the signal path through the board. The resistors R7, R8, R9 and RIO which make up the input pad can withstand a continuous input level of I W and the switching system ensures that no other pad can receive more than 8 mW.

21. The power monitoring circuit is attached between the attenuator input and the overload protection relay RLA. RF up to the measured limit of 1 W is sampled by the chip resistors R5 and R6 which give 10 : I voltage division. The output from this divider is rectified by diode D2 which operates in the square law region at levels of 10 mW or so and approaches linear operation at I W input. The diode is biased by 7 pA of forward current in order to over- come the pedestal and improve sensitivity at low levels. Diode DI is selected to match D2 and provides zero signal offset. The dc analogue of r.f. power is taken from the reservoir capacitor C2 via RI, which gives some r.f.
filtering, to the amplifier/trip circuit on the AB3 board.

22. The final stage in this amplifier is preset to trip the overload relay RLA when the input to the instrument passes the 2 W level. The coil of the relay is shunted by D3 and D4 which limit the reverse transient to 24 V when the relay is released thus protecting the output stages of the amplifier on AB3 and speeding up the decay of the magnetic field. Operational delay from the instant of overload to the relay opening is, typically, less than 100 ps.

23. RLA is a dry reed relay with coaxial sleeve and solenoid, fully encapsulated and of 50 n nominal impedance. When the relay is de-energized and open, the isolation at 2 GHz is 15 dB, increasing at lower frequencies. Chip capacitor C3 provides isolation from d.c. voltages associated with input signals up to a maximum of 50 V. When the overload relay is tripped, information is passed from the AB3 (VCO) board as a high on the r.f. overload tripped/reset line to the processor latches via ABII and ACI.

24. Clamping is applied to the ABI output by the Schottky diodes D8 and DII which are returned to d.c. potentials defined by the forward biased diodes D9, DIO, D12 and D13 at +1.3 V. The Schottky diodes conduct when the signal level reaches 2 V and give instantaneous protection to the fast diodes in the sampling gate mixer on AB2A board - which have a peak inverse rating of 5 V - until higher attenuation is selected or the overload relay opens.

AB2 Mixer board
Circuit diagram : Foldout 6.

25. This board contains the double-balanced mixer used for input signal frequencies below 56 MHz and the sampling gate mixer which, together with its associated circuits, forms a separate sub-assembly (AB2A) on a low-loss board material that is mounted onto the main board by its interconnections. The principal functions of AB2 and AB2A are shown in the block diagram of Fig.4-4 in similar spatial relationships to that of the circuit diagram, so that rapid location of any problem area is simplified by the use of both diagrams in association.

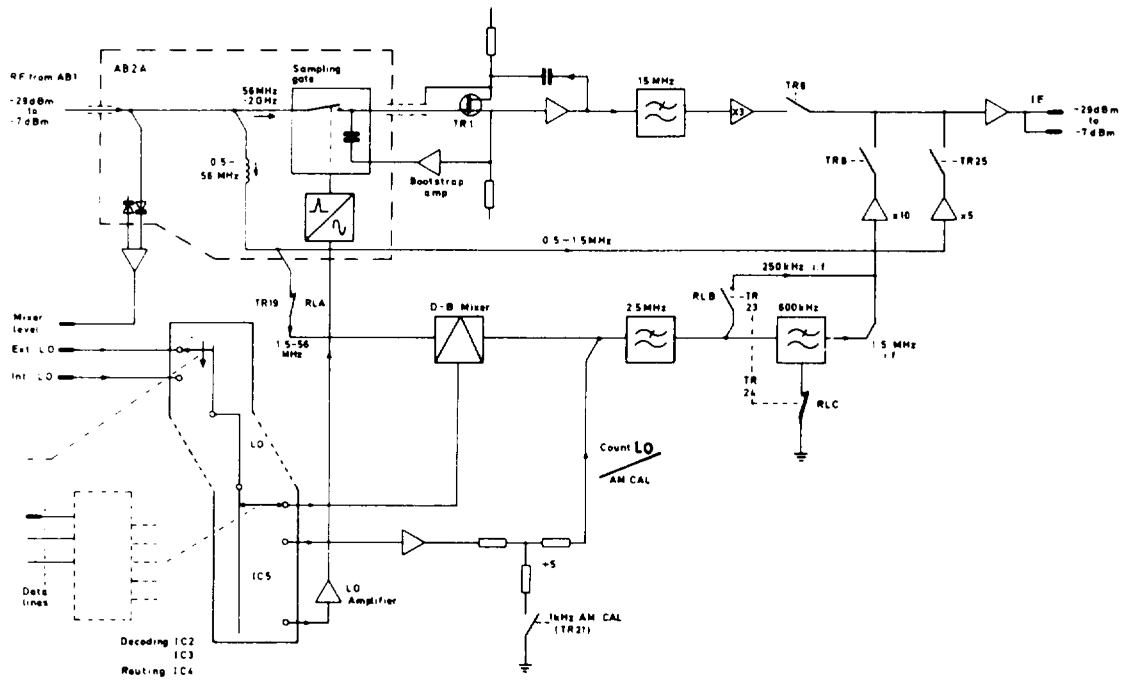


Fig.4-4. Mixer board AB2 - block diagram

26. In the board design, gain distribution is arranged so that the conversion loss is a nominal 0 dB between the r.f. input terminal SKBB and the i.f. output from PLBJ of all frequencies. The signal received from the ABI (input attenuator) board is limited to a maximum of -7 dBm at SKBB by the action of the microprocessor in introducing 7 dB increments of attenuation as input signals are increased above this level to the specified permissible maximum of +30 dBm. (The insertion loss of AB1, with all 5 switchable elements out of circuit, is 2 dB). As input levels fall attenuation is removed, keeping the SKBB signal within a nominal 7 dB window of -7 dBm to -14 dBm. In practice, tolerance and hysteresis in the switching action can result in the -14 dBm limit dropping several dB in certain circumstances. Signal inputs falling below this threshold are unattenuated and so the full dynamic range at the input to AB2A (corresponding to the specified dynamic range of input signal of +30 dBm to -27 dBm) is -7 dBm to -29 dBm. As the AB2 conversion loss is 0 dB the same range of levels at frequencies within the i.f. range will appear at the output PLBJ.

27. Signal routeing within the board is accomplished via seven switching transistors in response to the instructions carried on the 3 latched control lines DI, D2 and D3. The instructions are decoded by IC2 and routed by IC4 and IC5 in accordance with the patterns shown in Table 5 below. During the auto-tuning sequence the board is operated in the sampling gate mixer function. After the input signal frequency is identified, the signal is routed through the board according to frequency and the design requirements as shown in Tables 5 and 6.

TABLE 5. MIXER BOARD AB2 (part one)

State of control data and switching elements vs instrument functions

	Address A4L1 Control data					Switching elements							
	Line	D3	D2	D2	D0	Transistor	TR6	TR8	TR19	TR21	TR23	TR24	TR25
	PLBH pin	4	3	2	1	Relay	-	-	RLA	-	RLB	RLC	-
Signal frequency 0.5 to 1.5 MHz (both mixers by-passed)		L	L	L	-		X	X	0	0	X	0	0
Signal frequency 1.5 to 5.5 MHz (double-balanced mixer-250 kHz i.f.)		L	L	H	-		X	0	X	0	0	X	X
Signal frequency 5.5 to 56 MHz (double-balanced mixer-1.5 MHz i.f.)		L	H	L	-		X	0	X	0	X	0	X
Signal frequency 56 to 2000 MHz (sampling gate mixer-1.5 MHz i.f.)		L	H	H	-		0	X	0	0	X	0	X
Count L.O. (L.O. routed to counter/limiter)		H	L	L	-		X	0	0	0	X	0	X
AM trough		H	L	H	-		X	0	0	X	X	0	X
Internal L.O.		-	-	-	H								
External L.O.		-	-	-	L								

X = Switch or Relay closed, Transistor ON
0 = Switch or Relay open, Transistor OFF

The DO control line is used to switch between the internal and external local oscillators. Signals up to 56 MHz will pass from SKBB through the network LI, R2, R3, R4 and thence to the main AB2 board via pin and socket 4. This network introduces a 6 dB loss at low frequencies and defines a 50 n system. At higher frequencies it provides a measure of buffering between the low frequency system and the input circuit for the sampling gate. The subsequent processing of signals below 56 MHz differs for each of 3 separate bands of frequencies.

TABLE 6. MIXER BOARD AB2 (part two)

State of circuit functions vs. state of switching elements

Switching elements		Circuit function	Switching element state X	0
TR6		Sampling gate output	Off	On
TR8		Double-balanced mixer output	Off	On
TR19	RLA	Double-balanced mixer input	On	Off
TR21		AM trough generated	On	Off
TR23	RLB	600 kHz i.f. filter, bypass	Out	In
TR24	RLC	600 kHz i.f. filter, shunt path	In	Out
TR25		Mixer bypass path	Out	In

State of circuit function controlled

Signals from 0.5 to 1.5 MHz

28. The signal is passed without frequency changing via buffer potentiometer R75, R76 and C59 to TPI4 and the output stages TRIO and TRII. Amplifier TRIO has a voltage gain of x5 which compensates for buffering loss. The emitterfollower TRII provides isolated drive to the a.m. detector AB7 and to the 'count i.f.' via AB6.

Signals from 1.5 MHz to 5.5 MHz 29.

29. To tune to this band, the microprocessor will cause line DI to go high resulting in the x5 amplifier TRIO being disabled and the xl0 amplifier TR9 made active. RLA is closed, so applying the input signal to the mixer XI. Transistors TR23 and TR24 act as a toggle and switch the 600 kHz low-pass filter in and out of the i.f. channel as required. For this band of frequencies the filter is in.

Signals from 5.5 MHz to 56 MHz

30. Treatment of these signals is similar to that given to the previous band except that RLB and RLC are caused to change over, thus taking the 600 kHz filter out of circuit.

Signals from 56 MHz to 2 GHz

31. Above 56 MHz, signals are routed to the sampling gate mixer instead of to mixer XI. Accordingly RLA is opened, both TR8 and TR25 are caused to conduct so disabling both TR9 and TR10. TR6 is switched off which activates TR7 and allows the i.f. from the sampling gate to pass to the output stage TR11.

The sampling gate mixer

32. The essential sampling gate components are the two diodes Di and D2 and the capacitors C6 and C7 the circuit being, in practice, balanced and not as shown for simplicity in the block diagrams. The diodes are switched by very short fast pulses at local oscillator frequency generated by the step recovery diode D6. The i.f. output is taken off the AB2A board via a high impedance guarded connection to the field-effect source-follower stage TRI. This drives the emitter-follower TR5 which, in turn, bootstraps the drain of TRI and the guard conductors. The bandwidth of the sampling gate at i.f. is increased from 2 MHz to II MHz by bootstrapping the sampling capacitors C6 and C7. This is achieved by the bootstrap amplifier TR2, TR3 and TR4 which takes the i.f. signal from TRI source and feeds it forward to the r.f. return of those capacitors.

Circuit detail (AB2A board)

33. Parts of the copper track pattern are intended to perform as r.f. components. The inductors LI, L2 and L3 are printed and the connection from SKBB is designed as stripline. The local oscillator signal is amplified to 10 V p-p at low impedance in the main board amplifier comprising TRI3, TR14 etc. to TR18. By clamping both positive and negative excursions of the coupling capacitor C14, the bias current through D6 can be set to a level - by a suitable choice of value for CI4 - that gives a very fast turn-off for D6 over the local oscillator octave frequency range. The collapse of current in D6 causes fast voltage pulses to be produced by the inductors L2 and L3 which are effectively joined together by C13 for the duration of the transient. The voltage pulses combine round the circuit C12, C17, D2, DI, C6, Cll, in series so as to turn D1 and D2 on and instantaneously to connect C6 and C7 together to the input signal.

34. Charge is drawn from the input signal into C6 and C7 in sufficient quantity to make up the voltage difference between the input and the bootstrap voltage at R10 and R11. The charging circuit is completed via R11, R12, R13, R14, C9 and C10. As C6 and C7 are charged in parallel, there is no discharge path for the sampled voltage, once DI and D2 are turned off, except via the i.f. output to TRI which has very low leakage. The sampling pulses, however, while turning the diodes on, charge up C6 and C7 in series so that, although there is no net d.c. voltage to earth at the i.f. output point due to this cause, there is produced a reverse voltage across D1 and D2 equal to the series sum of the separate voltages and this tends to approach the peak value of the sampling pulses in series. The shunt network R5, R6 etc., with D5, acts as a controlled leak to these series voltages while neither shunting off any significant amount of the switching current in the 'on' period nor appearing as a leakage path to. the parallel stored sample in the 'off' period. By limiting the D1 and D2 reverse voltage, their turn-on properties are enhanced.

35. The other components in the sampling gate circuit are concerned with enabling the 3 signals - sample pulses, i.f. output and i.f. bootstrap - to be routed without mutual interference. The 1.2p capacitor C8, balances the circuit stray capacitance. The AB2 input signal level (Mixer Level) is monitored by diode D3 buffered by RI. Balancing diode D4 is a selected match to D3 and experiences the same conditions. The diodes are connected via pin/socket combinations I and 5 to the difference amplifier ICI on the main AB2 board and are given 7 pA of forward bias in order to increase sensitivity to small signals.

Circuit details, main AB2 board

36. The detected mixer level voltage is amplified x4.7 and inverted in ICI prior to transmission to the voltmeter section of AC2. The i.f. signal from the sampling gate splits two ways at the output from the source follower TRI. One path is to the bootstrap amplifier TR2, TR3 and TR4. The negative feed- back connection of TR4 round the output half of the long-tailed pair improves the bandwidth and provides a convenient low impedance point from which to extract the output voltage. The other path, via emitter-follower TR5 is to the 15 MHz low-pass filter and the switched amplifier TR7 which, has a voltage gain of x3, before joining the main i.f. channel with the outputs from the other mixer.

37. The AB2 board functions in two other modes, AM CAL and COUNT LO. In AM CAL the local oscillator frequency is set at 1.5 MHz and is routed by IC5 to the emitter-follower TR20. The output from the emitter passes through R80 and R86 to the i.f. system via the 2.5 MHz l.p. filter. R80 and R86 are the upper arms of a nominal .5 T-pad, the stem being formed by R87 when brought into circuit by the action of TR22. TR22 is switched at a I kHz rate by TR2] which itself receives a TTL I kHz signal from the processor via LI, DI and IC2, causing both transistors to turn on and off together, the 'on' state for TR22 being defined by D12 which catches the gate excursion at +0.6 V. R85 and C61 slow up the transitions which might otherwise cause overshoot and ringing in the 2.5 MHz filters with consequent unpredictability in the response of the voltmeter peak detector. The switched +5 pad produces a nominal 66.7% a.m.
with a stability determined solely by that of the three resistors. In practice the resulting a.m. is given precise calibration by reference to a factory standard and it is this value that is stored in non-volatile memory for use in recalibrating the measurement circuits. By tying the waveform mark to space ratio to logic switching, the average value of the rectified half-wave is always precisely half-way between peak and trough excursions thus avoiding the complication of slightly differing peak and trough measurements when calibrating.

38. The COUNT LO mode is used when a counter/synthesizer self check has been introduced via keyboard second function 09. The local oscillator signal from IC5 follows the same path as in AM CAL but the FET switch, TR22, is turned off. The filters see a signal source resistance of R50 + R86 which gives an attenuation of approximately 50 dB and an output level of approximately 150 mV p-p to the Counter limiter board AB6.

AB3 Voltage-controlled oscillator board (VCO)

Circuit diagram : Foldout 7.

39. The 28 - 56 MHz local oscillator signal is generated in four separate VCO's each covering frequency bands of approximately a quarter octave (4y-: 1) and switched in as required by the tuning control logic. This sub-division of the oscillator ranges into four confers the following advantages :

(1) Tuning over a quarter octave can be effected using commonly available low noise variable capacitance diodes (Varicaps).

(2) Over the full octave the change in oscillator sensitivity (frequency change for a given control voltage change) is less than would be the case with a single oscillator and this eases design problems within the phase-locked loop.

(3) Over the full octave the average oscillator sensitivity is less and, accordingly, oscillator sensitivity to noise on the control line is also less.

(4) The oscillator adjustment needed for minimizing the production of f. . noise is more effectively accomplished over the smaller bands covered by the individual oscillators.

40. Each oscillator contains all the individual tuning elements, including varicap, necessary for its operation as well as its individual maintaining amplifier (one of JFETS TR5 - TR8). The JFET amplifiers are controlled from the data bus via the lines L2DO to L2D3 so that only one oscillator can be active at any one time. An oscillator is turned on when its control line goes high (+5 V) causing its control transistor (one of TRI to TR4) to change from the cut-off to the conducting state and so biasing its associated JFET on. The active oscillator draws source current via its switching diode (one of D7 to Dl0) and R14 in the gate circuit of the buffer stage TR9. The other oscillators remain isolated by their non-conducting switching diodes. The active oscillator is coupled into TR9 by the passage of its signal current through L13 and R14 in the gate circuit of TR9. This causes TR9 to act as a source follower and drive the TTL translator TRIO which in turn switches the inverter stages in ICI and 2. Tuning control for the oscillators enters at PLBN and operates over the range 0 V to -10 V corresponding to fmax and fmin respectively in each oscillator.

41. From the inverter stages, one l.d. output is taken via PLBP to the programmable dividers on AB4 board. The other buffered output goes to the programmable binary dividers IC3, IC5, IC6 and IC7 which divide by 2n (n = 0...5) in response to the control lines L3DO to L3D3. The binary divider is used to provide 1.o. steps for input signals below 28 MHz. The tuning control voltage (varactor control) comes from one or other of the two phase detectors on the AB4 board. These detectors compare the reference oscillator phase with that of the frequency-divided local oscillator signal and form a phase- locked loop. The control data for the local oscillators is given in Table 7 below. Note the fifth control state : 'all oscillators off'.

TABLE 7. CONTROL DATA - LOCAL OSCILLATOR

Oscillator range MHz	*Range No.*				*Address A4L2 Control line D3 D2 D1 DO*
28.00 - 32.99	0	L	L	L	H
33.00 - 39.99	1	L	L	H	L
40.00 - 46.99	2	L	H	L	L
47.00 - 56.00	3	H	L	L	L
Oscillators OFF	-	L	L	L	L

The control data for the binary divider is shown in the table below.

TABLE 8. CONTROL DATA - BINARY DIVIDER

Address Divisor	**A4L3 Control line**			
D3	D2	D2	DO	
1	L	L	L	L
2	L	L	H	L
4	L	L	H	
8	L	H	H	H
16	L	H	L	H
32	H	H	L	H

42. The remaining circuit on the AB3 board contains the overload detector amplifier and the trigger and trip stages. A d.c. analogue of the r.f. input power is passed from the detector on the ABI board to pins I and 2 of PLBR and from there to IC8 with the connection sense that causes an increasing r.f. input to increase the voltage negatively at the inverting input. IC8 is arranged to produce a voltage gain of 2 at the single-ended output which in- creases positively with increasing r.f. input. This output is routed to the voltmeter board AC2 for processing prior to display and also to the trigger stages via IC9 a second op/amp arranged to have a voltage gain of approximately x3.

43. In the normal operating (reset) mode with an r.f. input to the 2305 within its specified dynamic range, all the output transistors TRII, TRI2, TRI3 and TRI4 will be conducting hard so that most of the +5 V supply is connected between PLBR pins 4 and 5 which connect to the operating coil of the overload protection relay RLA in unit ABI so keeping its contacts closed. TRI2 and TRI3 are d.c. cross-coupled with two stable states. As part of the routine for establishing the instrument's initial status at switch-on, the reset line is caused to take the collector of TRI4 low. The switching leading edge is passed via C42 causing TRI2 to conduct and ensuring that the normal conducting state is established.

44. When the instrument input is overloaded, the positive excursion at the inverting input of IC9 passes into the switching region preset by R33 so causing TRII to be cut off. As the current through TRII and the coil of RLA falls, the regenerative action is passed to TR12 and TRI3 so causing a rapid change to the stable cut-off state. The two diodes connected across the coil of RLA in unit ABI allow the e.m.f. arising from the collapsing magnetic field to reach 24.V thus speeding up the charge transfer in the two de- coupling capacitors associated with the interconnection via the mother board ABO but without risk of damage to the transistors so speeding up the circuit break. The state of the trip circuit is monitored and buffered by TRI4 which takes the Tripped/Reset line high in the trip condition and causes the over- load lamp to come on.

AB4 Programmable divider board
Circuit diagram : Foldout 8.

45. In addition to the programmable divider, this board contains the two phase detectors used in the synthesizer phase-locked loop. One is a narrow band detector used for the main tuning of the synthesizer to lock the local oscillators in increments of 10 kHz. This is called the 'c.w.' (continuous wave) mode to distinguish it from the other, 'calibrate' mode in which a faster detector is used, in a well-damped loop, to lock the synthesizer frequencies, without overshoot, at each of the two frequencies between which it is switched at a I kHz rate.

46. The local oscillator signal enters the board via PLBP and is squared up by two TTL inverters IC7a2 after which it is fed to the programmable divider. The programmable divider is supplied with the required division instruction in the form of a 4 digit, 9's complement number that is stored in binary form in the two latches ICI and IC2*. To divide by 3444, for example, the 9's complement 6555 is loaded and when the presettable decade counters reach 9999, they reset to 6555 and count 3444 before resetting again, so achieving the required ratio.

47. In order to avoid lost counts which could occur at high oscillator frequencies during the counter reset and loading time, an early decode' scheme is used. The multiple input NAND gate ICIO is connected so as to detect the count state 9995 and then to provide a reset pulse. This allows the resetting and loading process to be spread over the next four cycles of the local oscillator signal which are counted by the dual flip-flop IC9. This stage then enables the input counter to register the fifth count as the first of a new division cycle. The mechanism by which this action is achieved may be better understood following reference to the programmable divider.

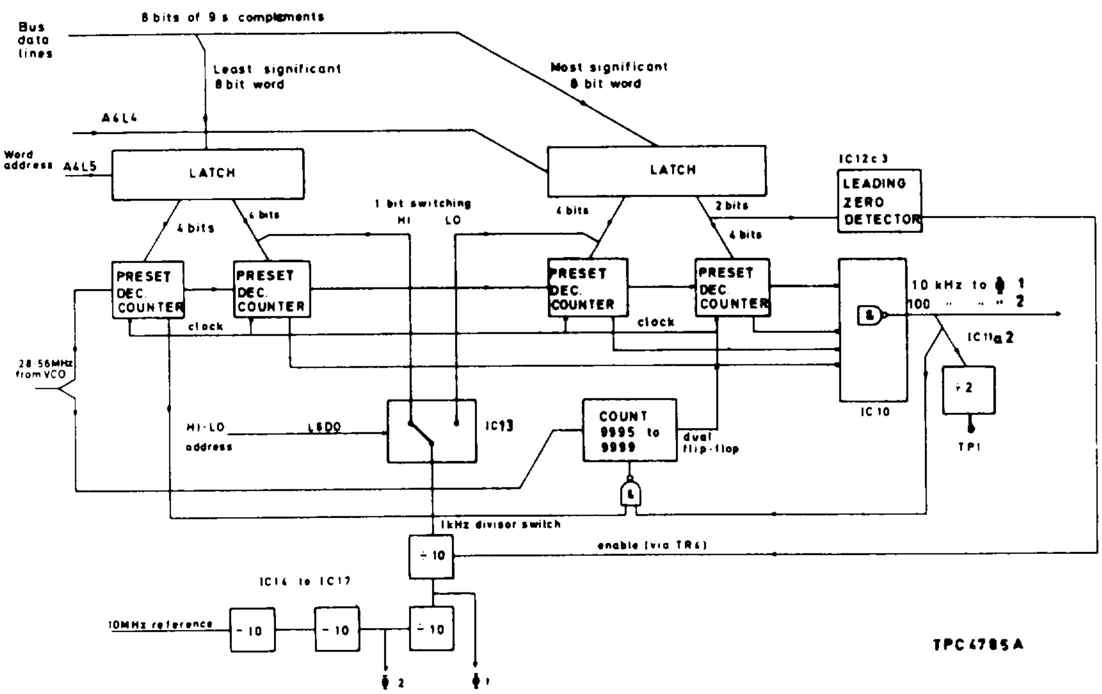


Fig. 4-5. Programmable dividers and f.m. cal. drive

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*A detailed account of the method of binary coding appears later in the AB4 section.

48. After frequency scaling by the programmable divider, the local oscillator signal for the phase detectors is taken from the ICIO output. In normal, c.w., operation the division ratio to give the required 10 kHz for phase detection will be between 2800 and 5600. For f.m. calibration purposes a sample and hold phase detector with a reference frequency of 100 kHz is used and, when f.m. cal. is programmed, the division ratio will, accordingly, have only 3 significant digits and a leading zero. IC12c3 recognizes the leading zero when the division instructions are registered by the latches and takes the line to TR4 high. TR4 collector then goes low so enabling IC17 to scale a I kHz output - the modulation signal - and changing over the relay RLA to select the loop signal from the CAL. instead of the c.w. phase detector. As an aid in fault finding, the narrow output pulses from IC10 are converted into square waves at half frequency by IClla2 and are made accessible at TPI.

CW phase detector

49. The main components are IC21, IC13b2 and the circuitry to the right. Reference should also be made to the diagrams in Fig.4-6and Fig. 4-7, Reference and local oscillator signals are supplied as 10 kHz inputs to IC21 from the divider chain IC14, IC15, IC16 and from ICIO respectively. A positive edge on either channel will change the state of the output from the flip-flop on that channel. A coincidence in the output polarity of both flip-flops causes a reversal of the NAND output of the opposite kind, so the arrival of the positive lagging edge sets the NAND output to zero which then resets both the flip-flop states to zero. With in-phase signals therefore, the output pulses will be identical but of opposite polarity and having pulse lengths dependent only on propagation times. However, as one channel starts to lag the other, the time at which the state of the leading channel is reversed will be progressively delayed so that the average level in that channel will increase with phase difference. The waveforms shown in Fig.4-6were as seen on a representative instrument using a 50 MHz oscilloscope. It can be seen that for phase lock to occur, the loop constants require the divided VCO input to lead the reference by about 20 ns. Because of inevitable small differences in the Q1 and Q2 output pulse shapes, it is difficult to see the effect of this small error signal in increasing the energy in the Q2 pulse which provides the required sense of an increasing negative output for an increasing lag in channel 1.

50. The complementary pair transistors TR5 and TR6 are biased off by the forward drop of diodes D2 and D3 in their emitter circuits. The voltage pulses of opposite polarity from the Q and Q outputs turn on either TR5 or TR6, depending on the lead/lag relationship, for a net duration which depends on the phase difference. Thus, for zero phase difference there will be short equal and opposite pulses of current in the collector circuit producing zero net charge in the output capacitor C31. As one channel starts to lead, the transistor in that channel will be turned on for a progressively longer proportion of the total time, so charging C31 towards the polarity of the power supply to which the particular emitter is returned. The phase lock loop gain is sufficiently high to ensure that lock is achieved in a condition close to zero phase difference and the duration of the pulse in the leading channel is, accordingly, little different from that in the lagging channel, both signals being short, 10 kHz pulses.

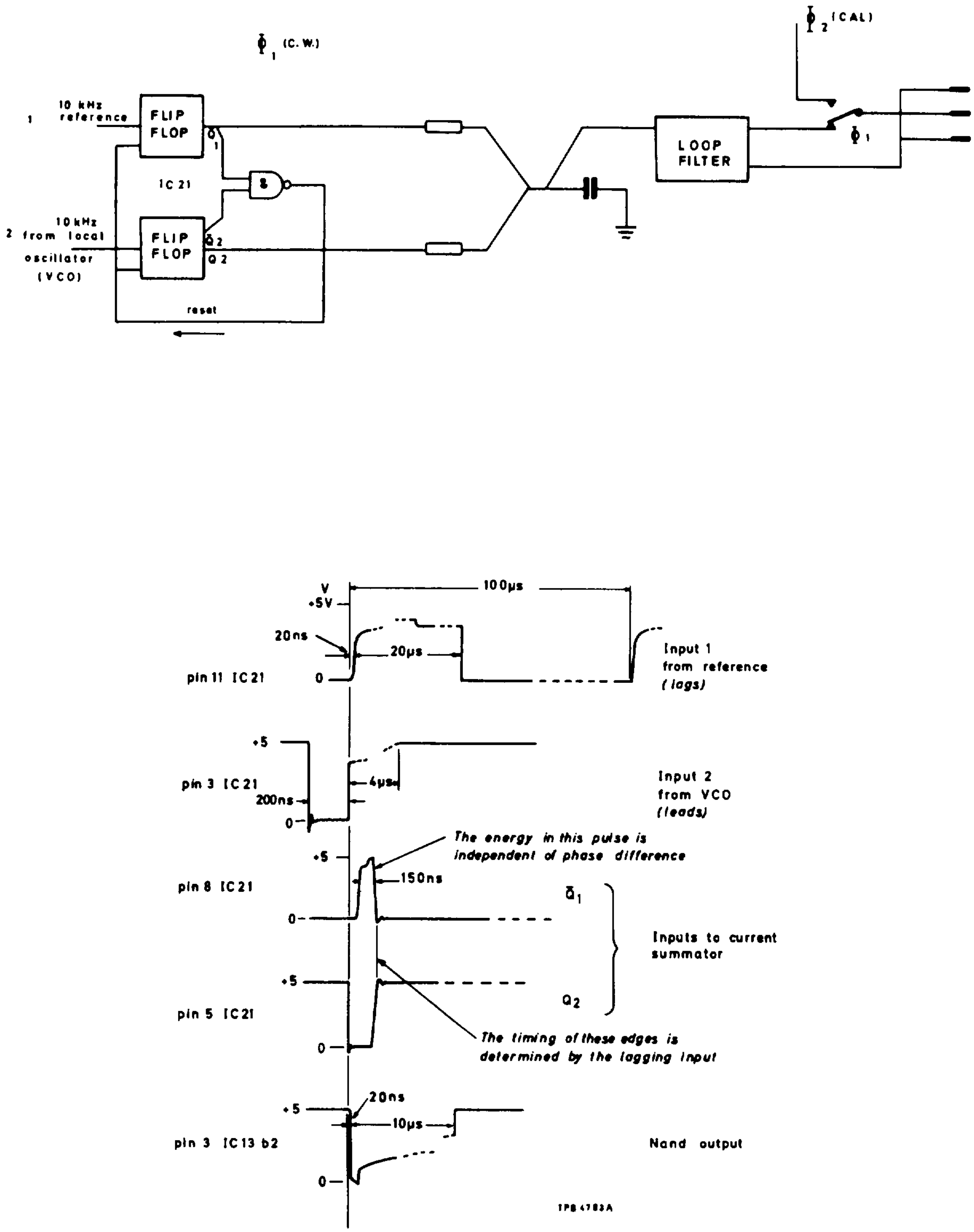


Fig.4-6. CW phase detector and waveforms

51. It will be appreciated that the choice of leading channel in the Fig. 4-6. illustration is arbitrary, as the starting point could equally have been chosen to make input 2 produce the first positive edge and in this case the durations of the waveforms on each channel would be reversed. In practice one condition will be unstable in closed loop conditions and the phase detector will revert to the other.

52. The error signal from the phase detector passes to the local oscillator varactor diodes via the loop filter comprising R28, R29, C31, C32, C33 and C34 which provides the correct loop response and an h.f. cut-off frequency of several hundred Hz. The amplifier IC22 meets any loading imposed by the loop without interfering with the functioning of the filter and ensures that no charge is withdrawn from C31 as this would result in 10 kHz ripple and unacceptable spurious f.m. The final output via relay RLA and connector PLCZ to the varactor diodes has a return signal path that is earthed only at the varactor end so as to remove the risk of earth loop couplings in a very sensitive line.

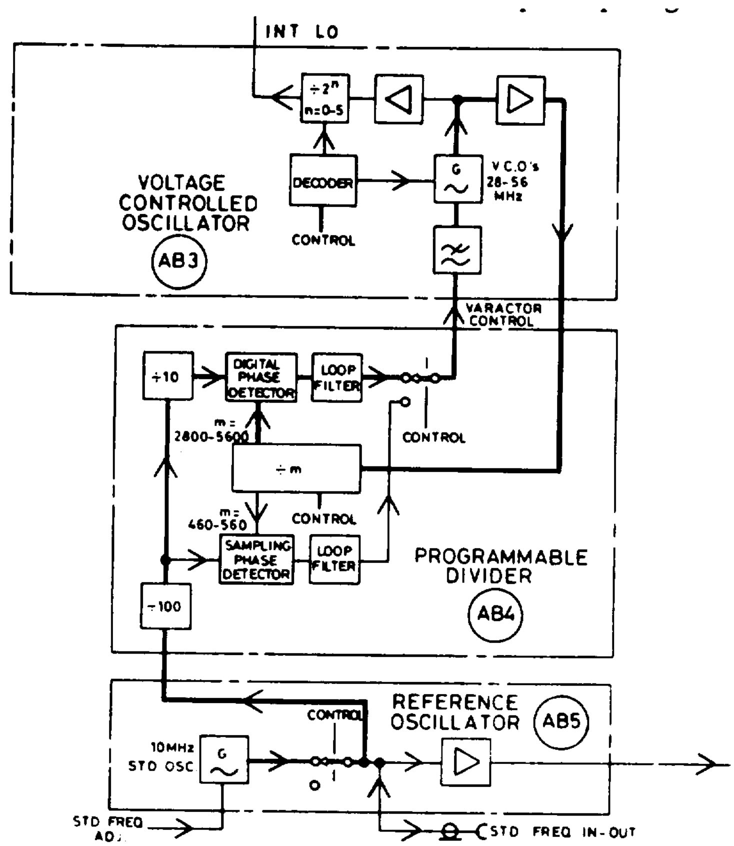


Fig.4-7. Main synthesizer loop, block diagram

FM calibration phase detector

53. The parts of the system actively involved are shown in the block diagram in Fig. 4-8. The remaining circuitry on the board, shown in the circuit diagram to the right of IC10, is the sample and hold phase detector used to switch the local oscillator synthesizer between two locked frequencies at a I kHz rate without overshoot. This requirement could not be met with the 10 kHz phase detector. Two pairs of frequencies are used, 47 MHz/49 MHz and 46 MHz/56 MHz, giving 1 MHz and 5 MHz peak deviation respectively.

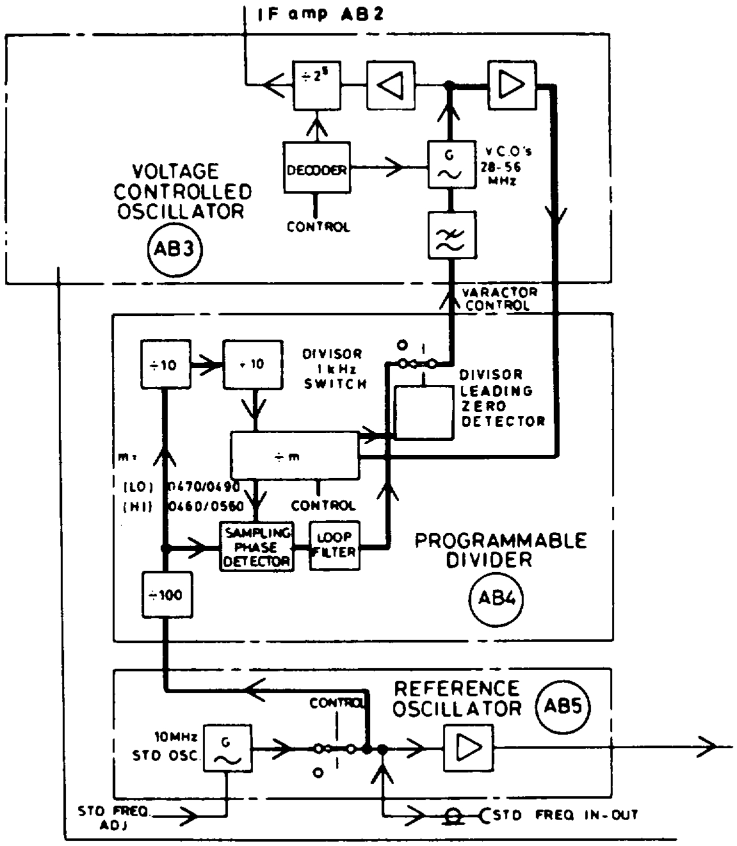


Fig. 4-8. FM calibration : synthesizer loop, block diagram

When subsequently divided by 25 on the AB3 board, this gives deviations of 31.25 kHz and 156.25 kHz on signals reasonably central within the i.f. amplifier pass band.

54. At the heart of the sample and hold detector are the two semiconductor switches in IC18 and the two capacitors which they connect into circuit, the ramp capacitor C11 and the hold capacitor C23. The detector is activated by the output from TR4 going low which enables the extra decade scaler IC17 and the flip-flop ICllb2. The next 100 kHz pulse from IC10 after this event, having turned on TR2 and discharged C11 to an initial condition, clocks a logic high at the pin 8 output of ICllb2 which closes the left-hand switch in IC18 and allows C11 to start charging to a potential defined by D5, C35, R13, R31 and R32. The next 100 kHz negative-going pulse in the reference channel arriving at pin 10 of IC11b2 via TR1 changes pin 8 to the low state and opens the ramp charging switch in IC18. This stops the ramp at a level that is a measure of the time difference between the two channels. The positive-going trailing edge of the reference channel pulse then triggers the monostable IC19 which delivers a short pulse at its output pin 10 after a fraction of a microsecond delay. This pulse briefly closes the right-hand switch in IC18 which samples the static ramp voltage and stores it on C23. The next pulse from IC10 will turn on TR2 and start the cycle again so that the output sample on C23 is updated every 10 us. IC20 is a high impedance buffer and R18/C24 aid loop stability. The main waveforms appear in Fig. 4-9.

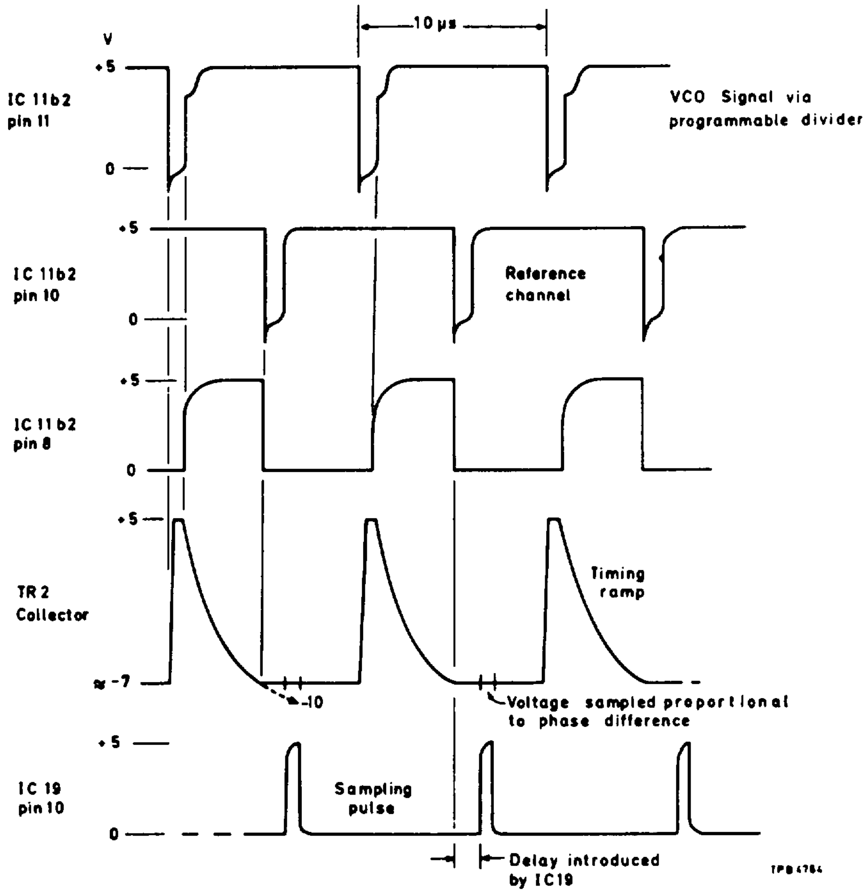


Fig. 4-9. FM calibrate.
Sample and hold phase detector, typical waveforms

55. The switching between the two frequencies that constitute each deviation pair is done by changing just one bit of the programming instruction in each case. The switching signal, at I kHz rate, is generated in IC17 and the bit selection is routed by IC13a2 on instructions via the line L6DO, 'HI/LO' deviation.

BCD control of the divisor

56. Consider a required local oscillator frequency of 43.21 MHz. In order to match the 10 kHz reference, this must be divided by the number 4321. The nines complement of 4321 is 5678 and will be loaded into the divider as follows:

Digit	5	6	7	8
Loaded into	IC6	IC5	IC4	IC3

but the digits will first be translated into binary form thus :

Decimal digit	5	6	7	8
Binary	0101	0110	0111	1000

The numbers are programmed in pairs. The two most significant decimal digits give rise to the most significant 8 bit word and the two least significant decimal digits to the least significant 8 bit word. For latching purposes the data is addressed as follows :

Most significant word address = A4L4
Least significant word address = A4L5

For the above number the data lines would be loaded as below.

Line	D7	D6	D5	D4	D3	D2	D1	D0
Address A4L4	0	1	0	1	0	1	1	0
Address A4L5	0	1	1	1	1	0	0	0

FM calibration

57. The address A4L6 selects whether the high or low deviation ratio is required.

Address A4L6 D0	Divider ratio	Deviation (MHz)
1	0470	1
0	0460	5

The deviations are obtained by manipulating 1 bit in the least significant and most significant binary words to give 5 MHz and 5 MHz respectively.

	Deviation 1 MHz
Divider ratio	0470 to 0490
as 9's complement	952E to 95'
least significant binary words	00101001 to 00001001

The change required is to the third most significant binary digit only.

	Deviation 5 MHz
Divider ratio	0460 to 0560
as 9's complement	39 to E 39
most significant binary words	10010101 to 10010100

The change required is to the least significant binary digit only.

AB5 Reference oscillator board

Circuit diagram : Foldout 9.

58. The oscillator is a self-contained unit which includes a well-regulated oven. The oscillator is switched off by TTL from the microprocessor via PLBW on receipt of a keyboard second function instruction to change to an external standard. In the absence of such an instruction the line from PLBW stays logic high which, after a double inversion in TRI and TR2, presents a high to pin 3 of the oscillator. The crystal oven remains energized so long as the instrument is switched on and does not de-energize when the instrument switches to external standard.

59. Fine adjustment of the internal standard is carried out via a potentiometer on the rear panel which supplies pin 5 of the oscillator from a voltage source that is very accurately defined by diode Dl. Signal switching between internal and external sources is carried out in ICI in response to Internal/ External commands to pin 6 and (inverted) to pin 2. The effect of the switching is to route whichever source is selected to the synthesizer (via PLBU) and to the counter (via PLAF and the mother board). The internal oscillator signal path is also taken to the rear panel connector STD. FREQ. IN-OUT via a buffering resistor so that, when in local mode, the 10 MHz reference signal is available for monitoring or other purposes.

<u>AB6 Counter limiter board</u>

Circuit diagram : Foldout 10.

60. The purpose of the counter limiter is the conversion of the i.f. signal to TTL levels in order to drive the counter. There are two inputs. One is taken from the Mixer board AB2 in order to enable the wide band (15 MHz) output from the sample and hold mixer to be counted during auto-tuning but also so that the l.o. frequency can be counted when this is routed via AB2. The second input takes the much more narrow-band i.f. from the AB7 board where it appears and is amplified at a later stage in tuning.

61. Amplification by the two wide band video amplifiers is followed by limiting at TTL levels in TR4. The low pass filter L2, L3 etc. aids in the removal of residual local oscillator components. Input signal routing is accomplished by TR2 and TR3 and the diodes D2 and D3. TRI provides compatibility with the logic levels received from the data latches on AB11.

AB7 AM detector board
Circuit diagram : Foldout 11.

62. In addition to the a.m. detector, this board contains the main i.f. amplifier and two i.f. detection channels.

IF amplification

63. The products of the mixing processes after preliminary filtering on AB2 board, enter AB7 via PLBJ and pass directly to the i.f. detection circuits via emitter follower IC4a3. The input to the main i.f. amplifier is taken via the 3.5 MHz low-pass filter L1, L2, C4, C5 and C6 which removes unwanted components. The i.f. amplifier stages TR1, TR2, TR3, TR4 and TR5 are shared by both frequency and amplitude modulated signals which subsequently take separate paths. The collector impedance of TRI forms a very high impedance load for TR2 and is shunted by the variable channel resistance of the junction gate FET's TR6 and TR7 which control the gain of this stage in response to the demand of the a.l.c. signal. Some i.f. signal is fed to the inputs of TR's 6 and 7 in order to null out distortion caused by variation of FET channel resistance with the instantaneous amplitude of the i.f. signal.

64. Following the TR5 stage, individually buffered outputs are taken to:

(i) the front panel (IF OUTPUT),
(ii) the f.m. detector and
(iii) the counter limiter.

For the purpose of a.m. measurement, the i.f. signal passes to TR9 which has a frequency-selective network in its emitter circuit which, together with that of TR4 compensates for imperfections in the overall amplitude/frequency response and so inhibits the production of spurious a.m. which would otherwise result from any spurious f.m. in a.m. signals. From TR9 the a.m. signal passes through a 1.5 MHz low pass filter to the a.m. detector (TR's 14, 15, 16 and 19) either directly, or via the 250 kHz low pass filter when the input frequency lies within the range 1.5 MHz - 5.5 MHz. The two i.f. filters ensure that a.m. is measured on the fundamental component of the carrier by rejecting harmonics of the i.f. The emitter-follower stage TR13 buffers the a.m. detector input from the filters.

AM detector

65. Signal voltages at the emitter of TR13 are converted to signal currents in the collector circuit of TR16, As TR14 and TR15 present a high impedance to signal currents, these will pass instead through C37 into D6 (positive half-cycles) and TR19 (negative half-cycles) so that the rectified negative half of the i.f. waveform appears across the TR19 load, R150. The carrier (i.f.) component of this waveform is removed by the active filter built around IC3 leaving just the audio component - proportional to modulation depth - and the d.c. component - proportional to the carrier average value - at the output plug PLCF.

ALC

66. The d.c. and audio components are separated by an RC time constant made up from one of R51 to R55 with C46. The time constants are switched by IC2 so that the slowest circuit is only brought in when the lowest audio frequencies (as signalled by the filter in use) are being measured. This ensures that the speed of measurement response is always optimized. Any residual audio component on the a.1.c. line would cause degeneration and, consequently, an error in a.m. measurement.

67. The a.1.c. signal is passed to the differencing amplifier IC1 together with a reference voltage from the potential divider R41, R42. IC1 is connected as an integrator and provides slewing of the transients arising from time constant switching. The diode D5 catches the output at zero potential and eliminates any positive transients. The negative a.1.c. voltage at the gates of the FET's changes the i.f. gain in the way necessary to reduce the net input to IC1 to zero and so defines the carrier average level at the a.m. detector. Open loop checks can be made by removing the mini-jump connector and applying a d.c. control to TP1.

IF detection circuits

68. The full 15 MHz bandwidth i.f. signal is also taken from PLBJ to two i.f. detection circuits which are needed for auto-tuning purposes and for fault diagnosis. The signal is given x4 voltage amplification in IC4a3 before splitting into two paths each terminating in a detector. In the upper path the amplified signal is detected in IC4b3. In this detector, the lower transistor serves to provide accurate stabilization of the working point. The upper transistor conducts readily on positive half-cycles charging the capacitor C59 to the peak positive emitter excursion. On negative half-cycles, the transistor cuts off and the emitter remains held by the reservoir capacitor. This detected peak is passed to the voltmeter section via PLCC to provide evidence of the presence of an i.f. signal for setting up and diagnostic purposes (IF Level). It also provides one input to the differencing amplifier IC5.

69. In the lower path, further voltage gain of about x3 is provided by TR17 and this is followed by cascaded low-pass and high-pass filter sections giving pass band of 3 MHz to 11 MHz. Any signal falling within this band is peak detected by IC4c3 an identical stabilized detector to that employed on the upper channel. Detected signals are supplied to the other input of the differing amplifier IC5 which translates the i.f. tuning state into TTL on the IF TUNED line via the bottoming transistor TRI8. LED D9 gives local indication of the state of this line and lights up for logic low.

IF frequency	*LED*	*IF TUNED LINE*
3-11 MHz	OFF	High
otherwise	ON	Low

TABLE 9. CONTROL DATA, IF BANDWIDTH

Filter selection	*Address A4L7*
IF filter	D0
1.5 MHz	1
250 kHz	0

TABLE 10. COlNTROL DATA, ALC RATE
(function of LF cut-off)

ALC rate	*Address A4L8*	
LF cut-off	*D1*	*D0*
300 Hz	0	0
50 Hz	0	1
26 Hz	1	0
12 Hz	1	1

AB8 FM detector board

Circuit diagram : Foldout 12.

70. Input signals to this board originate either from one of the two i.f. systems 1.5 MHz or 250 kHz, depending on the detected input frequency, or from the signal directly which is not subjected to frequency changing when its frequency is less than 1.5 MHz. The input is first amplified and limited via IC1 the output being antiphase squarewaves balanced about 0 V and with amplitude 250 mV p-p. The use of a balanced system up to the frequency discriminator helps to minimize the response to a.m. so that small amounts of spurious f.m. can be measured in a.m. transmitters.

71. The long-tailed pair amplifier TRI and TR2 produces a 2 V p-p signal which drives the precision limiter TR3, TR4, DI to D6 etc. The TR3 and TR4 collector excursions are caught at ±6.2 V, the levels being accurately defined by the low temperature coefficient Zener diodes D5 and D6. The accuracy of the catching levels determines the accuracy of charge transfer made at each stroke of the charge pump on successive positive-going transitions of the drive waveform which occur alternately at C17 and C19. A negative-going edge causes C17 or C19 to be caught by D7 or D8 and charged between the +15 V rail and the negative reference level. The subsequent positive transition first discharges the capacitor concerned and then charges it in the opposite direction between the upper reference level and the zero voltage return of R20 and the pump transistor. The amount of charge that is transferred in this process passes into the emitters of common base stages TR5 or TR6 causing a high impedance equivalent to flow via the collector circuits into R20. The presence of LI and L2 in the TR3 and TR4 collector circuits improves the definition of the charge transferred per cycle by enabling the inductor that is in circuit with the conducting transistor to store up energy gradually in the period immediately following the positive-going transient while energy can readily be supplied from the bottomed transistor to the charge pump. As a transistor is cut off, the back e.m.f. from the associated inductor releases the stored energy and ensures a rapid recharge of the pump capacitor to the negative reference potential. In this process, the inductor supplies energy which would otherwise need to be supplied from C16 via either D2 or D4. The overall effect is to minimize the change of charge in C16 and to speed up the pump charge and discharge times so that the charge pumped per cycle is independent of frequency. A linear voltage rise at the integrated output is ensured, within the limits of the power supply voltage, by the isolation given by the collectors of TR5 and TR6.

72. As the pump transfers charge on each half-cycle of the input square wave, the voltage appearing across R20 is at twice the frequency of the i.f. and this, coupled with the 13 V p-p swing of the limiter output produces a high sensitivity to f.m.. As the charging potentials are precisely defined by the limiter, and as each capacitor completes a charge/discharge cycle within one period of the i.f. up to the highest i.f. components, the rate at which charge flows through the I kO load depends only on frequency. The 450 kHz low-pass filter removes the doubled i.f. components when the nominal 1.5 MHz i.f. is selected. The 30 kHz l.p. filter is selected for use with the 250 kHz i.f. The filters are also used to remove i.f. components from the a.m. detector output which enters the board at PLCF. The relays RLA, RLB and RLC associated with filter switching are controlled by transistors TR7, TR8 and TR9 via PLCJ. The ferrite bead Xl prevents spurious oscillation in a loop involving the charge pumps without significantly affecting filter performance.

73. Audio output from the board is at PLCK and at this point 100 kHz f.m. deviation or 100% a.m. produces a signal of approximately 600 mV p-p.

TABLE 11. CONTROL DATA AM/FM DETECTOR SWITCHING

AM/FM modulation	*Address A4L9 D0 line*
AM	0
FM	1
Filter	*D1 line*
30 kHz	0
450 kHz	1

AB9 LF amplifier board

Circuit diagram : Foldout 13.

74. The performance requirement for this board is for a gain of 60 dB of which 50 dB is switchable in 10 dB steps. The other basic needs are : -3 dB bandwidth, 0.3 Hz to 450 kHz, output, 9 V p-p (full-scale). There are also stringent requirements for phase and non-linear distortion to be compatible with the specification for the l.f. output : 0.15% t.h.d. and a stereo channel separation of 50 dB at l kHz.

75. The amplifier has 3 a.c. couplings in the forward path which remove d.c. offsets present in the input and those arising from the operational amplifiers in the circuit. The a.c. couplings are required to have long time constants for an extended low frequency response but without the inconvenience of high value capacitors. The requirement is achieved by the use of a bootstrapping technique in which a portion of a gain stage output voltage is fed back in phase with the input to the return point of the coupling resistor thus increasing its effective resistance many times. The technique is used around the first gain stage (IC1, 10 dB) via R3, C2, R1 and R2. The resistor values are carefully chosen to optimize the low frequency response. A similar technique is used for the other two a.c. couplings which accompany the unity gain buffer stages.

76. Switchable gain is provided by IC4, IC7 and IC9 which, in conjunction with their associated electronic switches IC3, IC6 and IC8 provide stage gains of 20 dB, 20 dB and 10 dB respectively. The IC types LF357 used in the 20 dB stages were chosen for their high, bandwidth and slew rate. The non-switched 10 dB input stage is designed for low noise and, with a noise threshold lower than that of the f.m. demodulator and of the synthesizer, it contributes very little to the overall noise performance.

77. The long coupling time constants create a settling time problem as both the f.m. and a.m. demodulators have d.c. output components which vary considerably during the tuning process. If the amplifier had much gain switched in, it would become blocked-off during tuning for unacceptably long periods. The difficulty is overcome by transient suppression circuits around TR1, TR2, TR3 and TR4, which reduce the charging time constant by providing low resistance charging paths to ground potential for the coupling capacitors while tuning is carried out. Information concerning the tuning duration passes from the microprocessor to TR6 which translates the TTL instruction into a -15 to 0 V swing and turns the FET transistors TR1 to TR4 on.

78. A somewhat more elaborate arrangement is required for IC1 as this amplifier has a bipolar input which draws a finite input current. When transient suppression is on, the output of IC1, which is normally close to zero volt , is connected by TR2 to the inverting input of IC2. As the output from IC2 is simultaneously connected via TRI to the non-inverting input of IC1, a d.c. degenerative loop is formed in which IC1 output is forced near to zero volts by the amplifying action of IC2 which consequently provides any necessary input current to IC1. The effect of this is for IC1 to be released from transient suppression in its proper operating state with C1 in its normal state of charge. The diodes Dl and D2 limit the excursions of IC2 output while transient suppression is switched in and out. The other two a.m.
couplings feed into MOS operational amplifiers which exhibit no shift in operating point when their inputs are released at the close of transient suppression.

79. The 500 kHz low-pass filter gives attenuation of any residual h.f. components in the amplifier and supports the action of the 450 kHz filter in the output of the f.m. detector on the AB8 board. The output from IC11 is monitored before it leaves the board by the ranging detector constructed around IC12. Signal positive peak values are stored on C33 which is discharged during tuning by TR5. The C33 voltage is used by the microprocessor to switch the amplifier to an appropriate range. It is necessary to make ranging decisions at this point rather than subsequent to the pass band shaping that occurs on the filter board as high frequency signals might otherwise overload the amplifier and remain undetected after attenuation in the filters.

80. Range switching is designed to provide a normal 10 dB range of 2.8 V to 9 V peak-to-peak at the output (approximately I V to 3 V r.m.s.). The interpretation of the subsequent detection process on the AC2 Voltmeter board by the microprocessor takes account of the gain switching state in AB9 when preparing the measurement display which it does solely on the basis of presenting four significant digits and no leading zeroes. It follows that 'range' changing in AB9 will not be accompanied by any observable effect in the display.

81. In order to prevent frequent random ranging in AB9 being caused by the presence of noise with signal, an immunity to peak noise of at least 10% of signal is obtained by building in 20% hysteresis into the process in which the microprocessor examines the C33 voltage and makes range changing decisions. The effect of the hysteresis is shown in *Figure 4-10.

82. Consider an input lying within the 30 dB range. As the demodulated signal at the amplifier input increases to the 0.28 V p-p level, the output level approaches the 9 V p-p full-scale value. As further increase in the input takes the amplifier into the shaded 'over-range' region, the output continues to rise linearly until the UP threshold is reached, possibly due to an instantaneous random variation in the modulation level, and the amplifier is triggered into the 20 dB range. The amplifier output then falls by 10 dB to a level 20% above range minimum. The important point is that for a return to the 30 dB gain range to occur, the signal voltage level must fall by 20% from the value that triggered the switch to up-range i.e. to the 20 dB gain range nominal minimum. So a signal having an average peak value in the middle of the hysteresis zone may have added random fluctuations of up to ±10% before range switching will try to follow the same random pattern. It will be apparent that the mid-zone signal is the worst case for noise immunity in range switching and at other levels the tolerance is greater.

83. The modulation measurement levels that correspond to the nominal range full-scales are given in Table 12 below for each type of modulation.

TABLE 12. CONTROL DATA, LF AMPLIFIER RANGES

AB9 switchable gain range	*Range full-scales*			*Address A4L10*		
	a.m	*f.m*	*∅.m*	*Lines*		
dB	*%*	*kHz*	*rads*	*D2*	*D1*	*D0*
0	500	500	H	H	H	
10	150*	150	150	H	H	L
20	50	50	50	H	L	H
30	15	15	15	H	L	L
40	10	5	5	L	L	H
50	5	1.5	1.5	L	L	L

Transient suppression : Line D3, Suppression ON, line H. OFF, Line L.

* 100% is the practical limit for a.m. measurement.

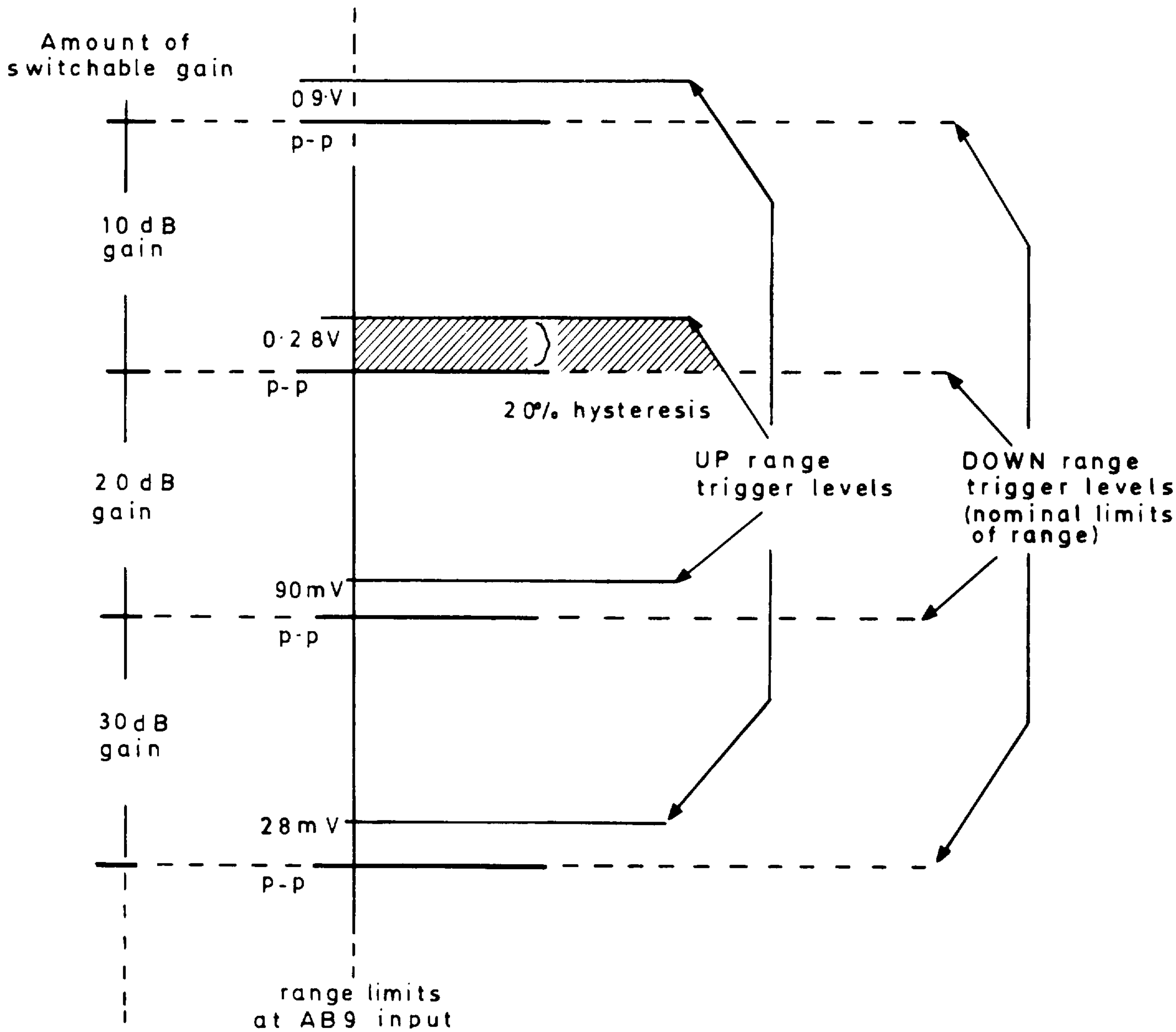


Fig.4-10. Effect of hysteresis in amplifier range changing

84. Non-steady state modulation such as that deriving from speech or entertainment signals will cause the amplifier to auto-range over the signal dynamic range at a rate determined by the 0.15 s time constant of the range detector. In this case, if the LF OUTPUT is required to be an accurate reproduction of the modulating signal over its full dynamic range, it will be necessary to inhibit auto-ranging, and hold a range that can accommodate the maximum modulation level, by second function keying.

AB10 LF filter board

Circuit diagram : Foldout 14.

85. The LF filter board contains the four band-pass filters that may be introduced into the demodulated signal channel by operation of the front panel keys. The fifth band-pass characteristic is the one which is obtained when all the filter elements are switched out. The pass bands are as follow :

Key	-3 dB bandwidth	-1% voltage bandwidth (flat)
30 - 50k	12 Hz - 125 kHz	30 Hz - 50 kHz
50 - 15k	50 Hz - 15 kHz	125 Hz - 6 kHz
300 - 3.4k	300 Hz - 3.4 kHz	750 Hz - 1.4 kHz
65 - 250	26 Hz - 625 Hz	65 Hz - 250 Hz
10 - 300k	0.5 Hz - 400 kHz*	10 Hz - 150 kHz

* As this pass band is dependent on overall circuit performance and is not defined by a filter, the characteristic is necessarily approximate.

The board also contains the de-emphasis circuit, which provides 3 time constants, and the phase detector roll-off that is brought in automatically when ∅.m. is selected but which is not accessible for use with other functions.

86. Demodulated audio signals arrive from the LF amplifier board (AB9) at plug PLCN and are routed through the active filter elements by the analogue multiplexers which are driven from the instrument bus via the latches board (AB11). Each filter has separate high-pass and low-pass elements which are selected in pairs. Multiplexers IC1, IC3, select the high-pass sections, IC5 and IC7, the low-pass sections and introduce them around the active elements IC2, IC4 and IC6. All filter sections have third order roll off.

87. Exceptionally, the 15 kHz low-pass section is selected in isolation without a high-pass section. This is for two purposes : firstly in the CALIBRATE mode, unwanted high frequency distortions that could affect accuracy are removed and the risk of introducing low frequency distortion is reduced. Secondly, the low-pass section is selected separately in the keyboard second function intended for measurements of ILS modulation where a high-pass section would cause unacceptable phase distortion between the 90 Hz and 150 Hz tones. The 15 kHz section is retained for noise reduction.

88. After filtering, the signal is routed to the AUDIO IN-OUT jack on the back panel isolated by buffer amplifiers IC8a2 and IC8b2 on each side. If nothing is introduced externally at this point, when f.m. and a.m. functions are employed the signal will be transmitted unchanged to the demultiplexer IC12 for onward transmission to the measuring circuits. It also branches to the de-emphasis and phase modulation roll-off circuits based on the amplifier IC9 and the demultiplexer IC10. When ∅.m. is chosen, IC10 will select the output from IC9. This has the necessary first order roll off for ∅m. demodulation provided by R29 and C45. The stage gain of 18 dB at 300 Hz ensures that the overall gain is the same for both f.m. and ∅.m. functions. The demodulated output will then be routed to the voltmeter by IC12.

89. De-emphasis, when selected, is introduced into the l.f. circuit after the point at which the demodulated l.f. is taken off to the voltmeter measurement circuit so that it takes effect on the l.f. signal made available at the LF OUTPUT socket on the front panel. This signal will also have been acted upon by any network introduced from the options board if one has been installed. In this case, the SINAD and DIST functions will cause the shaped l.f. signal to be routed via IC12 to the voltmeter so that relative measurements can be made. It is also possible as a second function for the de-emphasized signal to be routed to the voltmeter and measured.

90. The LF OUTPUT signal is supplied via the amplifier IC13 which is itself controlled by the LF LEVEL control. The amplifier is protected from the effects of short circuiting by R38 and C58 which, as they are within the feedback loop, do not degrade the output impedance until the rated load is exceeded. The de-emphasis time constants are based on one capacitor C50, which is introduced by TRI and RLA and is used in conjunction with whichever of R33, R34 or R35 is switched in by the demultiplexer IC10.

91. The control data for the various switching functions on AB10 are given in Table 13 below.

TABLE 13. CONTROL DATA, LF FILTERS

Function		*Control line*							
		D7	*D6*	*D5*	*D4*	*D3*	*D2*	*D1*	*D0*
Output to voltmeter AC2 via AC1	Pre de-emphasis	L	L						
	Post de-emphasis	L	H						
	Filter options (AE1)	H	L						
Filter selection	Phase			H	L	H	L	L	L
	50 Hz - 15 kHz						L	L	H
	300 Hz - 3.4 kHz						L	H	L
	10 Hz - 300 kHz						L	H	H
	30 Hz - 50 kHz						H	L	L
	65 Hz - 250 Hz						H	L	H
Calibration	15 kHz LPF			L	L	L	H	H	L
De-emphasis	None			L	L	L			
	50 µs			L	H	L			
	75 µs			L	H	H			
	750 µs			H	H	H			

92. It should be noted that in modulation measurement the voltmeter signal is taken from a point in the circuit before de-emphasis and that de-emphasis is only normally included in the measurement channel when relative measurements are being made. The exception occurs when de-emphasis is introduced via second function 26.

AB11 Latch board

Circuit diagram : Foldout 15.

93. Control data on the 'quiet' bus is decoded and latched on this board for routeing to units in the r.f. box. Exceptions are two octal latches needed for the programmable divider which are with the divider on AC4 and are not on AB11. A summary of the r.f. box latching is given below.

TABLE 14. RF BOX CONTROL SIGNALS LATCHING DATA

Latch no.	*No. Function*	*of data lines*	*TTL latch*
0	Attenuator AB1	3	74LS175
1	Mixer AB2	4	74LS175
2	VCO range & VCO on/off AB3	4	74LS175
3	Binary divider AB3	4	74LS175
4	Programmable divider AB4 (most significant word)	8	74LS273*
5	Programmable divider AB4 (least significant word)	8	74LS273*
6	Phase detector switch AB4	1	½74LS74
7	AM detector IF filter AB7 (1.5MHz/250kHz)	1	½74LS74
8	AM detector AGC speed AB7	2	74LS74
9	FM detector AB8 FM/AM and 30kHz/450kHz filter	2	74LS74
10	LF Amp. AB9. Gain switching and transient suppression	4	74LS175
11	LF filters & de-emphasis AB10	6	74LS74
12	10MHz Standard INT/EXT AB5	1	½74LS74
13	Counter-limiter input AB6	1	½74LS74

* Latches 4 and 5 are on the AC4 board.

AC2 Voltmeter board
Circuit diagram : Foldout 17.

94. The l.f. measurement signal supplied to this board from the l.f. filters enters at edge connector 20 and is passed through an a.c. coupling C28, R67 in order to remove d.c. offsets. After buffering by the unity gain stage IC1a2, it passes to both the average and peak detectors.

Average detector

95. Transistor TRI provides a conversion of the signal voltage to a current source. The transistor current is supplied from the collector impedance of TR2 which has its operating point set by the resistor biasing network R4, R5 and R6 via the amplifier IC2a2. The result is a high resistive source impedance at the collector of TR1. Signal currents are steered according to polarity into the 1k resistors R7 and R8 by diodes D1 and D2. As the negative going half-wave is inverted in IC2b2, the output waveform is a full-wave rectified positive-going version of the input. Capacitors C4 and C5 provide initial averaging of the higher frequency components and reduce the peaks. Final averaging of all frequency components within the post detector bandwidth is carried out in the active filter C6, C7, R9, R10 and IC3a2. The output is protected against random transients by diodes D3 and D4 which catch at +5 V and 0 V.

Peak detector

96. The input l.f. signal is buffered by the unity gain op. amp. ICIa2 which is shared with the input to the average detector. The next stage, IC3b2 is a unity gain stage which can be switched between inverting and non-inverting by the action of the analogue multiplexer IC10 in response to control via the instrument bus and the latch IC17 depending on whether positive or negative peak has been selected. The comparator stage IC4 compares the positive-going output from IC3b2 with the charge stored on the peak hold capacitor C10. If the stored level is less than an arriving peak, the peak will cause the output to D7 to go high, thus charging C10 rapidly with the assistance of the pull-up resistor R14. As soon as the difference is made up, the comparator output slews rapidly negative leaving the peak held in C10 with only very low leakage paths connected to it. This condition relates to the PEAK HOLD operating condition. For normal peak measurement the display must be updated several times per second and this is achieved by addressing the discharge switch TR3 via the decoder/demultiplexer IC16. TR3 discharges C10 towards the -15 V rail at a rate limited by R17 until it is caught by diode D8 at one diode drop below ground potential. The common reference level for the comparator is established at approximately the same point by the 16 V Zener diode D6.

97. The peak detector is discharged before and after each measurement. The interval between discharges is at least 33 ms so allowing a true peak to be captured at the lowest frequency measured. The detector is reset by an address pulse on A5L9. As there is only one peak detector, positive and negative peaks are measured sequentially not simultaneously. In the case of the $\frac{P\text{-}P}{2}$ measurement, the microprocessor requests the peak measurements in turn and then calculates the average from the two quantities. The unity gain buffer IC5a2 buffers the voltage stored on C10 for onward transmissions via

the potentiometer R19, R20, and for backward transmission to the comparator. Diodes D9 and D10 catch the output at 0 V and +5 V so as to protect IC11 from possible transient damage.

Voltage to frequency converter

98. The voltage to be converted is selected from the several potential inputs by the address latched into the 8 channel analogue multiplexer/demultiplexer IC11. The selected voltage is supplied via a unity gain buffer amplifier IC5b2 to one of the resistors (R21) of a summing network supplying the input to an op. amp. integrator IC6. The other two inputs to the summing network are 1) a small bias current via R22, and 2) the output from the precise pulse forming multivibrator IC7. The multivibrator is the last link in a nulling loop beginning with the integrator IC6 output which drives a VCO (IC9) via the inverting, level shifting stage TR4. The VCO output frequency is divided by 10 in IC8 and the IC8 output triggers the multivibrator. As the loop requires the input to IC6 to be zero, the integrated output from IC7 must equal the sum of the inputs due to the input voltage and the bias current via R22. As the pulse formed by IC7 is very well-defined the average current into R23 is accurately proportional to pulse frequency and as the loop gain is high, a current input via R21 will bring about a change in the loop frequency that is closely proportional to the voltage input. Accuracy is dependent mainly on the stability of the pulse-forming components C13 and R24 and of the summing resistors. Within the loop, the VCO IC9 receives a bias of +1.5 V when D12 is not conducting which prevents the frequency falling too low and the oscillator from stopping. The VCO output is a 15 V peak-to-peak square wave which is taken off the board at edge connection 24 for transmission to the counter. The square wave is d.c. restored to between 0 V and -15 V by TR5 and is frequency divided x 10 in IC8 thus ensuring that the duty cycle of IC7 is sufficiently small to make the waveform substantially independent of the device properties. The pulse length is a nominal 6.5 ps. Other points of significance concerning the operation of this circuit are the following.

99. Currents into the null point summing network from R22 and R21 are positive and require the pulses from pin 11 of IC7 to be negative-going. The bias current via R22 gives a reasonably well-defined frequency to correspond to zero voltage input. This frequency is, typically, 25 kHz and the conversion slope is around 250 kHz per volt.

100. The need for high linearity, which follows from the required modulation measurement performance is for a range of 10 dB plus about 20% for range hysteresis.

101. The voltmeter input is grounded before each measurement so that an accurate zero count can be obtained for use in the individual calculations.

TABLE 15. CONTROL DATA, VOLTS TO FREQUENCY CONVERSION

Input	*Address A5L8* *D3*	*D2*	*D1*	*D0*
P-	0	0	0	0
P+	1	0	0	0
Average	-	0	1	0
RF power	-	0	1	1
IF level	-	1	0	0
Zero	-	1	0	1
Mixer level	-	1	1	0
LF level	-	1	1	1

Frequency multiplier

102. The multiplier is required so that low modulation frequencies can be measured by the counter with satisfactory resolution in a 100 millisecond gate time. The chosen multiplication factor of 100 then gives a resolution of 0.1 Hz. The circuit complexity involved in multiplication is less than that which would be required for the generation of reciprocal numbers if the alternative approach of period measurement at low frequencies was to be adopted. The multiplier is introduced for the measurement of frequencies below about 6 kHz.

103. The demodulated audio entering the board at edge connection 20 is amplified x4 in IC1b2. Diodes D15 and D16 limit the drive to TR6 to a voltage of about 7 V peak-to-peak. TR6 and TR7 form a Schmitt trigger stage the output from which is converted to a TTL square wave for transmission to the steering gates in IC15 and to the phase detector reference in IC12 (pin 14). The VCO output, pin 4 of IC12, is also taken to the steering gates in IC15 and, via the +100 stage IC13, to the other phase detector input in IC12. The phase detector output at pin 13 of IC12 is connected to pin 9, the VCO control input, so completing the phase-locked loop around the VCO and the VCO +100 stages and fixing the VCO output frequency at 100 times that of the input.

104. The VCO control voltage is monitored by IC14 where it is related to a reference of +3 V supplied to the non-inverting input. When the l.f. input is less than 6 kHz, the VCO control voltage is less than +3 V and pin 6 is high, taking the collector of TR9 low. The line from TR9 collector switches the steering gates in IC15 so that for inputs less than 6 kHz, the x100 version is allowed through to pin 25 on the edge connector.

105. When the input frequency reaches 6 kHz or thereabouts, the VCO control voltage will pass through the 3 V reference of IC14 and the output will go positive. The output line from TR9 is taken low so allowing the direct, non-multiplied input frequency to pass off the board for counting.

106. The TR9 output connection also provides an input to TR12 so that it can take charge of the state of TR12 when it is released from control by TR11. By this means the microprocessor is informed on line D0 as to whether the x 100 multiplier is in circuit or not and whether the counter readings need to be divided x 100.

TABLE 16. CONTROL DATA, x1, x100 FREQUENCY MULTIPLIER

Address A5L10	
Multiplier	*D0*
x1	0
x100	1

AC3 Counter board

Circuit diagram : Foldout 18.

107. The counter is based on a custom MOS LSI chip, which contains a programmable time base divider, decade counter chain, data latches and data output multiplexer. The counter measurement cycle is completely automatic after it has been initiated by a command from the microprocessor. Selection from three input sources and gate periods of 10 ms and 100 ms can also be made by the processor. Reading of multiplexed data is under the complete control of the processor.

108. The processor controls the AC3 board over an 8 bit data bus (D7 to D0), a 4 bit address bus (A3 to A0), and a data valid line (VALID 1). These lines are common to other parts of the instrument, e.g. voltmeter board, front panel etc., so each function has a unique address on the address bus shown in Table 16.

109. On the AC3 board the address decoding is carried out by IC1, a 1 of 8 decoder. One of the 8 outputs of IC1 (only 7 are used) selected by the address lines A2, A1, A0, will go low, providing A3 is low when VALID 1 goes low. All other outputs remain high. Therefore a function on AC3 will be activated when an address of 010 to 610* is present on the address bus and VALID 1 goes low.

110. Most of the functions on AC3 use the decoded address directly to operate them; i.e. data output enable, start count, stop count, ext. scan, scan reset. The input selection and gate time functions use the decoded address to clock data from the data bus into a latch, the latched output controlling the function.

111. A signal from one of three sources can be measured by the counter. These are the i.f. (from AB6 limited board), the l.f. signal (from AC2 voltmeter), both at TTL levels, and the output of the voltage to frequency converter (from AC2 voltmeter). This signal is at 15 V CMOS levels and is converted to TTL levels by TRI. Data lines DI, DO are latched by address 310 into IC2. IC3 decodes the outputs of IC2 into three lines to enable I out of 3 of the gates in IC5. The other inputs to IC5 gates are the three input signals. The enabled gate in IC5 (IC3 output high) passes the signal to IC6 (disabled gates in IC5 have high outputs) which combines the outputs of IC5 and is also the counter gate, controlled by IC7. When the gate is open (IC6 pin 5 high) the signal passes to the external decade counters IC9, IC10, IC11. The use of external TTL counters enables high frequencies to be measured, because the upper frequency limit of the MOS counters in IC14 is only about 3 MHz. These counters form the first 2 and 1 bit decades of the counter chain (only the .2 stage of IC11 is used) and count data from these is fed into the on chip latches in IC14. The 'C' input of IC14 (pin 27) is also the input to the first MOS counter stage.

112. The 10 MHz reference from AB5 is divided down to 1 MHz by IC4 and feeds the input to the time base divider in IC14 (TBIN, pin 6). This divider can be programmed to divide by 101 to 107, but in this application only $\div 10^4$ and $\div 10^5$ are used. Division is controlled by T4 ($\div 10^4$, pin 10) and T5 ($\div 10^5$, pin 9). A high on the appropriate pin sets the divider to that ratio. This is controlled by catching D0 with address ^{4}10 in IC12. The output is fed to T5 and, complemented by IC13b, to T4.

* Suffix 10 denotes ordinary decimal numbers.

113. The other half of IC12 is used to control the measurement cycle. In its 'normal' state (having completed a measurement cycle and waiting ready for the next) it is reset. The count complete output (Q output, pin 6 IC12) is high and pin 5 IC12 (Q output) is low holding IC7 and the time base divider in IC14 (R9, pin 4) reset, the time base divider output (TB0, IC14 pin 15) is high. When address 010 becomes valid, IC12 is set, the count complete output goes low, and the reset is removed from IC7 and IC14 pin 4. On the next low going edge of the 1 MHz clock at TBIN, TB0 goes low, this is inverted in IC5 and clocks the first D type latch in IC7. IC7 pin 5 goes high, and on the next high going edge of the 1 MHz clock this high is latched into the second D type latch in IC7. Pin 9 goes high and opens the gate, IC6.

114. At the end of the measuring period TBO goes low again (having returned to the high state during the measuring period), clocking the first half of IC7 and causing pin 5 to go low. On the high going edge of the 1 MHz clock this low is transferred to IC7 pin 9, which closes the gate. The rising edge at IC7 pin 8 (output) triggers the first monostable in IC8, which produces a 10 ps (approx.) wide low going pulse from pin 4 that is used to latch the new count data into the latches in IC14, (MEM, IC14 pin 2). The falling edge at IC8 pin 13,when the first monostable period ends, triggers the second monostable which provides complementary pulses to reset the external decade counters, the counter chain in IC14, and the control flip-flop in IC12. IC12 pin 6 (Q output) goes high to indicate count complete, and pin 5 (Q output) goes low, resetting the time base divider in IC14 and applying a reset to IC7. At the end of a measurement cycle the flip-flops in IC7 are in the reset state anyway so this reset has no effect. A rising edge from a valid address 610 will also cause reset pulses from IC8. If this occurred during a measurement cycle (where it would normally be used) IC7 would be reset by IC12 and the gate, IC6, would be closed immediately. This would trigger IC8 in the usual way, resulting in zeroes being latched into the data latches in IC14. The counter is then ready to be started again by a valid address 010.

115. The data output from the counter is fed onto the data bus,via tristate buffers, which are enabled by a valid address ^{5}10- The data consists of:

D7 count complete indicator.	A high indicates that the measurement cycle is complete and the data can be read.
D6 (MSB) digit position address.	Indicates the position of the digit whose data is present on D3 to D0. Ranges from 000 = MSD.
to D4 (LSB) to 111 = LSD.	
D3 (MSB) digit data.	Presented in inverted BCD format, e.g. 710 = 0111 would be read as 1000.
to D0 (LSB).	

116. The data multiplexer is controlled by two addresses, a valid address ^{2}10 resets the multiplex scanner to MSD (scan reset). A valid address ^{1}10 clocks the multiplex scanner (external scan) to read the next digit. (Except for the first ext. scan pulse following scan reset, which has no effect). To read out the 8 digits the procedure would be as follows:

1	Pulse scan reset	-	multiplexer reset to MSD
2	Pulse external scan	-	no change
3	Read data	-	read MSD
4	Pulse ext. scan	-	multiplexer to next digit
5	Read data	-	read next digit
	repeat 4 and 5 for subsequent digits		
16	Pulse ext. scan	-	multiplexer to LSD
17	Read data	-	read LSD

TABLE 17. CONTROL DATA, COUNTER FUNCTIONS

Address					*Data*		*Function*
	A3	*A2*	*A1*	*A0*	*D1*	*D0*	
0	0	0	0	0	X	X	Start count
1	0	0	0	1	X	X	Ext. scan (clock mux scanner)
2	0	0	1	0	X	X	Scan reset (reset mux scanner)
3	0	0	1	1	0	0	Voltmeter
					0	1	LF input
					1	0	IF selection
					1	1	Off (no i/p selected)
4	0	1	0	0	X	0	10 ms gate time
					X	1	01 100 ms) gate time
5	0	1	0	1	See description		Read data
6	0	1	1	0	X	X	Stop count (abort count in progress)

AC4 and AC5 The microprocessor boards

Circuit diagrams : Foldouts 19 and 20.

117. The microprocessor system is contained on the two boards. AC4 holds the 8085A microprocessor and the program memory. The input/output ports and non-volatile memory are on AC5.

AC4

118. The 8085A microprocessor IC2 has an 8-bit multiplexed data/low order address bus which is demultiplexed by latch IC3. IC4 decodes A12, A13, A15 and is disabled by A15 high. It selects one of memories IC5 to IC12 inclusive. IC5 to IC11 are 4k x 8 bit uv-erasable PROMs but only 6 are fitted at present, the socket for IC11 being empty. IC12 is 2k x 8 bit RAM. IC1 provides two chip select lines for AC5 when A15 is high.

AC5

119. IC1 and IC2 each contain 256 bytes of RAM and are used to interface the instrument data buses and EAROM (IC4) to the microprocessor. IC4 provides nonvolatile storage of calibration data, control settings etc. The three ports on IC1 are used to control the data flow in and out of IC4, which is a 4k bit non-volatile read/write memory. Since the memory is arranged as Ik x 4 bit bytes, there are 4 data lines and 10 address lines, so whilst the data bits are on Port C (pins 1, 37-39), the address lines are divided between Port A (pins 21-28), which carries the least significant 8 bits, and Port B (pins 2934), which carries A8 and A9 in addition to the 4 control lines required to instruct IC4.

120. In order to write into or erase IC4, a supply of -30 V must be made available. To avoid accidental corruption of the stored data, this supply is made software switchable (via pin 35 of IC1 Port C), and incorporates protection circuitry to avoid accidental enabling of the supply when switching on and off. The -30 V is generated by a diode-capacitor voltage doubler (D5, D6 and C9, C10) fed from TR6 and TR7, which are in turn driven by an oscillator, part of IC3. This is switched on or off by TR2 and TR3. TR4 and TR5 form a network to detect the failure of the +5 V supply when the instrument is switched off, ensuring that the oscillator is also held off. TR8 and TR10 ensure that whenever the oscillator is stopped, the -30 V supply is pulled up to +5 V: TR9 acts as a buffer to switch off the -30 V output when this pullup occurs.

121. The ports on IC2 drive two bi-directional 8-bit instrument busses. IC8 and IC9 form one bus with 8 bi-directional data lines DO to D7, 4 address lines A0 to A3 and 4 data valid lines VALID 0 to VALID 3. This bus drives the parts of the instrument external to the screened r.f. box.

122. IC5, IC6 and IC7 form a second ’quiet’ bus to drive the screened r.f. box. Data lines BD0 to BD7 are for output only. BA0 to BA3 are address lines and there are three data valid lines B VALID 0 to B VALID 2. Input is handled by IC5 which is enabled by the remaining output of IC7.

123. IC2 Port A is the bi-directional data and Port B the addressing data. Port C controls the selection of bus and direction and provides one line to drive TR1 and reset the overload trip. The mode of operation of the address bus is that the required address is presented to the bus with bits A4-A7 high

and the bus is allowed to settle. Then the required data valid line is activated by pulling it low, which either latches the information on the data bus onto the addressed latch (for outputs from the microprocessor) or allows the addressed data source to drive the data bus (for inputs to the microprocessor, either from keyboard or GPIB board). The data valid lines are thus only activated when a valid (and stable) address is present on the other 4 address lines.

Power supplies (Main chassis AZ0 and AD1 board)

Circuit diagram : Foldout 21 and 22.

124. The power supply circuits divide between the main chassis and the Regulator board AD1. The +5 V and +15 V regulators are carried on the heat sink on the rear panel. The bridge rectifier system which provides the raw 9 V d.c. supply for the +5 V regulator is mounted onto the main chassis. The mains transformer is a standard item and has an unused secondary in this instrument. The remaining components including the whole of the -15 V regulated supply are carried on the AD1 board. The microprocessor is supplied via a separately decoupled branch of the +5 V rail.

125. The loads on the supplies with the 2305 in a normal operating mode are, typically,

+5 V to microprocessor	660 mA
+5 V to remainder	1.4 A
+15 V	500 mA
-15 V	450 Ma

Noise on the power rails at supply frequency and harmonics is generally of the order of tens of microvolts.

AE1 Distortion/Weighting filter (optional accessory)

Circuit diagram : Foldout 23.

126. The AE1 board contains two weighting circuits and a distortion measuring circuit based on the distortion factor principle in which the fundamental component of the signal is tuned out so that all the residual components can be measured and expressed as a fraction of the total signal i.e. fundamental plus residuals.

$$\text{Distortion factor} = \frac{\text{Distortion + hum + noise}}{\text{Signal + distortion + hum + noise}}$$

127. The distortion measurement functions are introduced by the dual function DIST/SINAD key. The SINAD ratio is the reciprocal of distortion factor and is expressed in dB. Distortion factor is presented as a percentage. As both measurements are automatic and require no manual tuning or level setting, once the modulation frequency has been accepted by the circuit, the system is particularly well-suited to SINAD measurement which is commonly monitored over a range of carrier signal levels.

128. The definition of distortion factor requires each Dart of the ratio to be measured as an r.m.s. voltage. In the 2305 the average detector is used, an approximation commonly made in distortion instrumentation, which introduces insignificant errors at practical distortion levels.

129. The weighting circuits provide the characteristics contained in CCITT recommendation P53 and CCIR recommendation 468-2 for the measurement of noise in telephone and broadcasting systems respectively. Either one of these two filters may be pre-selected by second function keying to be made available via the WTG ON/OFF key on the front panel.

130. The design principles of the AE1 board may be seen freed from the complexity of control switching and other supporting circuitry, in the block schematic diagram Fig.4-11. The switches shown in the diagram are, in fact, CMOS analogue multiplexers /demultiplexers except for the four s.p.s.t. switches associated with the tuning capacitors in the DIST/SINAD section which are bipolar transistors. The board has three main functions, the introduction of weighting, frequency notching (fundamental rejection) and gain. If none of these functions is required, the board is bypassed along the uppermost path at the top of the block diagram which bypasses all circuitry except for the unity gain buffer amplifier at the output and one CMOS switch section. The bypass path is used by all audio measurement signals when the options board is installed and is therefore required to have an accurate and consistent zero insertion loss. This property enables the board to be retro-fitted by 2305 users by merely inserting it in place of the link between pin 2 and pin 3 of PLAR on the mother board AC1 without causing any disturbance to the other services provided by the instrument.

131. The AE1 board is operated by control signals from the microprocessor in response to inputs from the keyboard and elsewhere in the instrument. Weighting and notching can be introduced together and the gain function is normally used with notching in order to produce measureable voltages on low distortion signals but may be used independently via keyboard second functions to expand the display of small amounts of modulation.

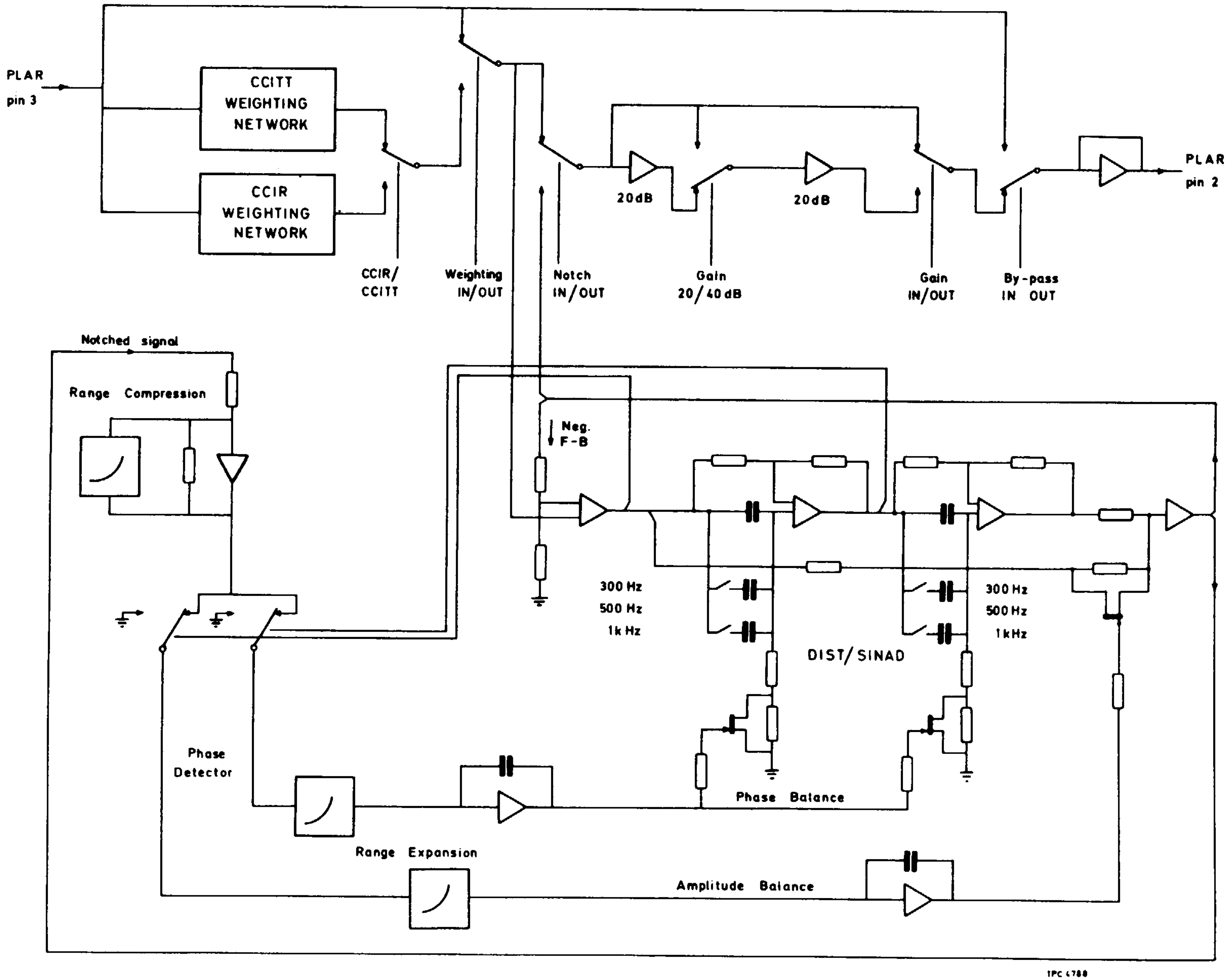


Fig. 4-11. Options board : block schematic

132. The rejection circuit employs two all-pass phase shift networks in cascade to produce a total phase shift of 1800 at three switchable frequencies 300 Hz, 500 Hz and I kHz. A null is produced at each of these frequencies by combining an in-phase signal of equal amplitude with the antiphase signal. This signal is passed down the parallel path alongside the phase-shifters. The width of the notch at levels of small attenuation is considerably reduced by the application of overall negative feedback which reduces the gain of the system wherever it is finite and thus sharpens up the notch considerably.

133. Fine tuning of the notch is carried out automatically over a range of ±5% with respect to the nominal switched frequencies. Tuning is carried out by varying the resistance of the RC combination in both phase shifters and of the combining resistor in the in-phase path. This ensures that the resultant phase shift is exactly 1800 at the signal frequency (nominally 900 in each section) and that the amplitude of the in-phase component produces an exact null. The resistance variation is brought about by shunting the components concerned with the source/drain resistance of an FET. The operating conditions of the FET's are controlled to produce symmetrical operation so cancelling even order distortion. Odd order distortion is minimized by restricting the peak source to drain voltage to 100 mV.

134. The loop error signals are obtained by examining the null voltage with two phase detectors, one driven by the in-phase signal and the other from a quadrature voltage taken after the first phase shifter. The existence of a quadrature component means that the overall phase shift is not exactly 1800 and so the error signal in this channel is connected to both phase shifters in the sense needed to reduce the effect. The presence of an in-phase component arises from a lack of balance between the two paths and is corrected by applying the error signal to the trimming FET on the in-phase combining resistor.

135. Because of the very large dynamic range of the notched signal between the off-tune state and the state corresponding to 70 dB of rejection, it is necessary to compress the range handled by the phase detectors by using nonlinear negative feedback. The same non-linear networks are used in the forward paths to re-expand the error signals prior to integration and application to the balancing FET's. The non-linear circuits are made up from diodes biased by resistor networks and bring about a change in voltage transmission of x100 over a range of signals from 4 V peak to 8 V peak and above. The non-linear circuits are made up from diodes D7, D8, D9 and D10 for the feedback path, D14 etc. and D18 etc. for the two forward paths. Control is exercised via the data lines D0 to D5, which are latched and decoded in IC3. Coding is accomplished on one address, A7L15 and the valid line A8 (VALID 3) is shared with the display board.

136. A requirement for any one of the board functions, weighting, gain or notching, results in a logic 1 appearing at an input to the multiple NOR gate IC10 which causes the BYPASS path to the board to be switched out. It is only when there is no requirement for any of these three functions that all the inputs to IC10 are logic 0 and the bypass is switched in.

137. The control data input to IC6 for control of notch frequency is shown in the small table on the circuit diagram. The instrument bus control for AE1 is in accordance with that shown in Table 17.

TABLE 18. CONTROL DATA, DISTORTION/WEIGHTING FILTER FUNCTIONS

Function	*Address : A7L15*					
	Line					
	D0	D1	D2	D3	D4	D5
Weighting CCIR	H	-	-	H	-	-
Weighting CCITT	L	-	-	H	-	-
Weighting OUT	-	-	-	L	-	-
Gain 20 dB	-	H	H	-	-	-
Gain 40 dB	-	H	L	-	-	-
Gain OUT (0 dB)	-	L	H	-	-	-
Notch 300 Hz	-	-	-	-	H	H
Notch 500 Hz	-	-	-	-	H	L
Notch 1 kHz	-	-	-	-	L	L
Notch OUT	-	-	-	-	H	L

For control purposes, the earthing of PLAR pin 7 by the options board provides the microprocessor with the information that the board is fitted.

Weighting circuits

138. The CCITT characteristic is realized in a purely passive network that is buffered by IC1a2 and IC1b2 with the latter providing sufficient variable gain to set the overall gain to 0 dB at 800 Hz as required by the P-53 recommendation. The preset control is potentiometer R6. The CCIR characteristic is provided by a relatively simple active network giving zero overall attenuation at I kHz and 12.5 kHz.

139. The functions of most circuit detail will become evident if a comparison is made between the full circuit and the block schematic. Much of the complexity is associated with the three non-linear networks associated with IC13, the catching diodes, power rail decoupling and frequency compensation of the GAIN amplifiers.

AG1 GPIB adapter module

140. This module is an optional item and is only fitted to 2305 when remote facilities are required. The module, when connected to the rear panel, allows direct connection from a GPIB talker/listener device and implements the full IEEE 488 specifications (no control function).

141. IC2 (8291) GPIB talker/listener integrated circuit is connected to AC4 and AC5 microprocessor via SKAJ and ACO mother board providing both talker and listener capabilities, details of which are given in Chap. 3 of the Operating Manual. IC3a and IC8 determine the read and write address decoding cycle. IC1 operates as an independent clock whose frequency (between I and 2 MHz) is used to time out an approximate 2 ps delay allowing the bus to settle after sending data.

142. IC4 - IC7 transceivers are used to translate the negative true logic and act as drivers. IC3b provides the logic 'low' level for the receive instruction TR/1 to IC5, pins 7, 9; or the talker 'high' level for IC5, IC6 and IC7 and also provides the additional buffering necessary for the three IC's in line.

The 2305 auto-tune process

143. The 2305 uses a 3 step process to acquire the measurement signal.

(1) It establishes that there is a signal present at the input that is within its range.
(2) It measures the frequency of the signal.
(3) It sets the local oscillator (l.o.) frequency to a value that centres an i.f. signal within the appropriate band.

Note . . .

In the FREQ TUNE mode steps I and 2 are omitted as the equivalent of step 2 is carried out manually when the reference frequency is entered on the keyboard.

Detecting an input signal

144. When the 2305 is first switched on, the input attenuator pads are all removed from circuit and the local oscillator is connected to the sampling gate mixer. The output from this is routed to the i.f. output of the mixer board. The l.o. drive is then caused to switch rapidly between 28.1 MHz and 28.4 MHz.

145. Any signal that is within the instrument's range will be detected by the wide band 'mixer level' detector and the detected signal will then cause the microprocessor to switch in attenuator pads if and as necessary to keep the signal at the mixer within design limits.

146. The width of the pulse that switches the sampling gate is less than one period of the highest specified input frequency and so the mixer will produce IF signals in its output having frequencies equal to the difference between that of the input signal and the nearest 1.o. harmonic to it up to the 72nd. Difference frequencies up to 14 MHz will clear the low-pass filters preceding the IF level detector.

147. The act of switching a 300 kHz 1.o. increment in and out overcomes the problem of coping with a signal having a frequency close to an 1.o. harmonic which would otherwise run the risk of producing an IF below the bottom end of the IF pass band and going undetected as, if one 1.o. frequency fails to produce an IF, the other will.

Finding the input frequency

148. At this stage the local oscillator will have stopped frequency switching and there will be an output IF of 14 MHz or less from the AB2 board. The signal will pass to the counter-limiter AB6 where the frequency is measured.

149. As frequencies at extremes of the 0 to 14 MHz range will not be counted accurately, especially if FM is present, the local oscillator is next programmed to produce an IF of around 7 MHz. To bring this about, the 1.o. is given octave increments of 0.11, 0.22, 0.44, 0.88, 1.76, 3.52 and 7.04 MHz on to base frequencies of first 28.1 MHz and then 28.4 MHz. In practice, broad limits are permitted and any IF within the range 3-11 MHz will be accepted and the search stopped.

150. The processor now has to identify the 1.o. harmonic number and it does this by making a small (40 kHz) change in the 1.o. frequency and observing the change in the IF that results. Then :

$$\text{Harmonic number} = \frac{\text{change in i.f.}}{\text{change in 1.o. frequency}}$$

and the sign of the measured ratio establishes whether the local oscillator harmonic frequency is greater or less than that of the signal.

151. The input frequency is now calculated from :

$$\text{Input frequency - (Harmonic number} \times \text{1.o. frequency)} \pm \text{intermediate frequency}$$

and the result is displayed in the FREQUENCY window.

152. Signal frequencies below 17 MHz cannot yield an IF of 3-11 MHz with this program and, at this stage, a failure to measure the frequency of the detected input signal is assumed to mean a signal frequency of less than 17 MHz. Accordingly, the 1.o. is turned-off, the mixer bypass path is enabled and the signal is passed directly to the IF system and counted.

Final adjustment of the local oscillator

153. As the signal frequency is now accurately identified, the processor can take the correct actions to route signals in accordance with the instrument's design. Signals below 1.5 MHz are allowed to pass directly to the IF via the bypass path. Signals between 1.5 and 5.5 MHz are routed to the double-balanced mixer and then via the 250 kHz IF system. Between 5.5 and 56 MHz the same mixer is used with the 1.5 MHz IF. Above 56 MHz, signals are routed to the sampling gate.

154. The processor then switches the 1.o. to a frequency that will produce an IF of 1.5 MHz ±150 kHz for signal frequencies of 5.5 MHz and above and an IF of 250 kHz +20 kHz for frequencies of 1.5 to 5.5 MHz.

155. The modulation measurement now goes ahead. In each cycle of measurement routine checks on the IF frequency and level and on the level at the mixer are included. By this means any small changes occurring in the signal are accommodated by re-entering the auto-tuning process at step 3 and without incurring the loss of time which a full search involves. No frequency corrections are made automatically when the instrument is operated in the FREQ TUNE mode and tuning remains under manual control.

156. The auto-tune process is a very reliable one in practice and can only give a false frequency display if, following completion of tuning, the signal is given a sudden change of frequency to somewhere close to the image value. This will still produce an acceptable IF until further signal drift reaches a point when correction becomes necessary and the calculated correction given is of the wrong sign. The IF will then be placed out of band and auto-tuning will start again from the beginning. The effect which is hardly likely to cause any difficulty in practice, is shared with other instruments of similar type having automatic tuning.

The 2305 auto-calibration routine

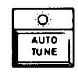
157. The auto-calibration routine comprises a set of measurements and calculations carried out under microprocessor control which yield nine numerical quantities for auto-comparison with reference quantities entered into non-volatile EAROM at the time of manufacture. If all nine are within acceptable limits of the reference quantities the calibration is deemed successful and the PASS indication is shown in the FREQUENCY display.

158. The subsequent action taken by the 2305 will depend on the way in which the routine was started. If it followed a normal operation of the

key, the results of the new calibration will also be entered into EAROM as 'last user calibration' and will form the basis for subsequent measurements. If, however, the auto-calibration routine began as part of the self-check switch-on sequence or, if the

key action had been re-allocated via second function 40 to a purely self-check role, a PASS indication would be followed by a return to measurement using unchanged standards; that is to say either to the previous 'last user calibration' or, if no recalibration had been made since the instrument was new, to the reference data entered during manufacture.

159. An indication of calibration failure given by the appearance in the RHS of the FREQUENCY display of a single digit, 1 to 9, also signals an inhibition of automatic return to the measurement functions. If, however,



is now pressed, the measurement circuits will have their function restored using the previous set of calibration data. Measurements then made may however be beyond the expected limits of uncertainty and steps should be taken to diagnose and remedy the source of drift at the earliest opportunity. The 2305 will, in the unlikely event of multiple calibration failures, display only that number corresponding to the first calculation found to lie beyond the limits of acceptance and will not show the existence of any other possible failures.

160. The key linking the numbers displayed with the measured quantities concerned appears below.

No. Displayed	*Measured quantity*
1	Gain of 10 dB ranging amplifier
2	Gain of 1st 20 dB ranging amplifier
3	Gain of 2nd 20 dB ranging amplifier
4	Overall FM gain $\frac{(P - P)}{2}$
5	Overall AM gain $\frac{(P - P)}{2}$
6	Peak + detector
7	Peak - detector
8	Offset (peak + detector)
9	Offset (peak - detector)

The order in which the tests are carried out and the results calculated is in accordance with the following and is not related to this display number sequence.

Test sources, (modulation : 1 kHz square wave)

161. FM.

Wide deviation :156.25 kHz
Narrow deviation : 31.25 kHz.

AM.

Nominally 67% AM. The precise value is entered into EAROM during factory calibration.

Test sequence

162. (1) Wide deviation source,

LF switched gain :	0 dB.
LF filter :	15 kHz. LP.
De-emphasis :	50 µs.

Measure P+ and P-.

(2) As (1) but with +10 dB of switched IF gain.

(3) As (2) but with narrow deviation.

(4) As (3) but with the first 20 dB of switched IF gain in place of the 10 dB section.

(5) As (4) but with second 20 dB of switched IF gain in place of the first.

(6) AM source, via normal AM route.

LF switched gain :	10 dB.
LF filter :	15 kHz.LP.
De-emphasis :	50 µs.

Measure P+ and P-.

163. The test sequence also includes an operation to correct for drift in the IF level detector. The operation does not affect accuracy in the measuring circuits but is important because this detector is the one used during auto- tuning to indicate the presence of a signal. The test and correction are carried out immediately before the start of the measurement sequence proper in the following way.

164. The 2305 has been put into a no-signal state by initiation of the self-check sequence which disconnects the local oscillator drive to both mixers. At this stage the local oscillator has not yet been put into its CAL mode and is off. The microprocessor notes the output from the A-D converter in AC2 corresponding to the no-signal state and sets the detection threshold a few counts. above this level. By including this drift correction in each switch-on or CAL sequence, the possibility that temperature changes could cause the 2305 to drift either into insensitivity or into the creation of false signal acquisition messages during normal use is much reduced.

Calculations

165. From tests (2) and (3) two well-spaced calibration points within the dynamic range of the measuring circuits are obtained. The slope of the straight line joining these points and its intercept on the vertical axis are calculated for both P+ and P- readings.

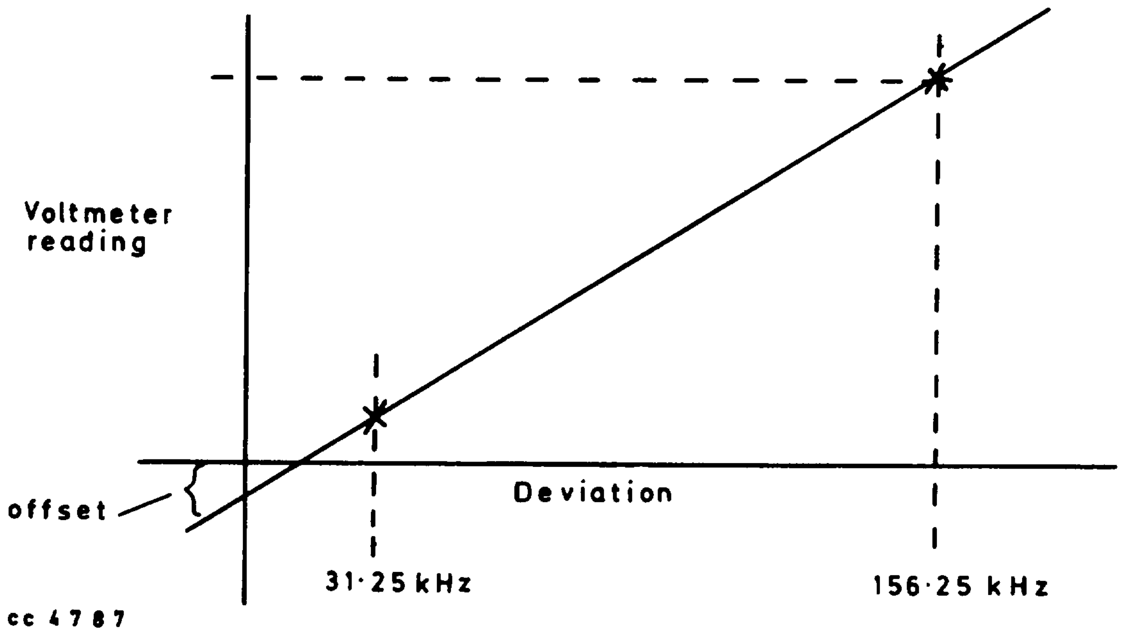


Fig. 4-12. Peak detector gain and offset calibration

166. It is assumed that the offsets arise in the AC2 circuits after the last a. c. coupling and that there is no significant non-linearity. The calculations yield the 'peak detector gain' and 'offsets' : display numbers 6, 7, 8 and 9 respectively.

167. The 'overall FM gain' is calculated from the results of test no. (1) by using the P+ and P- offsets calculated from tests (2) and (3) to correct the P+ and P- values from test (1). $\frac{P-P}{2}$ is then calculated from the corrected quantities and is divided by the wide deviation figure, 156. 25 kHz. The true gain figure for the 10 dB switched stage is then obtained as the difference between the overall FM gain just calculated and the mean of the two peak detector gains.

168. The 'peak detector gains' are now calculated for tests (4) and (5) using the offset data and the deviation figure of 31. 25 kHz and by comparing the $\frac{P-P}{2}$ values with that of the overall FM gain, true gain values for the 20 dB switched stages are obtained in similar fashion to that employed for the 10 dB stage.

169. The overall AM gain is obtained from the results of test no. 5 which, after correction for offset, are averaged and divided by the reference value for the AM calibrator stored in EAROM.

170. The assumptions behind the calibration process are that the measuring circuits are essentially linear systems but have potential small gain and offset drifts to be corrected. In particular the switched amplifiers are considered linear beyond the range corresponding to normal use and the calibration signals as a result are not constrained to values falling 'within range'. It is also assumed that all filter sections have essentially the same (0 dB) mid-band gain at the 1 kHz modulation frequency.

171. On the two most sensitive FM ranges all the calculated gain factors are in operation together and the inevitable small errors associated with each test can combine to cause inaccuracy. On these two ranges (0 - 1. 5 kHz and 1. 5 kHz-5 kHz) software adjustments of up to +1% can be entered via the front panel (second functions 51 and 52) in order to improve the measurement accuracy. The correction needed appears to be constant for any one set of hardware and the factory correction should not require change unless major servicing affecting the measurement circuits has taken place.

CHAPTER 5

MAINTENANCE

Section I. PREVENTIVE MAINTENANCE CHECKS AND SERVICES

Preventive maintenance consists of periodic cleaning and visual inspection. A regular schedule of preventive maintenance can prevent breakdown and improve the reliability of this instrument. PMCS reporting for this instrument is not required. Check the mechanical parts of the case or rack mountings; if rack mounted, for safe installation. If the equipment has not recently been on line check the fuse and panel lights. Also check the pushbuttons and indicator for positive action and correct indication.

The 2305 should be cleaned as often as operating conditions require. Dirt accumulated in the instrument acts as an insulating blanket that can cause break-down by preventing efficient heat dissipation. Under high humidity conditions, accumulated dirt can also provide an electrical conduction path causing shorting condition of some components.

CAUTION

Avoid using chemical cleaning agents that might damage the plastics used in this instrument. Chemicals to avoid include Benzene, Toluene, Xylene, Acetone, or Trichlorotrifluoroethane.

Exterior. Loose dirt on the outside of the 2305 can be removed with a soft cloth, dampened in a solution of water and mild detergent, or with a small paint brush.

CAUTION

Avoid using nylon brushes on this instrument as it contains components susceptible to electrostatic discharge. Review the ESD caution on pages C and D in the front of the book.

A dry brush is useful in dislodging dirt from around the INPUT and OUTPUT jacks, and from around the pushbutton. A liquid solution is not recommended in these areas. Do not use abrasive cleaners.

Interior. All interior cleaning and maintenance is to be performed by members of an area calibration and repair team or center.

Visual Inspection. Inspect the 2305 for broken connectors, loose or disconnected wires, improperly seated components, damaged circuit boards, and heat damaged components.

Periodic checks of transistors and integrated circuits are not recommended. The best check of the performance of active devices is actual circuit operation. Performance of the circuit is thoroughly checked during periodic calibration. Any substandard component will usually be detected then.

Section II. GENERAL SUPPORT MAINTENANCE

INTRODUCTION

1. This chapter contains information for keeping the equipment in good working order, checking overall performance, fault finding and realignment procedures. Before attempting any maintenance on the equipment you are advised to read the preceding chapter containing the technical description.

2. Test procedures described in this chapter may be simplified and of restricted range compared with those that relate to the generally more comprehensive factory test facilities, which are necessary to demonstrate complete compliance with the specifications.

3. Performance limits quoted are for guidance and should not be taken as guaranteed performance specifications unless they are also quoted in the performance data in Chap. 1. When making tests to verify that the instrument meets the stated performance limits, allowance must always be made for the uncertainty of the test equipment used.

4. In case of difficulties which cannot be resolved with the aid of this book, please contact our Service Division at the address given inside the rear cover, or your nearest Marconi Instruments representative. Always quote the type and serial number found on the data plate at the rear of the instrument.

5. Integrated circuit and semiconductor devices are used throughout this instrument and, although these have inherent long term reliability and mechanical ruggedness, they are susceptible to damage by overloading, reverse polarity and excessive heat or radiation and the use of insulation testers.

6. Sundry chip capacitors and resistors are fitted in this equipment. These have silver palladium end cap terminations. When soldering these devices the following precautions should be observed.

(i) Use solder containing 2% silver, and a temperature controlled 45 watt soldering iron set to 315^{0}C (600^{0}F). The use of a high wattage soldering iron will minimize the time taken to solder the device.

(ii) When soldering chip components to printed circuit boards a long fillet of solder should be laid on the track leading up to each end cap termination. This reduces the otherwise adverse inductive effects at high frequencies.

7. Static sensitive components. ⚠. The c. m. o. s. integrated circuits used in this instrument have extremely high input resistance and can be damaged by accumulation of static charges (see preliminary pages, Notes and Cautions). Boards that have such integrated circuits all carry warning notices against damage by static discharge. Care must also be taken when using freezer sprays to aid fault finding. These can create a static charge likely to change the programmed memory of (E)PROMS.

8. The emphasis in this chapter is more directed to fault-finding procedures than to test descriptions needed for the overall verification of performance. The reasons for this are associated with the nature of the 2305's design which is generally capable of absorbing the effect of drifts in components to be expected during the instrument's life. This arises from the ability which the 2305 has to learn, store and apply the results of its self-calibration procedures which, together with modern circuit techniques, results in an absence of calibration preset adjustments which were a common feature in

earlier designs. It is therefore necessary to give first priority to procedures aimed at securing fault diagnosis to board assembly or component level so that the automatic check-out and calibration procedures can be got working successfully again after a component failure.

9. External calibration is required for the 2305's RF power measurement function and for checks on allied aspects of performance i. e. input sensitivity and overload protection. Performance tests are suggested in brief out-line only for the verification of residual spurious effects. These are low enough to require the use of special purpose limited range modulation sources although distortion of the IF . output can be checked using standard measuring equipment. Filter response checks require an external signal but can rely mainly on the 2305's built-in capability for frequency and level measurement. Similarly, calibration of phase measurement derives from the internal FM calibrator and frequency standard. Calibration adjustments are carried out via keyboard second function groups P1, P2 and P3. The P1 functions are fully described on page 3-16and the P2 and P3 groups are given here in the next main section.

10. Confidence in the internal standards derives from the simplicity of their design approach. The AM standard is based upon the ratio of high stability resistors and is assigned a numerical value from reference modulation standards in the factory during manufacture. The FM standard relies on exact ratio switching between known frequencies using digital circuits and a self-check procedure is described in a later section (FM calibrator verification) which removes all reasonable doubt about the calibrator performance. The action of this calibrator is also checked during manufacture.

11. It is thought unlikely that many servicing organizations will have access to test systems which can generate sufficiently accurate standards of modulation to verify the 2305's AM and FM performance within the performance data specified in Chap. I of the handbook and no test procedures are suggested for this purpose. The methods employed within the factory for master reference and for the provision of traceable to National level are based on the method of digital synthesis.

12. Organizations having a traceable standard of AM with an appropriate uncertainty level and wishing to assign a quantity to the 2305 internal calibrator deriving from their own standard will find the appropriate procedure contained in the descriptions of the P3 group of second functions in a later section.

13. The 2305 is a complex system in which much of the internal operation is controlled by the microprocessor. This might tend to make fault location by traditional means very difficult. However, the advanced software in the 2305 contains many facilities via second functions (or GPIB command), which either incidentally or specifically, provide powerful diagnostic tools. Descriptions of the diagnostic second functions are repeated for convenience within the fault-finding sections. Fault location is aided by a set of 8 flow charts which are provided for ease of reference and which by directed questions lead the user progressively to the fault location. Due to the 2305's inherent capability for diagnosis, the only additional requirement is likely to be for an oscilloscope and a signal source plus, possibly, a voltmeter.

GROUPS P2 AND P3 SECOND FUNCTIONS

<u>Second functions dedicated to adjustment and calibration</u>

14. Second functions 40 to 52 are concerned with access to two levels of calibration data and control the basic measuring accuracy of the instrument. Functions 40 to 45 inclusive form group P2 and are covered by the second level of protection. Functions 46 to 52 inclusive form group P3 and are covered by the third level of protection. Group P2 functions control options on the use of the internal calibrator and group P3 functions allow access to basic calibration introduced during manufacture which should only require revision after major repair or board replacement. All data entered via groups P2 and P3 second functions is stored in non-volatile EAROM.

15. Unlocking procedures do not need to be carried out sequentially, that is to say it is not necessary to unlock groups P1 and P2 before group P3. When group P3 is unlocked, groups P1 and P2 are unlocked in the same operation. Similarly, group P1 is included when P2 is unlocked.

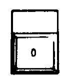
Note. . .

> The unlocking procedures are designed to prevent inadvertent or unauthorized access to secure data via the instrument keyboard. For remote operation in systems use it is assumed that access is controlled by other means and all second functions are immediately available via the GPIB without the need for prior unlocking.

To unlock P2 protection

16. Press : (1) 

(2) 

then press again and hold it 

down. With the disengaged hand, press 

and WTG 

together and hold all 3 keys down for about 5 seconds until the figure 2 shows in the frequency display to indicate that unlocking to this level is complete.

17. Before now attempting to operate any second function it is first necessary to leave the unlocking mode as represented by the 'on' state of the

ENTER light and the figure 2 in the display. To do this press 

again or almost any other function key.

To unlock P3 protection

18. P3 unlocking details are contained on page 5-6. In all respects apart from this paragraph pages 5-5 and 5-6 are identical but page 5-6 may have been removed for security purposes.

GROUPS P2 AND P3 SECOND FUNCTIONS

Second functions dedicated to adjustment and calibration

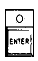
14. Second functions 40 to 52 are concerned with access to two levels of calibration data and control the basic measuring accuracy of the instrument. Functions 40 to 45 inclusive form group P2 and are covered by the second level of protection. Functions 46 to 52 inclusive form group P3 and are covered by the third level of protection. Group P2 functions control options on the use of the internal calibrator and group P3 functions allow access to basic calibration introduced during manufacture which should only require revision after major repair or board replacement. All data entered via groups P2 and P3 second functions is stored in non-volatile EAROM.

15. Unlocking procedures do not need to be carried out sequentially, that is to say it is not necessary to unlock groups P1 and P2 before group P3. When group P3 is unlocked, groups P1 and P2 are unlocked in the same operation. Similarly, group P1 is included when P2 is unlocked.

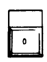
Note . . .

> The unlocking procedures are designed to prevent inadvertent or unauthorized access to secure data via the instrument keyboard. For remote operation in systems use it is assumed that access is controlled by other means and all second functions are immediately available via the GPIB without the need for prior unlocking.

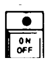
To unlock P2 protection

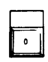
16. Press : (1) 

(2) 

then press 

again and hold it down. With the disengaged hand, press 

and WTG 

together and hold all 3 keys dc 

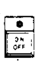
or about 5 seconds until the figure 2 shows in the frequency display to indicate that unlocking to this level is complete.

17. Before now attempting to operate any second function it is first necessary to leave the unlocking mode as represented by the 'on' state of the ENTER light and the figure 2 in the display. To do this press 

again or almost any other function key.

To unlock P3 protection

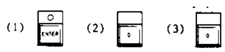
again and hold it

18. Press : (1)  (2)  then press  again and hold it down, using fingers on both hands press 
WTG   and hold all four keys down for about 5 seconds until the figure 3 shows in the frequency window. Leave the unlocking mode as for P2.

19. Note that the second operation of the zero key has to be signaled in advance of the operation of the other ’held’ keys. These keys should be, so far as is possible, operated simultaneously - as a ’chord’ - as any significant delays after CARRIER is pressed must be interpreted by the 2305 as a request for a lower status unlocking. If for any reason it is necessary to abort the operation press  and begin again.

To re-lock protection

20. When access to the second functions in any protected group is no longer 0o

required, select  A zero will appear in

the frequency display to indicate that only group PO second functions are now available.

21. Press  again to restore normal working or enter any other function.

When unlocked, second functions are entered and data is entered or changed in the standard way ending with use of  as described in Chap. 3.

22. To guard against accidental failure to carry out the re-locking procedure, locking of all levels of protection is restored automatically following a switch-off/on cycle.

Group P2, second functions 40 to 45

23. Second functions 43 to 45 inclusive are spare. The P2 level provides an extra level of protection for internal calibrator options.

40 : Calibrator mode.
Re-allocates the action of the CAL key.
Enter 0 for self-check only (as in switch-on sequence),
1 for full recalibration. The 2305 is supplied from the factory
with the recalibration function asserted.

41 : Lock instrument stores.
Enables stored control settings to be locked so that they may be recalled for use in routine applications but not over-written during normal operation. Enter 1 to lock, 0 to unlock. The 2305 is supplied from the factory with store access unlocked.

42 : Recalibrate to factory data.
Substitutes stored factory calibration data in place of user generated data on next CAL operation. (i. e. no use is made of internal calibrator.) Enter 1 to enable, 0 to disable.

Group P3, second functions 46 to 52

24. The P3 level protects access to basic factory calibration required only for use after major repairs.

<u>46 : Calibration of AM standard.</u>
Enables a new value to be substituted for the internal standard as required when a replacement AB2 board is fitted. Key-in 4 digit Z AM as inscribed on replacement board (64. 00% to 69. 00% accepted).

<u>47 : Recalibration of internal AM standard against external standard</u>. Enables a new value to be assigned to the internal standard by measurement of an external standard lying within the range 50% to 90% AM

Enter 4 digits of external standard. On the fourth digit the 2305 makes the measurement and, after a short delay, displays the value that would need to be assigned to the internal standard if the 2305 is to be aligned

with the external standard. Press  CLI to enter this value into EAROM in place of the value previously stored.

To realign the measurement circuits with the internal AM standard's new value, press 

Until this action is carried out the measuring circuits retain the performance resulting from the previous re-calibration.

Note . . .

The original factory calibration is lost as soon as the new value is stored.

<u>48 : Circuit self-alignment.</u>
Measures circuit residuals and corrects via software for following :

(1) 300 Hz - 3400 Hz filter insertion loss.
(2) ϕ m. detector calibration.
(3) Average detector calibration.

For the self-alignment to occur, the 2305 requires a source of low distortion FM at a 1 kHz ± 0. 1 % modulation frequency and 100 kHz deviation on a carrier around 100 MHz. Connect the source, then use this second function only when board AB10 or AC2 has been serviced or replaced.
The entry digits are in binary sequence, enter :

1 for filter insertion loss(board AB10)
2 for ∅ m. calibration
4 for average detector calibration (board AC2).

Follow the entry digit required with.  For more than one circuit, add together the entry digits. Thus an entry '3' will align the first two and an entry '7' will align all three.

When the n. m. demodulator is calibrated, the measurement of source deviation in kHz is assigned to the output from the demodulator as radians. This derives from the relationship

$$\Delta\phi = \frac{\Delta f}{\text{Mod. Freq.}}$$

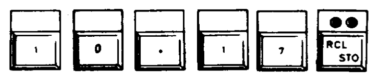
When the average detector is calibrated, its output is assigned the same value as that given to the peak detector when both detectors are supplied with the same good quality sinusoidal input. This meets the requirement that the output from the averaging detector is that of the peak value of the sine wave having the same average value.

<u>49 : Set factory cal.</u>

Establishes a particular set of calibration data as the factory reference and enters it into EAROM. Enter I to enable. The next operation of the CAL key will enter the results of this calibration as the factory reference in place of the original data as well as replacing the 'last user calibration'.

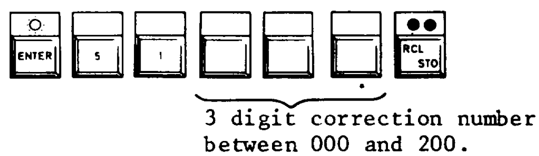
<u>50 : Set power measurement calibration factor.</u>

Factory calibration of RF power detectors. The correction data is entered as XN. NN where N. NN is the correction in dB and X is the algebraic sign : 1 for minus and 0 for plus. The maximum entry is ± 9. 99 dB. e. g. if the 2305 in its POWER function indicated +15. 17 dBm for an input believed to be exactly +15. 00 dBm, the error would be +0. 17 dBm and the correction -0. 17 dBm. The data entry sequence following access to second function 50 would be



<u>51 : FM correction 1. 5 kHz - 5 kHz.</u>

Corrections entered to compensate for the small errors in the self-check gain factor on low FM. The range of the correction available is a uniform ± 1% of reading over the range.



Enter 000 for -1% correction,
100 for zero correction,
200 for +1% correction.

Changes in this entry should only be necessary after major servicing involving the measurement circuits.

<u>52 : FM correction 0 to 1. 5 kHz.</u>

As second function 51 except for the deviation range to which the correction applies.

PERFORMANCE CHECKS

RF power checks and calibration

25. The 2305 can be directly calibrated at power levels greater than the normal maximum using non-volatile storage via second functions 30 - 34 in group P1. This offers the opportunity to improve the input v. s. w. r. by the addition of one or more power attenuator pads at the 2305 input and the method has much to commend it when the best accuracy is required. Factory calibration of the 2305 is carried out at 800 MHz using second function 50. If a revision of the factory entered data is required, it may be centered on any frequency to suit local requirements, the only special merit of 800 MHz being that it is reasonably mid-band and is the basis of the accuracy specification.

26. Equipment required : (50 f system).

Signal sources/amplifiers to suit frequencies and power levels required.

Power splitter : either resistive, for power levels up to around +20 dBm, or directional coupler for higher levels.

Standard milliwattmeter to suit frequency.

Coaxial pads rated to suit.

Low-pass filters to reduce distortion components below -30 dB at the highest level generated. NB. The 2305 power detector responds to peak voltage.

27. Method

Refer to Fig. 5-1.

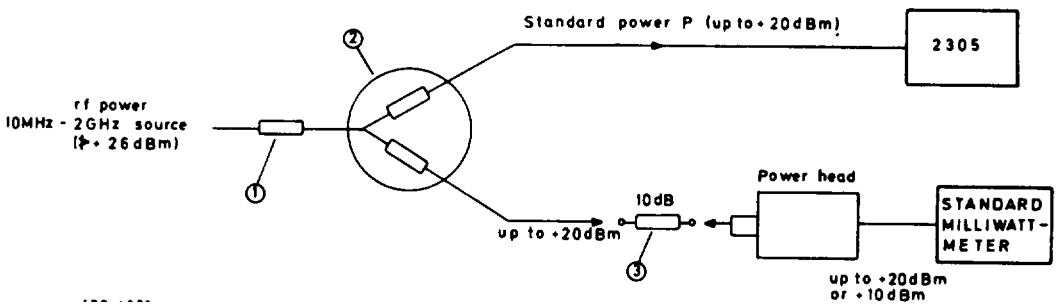
For checks and calibration up to +20 dBm the wideband resistive power splitter generally provides the most convenient basis for comparison. For checks at higher levels and for calibration of the 'offset' modes using external high power attenuators a calibrated directional coupler of appropriate coupling factor and pass band is required. Another alternative would be a proprietary form of through-line wattmeter.

28. Connect the source to the splitter/coupler input via a suitable low-pass filter if necessary. Connect the milliwattmeter to the coupled arm output of the directional coupler or to the second output port of the splitter. A calibrated pad may be placed in front of the milliwattmeter if the level there is too high.

29. For direct recalibration of the 2305 factory-entered data, a level of +15 dBm should be used. This requires +21 dBm at the input to the splitter. The level at the other output port should be noted after allowance has been made for any corrections required for the milliwattmeter and pad if used. Enter this value via second function 50 as described earlier. The entry of offset data via second functions 32 - 34 is described in Chap. 3. If the 2305 exhibits power errors substantially beyond the specified performance limits, refer to fault-finding ABI and AB3.

CAUTION

If signal sources are to be used that have output power capability above that at which damage could be done to other items, it is wise to reduce the available power to the maximum needed for the test by interposing a suitably rated attenuator pad.



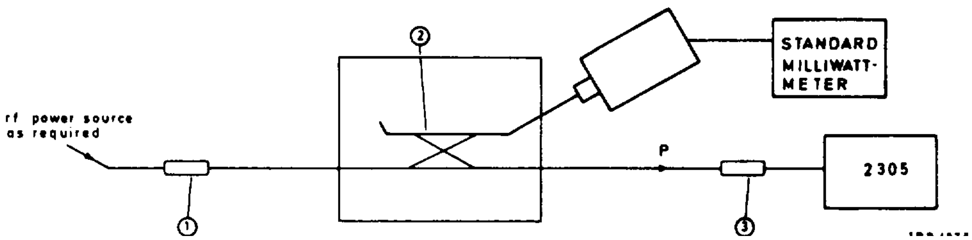
TPB 4876

(a) Calibration up to +20 dBm.

Item 1 band-pass or low-pass filter (if needed).

2 0. 5 W resistive splitter.

3 calibrated 10 dB pad (if needed to suit milliwattmeter)



TPB 4875

(b) Calibration above +20 dBm.

Item 1 band-pass or low-pass filter (if needed).

2 directional coupler : coupling factor and pass band to suit requirements.

3 range extension pad : rating and attenuation to suit requirements.

Fig. 5-1. RF power calibration methods

Input sensitivity

30. Equipment required : (50 n system).

CW signal source(s) over frequency range of interest, output at least -10 dBm.

Resistive power splitter.

Standard milliwattmeter -25 dBm to 0 dBm.

31. Method.

Refer to Fig. 1a

Connect the signal source to the input of the power splitter and the outputs to the 2305 and milliwattmeter respectively. If extra power (0 dBm or more) is available a 10 dB attenuator pad could usefully be placed between the power splitter and the 2305 and 10 dBm subtracted from the milliwattmeter indication. With this proviso, the power applied to the 2305 is the same as that measured by the milliwattmeter after any necessary corrections have been applied. Keep the output connections from the splitter as short as possible.

32. Increase the applied power at frequencies of interest from a low level of about -40 dBm (as indicated on the signal source) to the level at which auto-tuning occurs. This level should be not greater than :

-25 dBm 500 kHz to 1GHz,
-18 dBm 1GHz to 2GHz.

In case of problems with input sensitivity refer to fault finding ABI and AB3.

Overload protection

33. Equipment required : (50 Ω system).

Through-line or terminating power meter, 2 W.

RF power source at frequency (ies) of interest capable of at least 2 W into 50 n.

34. Method.

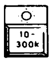
Calibrate the source at 2 W into 50 Ω, ideally using a calibrated directional coupler/milliwattmeter combination or through-line wattmeter as shown in Fig. 1b but using a 2 W dummy load. Alternatively power may be transferred from a terminating power meter. Note that in this second case, the range of possible uncertainty due to mismatch effects is much greater.

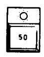
35. Transfer the calibrated power at 2 W level to the 2305 input being prepared to remove it at once should the 2305 be faulty and fail to trip. Ensure that the trip can be reset by a further operation of the POWER key. The trip should operate consistently at 2 W available power. Note that the 2305 fails safe in the event of a supply failure with the protection relay in the disconnected state. The trip circuit should not operate at levels up to and including the maximum permitted input level of 1 W. In case of faulty operation, refer to fault-finding AB1 and AB3.

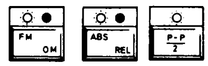
FM calibrator verification

36. The user is not recommended to attempt verification of the 2305's calibration by setting up sources using the Bessel zero technique unless he has access to very pure sources of modulated signal, as the uncertainties other-wise introduced by this method would be comparable with or greater than those which it is required to demonstrate for the 2305. A more useful alternative is likely to be the following procedure which allows the carrier frequencies (IF) of the two standard levels of FM generated internally to be measured by the internal counter. In view of the digital processes involved it is most improbable that the programmable divider would produce the standard IF's from any combinations of switched frequencies other than those intended.

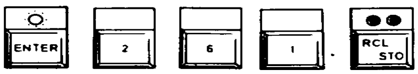
37. (1) Select :

, 

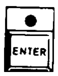
filter, 

de-emphasis, 

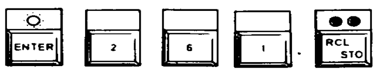
(2) Unlock the first level of protection



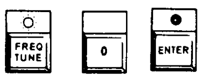
holding the last two keys down until a 1 appears in the frequency window.

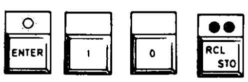
(3) Press 

again to return to normal operation.

(4) Select : 

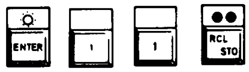
(measurements with de-emphasis)

(5) Select : 

(6) 

(sets the internal FM calibrator running with 156.25 kHz deviation on an IF of 1.59375 MHz).

This IF should now be displayed in the frequency window although the counting process may result in a random variation from this figure of up to 2 least significant digits. Provided that a recent user calibration has been carried out the display in the modulation window should be within ± 0. 2% of the calibrator deviation.

(7) Select: 

(sets the internal FM calibrator running with 31. 25 kHz deviation on an IF of 1. 50000 MHz).

This IF should now appear in the frequency window and the deviation displayed should be within +0. 2% of the calibrator value. The same reservations apply as in (6).

38. Provided that the 2305 behaves as predicted in these two tests, it can be assumed that its FM accuracy will have been established to limits within those claimed. In the event of any problem, enter fault-finding chart 3 at the appropriate point.

AM calibration

39. The internal standard has its value defined by the ratio of high stability resistors. Drift in the AM defined by this ratio is likely to be very small and slow. The main purpose to be served by an AM measurement inter-comparison is to provide verification one way or the other if it is suspected that a dramatic change may have occurred in one of these resistors or in the switching transistor TR22. For this purpose, an inter-comparison with another modulation meter or an oscilloscope measurement will be adequate.

40. For serious re-calibration, a source known to be substantially within ± 1% of its nominal value is required. Such sources are rare and if routine re- calibration with national traceability is required, a practical alternative to sending the complete instrument away may be the acquisition of a spare AB2 board. This board, if returned to the works for recalibration, would be sent back with the four digits of recalibrated AM marked on it for incorporation in the instrument and realignment using second function 46. If a suitable source of AM is available locally and revision of the existing calibration appears desirable, the new calibration may be transferred directly from the standard source at any level between 50% and 90% using second function 47, see page 5-7. If the AM performance is suspect or if self-check error code 5 is displayed, see fault-finding chart 5.

ΦM calibration

41. Equipment required :

A source of FM with less than 1% total harmonic distortion, modulation frequency I kHz to 16 kHz, deviation 100 kHz, carrier frequency around 100 MHz.

42. Method.

Set up the equipment, with the 2305 measuring FM, for 100 kHz deviation and 1 kHz ± 0. 1% modulation frequency. Switch the 2305 to φ m. The reading should be 100 radians. Increase the modulation frequency in octave steps i. e. to 2, 4, 8, 16 kHz while keeping the 100 kHz deviation constant. The φ m. indication should halve with each step. In case of problems in φ m. performance, fault find board AB10. It should not be necessary to realign via second function 48 unless there has been abnormal component deterioration or component replacement.

LF filter responses

43. The IF filter responses can be given useful checks via front panel access. A source of wideband FM that is capable of accepting modulating frequencies up to 300 kHz is necessary if the full range of pass band options is to be tested.

44. Method.

Use 100 kHz deviation with I kHz modulation frequency to establish 0 dB reference (2305 in the REL mode). Vary the modulation frequency at constant level and investigate the filter specifications as below :

Filter	*Performance*
10 - 300 k	Flat within ± 0. 1 dB, 10 Hz to 300 kHz.
30 - 50 k	Flat within ± 0. 1 dB, 30 Hz to 50 kHz.
50 - 15 k	-3 dB ± 0. 5 dB bandwidth, 50 Hz to 15 kHz.
300 - 3. 4 k	-3 dB ± 0. 5 dB bandwidth, 300 Hz to 3. 4 kHz.

and with a change of reference frequency to 125 Hz,

65 - 250 Hz	flat within ± 0. 1 dB, 65 Hz to 250 Hz.

45. Note that the HF specification for the 300 kHz and 50 kHz filters can- not be totally verified via front panel access, as the 2305 FM frequency response itself, which derives from other parts of the 2305 circuit, will be significant. The fault-finding section includes details for AB10 if this performance is not obtained.

LF output distortion and distortion/weighting filter option

46. Equipment required :

FM/AM special purpose test source with inherent distortion substantially less than 0. 1%.

A distortion measuring system : if the 2305 Distortion/Weighting filter option is fitted, it may be used at its pre-selected frequencies.

47. Method (1) FM

Set up about 100 kHz deviation, 100 MHz carrier frequency and I kHz modulation frequency. Select the 50 Hz to 15 kHz filter and measure the distortion, either internally or externally at the IF . output terminal. The measured distortion should be less than 0. 1%. Vary the modulation frequency over the range 20 Hz to 20 kHz choosing a filter to pass several harmonics whilst restricting the noise bandwidth as much as possible.

48. Method (2) AM

Check distortion at modulation depths of 30% and 95% over the frequency range I kHz to 20 kHz using the same criteria in the selection of filter band-widths as for FM Measured distortion should be :

at 1 kHz, less than 0. 3%,
at 20 kHz, less than 1%.

49. When fitted, the proper operation of the distortion/weighting filter option in these tests and its successful indication of distortion of 0. 1% or less is a sufficient check on its performance. For problems in IF . distortion see para. 65 (10). The distortion/weighting filter option board has its own fault-finding section.

Residual AM/FM (AM/FM noise)

50. Equipment required :

Standard FM signal generator.

AM/FM Test Source : 560 MHz carrier, residual AM <0. 01%,
residual FM <3 Hz.

Distortion Factor Meter capable of manual operation.

51. Method (1l) FM

Feed the 2305 with an FM signal of I kHz deviation and I kHz modulation frequency on a carrier of around 100 MHz. Set up a reference datum on the distortion factor meter. Select the 300 - 3. 4 k filter on the 2305 and transfer its input to the low residual FM source. Tune the 2305 manually to each of the following frequencies :

110. 82 MHz, 130. 62 MHz, 158. 94 MHz, 202. 70 MHz.

At each frequency the residual noise should be at least 34 dB below the 1 kHz reference. The frequencies are chosen so that the 560 MHz low residual FM source is tuned using each local oscillator in turn.

52. Method (2) AM

Repeat as above from the point at which the low residual FM source is connected to the 2305 but with the 2305 switched to AM. The residual AM should be <0. 02%. The distortion factor meter is not required for this test.

FM rejection (spurious AM caused by the presence of FM)

53. Equipment required :

Source of very pure FM, a special purpose test source having <0. 08%
residual AM is required.

54. Method.

Set up 50 kHz deviation FM on the test source at around 100 MHz carrier frequency with a I kHz modulation frequency. Switch the 2305 to measure AM with the 50 - 15 k filter selected. The AM indication should be <0. 5%. If the AM is excessive see the fault-finding section dealing with AB7 on page 5-56.

AM rejection (spurious FM caused by the presence of AM)

55. Equipment required:

Source of very pure AMA special purpose test source having <8 Hz spurious FM is required.

56. Method.

Set up 50% AM on the test source at 12. 5 MHz carrier frequency with a I kHz modulation frequency. Switch the 2305 to measure FM with the 300 - 3. 4 k filter and the NOISE AVG detector selected. The deviation displayed should be <40 Hz.

Stereo separation

57. Equipment required:

Stereo generator : stereo separation typically >60 dB.

AM/FM Stereo decoder.

FM test source : stereo separation typically >60 dB.

58. Method.

Connect the stereo generator to the AUDIO INPUT of the test source and the stereo decoder to the LF OUTPUT of the 2305. Set up 100 kHz FM deviation at 1 kHz modulation frequency by adjusting level on the stereo generator. Apply stereo multiplex signal with 10 - 300 k filter selected on the 2305. The measured stereo separation should be better than 50 dB at 1 kHz and typically 52 dB at 80 Hz. If this performance is not achieved see the fault finding sections on AB9 and AB10.

FAULT FINDING

59. Entry into the procedures should begin by reference to the top-level flow charts nos. 1 and 2 which direct attention through a few simple checks to all areas of possible malfunction. Accompanying numbered notes enable further checks to be made with increasing specialization to other flow charts and explanatory sections. The process begins with the system or function in which the fault is first identified and then narrows down the number of possible sites for the fault further tests being indicated as necessary. As most circuit malfunctions are likely to disturb either the self-check/cal. or auto-tune sequences, these are the starting points for chart no. 1.

Board servicing and recalibration

60. Most boards in the 2305 can be changed or serviced without affecting the calibration status of the instrument. The exceptions are listed below with the recalibration required and the place in the manual where details are given.

	Board changed	Recalibration quantity	Refer to details
AB1	Input attenuator	RF power	Page 5-9, paras. 25 to 29
AB2	Mixer board	AM	Page 5-13, para. 40
AB3	Voltage controlled oscillator	Residual FM	Page 5-15, para 51
AB10	LF filters	ϕM 300-3. 4k filter	Page 5-7, 2nd Function 48
AC2	Voltmeter detector	Noise averaging	Page 5-7, 2nd Function 48
AC5	Microprocessor	No recalibration, but if board is changed, the EAROM should be retained as it holds calibration data.	

Access to the circuit boards is simple and full guidance is given on page 4-7 in Mechanical Design Principles.

Using the fault-finding charts

61. The sequence of the charts is from top to bottom. Where a number appears in brackets, e. g. (7), it refers to an instruction to be carried out in the course of fault-finding. The instruction can be found on the accompanying instruction sheet. A rigorous approach requires that the charts are explored in sequence from the top level. With experience it may prove possible to take a short cut to a later stage. When the final stages are reached, it may be found convenient to have the board position diagram (FO-2)and the main block diagram FO-1) pulled out clear of the text for ease of comparison with the circuits or other reference material.

FAULT FINDING

Servicing diagrams are printed on the fold-out sheets in the rear of this manual

FAULT-FINDING CHART No. 1
Top level (1)
Faults apparent at switch-on.

’Top level’ fault-finding

62. The top level section is concerned with identifying, from the externally observed behavior of the instrument, the general area of a fault. In most cases, faults can be localized in this way to one or two boards within the instrument without the need to remove the instrument covers.

63. The two top level tables should be followed first. The auto-tune and calibration sections fall in the top level category. A list of diagnostic second functions is provided, along with elaboration of the important diagnostic function 08.

64. When the top level section has been consulted one can then proceed to the board/module sections.

Fault finding instructions

65. (1) See operating instructions for description of switch-on sequence.

(2) Ensure that mains selector on rear panel is set correctly for mains supply.

(3) See Chap. 4for description of calibration sequence.

(4) See fault-finding sections on front panel (boards AAI and AA2, the keyboard and display).

(5) See fault-finding section on the microprocessor system. Disconnect peripheral units such as the GPIB transceiver or Options board AEI to see if the fault clears. If it does, one of these units is faulty and is disrupting normal instrument bus operation.

(6) If the switch-on calibration routine is shortened, or disrupted (see description in Chap. 4a microprocessor or instrument bus fault is indicated.

(7) Apply a signal with some FM deviation within the instrument’s normal range.

(8) There may be a fault in the signal flow. Check AM Detector (AB7), FM Detector (AB9), LF Amplifiers and Filters (AB9 and AB10) and Voltmeter (AC2). Or the EAROM may have lost its contents : see the section on the microprocessor system.

Auto-tune failure

70. Before attempting to diagnose the reason for a failure to tune to an applied input signal, ensure that the input signal is within the range of levels and frequencies which the instrument is designed to accept (though the latter condition is usually indicated on the front panel). Conditions such as two signals of comparable amplitude, high AM depths - especially at high modulation frequencies - and wide deviation FM at very low modulation frequencies may all prevent successful auto-tuning.

71. Successful auto-tuning involves complex interactions within the instrument. The following circuit modules are involved in the process and each must perform correctly

(a) Input attenuator (including input cable, connectors, protection relay).

(b) Mixer (sampling and double-balanced mixers, and straight-through channel).

(c) Mixer level detector.

(d) IF level detector.

(e) 3 - 11 MHz IF detector.

(f) Synthesizer.

(g) Counter (including counter limiter).

(h) Voltmeter,

(i) Microprocessor system.

72. The following list gives fault conditions which may occur together with their likely causes.

(1) No response - instrument displays dashes in frequency display and INPUT LOW annunciator in modulation display at all input frequencies. There could be a break in the signal path, a synthesizer fault, or an IF level detector fault. See, in order, the sections on ABI - the input attenuator, AB2 - the mixer, AB7 - the IF detector and the synthesizer. See also the diagnostic second functions.

(2) No response above 54. 5 MHz, satisfactory below. The sampling mixer system has a fault. See the section on AB2 - the mixer board.

(3) No response below 54. 5 MHz, satisfactory above. The double-balanced mixer system has a fault. Again, see the section on AB2.

(4) Error 57 with no input applied. During the switch-on self-check or a calibration cycle, the instrument measures its own zero input level condition, and sets the signal detection threshold some way above this level. Warm-up drift can cause this detection threshold to drop into the noise level so that the instrument thinks a signal is present, tries to tune to it unsuccessfully, and presents the above error code. This can normally be removed by a calibration or self-check cycle. This condition should not be regarded necessarily as a fault since the instrument may in fact be very sensitive and auto-tune correctly once a real input signal has been applied.

Second functions relevant to fault-finding and performance-checking

73. Group P0 second functions. See Chap 3&4 for guidance on method of access.

04 Select external frequency standard (0 = internal; I = external).
Could be used to check acceptance of external 10 MHz standard or correct operation of instrument when internal standard is faulty.

05 Display mixer level.
The mixer level is monitored by the voltmeter. When the level is greater than a certain value, an attenuator pad is placed in the signal path. This second function gives a display of the mixer level to establish the correct operation of the attenuators, power protection relay, and the detector itself. It can be used in conjunction with second function (SF) 35.

06 Display IF level.
IF level again monitored by the voltmeter. If above a certain threshold, it indicates to the processor that a signal is present at the input. If the reading becomes too high, error 53 is indicated, which should only happen if an input attenuator fault occurs.

07 Display demodulated audio level (prior to IF . filters).
There is a detector prior to the IF . filters, on the output of AB9 (LF Amplifier) which feeds the voltmeter. The detected level is used to select the correct amplifier range.

08 Display voltmeter reading.
In normal operation, the voltmeter cycles through its various inputs at a rapid rate, which would make fault location on the voltmeter board very difficult. This function allows a single input to be selected so that the board can be checked or the presence of the various input signals established. The inputs are selected by the following digits :

0 Peak -ve audio detector.
I Peak +ve detector.
2 Averaging detector.
3 RF power detector.
4 IF level detector.
5 Zero reference.
6 Mixer level detector.
7 Demodulated audio level detector.

Note that although these appear to duplicate some of the functions above, the point is that with SF8, the voltmeter input itself is frozen at a particular setting. Even the zero reference, which is normally subtracted from the reading, is ignored, and can itself be checked (No. 5).

09 Synthesizer/counter self-check.
This is a very powerful function. The synthesized local oscillator signal is fed to the counter. A number of frequencies in each oscillator range are programmed and checked on the counter. Failure on any of the tests will be indicated by display of error code 13.

See separate sheet for details of synthesizer self-check.

10 Wide FM calibrator signal.
The FM calibrator is set to its wide (5 MHz) deviation setting and the signal is made available continuously at the IF output.

11 Narrow FM calibrator.
Similar but gives narrow (IMHz) deviation signal.

12 AM calibrator.
AM calibrator signal at nominally 66. 7%. AM depth available at IF output for approximately 10 seconds.

74. Group PI second functions

26 Measure with de-emphasis (0 - off, I - on).
Normally, the de-emphasis does not affect deviation readings. The post de-emphasis readings may be selected, however, to check the de-emphasis time-constants. Using the relative mode, the indicated effect of the de-emphasis will be :

De-emphasis (ps)	Mod rate (kHz)	Effect (dB)	
50	1	0. 41	within ± 0. 2 dB.
75	1	0. 87	
750	1	13. 7	

35 Override input attenuators.
Allows manual setting of input attenuators.
Enter 5 to set 0 dB, 4 for 10 dB, 3 for 20 dB etc. to zero for 50 dB. Any number greater than 5 will restore automatic operation.

36 Override IF . amplifier range.
The IF . amplifier 10 dB ranges can be manually set using digits 0 - 5. Selection of >5 gives A (automatic). The ranges are as follows.

Range selection digit	Amplifier gain (dB)	FM range (kHz)	AM range %
0	10	1. 5	1. 5
1	20	5	5
2	30	15	15
3	40	50	50
4	50	150	150
5	60	500	-

37 Override Distortion/Weighting Filter board Rain.
The two 20 dB gain stages can be manually selected using:

Range digit	*Amplifier gain (dB)*
0	0
1	20
2	40
>2	A (automatic selection)

38 Override distortion notch selection.
The distortion notches can be forced into circuit.

Selection digit	*Notch frequency*
0	None
1	300 Hz
2	500 Hz
3	1 kHz
>3	A (automatic)

39 Returns SF35, 36, 37, 38 to fully automatic state together.

Diagnostic second functions 05 to 08

75. These second functions which have been provided purely for diagnostic purposes are described in Chap. 3, page 3-16.

76. The following table gives a list of typical readings which may be used as a fault-finding guide. The readings given are only to be regarded as approximate, and measured readings differing by 10% or so should not be taken as faulty. The table was compiled with the following conditions at the input socket:

Input level : -10 dBm
Carrier frequency : 100 MHz
FM deviation : 100 kHz

Second function 08

Selection digit	*Voltmeter input*	*Typical reading*
0	Peak -ve	3500
I	Peak +ve	3500
2	Averaging detector	3500
* 3	RF power detector	500
4	IF level detector	1000
5	Zero reference	250
6	Mixer level detector	600
7	Demodulated audio level detector on AB9	1700

* Measured with an input level of +10 dBm.

Excessive residual a.m./f.m. (a.m./f.m. noise)

77. FM noise.

FM noise comes predominantly from two sources, the local oscillator (AB3) and the f.m. detector (AB8). It is possible to eliminate AB8 if the noise is only present at the relatively high frequency used in the performance check. If the noise disappears when a low noise source having a frequency of a few MHz is used, then the noise almost certainly originates in AB3. The frequencies used in the performance check ensure that each of the four local oscillators is tested. The relationship is as follows :

Source frequency 560 MHz.

Manually tuned frequency (MHz)	Oscillator range
110.82	1
64.56	2
78.72	3
202.70	4

78. Identify which oscillator is noisy. It is now necessary to identify the offending component. This may be difficult although those posing the greatest potential risk are the oscillating transistor and the tuned-circuit polystyrene capacitors. Defective decoupling capacitors can also give trouble. The use of localized heating and cooling may help to track down the source. If all ranges are noisy the problem probably originates in the transistor amplifier stage or in the TTL buffer stages. If the noise is present when low frequency sources are used, provided that these are themselves suitably low noise, it probably arises in the f.m. detector AB8 which should be examined for noisy components or supply rails. Noise on supply rails should not exceed a few tens of microvolts.

79. AM noise.

Contributions to the a.m. noise floor derive from attenuator components, mixers and i.f. amplifying stages. A deterioration in a.m. noise may be accompanied by a loss of signal sensitivity caused by a fault in the signal chain altering the gain distribution and the signal/noise ratio in the i.f. Such a fault is amenable to standard signal tracing fault-finding procedures.

80. If a.m. noise has increased without any falling off in sensitivity then a device has probably become noisy. First check by examining the i.f. output that the i.f. is levelled satisfactorily down to low input levels. If it is not, then an amplifier stage in AB7 may lack gain. If the levelling appears correct it may be difficult to isolate the source of the extra noise. Again localized heating and cooling may help by respectively augmenting and reducing the noise contribution from the component affected. If the cause cannot be found and eliminated, the 2305 should be returned to Service Division or to your nearest agent for repair.

FAULT-FINDING CHART No. 3

Failure in f.m. calibration

Fault finding instructions

81.

(1) Set the internal calibrator running on wide deviation with the other conditions closest to those actually occurring during a normal calibration sequence, i.e.

(a) Select f.m.

(b) Select 10 300 k filter.

(c) ENTER 0 0 CARRIER.

hold simultaneously for 5 seconds until I appears in frequency display window.
Press ENTER to terminate.

(d) ENTER 26 1 RCL/STO. This sets the instrument to measure with de-emphasis.

(e) Select 5.

(f) FREQ TUNE 0 ENTER selects external local oscillator.

(g) ENTER 10 RCL/STO sets internal calibrator running with wide deviation 156.25 kHz at a frequency of 1.59375/6 MHz. This frequency should normally be displayed in the frequency window and the modulation display should read about 156.5 kHz.

(2) Examine i.f. output by inserting a BNC-adapted oscilloscope probe onto the i.f. output socket and observing the i.f. on an oscilloscope.

(3) To set narrow deviation f.m. calibrator running, repeat steps (a) to (f) in (1) above then:

(g) ENTER 11 RCL/STO sets the internal calibrator running with narrow deviation 31.25 kHz at a 1.5000 MHz carrier frequency. This frequency, and a deviation of close to 31.30 kHz displayed.

(4) Run synthesizer self-check by keying in : ENTER 9 . After a delay, the instrument will return to normal operation if the check is completed satisfactorily. If unsuccessful, a failure number will appear in the frequency display. See the section on synthesizer fault-finding.

(5) At this point, many parts of the instrument have been found to be functioning. The lack of an i.f. output is probably due to a fault in the AM Detector board AB7 and the fault-finding section for this should be consulted. Once the fault is rectified, the f.m. calibrator chart should be followed from the top.

(6) When this point is reached, the commonest cause of failure is the top range oscillator on AB3 not covering the correct frequency range, possibly due to a cracked adjusting core in L4, or an oscillator component change in value. The instructions for setting the oscillator should be followed, see para. 82. If the oscillator is found to be in adjustment, it is possible that an amplifier range on AB9, the LF Amplifier board, has changed in gain, and the fault-finding section for this should be consulted. Alternatively one of the l.f. filter responses may be out, and the section on this should be sought.

(7) Remove the top instrument cover and top r.f. box lid.

85. It can be seen that a considerable fraction of the whole instrument must be working in order to run a failure-free test. Since the test is so thorough, a good level of confidence in the system is given by satisfactory completion.

86. The test routine is split into two parts. The first section uses the VCO ranges I and 2 (28 32.99 and 33 39.99 MHz) and selects different programmable divider ratios with a view to checking the correct response to each control bit. The second section sets the oscillator to the bottom, middle and top of each range to verify that the oscillators are oscillating with the correct frequency coverage.

87. The following tables show the nature of the tests, and the control bits which are set. Failure on all tests, because of the large number of elements involved, does not provide much information, and the fault-finding table should be studied. The two tables detailing the tests should enable particular failed tests to identify the source of the problem. This is probably best illustrated by means of a couple of examples.

Ex. 1. Test 3 fails, all other 23 tests being satisfactory.

From the second table, we see that only on test 3 does ICI pin 5 assume a logic ' 1' state. This control line and ICI should be examined to establish what is pulling the line permanently low.

Ex. 2. A failure on tests 18, 19 and 20 indicates that range 3 oscillator has ceased oscillation, since range 3 is active only on these tests.

TABLE 1 SYNTHESIZER SELF-CHECK

Test No.	*Oscillator range*	*Frequency (MHz)*
1	1	28.00
2	1	28.01
3	1	30.02
4	1	30.04
5	1	30.08
6	1	30.10
7	1	30.20
8	1	30.40
9	1	30.80
10	1	31.00
11	1	32.00
12	2	34.00
13	2	38.00

continued.......

TABLE 1 SYNTHESIZER SELF-CHECK (contd.)

Test No.	*Oscillator range*	*Frequency (MHz)*
14	1	28.00
15	1	32.99
16	2	39.99
17	2	36.40
18	2	33.00
19	3	40.00
20	3	43.50
21	3	46.99
22	4	56.00
23	4	51.50
24	4	47.00

88. The first group of tests is primarily aimed at checking the correct operation of the programmable divider as the control bits are changed. The second group is primarily concerned with checking oscillator coverage.

Oscillator ranges

1 28 - 32.99 MHz
2 33 - 39.99 MHz
3 40 - 46.99 MHz
4 47 - 56 MHz

TABLE 2 PROGRAMMABLE DIVIDER CONTROL INFOIRMATION

Test No.	*Programmable divider instructions*															
	IC2 Pins:								*IC1 Pins:*							
	19	*16*	*15*	*12*	*9*	*6*	*5*	*2*	*19*	*16*	*15*	*12*	*9*	*6*	*5*	*2*
1	0	1	1	1	0	0	0	1	1	0	0	1	1	0	0	1
2	0	1	1	1	0	0	0	1	1	0	0	1	1	0	0	0
3	0	1	1	0	1	0	0	1	1	0	0	1	0	1	1	1
4	0	1	1	0	1	0	0	1	1	0	0	1	0	1	0	1
5	0	1	1	0	1	0	0	1	1	0	0	0	1	0	0	1
6	0	1	1	0	1	0	0	1	1	0	0	0	1	0	0	1
7	0	1	1	0	1	0	0	1	0	1	1	1	1	0	0	1
8	0	1	1	0	1	0	0	1	0	1	0	1	1	0	0	1
9	0	1	1	0	1	0	0	1	0	0	0	1	1	0	0	1
1	0	1	1	0	1	0	0	0	1	0	0	1	1	0	0	1
11	0	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1
12	0	1	1	0	0	1	0	1	1	0	0	1	1	0	0	1
13	0	1	1	0	0	0	0	1	1	0	0	1	1	0	0	1
14	0	1	1	1	0	0	0	1	1	0	0	1	1	0	0	1
15	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0
16	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	1	1	0	0	0	1	1	0	1	0	1	1	0	0	1
18	0	1	1	0	0	1	1	0	1	0	0	1	1	0	0	1
19	0	1	0	1	1	0	0	1	1	0	0	1	1	0	0	1
20	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0
21	0	1	0	0	0	0	1	1	1	0	0	1	1	0	0	1
22	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	1
23	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	1
24	0	1	0	1	0	0	1	0	1	0	0	1	1	0	0	1

89. Failure on a test will be indicated by the appearance of the test number at the right-hand side of the frequency display, in a similar manner to the calibration sequence. The number indicates the first test failed. Pressing a key will cause the next failed test number to appear, and so on in sequence until the whole test is complete, upon which the instrument returns to its manual condition. Therefore, by examining carefully the failed test numbers, a good indication can be obtained of the source of the problem. Note that over the GPIB, a self-check error is indicated by an error number 13 being sent.

Note...

Since the counter is used to check the synthesizer frequency, it is entirely possible that a counter fault could give rise to fault conditions which could be wrongly ascribed to the programmable divider. In the case of a fault which appears to be due to wrong control information to the programmable divider, and where on closer examination this information appears to be correct, the counter should be tested using a signal source below 1.5 MHz, where only the counter, and not the synthesizer, is used. This is mentioned again in the section on fault-finding AB4, the programmable divider.

FAULT-FINDING CHART No. 4

Failure in synthesizer self-check.

Fault finding instructions

90. (1) Run synthesizer self-check routine i.e. ENTER 09.

(2) See sheets on fault-finding for AB4 (Chart 6).

(3) See section on AB3 (voltage controlled oscillator).

(4) An oscilloscope should be used to look at the STD FREQ IN-OUT socket on the rear panel. There should normally be a 10 MHz signal of approx. 3 V peak-to-peak available here.

(5) Re-select internal standard and request synthesizer self-check again.

(6) Remove top instrument cover and top r.f. box lid.

(7) Refer to AB5 (reference oscillator) fault-finding section. Note : An AB5 failure will usually result in error number 08 in the frequency display.

(8) Apply a carrier signal at 1.5 MHz and below to the r.f. input socket in the normal auto-tune condition, preferably such that its input frequency is well known i.e., synthesized source or source plus counter. The internal synthesizer is not used in this condition.

(9) See section in counter (AC3) fault-finding.

(10) Monitor ICla2 pin 10 on board AB3 using an oscilloscope probe. Manually tune the 2305 to 30 MHz, 35'MHz, 42 MHz, 50 MHz.

(11) Monitor IC7 pin 6 on AB3. Run synthesizer self-check routine again.

(12) Binary divider probably failed. See AB3 section.

(13) Monitor IC7a2 pin I on board AB4 having manually tuned to 30 MHz.

(14) There is a break in the signal path. Examine connectors and cable from PLBP and repair broken connection.

(15) Monitor TPI on AB4 with oscilloscope. A 5 kHz TTL square wave should be present.

(16) Programmable divider fault see fault-finding para. 128.

(17) Monitor 10 kHz reference pulses on IC21 pin 11.

(18) Check reference divider chain from 10 MHz input at PLBU to IC16. Repair faulty reference divider IC.

(19) Monitor VCO control line on the center conductor of PLCZ (or the feedthrough capacitor to which the coaxial cable inner connector is connected). Key in a frequency slightly different from 30 MHz. The control line should move in a +ve direction for an upward shift in frequency.

(20) Consult phase detector fault-finding information (AB4).

(21) The synthesizer loop appears to be satisfactory. There are two possibilities which could account for this point being reached with a test number still displayed.

(a) The circuitry on the mixer board routing the oscillator signal to the counter is faulty. This would also cause a failure of the self-calibration routine.

(b) There is an intermittent fault which causes the self-check routine to fail.

FAULT-FINDING CHART No. 5

**Failure in a.m. calibration
(fault no. 5 displayed)**

AM calibration

91. The process of a.m. calibration occupies a relatively small part of the total calibration sequence. A problem in a.m. calibration is likely to manifest itself with a failure number of 5. As with f.m., a fault in either the modulation measurement system or the calibration source itself will cause a calibration failure. Since the a.m. standard value is held in non-volatile memory from factory calibration, corruption of this memory will destroy a.m. calibration.

Fault finding instructions

92. (1) In order to check that the a.m. standard figure is present in the non-volatile memory, and of the correct order of magnitude, the instrument must be unlocked to level 3 protection : see para. 18, page 5-6.

A figure 3 should appear at the right-hand side of the frequency display. Press ENTER to clear.

To inspect the a.m. standard value : ENTER 46. The modulation depth produced by the internal standard will appear in the frequency display. This number, nominally 66.67% should at least be in the range 64 to 69%.

Press RCL/STO to clear this instruction.

(2) The non-volatile store (EAROM) has been corrupted. The source of the corruption needs to be identified and the a.m. must be recalibrated. This will probably necessitate the return of the instrument to the Service Division. The section on the faultfinding of the microprocessor system should be consulted.

(3) To set the a.m. calibrator running, press ENTER 12. The a.m. calibrator signal is then generated for about 10 seconds and then switched off. The presence of the signal can be monitored externally by means of a suitably BNC-adapted oscilloscope probe and oscilloscope used to examine the i.f. output signal. A 10 second burst of a.m. will appear. This should be at a carrier frequency of 1.5 MHz with a I kHz square envelope and a peak-to-trough ratio of 5 : 1. With a correctly triggered oscilloscope, this ratio can be measured sufficiently accurately to determine whether the calibrator is apparently functional or wildly wrong.

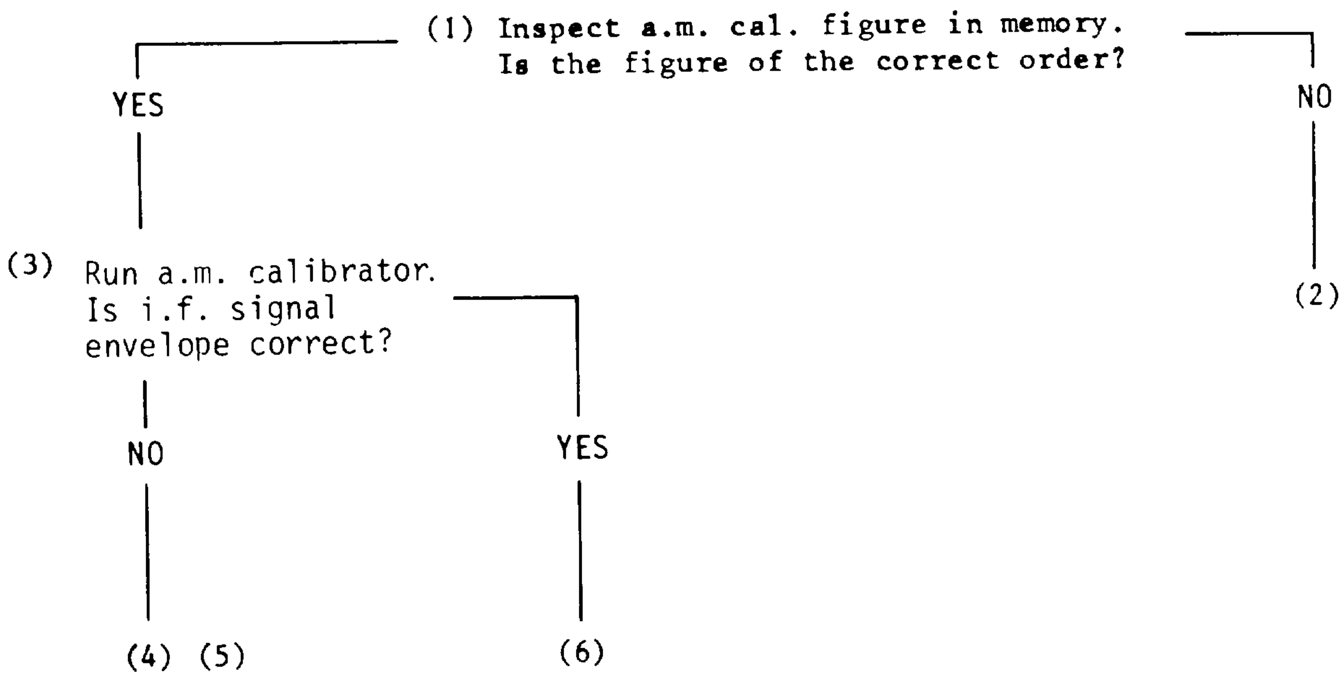
(4) Remove the top case cover and top r.f. box lid.

(5) On board AC2 (mixer board) examine the drain of TR22 for a I kHz switching waveform. If this is not present, work back via TR21, IC4, IC2 and then to IC3 (pins 6 and 15) on the latch board ABI] to locate which device is preventing the I kHz signal from switching the FET (TR22) which amplitude modulates the carrier. Replace the faulty device.

(6) It is likely at this stage that the problem lies in the main a.m. measuring system and not the calibrator itself. The section on a.m. fault finding should be consulted (Chart 7).

CHART #5. FAILURE IN AM CALIBRATION

Symptom: Calibration check fails with fault number 5.



FAULT-FINDING CHART No. 6

Sample and hold phase detector faults (AB4).

Fault finding instructions

93. (1) Set wide FM calibrator running : ENTER 10 RCL/STO.

(2) Remove top cover and top of box lid.

(3) Apply oscilloscope probe to TRI collector (the ’can’ of the device).

(4) The ramp on TR2 collector should be varying in amplitude at a I kHz rate. Ignore modulation of the ramp.

(5) Care should be exercised not to short together IC pins, or to short IC18 pin 13 to the -15 V rail, which will destroy TR3.

Power measurement and protection, AB1 and AB3

94. The circuit diagrams and descriptions of these units should be consulted. Attention will be drawn to this section if problems are experienced with power measurement or if the power protection relay fails to trip at the 2 W level, or trips prematurely.

95. Power measurements that are obviously wrong coupled with a failure to trip or premature tripping are probably caused by a failure of D1 or D2 or a faulty input on R45 on AB3. The diode forward voltages can be checked on feedthroughs coming from pins 1 and 2 of PLBC on board AB1. There should be approximately 0.3 V on each diode. The variable resistor R45 may be checked by placing a voltmeter across the two ends of the resistor. The voltage should vary as the resistor is adjusted.

96. If D1 or D2 is found to be faulty, both should be replaced by another matched pair. R45 is then adjusted so that TP1 sits at zero volts with no signal applied. A further test of correct operation is given by applying a signal to the 2305 input connector at a level of +20 dBm. TP1 should then be at typically 470 mV.

97. If this condition exists then a failure to trip may be traced by connecting a negative power supply to the feedthrough connected to pin 2 of PLBC. Starting at zero volts, increase the negative voltage until TP1 reaches 2.5 V. As this point is crossed, the relay should trip. TP3 should go low in voltage, turning off TR11, TR13 and 14. This test should enable the faulty component to be identified.

AA1 Keyboard

98. The top level fault-finding charts should be used to identify a front panel failure. If this is clearly implicated, the panel should be removed with its leads attached so that fault-finding can take place.

99. Failure to respond to a key press can be solved as follows. In the quiescent state, with no key presses, IC7 output should all be in the logic ’low’ state. If this is not so and the instrument bus data lines appear to be satisfactory, IC7 should be replaced. When a key is pressed, the keyboard interrupt line should go high momentarily. Failure to do so on a particular key means that the key switch is itself faulty and must be replaced. Failure of a front panel LED to light is most commonly caused by failure of the LED itself. That this is so can be checked by observing the latch output which drives an unlit LED. When that function is active, the output should be in a logic low state.

100. Before faulting the keyboard, ensure that the particular function requested is valid. For example, the 10 300 kHz filter is not available on a.m.

AA2 Display board

101. Despite the apparent complexity of the circuit diagram, display board faults should be relatively easy to identify.

102. If no LCD segments show on the display, the power supplies to the board should be checked and if present, the backplane drive multivibrator (IC17) should be checked for output.

103. Loss of any complete digit would be caused by failure of an LCD driver i.e.:

Corruption of one data line would give wrong displays on alternate digits, since alternate LCD drivers are controlled from the same set of four data lines. Failure of a particular segment should be investigated by examining the LCD driver output pins. This requires a two channel oscilloscope, one channel looking at the backplane drive, the other at the driver output pin. For a segment to show, the two signals should be in antiphase. If this is not the case, the driver is faulty and should be replaced. Otherwise, the connection to the display is faulty, or there is a problem in the display itself. This last case is not likely, however.

If a liquid crystal display is faulty and replacement is necessary the operation needs to be carried out with great care. Use of the special tool included with the tool kit available as an optional extra is strongly recommended.

AB1 Attenuator

104. Attenuator faults will normally be caused by damage to pads or relays due to applied power exceeding the 25 W protection limit, or faulty relays which, being electromechanical devices, may be less reliable than many of the purely electrical components. Fault-finding should be relatively easy. Apply a signal of, say 10 MHz (within the oscilloscope bandwidth), to the input of the instrument. Using second function 35, the attenuator pads can be brought in sequence. If the oscilloscope's high impedance probe is used to monitor the board output, the 7 dB steps should be clearly visible. Stepping through numbers 0 to 5 of the second function increases the switched in attenuation from zero to 35 dB. Naturally, during this check, avoid applying too great a signal. For instance, in the zero attenuation condition, the input should be restricted by 7 dB for each attenuator step so that the output remains constant.

105. Lack of an output caused by a break in the signal path can easily be traced. Check the protection relay and its drive. If drive is present (5 V across the coil terminals) but no signal passes through, the relay is faulty. Lack of drive should be investigated with reference to the section on power measurement and protection fault-finding. Carefully examine both sides of C3 since failure of end-cap bonding can lead to failure of this component which may look superficially intact.

106. If pads fail to engage or disengage, check that 5 V drive is present at the relay coil terminals. If the drive is satisfactory, the relay will require replacement.

107. If excessive power has been applied to the instrument, check D8 and DII for diode action with an ohmmeter, with power removed from the board. With power re-applied, feedthrough C4 should sit at +1.4 V and C6 at -1.4 V. Obviously, if resistors show signs of charring they should be replaced.

AB2 and AB2A Mixer board

108. This board is relatively complex. There are three general functions performed by the board :

(1) Mixer level detection.
(2) Signal processing.
(3) AM calibrator.

The a.m. calibrator is dealt with in fault-finding chart no. 5.

109. The mixer level detection process is straightforward and lends itself to easy fault diagrams. Correct operation is indicated by the table given with the diagnostic second function 08. Another test is that with an input of -7 dBm at 10 MHz, the voltage at TPI6 should be typically 400 mV d.c. If this is not the case, D3 may have been damaged by excessive r.f. power. Note that D3 and D4 are matched devices and should be replaced by a matched pair. They are located on the plug-in board AB2A.

110. The signal processing section occupies the majority of the board. Careful reading of the technical description is essential. Attention will be drawn to this area by the top level tables, usually in connection with a failure to auto-tune. The signal processing may be sub-divided into two general units; the sampling mixer system, used for input signals above 54.5 MHz (56 MHz local oscillator minus 1.5 MHz) and the double-balanced mixer system, used below, along with the direct signal feedthrough for signals below 1.5 MHz. The two units will be treated as being largely separate for fault diagnosis purposes.

AB2 and AB2A Sampling Mixer

111. A fault in the sampling mixer section will show itself externally as a failure to auto-tune to frequencies above 54.5 MHz, while maintaining operation below that frequency.

112. Manually tune the instrument to a relatively low carrier frequency of, say 100 MHz. This will select the sampling mixer. Also ensure that an external local oscillator is not selected with no such signal applied.

113. Check first that local oscillator signal is reaching the sampling mixer, which is housed on the plug-in unit AB2A. A large signal voltage swing of several volts peak-to-peak should be available at the emitters of TR17, 18 (or on R72 which is more accessible). If this is not the case, check that the correct logic instruction to the board is applied as in the technical description.

114. Trace the signal flow from PLBF to the sampling gate and replace the faulty device.

115. If local oscillator signal is present apply a 100 MHz signal to the input of the instrument. This should produce an i.f. signal at TP20. If the input signal level applied is around -4 dBm, the signal level at TP20 should be several tens of millivolts peak-to-peak. As there is no filtering applied to this point, some of the visible signal will be due to local oscillator signal due to imbalance in the sampling mixer. If no i.f. signal is produced at TP20, the 'daughter' board AB2A should be very carefully removed and inspected. The chip capacitors should be closely scrutinized for signs of cracks or detached end-caps. Diodes D1 and D2 may be lifted off the board and tested on an ohmmeter for diode action. If one diode has conclusively failed, perhaps due to an input overload exceeding the 25 W level, both diodes should be replaced with another matched pair. Beyond this limited level of inspection, there is little that can be done in the way of fault-finding on this board since its operation is dependent on pulses which are too fast to observe on anything but a very fast sampling oscilloscope. For many purposes, the unit should be regarded as a factory serviceable unit and a replacement board fitted. The board should not be removed and replaced more than necessary since this can cause flexing of the board and damage to the chip capacitors.

116. Before discarding AB2A, the bootstrap stage should be checked. This can be done with AB2A removed. Place a 1 kΩ resistor between connections 6 and 8, the locating sockets for AB2A. Inject a signal onto TR1 gate from a signal generator set to 1.5 MHz, at a level of 100 mV r.m.s. Observing TR20, this signal should be available at TP20 with only small loss. A similar signal should be available at connection 7 with a gain of between unity and two. In addition, the response should be reasonably flat at TP20 between 1 and 14 MHz. If these conditions are not met, the bootstrap stage should be inspected and the cause of failure rectified. The 'daughter' board should then be replaced and tested again.

117. When replacing sampling mixer boards, R24 should be re-adjusted. Manually tune the instrument to 100 MHz and apply a 100 MHz signal with a level of -7 dBm. A 1.5 MHz signal should be available at TP15 with a level of 100 mV r.m.s. Absence of signal here indicates a failure between TR5 and TP15. Check TR6, 7, 8, 9, 10, 11, and replace the failed device. Once a correct signal is achieved, tune the signal generator below 100 MHz. The i.f. will increase in frequency. The level at TPI5 should be relatively constant with frequency. When the i.f. reaches 11 MHz (i.e. 89 MHz signal input) R24 should be adjusted until the level relative to 1.5 MHz is 0.5 dB or 5% low. The oscilloscope should be adequate for this provided its bandwidth is adequate. Whether this is so can be checked by applying the signal generator directly to the oscilloscope with a 50 2 termination and checking the flatness to 11 MHz. It should be well within 5% for this purpose.

AB2 Double balanced mixer system

118. A fault in this system will cause auto-tuning problems with input frequencies below 54.5 MHz. Fault-finding consists largely in tracing the flow of signal with an oscilloscope. An input signal to the instrument of 10 MHz at -7 dBm is a suitable source.

119. First ensure that local oscillator signal is reaching the double-balanced mixer X1 with the instrument manually tuned to 10 MHz. If it is not, check the control lines and trace the local oscillator signal from PLBF as for the sampling mixer.

120. TP15 is the output monitoring point for all signals and signal tracing consists of working back from this point to find the failed component. Note that below input frequencies of 5.5 MHz, the i.f. changes to 250 kHz, and that below 1.5 MHz, the i.f. becomes the input signal, processed via TRIO.

AB3 : Voltage Controlled Oscillator

121. The oscillators themselves are simple circuits and fault-finding, in conjunction with the technical description, should be directed at examination of the control lines to the oscillators, the oscillating device itself and the signal steering diodes (D7 to D11). A good monitoring point is the junction of R15 and L13.

122. If the frequency coverage is in error, attention should be directed first at the oscillator coil (L1 to L4) before examining the capacitors for a change in value. The oscillator coil tuning slug should be unscrewed to ensure that it has not cracked.

123. Where re-alignment of an oscillator range needs to be carried out, it should be done to the following method. Note, that in the case of L4, adjustment is rather more critical since it is used in the f.m. calibration system. Adjustment procedure for this is given in the section on the f.m. calibrator.

(a) Manually tune the instrument to a frequency 1.5 MHz below the lower oscillator range limit.

(b) Adjust the oscillator core until the VCO control line is at about -10 V.

(c) Manually tune to 1.5 MHz below the range upper limit.

(d) The tuning voltage should then be in the range nominally 0 to +5 V. Fault-finding of the oscillator buffer is straightforward signal tracing to PLBP and ICI pin 6.

AB3 : Binary divider

124. The technical description contains details of the digital control instructions to this divider. Performance of the divider can be checked by the following method.

125. Manually tune the instrument to the following frequencies, observing the output at PLBF on an oscilloscope. 20, 10, 5 2.5 MHz. The waveform displayed should show successive stages of binary division in operation.

126. The lines where the various divided signals appear are shown on the circuit diagram and fault-finding is a matter of signal tracing. The division by 32 can be checked by running the internal calibrator or synthesizer selfcheck routine.

AB4 Programmable divider board

127. Note that the sample-and-hold phase detector, used only in the calibration process and housed on this board, has a fault-finding section of its own.

128. Detailed fault-finding of the programmable divider itself is not easy, because many of the circuit waveforms are of very short duration, with large mark-to-space ratio. There are two general types of fault in this section :

(1) The programmable divider control instruction being wrong, due to a faulty latch, pre-settable decade counter, or a fault on the instrument bus causing a control line to be jammed in one state. This type of fault should be identified by the synthesizer self-check routine. If such a fault occurs, study the technical description and then inspect the control lines between the latches (ICI and IC2) and the decade counters (IC3, 4, 5, 6). These are the most likely causes of failure and the faulty device should be replaced. A fault causing an instrument bus line to be jammed will usually manifest itself in ways more general than just a synthesizer fault.

(2) A faulty device causing a break in the signal flow and stopping the divider. This type of fault is best found by signal tracing using an oscilloscope. Because of the narrowness of the pulses in the working circuit, great care should be taken to see that none are missed and wrongly interpreted as an absence of signal. As an aid to servicing, the output of the divider is divided in a flip-flop and presented as an easily viewed square wave of half the output frequency at test point 1. Knowing the expected division ratio (see technical description) a frequency counter placed at the input and then at TP1, can be used to determine correct operation of the divider as a unit.

AB4 Phase-detector

129. The CW (digital)phase detector technical description should be read. Faultfinding can be done largely by following the waveforms on the circuit diagram. The amplitude of the pulses observed on an oscilloscope depend partly on the bandwidth of the oscilloscope since too low a bandwidth will not allow the peak of the signal to be viewed. If no output pulses from IC21 appear when input pulses are present on pins 3 and 11, IC21 and/or IC13 should be replaced. Correct operation of the phase detector can be ascertained in the following way:

(1) Manually tune the instrument to the middle of an oscillator range, e.g. by keying in 28.5 MHz, which will set the VCO normally to range 1 and 30 MHz, provided the synthesizer loop is working. The programmable divider will be set to divide by 3000 if functioning correctly.

(2) If the correct phase detector narrow pulses are not available at IC21 outputs, but wider pulses are available from one output only, the loop is not locking correctly. Remove plug PLCZ. Pull the VCO control line up to +5 V. Wide pulses should be present at IC21 pin 8 and none at pin 5. TR5/6 collectors should be at +5 V. Pull the VCO control line down to about -10 V. Wide pulses should now be present at pin 5, none at pin 8, and TR5/6 collectors should be at about -10 V. If these conditions do not exist, there is probably a fault in D2, TR5 or D4, TR6.

130. Given a correctly functioning programmable divider and phase detector, failure to lock is likely to be due to a fault in IC22 or RLA, due to either a relay fault or to its not being driven correctly by TR4.

AB5 Reference Oscillator

131. Fault-finding on this board is straightforward. The technical description and circuit diagram should enable all faults to be found using an oscilloscope.

132. The most likely problems are failure of the crystal oscillator, usually giving error 08 on the frequency display, and failure of the oven, giving warm-up drift on the frequency display.

AB6 Counter Limiter

133. This unit is also a straightforward signal processing circuit and technical description and circuit diagram should give sufficient guidance.

AB7 : AM Detector

134. For fault-finding purposes, this board is divided into its two sections. The first comprises the i.f. amplifier, a.m. detector integrator and levelling, and the second, the i.f. detectors.

135. The a.m. detector section, chart no. 7, will need to be referred to when problems of the following nature occur:

(a) No a.m.

(b) Distorted a.m.

(c) No i.f. output.

(d) Instrument fails calibration of a.m. when a.m. source appears satisfactory.

(e) IF output unlevelled.

The i.f. detector section is heavily involved in auto-tuning and will require reference in connection with failure to auto-tune. If there is excessive spurious a.m. caused by the presence of f.m. in early instruments, it may be improved by substituting a miniature 63 V PETP capacitor for the tantalum bead type used for C16.

FAULT-FINDING CHART No. 7

AM detector faults (AB7)

Fault finding instructions

136. (1) Ensure that a 1.5 MHz signal is present at PLBJ, either obtained from normal auto-tuning operation, or by injecting a signal at PLBJ, of a level which is shown on the circuit diagram.

(2) Remove lower instrument cover and bottom r.f. box lid. Trace the signal flow from the input to the board to the i.f. output socket and replace the defective components.

(3) Trace the signal flow to TR13 emitter.

(4) There may be a defective amplifying device or the lower i.f. filter may be in circuit. Check the control lines and coil voltages on RLA and RLB using the control data in the technical description.

(5) The functioning of the a.m. detector can be gauged by examining the waveforms at TR16 and TR11 collectors on an oscilloscope. TR16 collector should be at a nominal 5 V dc, but more importantly, have a 1.5 MHz signal which is of approximately square shape with an amplitude of 1.2 V peak-to-peak. TR19 collector should have a half-wave rectified i.f. signal, negative with respect to ground. If a.m. is applied to the input, the envelope should be seen on the negative-going signal, and the mean d.c. level should increase as the input level is increased.

(6) Check and replace where necessary, TR14, 15, 16, 19 and D6.

(7) Monitor i.f. output. Vary input level. IF output should maintain a constant output. IC1 pins 2 and 3 should be at -0.56 V in the static condition.

(8) The levelling speed, which can be gauged visually from i.f. output level changes, varies with I.f. filter selected from the front panel. The 300 Hz 3.4 kHz filter gives the fastest response and the 30 50 kHz filter the slowest.

(9) Remove the mini-jump connector joining test points 1 and 2. Turn off the input signal. IC1 output should slew towards its -7.5 V supply rail. Re-apply the input signal and increase the level to well above that shown on the circuit diagram. IC1 pin 3 should go below -0.56 V and the output at TP2 slew positive to 0.7 V.

(10) When this stage is reached, a failure in the levelling devices, TR6 and 7 is indicated. This can be confirmed by applying an input signal of level as shown on the circuit, and applying a varying d.c. level at TP1 from -7.5 V to + 0.7 V. The i.f. output level should vary, the level decreasing as the voltage at TP1 is increased.

NOTE

Replacement of components within varnished area of board (especially around IC's 1 and 2) may render the instrument susceptible to conditions of very high humidity unless the area is re-varnished.

AB7 IF Detector

137. In cases where the i.f. level detector is suspected, a software diagnostic feature is available via the front panel whereby the i.f. level can be read directly on the voltmeter. Full details are given in the section in diagnostic second functions. Second function 08, test 4 gives the i.f. level detector output on the voltmeter. If an input level of -10 dBm at 1.5 MHz is applied to the AB7 input, the indicated i.f. level will be in the region of 1000 for a functioning instrument. This would be obtained by applying a carrier frequency of this level at 100 MHz or below to the front panel input.

138. In some cases, the i.f. detector may have to be tested as a self-contained unit. This may be done by applying a 1.5 MHz signal to the board input with the level shown on the circuit diagram. The output is available at PLCC pin 1 or IC4 pin 7 and should have approximately the level given on the circuit diagram.

139. Faults in the detectors should be readily found using the circuit and technical description. Check that the amplifier stages IC4a3 and TR17 give approximately the correct gain. Tuning the input signal from 1.5 to 14 MHz should give a tuning indication over approximately 3 11 MHz as shown in the description. If the amplifier gains are correct and IC4 pins 7 and 10 do not move up and down in sympathy with the signal, IC4 will need replacement. A failure in IC5, TR18 or D9 will prevent the tuning LED and the 'i.f. tuned' line from functioning.

AB8 FM Detector

140. Fault-finding on this unit is very straightforward since waveforms and levels are given on the circuit diagram. Failure in any section should be readily apparent.

141. Note that when a.m. is selected, the filters on this board are used to remove i.f. signal from the recovered audio. The level of audio from a.m. at PLCK for 100% a.m. is the same as for 100 kHz f.m. deviation i.e. a given percentage a.m. depth should give the same audio level as the same number of kilohertz of f.m. deviation.

142. If the a.m. rejection is substantially worse than the 'typical' figure quoted in Performance Tests, it may be due to a faulty ICI although performance deterioration here is very unlikely. In case of difficulty, contact Service Division or your nearest agent.

AB9 : LF Amplifier

143. Fault finding, in conjunction with the circuit diagram and technical description, is straightforward, and largely consists of signal tracing. The control line information is given in the technical description. Second function 36 is very useful since it allows a particular amplifier range to be set. Range 0 gives the lowest board gain (10 dB) while 5 gives the highest, of 60 dB.

144. The detector output at pin 6 of IC12 should be a full-wave rectified version of the audio, with the peak level being stored on C33.

145. If audio signal disappears at some stage, check that the transient suppression transistor is not shorting the signal flow before replacing an operational amplifier or a signal routing switch.

146. If poor stereo channel separation is obtained, check the coupling and bootstrapping capacitors C1, C2, C10, C11, C21, C22 for low values and other components around IC1, IC5 and IC10. Ensure that the 10 300 k filter on AB10 is correctly in circuit.

AB10 : LF Filters

147. The fault-finding on this board consists of much the same signal tracing process as for the LF Amplifier board (AB9). There are, however, a few possible complications. Disappearance of signal at PLCT could be caused by the insertion of a jack in the socket on the rear panel, or by a faulty switch on this socket. Disappearance or distortion of signal at PLCS may be due to a fault on the Options board AE1 if fitted. This should be disconnected and the mini jump connector on the Mother board ACI moved to the adjacent position in order to check whether this is so.

148. A rough guide to whether the filters are functioning can be obtained from the front panel. If a high carrier frequency is applied to the input socket with a low f.m. deviation, and the demodulated audio observed at the l.f. output socket on an oscilloscope, the noise content of the signal will reduce with decreasing filter bandwidth. The de-emphasis can be checked using the relative mode as described in the list of second functions used for diagnostic purposes.

149. There is a complication in fault-finding on this board, in that the analogue multiplexers have derived 7.5 V supplies. If a multiplexer fails in such a way as to drag either supply low, this will stop the operation of all the other devices. The failed device may identify itself by becoming warm.

150. The filter pass band characteristics may be checked by injecting a source of audio at the input to the board and reading the response relative to I kHz from the modulation display using the relative mode. This can be done if the instrument is provided with a signal at the input to which it tunes. The audio source must be flat to within +1% from 10 Hz to 300 kHz. This test allows the filter pass bands to be checked, apart from the 10 Hz to 300 kHz position where the test will include the flatness of the voltmeter section. This is of no consequence, provided that the response is no more than 3% down at 275 kHz since this filter is included within the f.m. system which must be no more than 5% low at 275 kHz.

151. Where a response is outside specification, the problem is likely to be due to a faulty resistor or capacitor. For example, if the 50 Hz 15 kHz filter is more than 3.5 dB low at 15 kHz relative to its 1 kHz point, the low-pass section of this filter would be implicated, and either one or more

of the resistors R16, 17, 24 or one or more of the capacitors, C24, 29, 37 or 38 would require replacement. Starting with the capacitors, these components would need to be removed in turn and checked on a component bridge until the out-of-specification device was found.

AB11: Latch board

152. Attention will usually be brought to the latch board when a board within the r.f. box receives the wrong instruction. The faulty device can be easily identified since one device controls a given board. Note that the programmable divider latches are on board AB4 and not ABII.

AC2 : Voltmeter board

153. The technical description of this unit is fairly exhaustive, but chart no. 8 is given to provide additional assistance, since in the normal condition there is a great deal of interaction on this board with the microprocessor system which would complicate fault-finding if it were not for the special diagnostic aids provided.

154. Fault-finding of the frequency multiplier should be a straightforward matter of signal tracing in conjunction with the description and the circuit diagram.

FAULT-FINDING CHART No. 8

Voltmeter board faults (AC2).

Fault finding instructions 155.

(1) Use second function 08, test 5, to examine the voltmeter count when the input is grounded. A reading in the region of 250 is obtained. No reading (provided the counter board is functioning) indicates that the voltage-to-frequency converter is faulty.

(2) Remove top instrument cover and card-guide top restraint. Remove the board and replace it on the extender board provided in the maintenance kit.

(3) Examine IC9 output. Pin 9 should be at a small positive voltage. IC9 is probably faulty unless pin 4 has been shorted out.

(4) Apply audio signal to the voltmeter at PLAD on the mother board or PLAD on LF Filters board AB10. Observe d.c. level at TP2 using the PEAK HOLD facility.

(5) Trace the signal flow from PLAD to TP2. Press the P+ and P- keys to exercise IC3 and IC10. Check that the derived 7.5 V rails are correct. Check that TR3 is normally off and turned on by discharge pulses at its base.

(6) Apply audio in the same way as above, and monitor TP1. Observe the level rise and fall with audio input. The levels at TP1 and TP2 should be similar.

(7) Trace the signal from input to TP1 to identify faulty device.

(8) A signal will be present on all inputs if the instrument auto-tunes successfully and the inputs can be tested using second function 08 (see description). If auto-tuning is not working, the inputs can be tested individually (again using second function 08) by means of the following :

RF power and mixer level:	Apply power to the input socket in the range 10 mW to 1W.
IF level :	Apply signal of 100 mV to input of AB7.
LF amplifier level:	Inject audio to the input of AB9.

A response should be obtained on all these inputs, provided the relevant detectors are working.

(9) Check instruction on outputs of IC17 and replace if faulty. If correct, replace IC11.

(10) Discharge pulses should be available at IC16 pin 14, TR10 collector and TR3 collector.

(11) Trace the discharge pulses and replace the failed device.

(12) If the calibrator is fully functioning and the instrument fails to calibrate, the problem may be the voltmeter board voltage-to-frequency conversion factor having changed. This would manifest itself in both the a.m. and f.m. readings being in error.

(13) The primary determinant of the voltmeter voltage-to-frequency shape is C13. Check the value of C13 and replace if this outside the tolerance range.

AC3 : Counter board

156. Fault-finding on this board in great depth may be complicated by the presence of a number of signal loops. A total counter failure may be due to a number of components. As with the voltmeter, the board may be investigated by removing the top instrument cover, the card guide restraint over the top of the vertical boards, and placing the board on to the extender provided in the maintenance kit.

157. Check first of all that the 10 MHz standard signal is present and divided down to 1 MHz by IC4. Then ensure that the signal inputs are present on IC5 inputs and, periodically at the output pins. Time base and reset pulses should be available at pins 15 and 4 of IC14. If not, IC14 is probably faulty. IC7 pin 9 should periodically go to the logic 1 state, allowing 10 or 100 millisecond bursts of signal through IC6, the counter gate. IC5 or IC7 should be inspected if this is not the case. If pulses are present on IC7 pin 8, check that the monostable pulses are available from the outputs of IC8.

158. The decade counters can be readily checked by looking for signals on their output pins.

159. A fault in IC15 may hold the instrument bus lines in one state. Such a fault may cause IC15 to become hot. This may be identified by removing the board and examining the low lines to see whether the condition clears. If it does, replace IC15.

160. A fault in counting low modulation frequencies below about' 5 kHz is probably due to a fault on the frequency multiplier on AC2, the voltmeter board, and this section should be tested in such cases.

Microprocessor system

161. Virtually all of the instrument's operation is controlled by the microprocessor system. This contains a memory with a capacity of many thousands of bits of information, all of which must be stored and acted upon correctly for the instrument to function fully. Despite this, however, most faults occurring in the system show themselves in a fairly dramatic way, and fault-finding can be treated in a similar manner to that of the rest of the instrument.

162. The microprocessor system is based on boards AC4 and AC5 which are the rear pair in the vertical card rack. All the complex IC's are plugged into sockets. If the error message "H" is displayed at switch-on in the frequency display a fault in the random-access memory is indicated (IC12 on AC4, IC's 1 and 2 on AC5). If a "P" is displayed, a fault in the programmable read only memories (PROM's) is indicated (IC's 5 to 11 on AC4). The IC sockets and sockets and tracks should be inspected carefully for flaws, since these could be to blame for such an error message. The PROM set should normally be replaced complete.

163. Faults in the system would cause anomalous behavior such as an abbreviated calibration routine, failure to respond to the front panel or an incorrect set of LED's or annunciators being displayed. In such cases, a good first step is to remove the top cover and the restraint on the vertical boards, and to remove and replace boards AC4 and AC5 to ensure that they are seated correctly and making good contact.

164. A total lack of activity in the switch-on calibration sequence may be due to a lack of microprocessor clock signal. Board AC4 should be placed in the extender card. IC2, pin 37 should be examined. There should be a clock signal at approximately 3 MHz at this point. If this has failed, IC2, the microprocessor, should be replaced. If the clock is running, look for general bus activity on the address and data lines from the processor (pins 12 to 19 and 21 to 28). Again, a total lack of activity should cause IC2 to be replaced.

165. The interface between the microprocessor system and the rest of the instrument is a set of buffers on AC5, IC8 and IC9 driving one bus, and IC's 5, 6 and 7 driving the 'quiet' bus to the screened r.f. box. A fault in any of these IC's will cause a bus fault and anomalous operation of the instrument, such as an incorrect display. Such a fault may be traced by the fact that a failed IC may become hot to the touch. Bus activity should be inspected on the bus lines internal to the microprocessor system. Tri-state t.t.l. signals should be present. If a line is permanently low or high, the failed buffer IC should be sought. In difficult cases, the IC's may have to be replaced in turn. Note that a fault on the instrument busses themselves can be caused by anything connected to the bus, and not necessarily just the microprocessor system.

166. Faults in the EAROM system may be caused by either a faulty device, or by the -30 V line being activated at the wrong time. The most drastic effect in the complete loss of contents, giving a set of zeroes in the modulation display under all conditions. The operation of the EAROM can be checked using second function 20, which sets the SRQ mask. This function is stored entirely in EAROM, there being no RAM 'image'. Unlock the instrument protection to level P1. After accessing second function 20, enter a pattern of eight zeroes or ones which will fill up the frequency display. If the second function is then left and re-accessed, this pattern should have been stored correctly. If not, the EAROM circuitry should be checked.

167. The -30 V supply to the EAROM should be activated only when writing into the device, as when completing a store operation using the RCL/STO key. This should be checked by looking at IC4, pin 1 which should normally be at +5 V. If all appears to be correct, the EAROM should be replaced and the instrument recalibrated. If the -30 V supply is not turned off correctly, the supply generation circuitry should be investigated with reference to the technical description. If the EAROM has been erased, recalibration will be necessary using all the P3 second functions. External calibration will be necessary for r.f. power (SF 50) and f.m. correction (SF 51 and SF 52).

168. Failure to update the contents of the EAROM may be caused by failure of the -30 V supply and the course of action should be similar, except that recalibration should not be necessary. Again, correct operation can be checked using second function 20.

169. The section on the microprocessor system is completed with a table giving the conditions for correct operation of the EAROM supply circuitry.

TABLE 3 EAROM SUPPLY CIRCUITRY CONDITIONS

Test point	Static condition	Transient condition when completing a store and writing to EAROM
IC1, pin 35	TTL low	TTL high or tri-state.
IC3a2, pin 12	-15 V	Oscillates between -15 V and 0 V.
IC3b2, pin 2	0 V	Oscillates between -15 V and 0 V.
TR7 collector	0 V	Oscillates between +5 V and -15 V.
TR9 emitter	-15 V	-30 V.
IC4, pin 1	+5 V	-30 V.

AD1 Power supply

170. The power supply unit is of conventional design and should be straightforward to maintain.

171. If the instrument is switched on and there are no signs of activity, the fuses on the rear panel should be checked.

172. The transformer secondaries can be tested by removing the housing PLD on the top of board AD1, to which access is given simply by removing the top instrument cover.

173. If a d.c. supply rail is missing or low in voltage, the connectors PLM, PLN and PLP should be removed in turn. If the supply voltage returns, measured across C7, C8 or C9, one of the units is loading the regulators excessively. The fault should be traced and rectified. This should be straightforward since each board has its own supply which may be removed by unplugging a connector. All the r.f. box power supplies run on the same pattern of connector.

174. If transformer secondary voltages are present and the rectified and smoothed voltages are available across C1, C2 or C3, but a d.c. supply does not return when the loads are removed, the appropriate regulator should be checked and replaced where necessary.

175. It should be possible to adjust all the supply voltages above and below nominal by means of R2, R5 and R8. Failure of adjustment could be caused by a missing wiper on these items.

176. If the +5 V or +15 V lines cannot be adjusted sufficiently high in voltage when loaded, the rear heat sink should be removed from the rear panel and the screws securing the regulators to the heat sink should be tightened. This will remove any problem due to contact resistance which can drop a significant voltage since the current carried is quite large. This should also be done when power supply ripple becomes excessive. In normal correct operation, the power supply ripple at mains frequency and harmonics measured by a wave analyzer should be only of the order of tens of microvolts even under loaded conditions.

AE1 Distortion/Weighting Filter (Option) board

177. Since this board is divided into several modules, i.e. the two weighting filters, 20 dB gain blocks and distortion notch, each of which can be selected via the front panel, fault-finding is relatively straightforward. One complication which can arise, as for the l.f. filters and voltmeter, is with analogue multiplexers IC7 and IC9 which have derived 7.5 V supply rails. A failure in either device, or elsewhere, which pulls either rail down will result in distortion of signals in a number of places. Fortunately, failed components can often be traced by locating a hot component. Diodes D1 and D2 should be tested. If no obvious fault is found, remove IC7 and IC9 from the board. If the fault clears, replace either or both of these devices. Note that IC6 and IC10 also run off the positive derived 7.5 V rail, and these should be checked.

178. If signal distortion occurs whereby the options board is suspected, this can be verified by removing the options board from the signal path, by removing the ribbon cable and moving the blue mini-jump connector to the adjacent pair or pins on the mother board. If the fault persists, the options board is at least not the sole cause of the problem.

179. The table below shows the various circuit blocks on this board which are controlled independently by front panel second functions.

180. The weighting filters and 20 dB gain stages can be tested quite easily by means of signal tracing with an oscilloscope. The notch filters can be rather more difficult since two feedback loops are involved.

181. Note that for the distortion notch section to work correctly, the two 20 dB gain stages must be functioning and switched in correctly. These should be checked in conjunction with the notches by applying a sufficiently low signal level to the input to the board (e.g. by applying a low deviation signal or by lowering the main l.f. amplifier gain using the appropriate second function).

182. If a distortion notch fails to operate at all, check the applied modulation frequency to ensure that it is within 5% of the correct notch frequency. If one or two notches are faulty with at least one operational, check the switching transistors TR's 3, 4, 6 and 7 and their drivers TR1 and TR2, since the notch capacitors are not being switched in correctly. The highest notch frequency will be operating normally in this case. If all notches have failed, force the selection of one of them and apply the correct input frequency. Trace the signal through IC8b4 and the sections of IC11. The signal should be a faithful copy of the input. The outputs of IC12a3 should be squared-up signals at the input frequency with peak amplitudes tending towards the 15 V supply rails. The signals at pins 1 and 14 should be in quadrature. The phase detector outputs, IC13 pins 14 and 15, should vary as the input frequency is varied above and below the correct frequency, and the integrator outputs (IC12 pins 7 and 8) should slew up and down. Failure up to this point will require replacement of the faulty device. If all is well, the control FET's TR5 and 8 or TR9 are implicated and should be replaced.

183. Obtaining other notch frequencies. Other notch frequencies can be obtained by changing capacitors C44, C45, C46 and C48, C49, C50 noting the following points:

(a) The frequency of the notch is that for which the total capacitance between pins IC8 pin 14 and IC11 pin 12, and between IC11 pins 14 and 10, is given by the expression: $\frac{\text{33 nanofarads}}{\text{Notch frequency (kHz)}}$.

(b) The new notches will not be selected automatically, but must be selected via second function 38. The following table gives the conditions for the notches.

TABLE 4 SECOND FUNCTIONS CONTROLLING BOARD AE1

Circuit module controlled	*Second function*
Weighting filters	25
20 dB gain stages	37
Distortion notches	38

See the Operating Manual for full details.

TABLE 5 CIRCUIT CONDITIONS FOR DISTORTION NOTCHES

Notch	*Normal frequency*	*Capacitors in circuit*
1	300 Hz	C44 + 45 + 46; C48 + 49 + 50
2	500 Hz	C44 + 46; C48 + 50
3	1 kHz	C44; C48

AG0 GPIB Adapter Module

184. There are relatively few active components on this board on the circuit board AGI, contained within the module, and fault-finding will usually amount to replacement of one or more GPIB talker/listener IC's (4 - 7) or the GPIB talker/listener IC2. Also check very carefully all the leads and connectors associated with this unit.

Section III. SERVICING DIAGRAMS

NOTE

The servicing diagrams are the foldouts located in the back of this manual.

CIRCUIT NOTES

1. Component values

Resistors	:	Code letter R = ohms, k = kilohms (10^{3}), M = megohms (10^{6}).
Capacitors	:	Code letter m = millifarads (10^{-3}), p = microfarads (10^{-6}), n = nanofarads (10^{-9}), p = picofarads (10^{-12}).
Inductors	:	Code letter H = henrys, m = millihenrys (10^{-3}), µ = microhenrys (10^{-6}), n = nanohenrys (10^{-9}).
SIC	:	value selected during test, nominal value shown.

2. Components are marked normally with two, three or four figures according to the accuracy limit ±10%, ±1% or ±0.1%. The code letter used indicates the multiplier and replaces the decimal point. Because a marking 4m7 could be interpreted as milliohms, millifarads or millihenrys each value is placed near to its related symbol. In cases where the inductor symbol (∩∩∩∩) appears with a circuit reference but with no component value, the component referred to is the printed conductor itself which contributes significantly to the circuit behavior in this respect.

3. Electro-mechanical relays are all shown according to convention, in the de-energized state. The effect in the circuit diagrams corresponds to a state which could only be created by the removal of all power supplies and not to any practical operating condition.

4. Symbols

Symbols are based on the provisions of BS 3939 with the following additions:

edge connector

X1 ferrite bead

warning, see page (C), notes and cautions

AB2 unit identification number

All resistors are depicted as rectangular blocks

SIC (select in cal) component value chosen during test.

APPENDIX A

REFERENCES

A-1 SCOPE

This appendix lists all forms, field manuals, technical manuals and miscellaneous publications referenced in this manual.

A-2 FORMS

Reporting of Transportation Discrepancies in Shipment .... AR 55-38
Reporting of Item and Packaging Discrepancies .... AR 735-11-2
Discrepancy in Shipment Report (DISREP) .... SF 361
Report of Discrepancy (ROD) .... SF 364
Quality Deficiency Report .... SF 368
Recommended Changes to Publications and Blank Forms .... DA Form 2028-2
Equipment Inspection and Maintenance Worksheet .... DA Form 2404
Consolidated Index of Army Publications and Blank Forms .... DA Pam 310-1

A-3 FIELD MANUALS

Preservation, Packaging, Packing and Marking Materiels, Supplies
and Equipment Used by the Army .... SB 38-100
Field Instructions for Painting and Preserving Electronics Command Equipment
Including Camouflage Pattern Painting of Equipment Shelters .... TB 43-0118

A-4 TECHNICAL MANUALS

Administrative Storage of Equipment .... TM 740-90-1
Procedures for Destruction of Electronics Materiel to Prevent Enemy Use .... TM 750-244-2
The Army Maintenance Management System (TAMMS) .... DA Pam 738-750
Repair Parts and Special Tools List, Modulation Meter ME-505A/U
(Marconi Instruments, Model 2305) (NSN 6625-01-154-4844) .... TM 11 6625-3146-24P

APPENDIX B

MAINTENANCE ALLOCATION

MODULATION ME-505A/U

Section I. INTRODUCTION

B-1. General.

This appendix provides a summary of the maintenance operations for Modulation Meter ME-505A/U. It authorizes categories of maintenance for specific maintenance function on repairable items and components and the tools and equipment required to perform each function. This appendix may be used as an aid in planning maintenance operations.

B-2. Maintenance Function.

Maintenance functions will be limited to and defined as follows:

a. Inspect. To determine the serviceability of an item by comparing its physical, mechanical, and/or electrical characteristics with established standards through examination.

b. Test. To verify serviceability and to detect incipient failure by measuring the mechanical or electrical characteristics with prescribed standards.

c. Service. Operations required periodically to keep an item in proper operating condition, i.e., to clean, preserve, drain, paint, or to replenish fuel/lubricants/hydraulic fluids or compressed air supplies.

d. Adjust. Maintain within prescribed limits by bringing into proper or exact position, or by setting the operating characteristics to the specified parameters.

e. Align. To adjust specified variable elements of an item to about optimum or desired performance.

f. Calibrate. To determine and cause corrections to be made or to be adjusted on instruments or test measuring and diagnostic equipment used in precision measurement. Consists of the comparison of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared.

g. Install. The act of emplacing, seating, or fixing into position an item, part, module (component or assembly) in a manner to allow the proper functioning of the equipment/system.

h. Replace. The act of substituting a serviceable like-type part, subassembly, module (component or assembly) for an unserviceable counterpart.

i. Repair. The application of maintenance services (inspect, test, service, adjust, align, calibrate, replace) or other maintenance actions (welding, grinding, riveting, straightening, facing, remachining, or resurfacing) to restore serviceability to an item by correcting specific damage, fault, malfunction, or failure in a part, subassembly, module/component/ assembly, end item or system. This function does not include the trial and error replacement of running spare type items such as fuses, lamps, or electron tubes.

j. Overhaul. That periodic maintenance effort (service/action) necessary to restore an item to a completely serviceable/operational condition as prescribed by maintenance standards (e.g., DMWR) in appropriate technical publications. Overhaul is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like-new condition.

k. Rebuild. Consists of those services/actions necessary for the restoration of unserviceable equipment to a like-new condition in accordance with original manufacturing standards. Rebuild is the highest degree of materiel maintenance applied to Army equipment. The rebuild operation includes the act of returning to zero those age measurements (hours, miles, etc.) considered in classifying Army equipment/components.

B-3. Column Entries.

a. Column 1, Group Number. Column 1 lists group numbers, the purpose of which is to identify components, assemblies, subassemblies, and modules with the next higher assembly.

b. Column 2, Component/Assembly. Column 2 contains the noun names of components, assemblies, subassemblies, and modules for which maintenance is authorized.

c. Column 3, Maintenance Functions. Column 3 lists the functions to be performed on the item listed in column 2, When items are listed without maintenance functions, it is solely for purpose of having the group numbers in the MAC and RPSTL coincide.

d. Column 4, Maintenance Category. Column 4 specifies, by the listing of a "work time" figure in the appropriate subcolumn(s), the lowest level of maintenance authorized to perform the function listed in column 3. This figure represents the active time required to perform that maintenance function at the indicated category of maintenance. If the number or complexity of the tasks within the listed maintenance function vary at different maintenance categories, appropriate "work time" figures will be shown for each category. The number of task-hours specified by the "work time" figure represents the average time required to restore an item (assembly, subassembly, component, module, end item or system) to a serviceable condition under typical field operating conditions. This time includes preparation time, troubleshooting time, and quality assurance/quality control time in addition to the time required to perform the specific tasks identified for the maintenance functions authorized in the maintenance allocation chart. Subcolumns of column 4 are as follows:

C - Operator/Crew

O - Organizational

F - Direct Support

H - General Support

D - Depot

e. Column 5, Tools and Equipment. Column 5 specifies by code, those common tool sets (not individual tools) and special tools, test, and support equipment required to perform the designated function.

f. Column 6, Remarks. Column 6 contains an alphabetic code which leads to the remark in section IV, Remarks, which is pertinent to the item opposite the particular code.

B-4. Tool and Test Equipment Requirements (Sect. III).

a. Tool or Test Equipment Reference Code. The numbers in this column coincide with the numbers used in the tools and equipment column of the MAC. The numbers indicate the applicable tool or test equipment for the maintenance functions.

b. Maintenance Category. The codes in this column indicate the maintenance category allocated the tool or test equipment.

c. Nomenclature. This column lists the noun name and nomenclature of the tools and test equipment required to perform the maintenance functions.

d. National/NATO Stock Number. This column lists the National/NATO stock number of the specific tool or test equipment.

e. Tool Number. This column lists the manufacturer's part number of the tool followed by the Federal Supply Code for manufacturers (5-digit) in parentheses.

B-5. Remarks (Sect. IV)

a. Reference Code. This code refers to the appropriate item in section II, column 6.

b. Remarks. This column provides the required explanatory information necessary to clarify items appearing in section II.

SECTION II MAINTENANCE ALLOCATION CHART
FOR
MODULATION METER ME-505A/U

(1) GROUP NUMBER	(2) COMPONENT ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE LEVEL C	O	F	H	D	(5) TOOLS AND EQUIPMENT	(6) REMARKS
00	MODULATION METER ME-505A/U MARCONI MDL 2305	INSPECT		.08					A
		TEST		.16				2	B
		TEST				1.0		3-11	C
		REPAIR		.16				1	D
		REPAIR				1.0		3-11	E

SECTION III TOOL AND TEST EQUIPMENT REQUIREMENTS FOR MODULATION METER ME-505A/U

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/NATO STOCK NUMBER	TOOL NUMBER
1	O	TOOL KIT, ELECTRONIC EQUIPMENT TK-101/G	5180-00-064-5178	
2	O	MULTIMETER DIGITAL AN/USM-486	6625-01-145-2430	
3	H	MULTIMETER DIGITAL, TEK DM501A MIS-30526/4	6625-01-075-8583	
4	H	GENERATOR, SIGNAL, HP 8640B, MIS-28707 TYPE 1	4931-01-085-4229	
5	H	OSCILLATOR, TEST HP652A, MIS 10224	5963-00-113-2943	
6	H	COUNTER, FREQUENCY HP 5345A, MIS-28754/1	4931-01-039-4040	
7	H	ANALYZER, MODULATION, HP 8901A MIS-30866 TYPE 1	6625-01-071-1720	
8	H	POWER SPLITTER, WE 1870A	6695-01-108-9833	
9	H	METER, POWER HP EI2-432A MIS-30525	6625-00-148-8069	
10	H	MOUNT, THERMISTOR HP 478A	6625-00-886-1955	
11	H	GRAPHICAL DISPLAY SYSTEM MIS-28706	6625-01-043-2270	

SECTION IV. REMARKS
MODULATION METER ME-505A/U

REFERENCE CODE	REMARKS
A	PERFORM DAILY VISUAL INSPECTION FOR METER CLEANLINESS AND LOOSE OR DAMAGED KNOBS AND/OR LENS CAPS.
B	CHECK SWITCHES, CONNECTORS, FUSE AND FUSE HOLDERS.
C	PERFORM OPERATIONAL/SYSTEM TESTS USING BIT AND EXTERNAL TMDE.
D	LIMITED TO REPLACING FUSE, LENS CAPS, CONNECTOR P/N 23421-620, CABLE ASSY POWER AND TIGHTENING OR REPLACING KNOBS.
E	REPLACE ALL CIRCUIT BOARDS. FURTHER ACTION IS REQUIRED FOR THE FOLLOWING CIRCUIT BOARDS. AB1 INPUT ATTENUATOR CIRCUIT BOARD. PERFORM RF POWER CHECK AND USE SECOND FUNCTION 50 (SF50) PROCEDURE. AB2 MIXER CIRCUIT BOARD. ADJUSTMENT OF R24 REQUIRED. AB3 VOLTAGE CONTROLLED OSCILLATOR CIRCUIT BOARD. CORRECTION UTILIZING FM SECOND FUNCTION 51 & 52 (SF51 & SF52) PROCEDURE REQUIRED. AB5 REFERENCE OSCILLATOR CIRCUIT BOARD. PERFORM STANDARD FREQUENCY ADJUSTMENT. AB7 AM DETECTOR CIRCUIT BOARD. USE PROCEDURE SECOND FUNCTION (SF46) AND ENTER 4 DIGIT % AM. AB8 FM DETECTOR CIRCUIT BOARD. SECOND FUNCTION 51 & 52,(SF51) (SF52)PROCEDURER REQUIRED. AB10 LF FILTERS CIRCUIT BOARD. SECOND FUNCTION 48 (SF 48) PROCEDURE USING EXTERNAL SIGNAL SOURCE REQUIRED. AC2 VOLTMETER CIRCUIT BOARD. SAME PROCEDURE AS AB10. AC5 MICRO PROCESSOR I/O EAROM CIRCUIT BOARD. IC 4 (AROM) SHOULD BE RETAINED IN REPLACEMENT BOARD. AD1 POWER SUPPLY CIRCUIT BOARD. ADJUST DC VOLTAGES UPON REPLACEMENT.

By Order of the Secretary of the Army:

JOHN A. WICKHAM JR.
General, United States Army
Chief of Staff

Official:

MILDRED E. HEDBERG
Brigadier General, United States Army
The Adjutant General

Distribution:

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CHART #1. TOP LEVEL FAULT-FINDING (1)

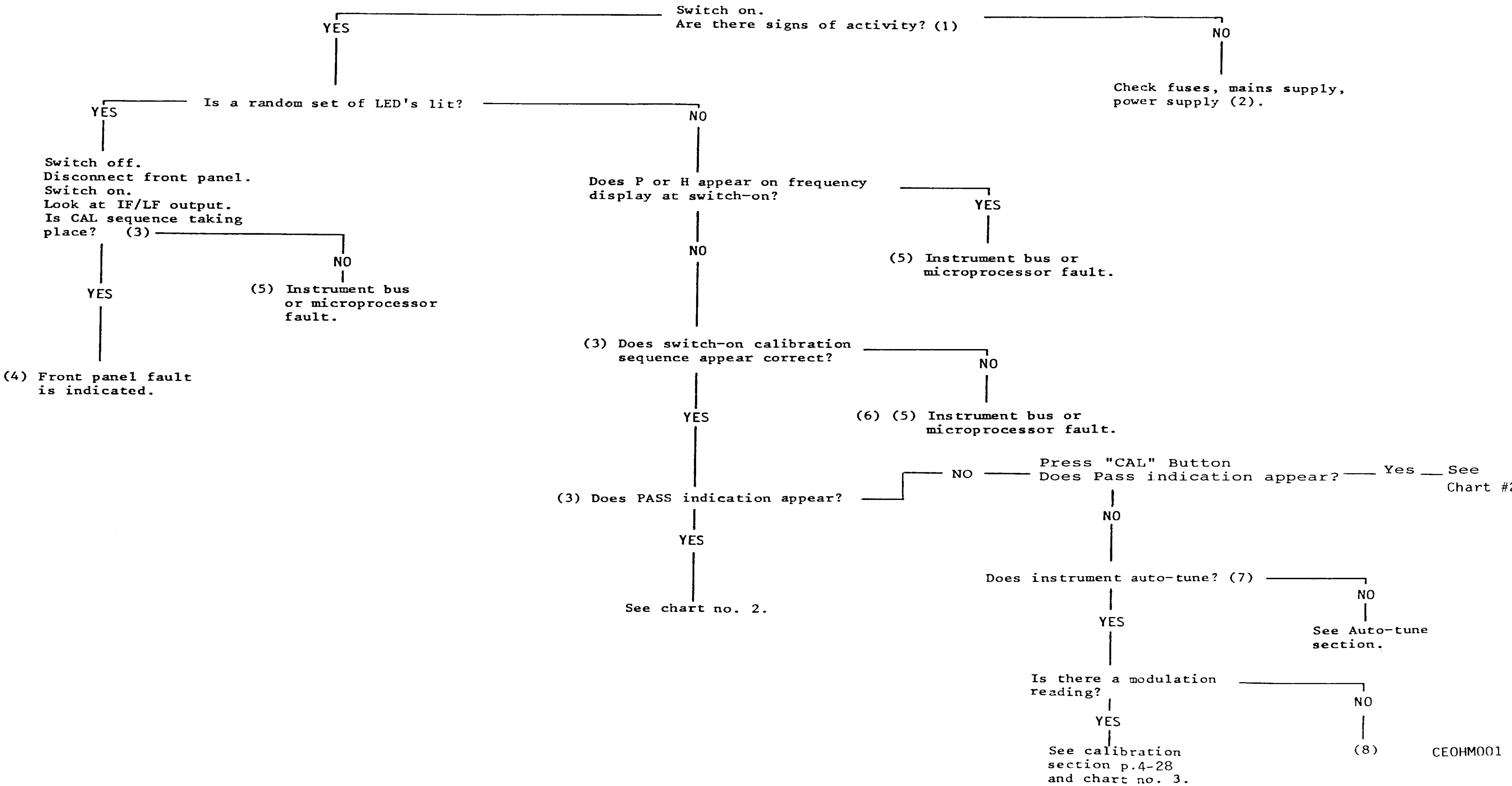
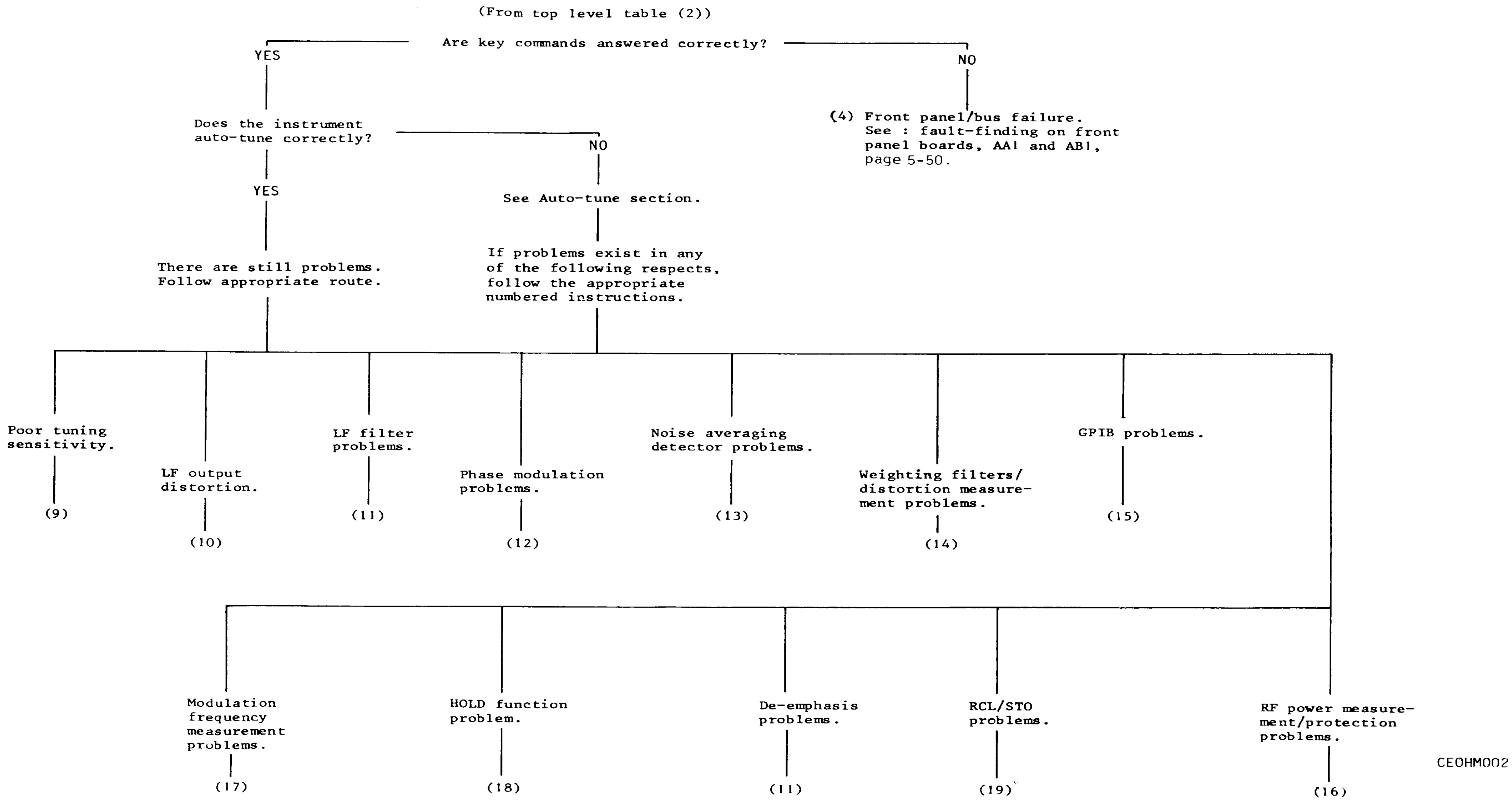


CHART # 2. TOP LEVEL FAULT-FINDING (2)



(8) the local oscillator frequency control line with an oscilloscope probe placed on the inner of the coaxial cable when feeds PLBN on board AB3 (the voltage controlled oscillator). With the calibrator running on wide deviation, there should be a rounded square wave here with peak-to-peak amplitude of approximately 12 V at a 1 KHz rate as illustrated in chart no. 3.

(9) The calibrator sample-and-hold phase detector is almost certainly at fault. Consult calibrator phase detector fault-finding chart no. 6 and technical description.

(10) The calibrator system appears to be completely satisfactory, and the cause of the problem is probably drift in the f.m. measuring system which needs to be identified and cured. See the following fault-finding sections:

AB8: FM Detector
AB9: :F Amplifier
AB10: LF Filters
AC2: Voltmeter

Setting up the local oscillator for use in f.m. calibration

82. Refer to the circuit of AB3. The top range oscillator, associated with TR8, covers the frequency range 47 to 56 MHz in normal operation. When used as the f.m. calibrator oscillator, however, this oscillator, must cover 46 to 56 MHz and the easiest way to ensure correct operation is as follows.

(1) Remove the instrument top cover and top r.f. box lid.
(2) Set the f.m. calibrator running on wide deviation by pressing

FREQ TUNE 0 ENTER
ENTER 10 RCL/STO

The frequency display should now show the calibrator centre frequency of 1.59375 MHz.

(3) Monitor the v.c.o. control voltage by placing an oscilloscope probe on the feedthrough capacitor which carries the coaxial cable inner lead to PLBN on AB3 or PLCZ on AB4.

The signal at this point should be the rounded square wave made up of many segments, with a peak-to peak amplitude of approximately 12 V shown in Table 3.

(4) With the oscilloscope/probe combination set to 2 V per vertical division, adjust the ‘zero’ line so that the waveform is in the centre of the screen

(5) Screw in the core of L4 until the top of the waveform is seen to break up. As the core is withdrawn the lower edge breaks up, but this is preceded by a point where the positive and negative deviations become unequal. This is seen as a ‘jump’ in the waveform and can be confirmed by a frequency reading of 1.59062 MHz. Screw the core in again to obtain the approx. Mid-point between the point of break-up of the waveform top, and the change in centre frequency. The positive peak of the waveform will typically be at +1 V (see fig.). The oscillator should now be in correct adjustment.

CHART # 3. FAILURE IN FM CALIBRATION

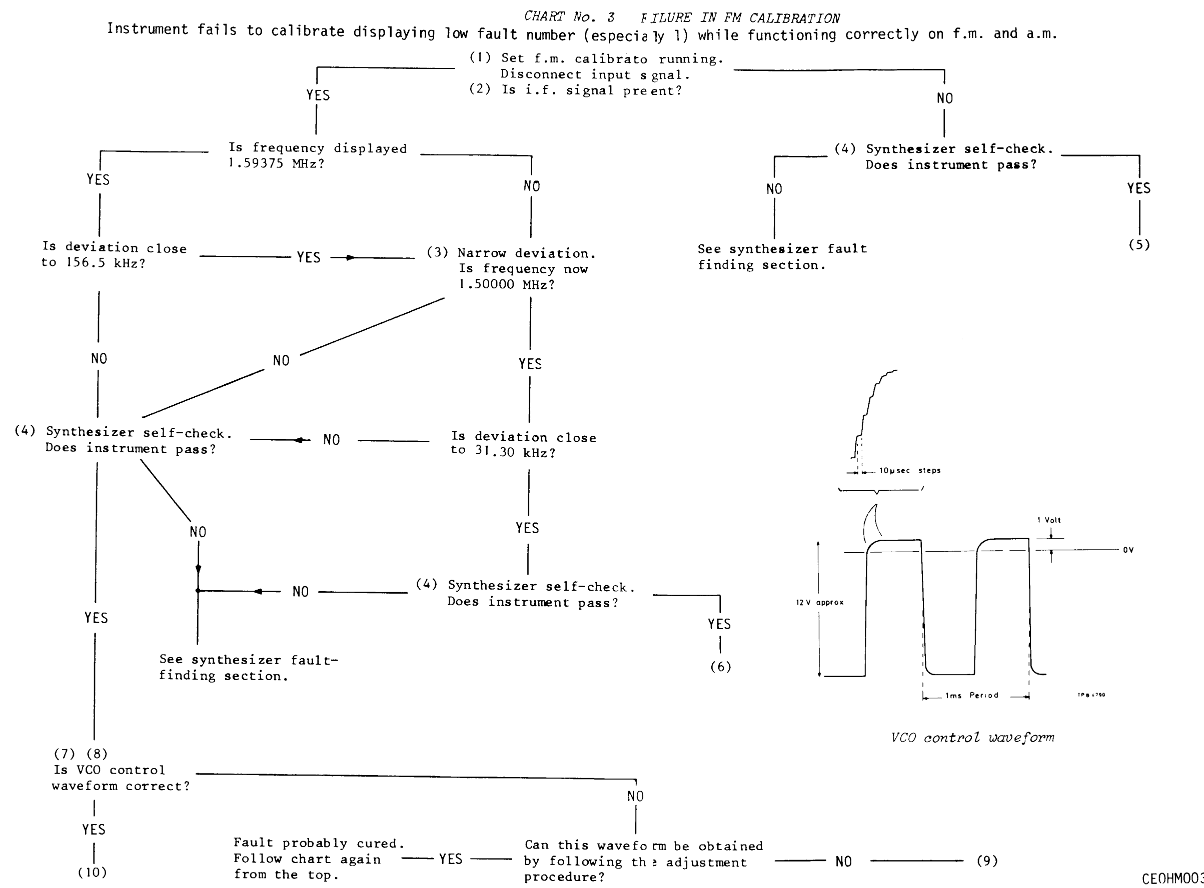


CHART # 4. FAILURE IN SYNTHESIZER SELF-CHECK

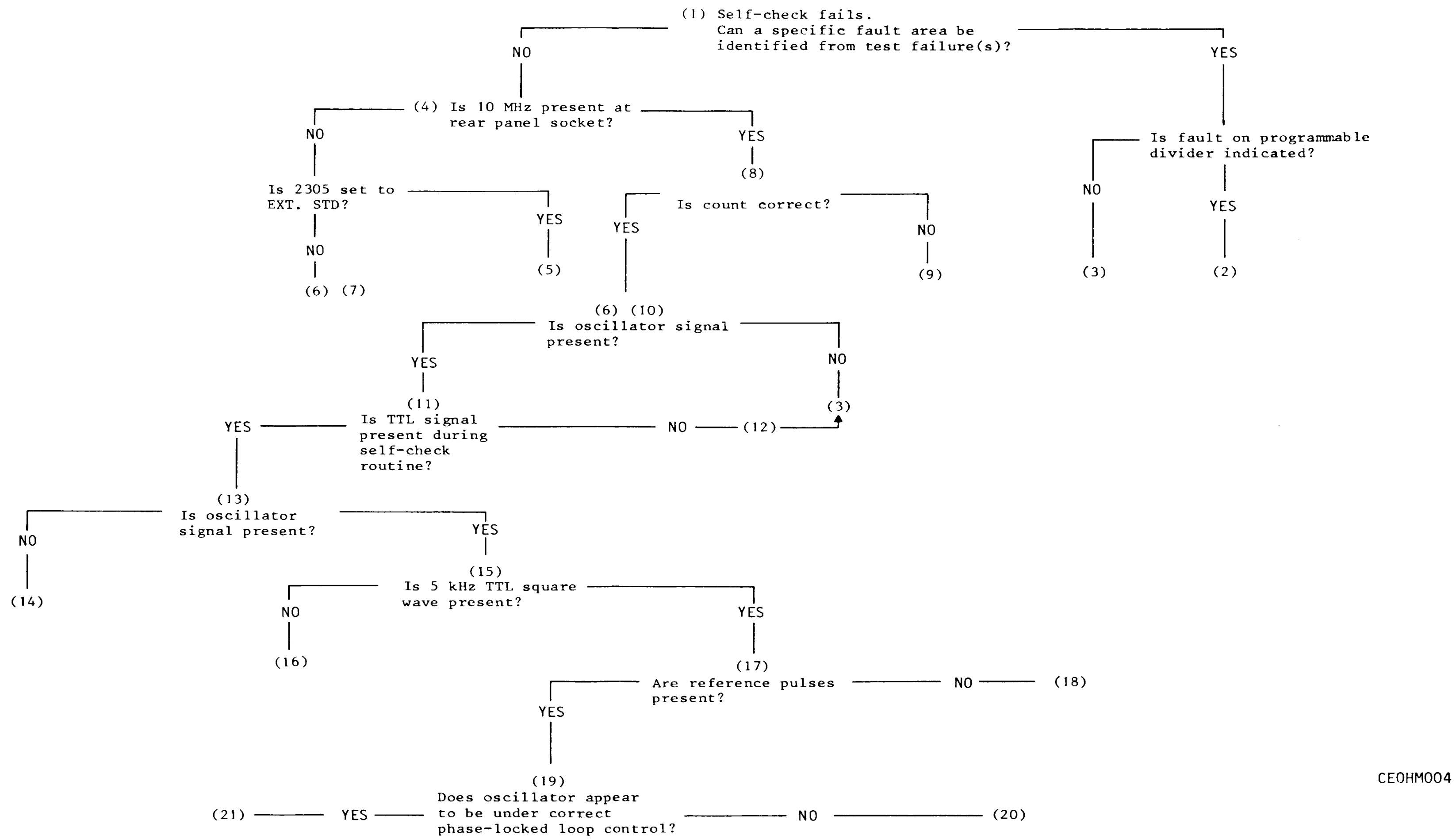


CHART # 6. SAMPLE AND HOLD PHASE DETECTOR (AB4)

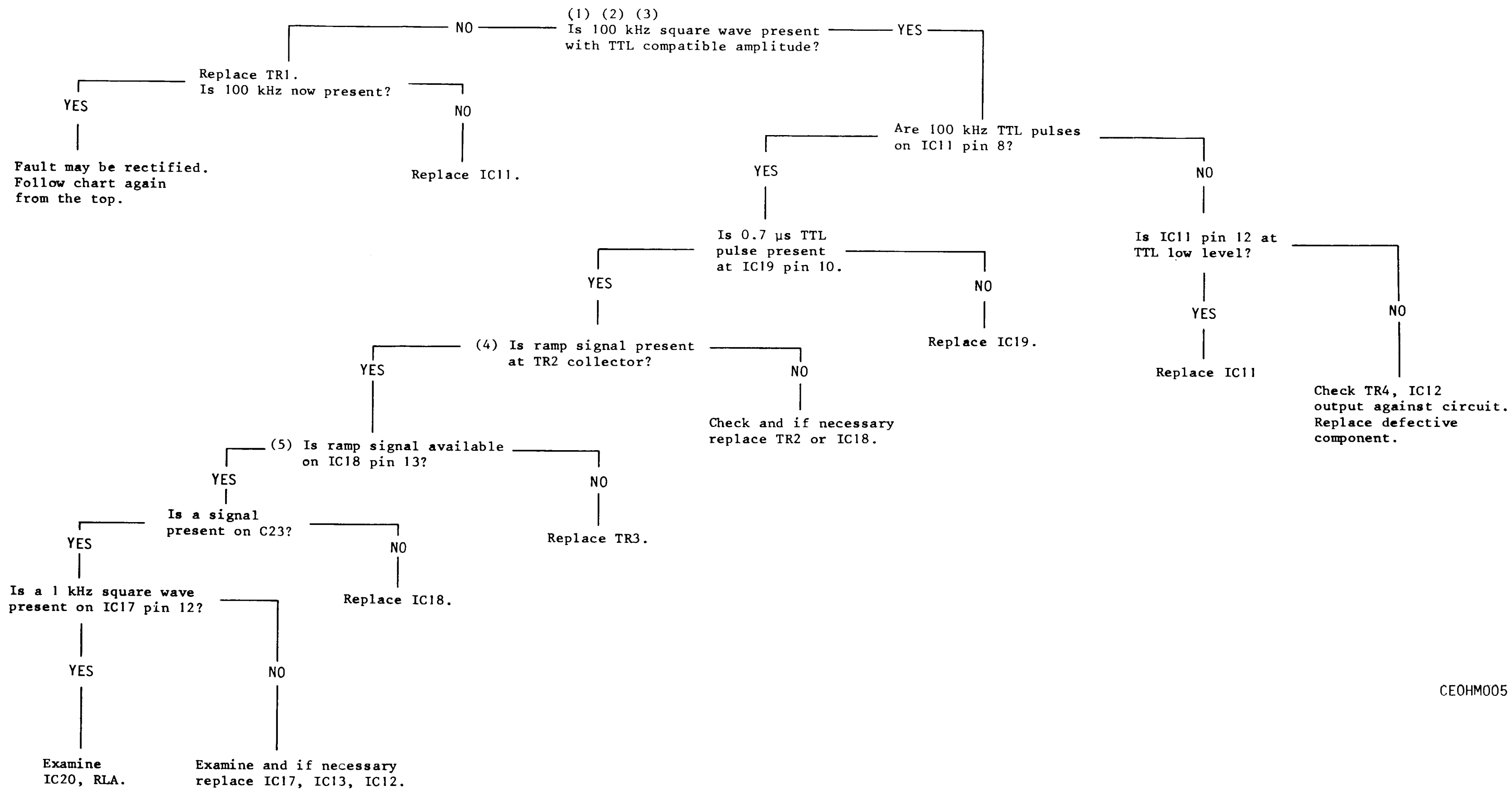


CHART # 7. AM DETECTOR FAULTS (AB7)

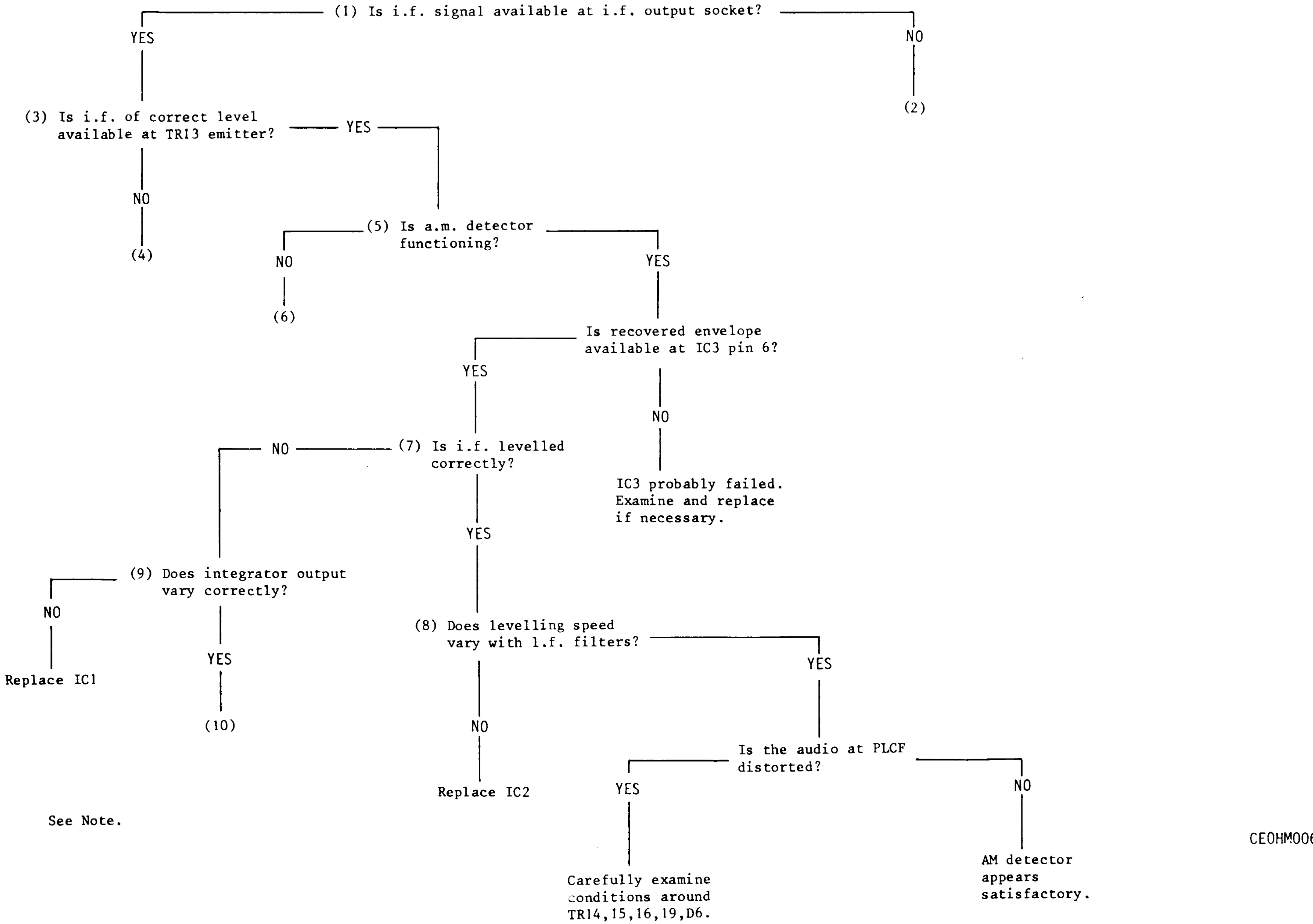
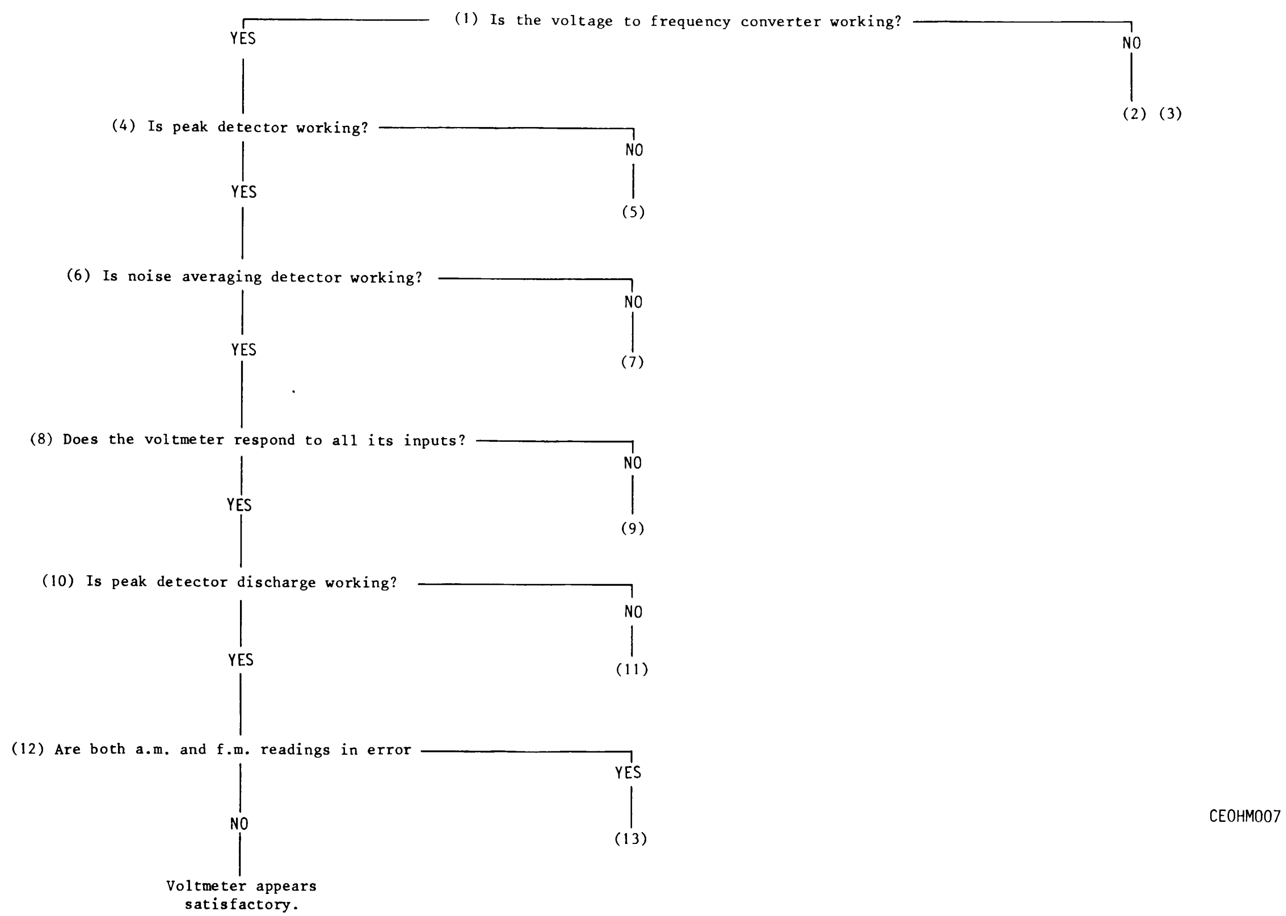
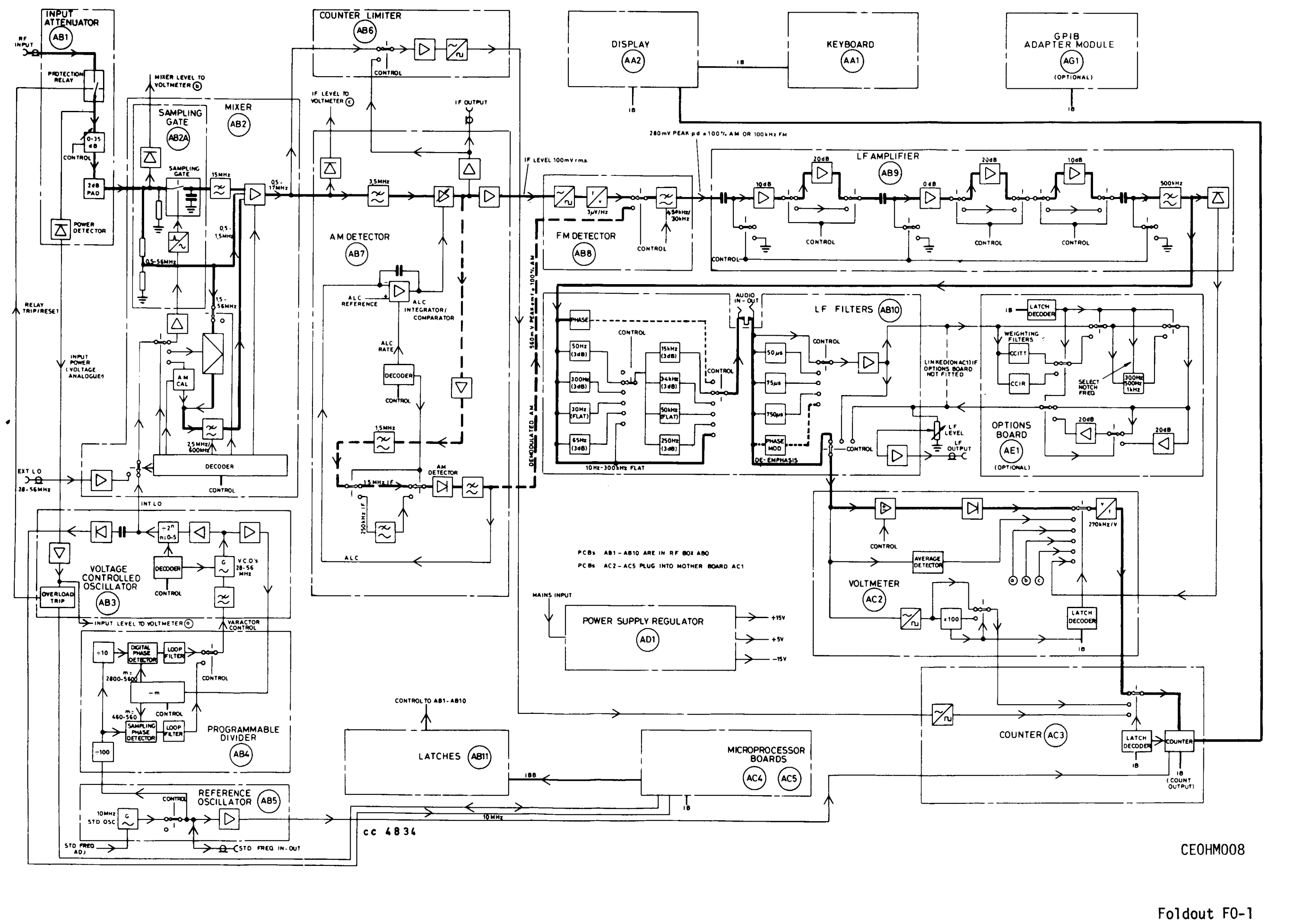


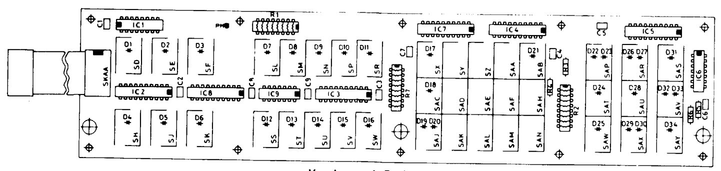
CHART # 8. VOLTMETER BOARD FAULTS (AC2)



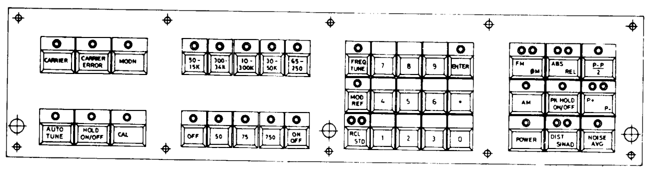


2305 Block diagram showing main signal path

Foldout FO-1



Keyboard Printed Circuit



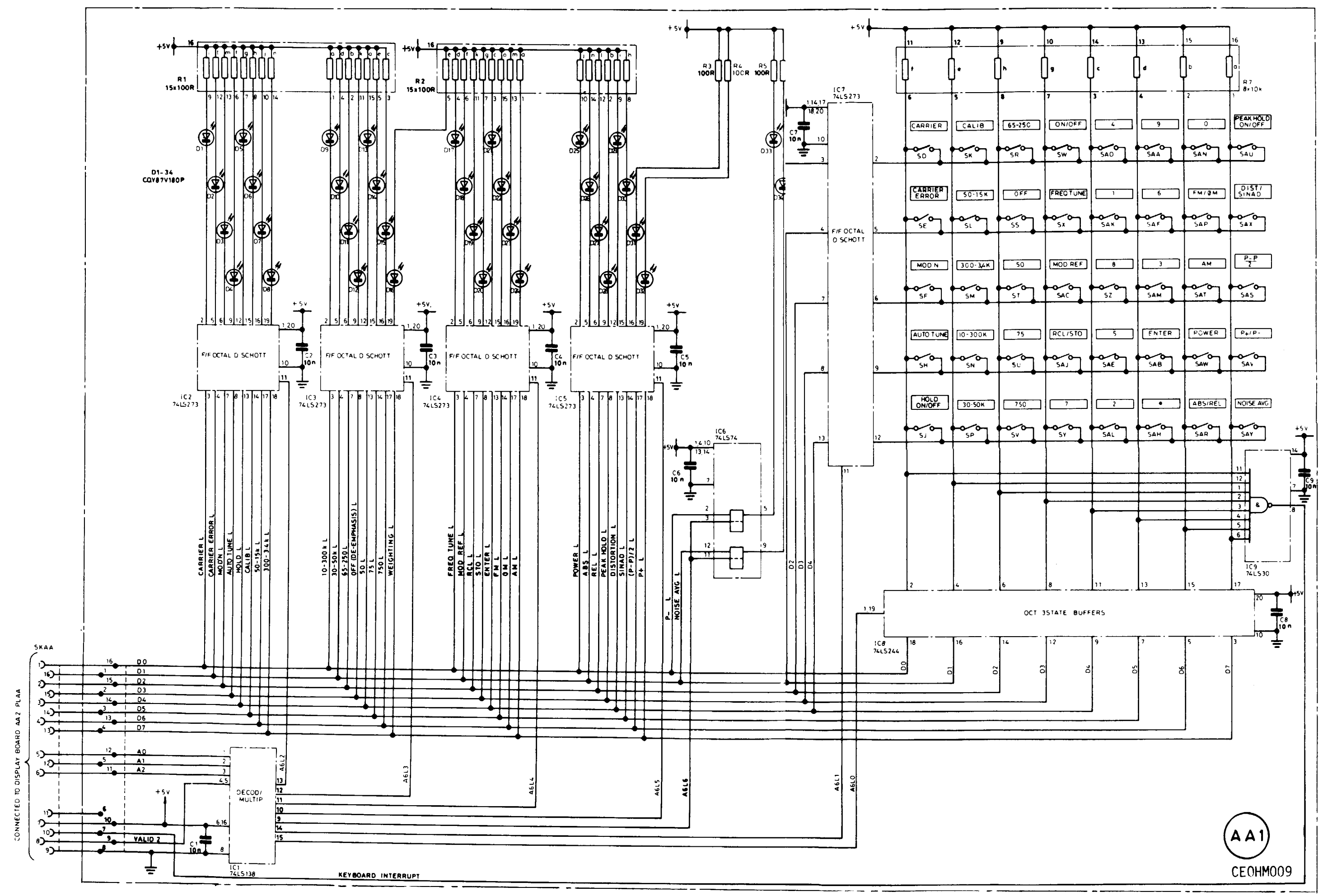
Front Panel Keyboard

NOTES:

THE OIL ARRANGEMENT WHERE SKAA RIBBON CABLE IS JOINED TO AA1 IS DIFFERENT FROM THAT OF SKAA ITSELF THE SOCKET NUMBERS OF SKAA CORRESPOND TO THE PIN NUMBERS OF PLAA(ON AA 2).

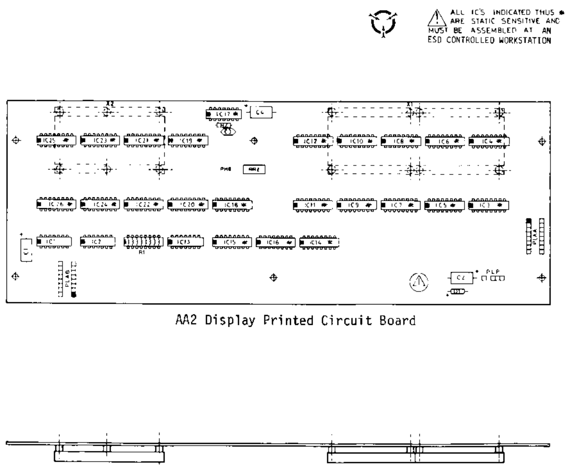
THE NUMBERING IS ALWAYS COUNTER CLOCKWISE WHEN VIEWED FROM COMPONENT SIDE OF P.C.B.

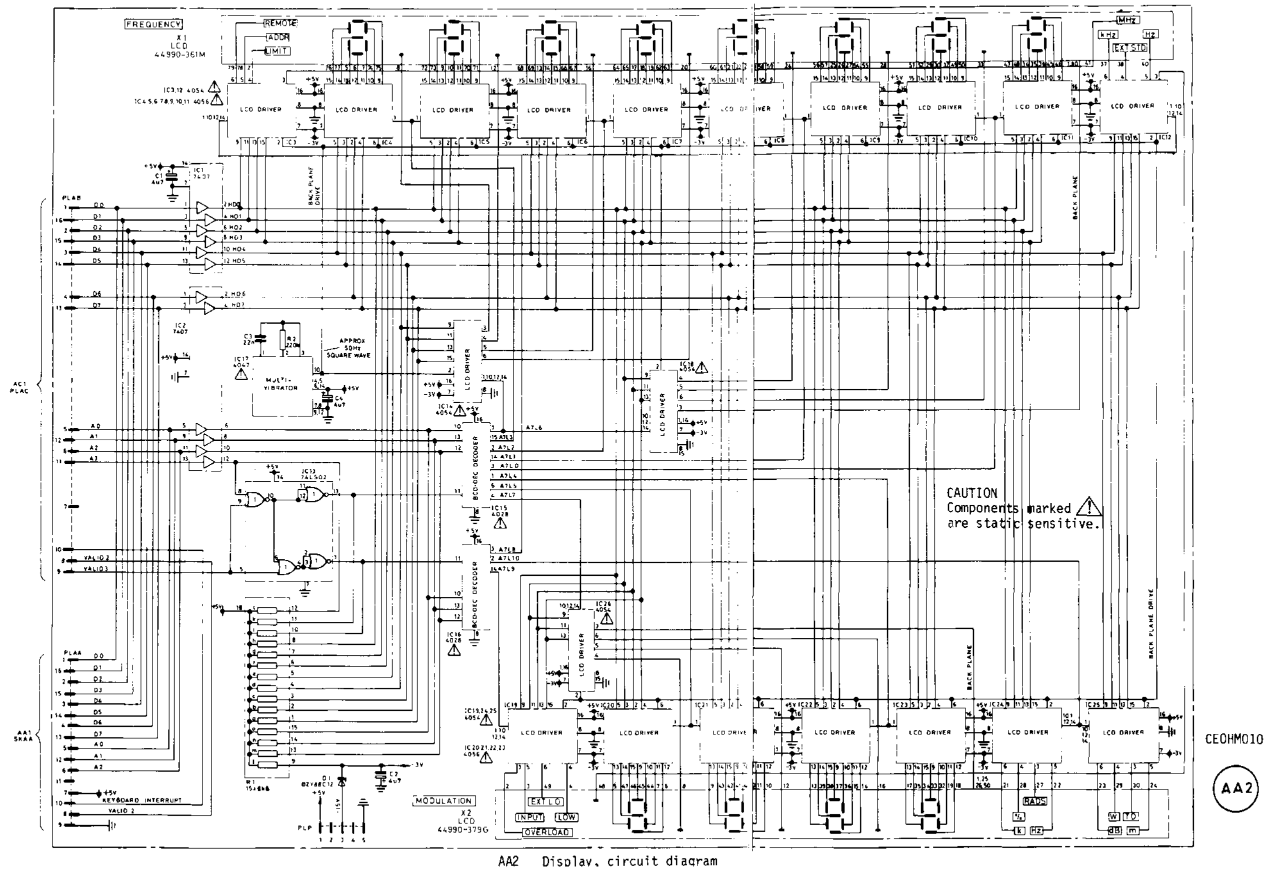
SOME CIRCUITRY SHOWN ASSOCIATED WITH SWITCHES DEPENDS ON LINKS WITHIN THE SWITCH MODULES CIRCUITRY IS NOT COMPLETE UNLESS THE FOLLOWING SWITCHES ARE FITTED: SE,SF,SL,SM,SN,ST,SU,SV,SW,SX,SAA,SAD,SAF, SAP & SAX.



AA1 Keyboard, Circuit diagram

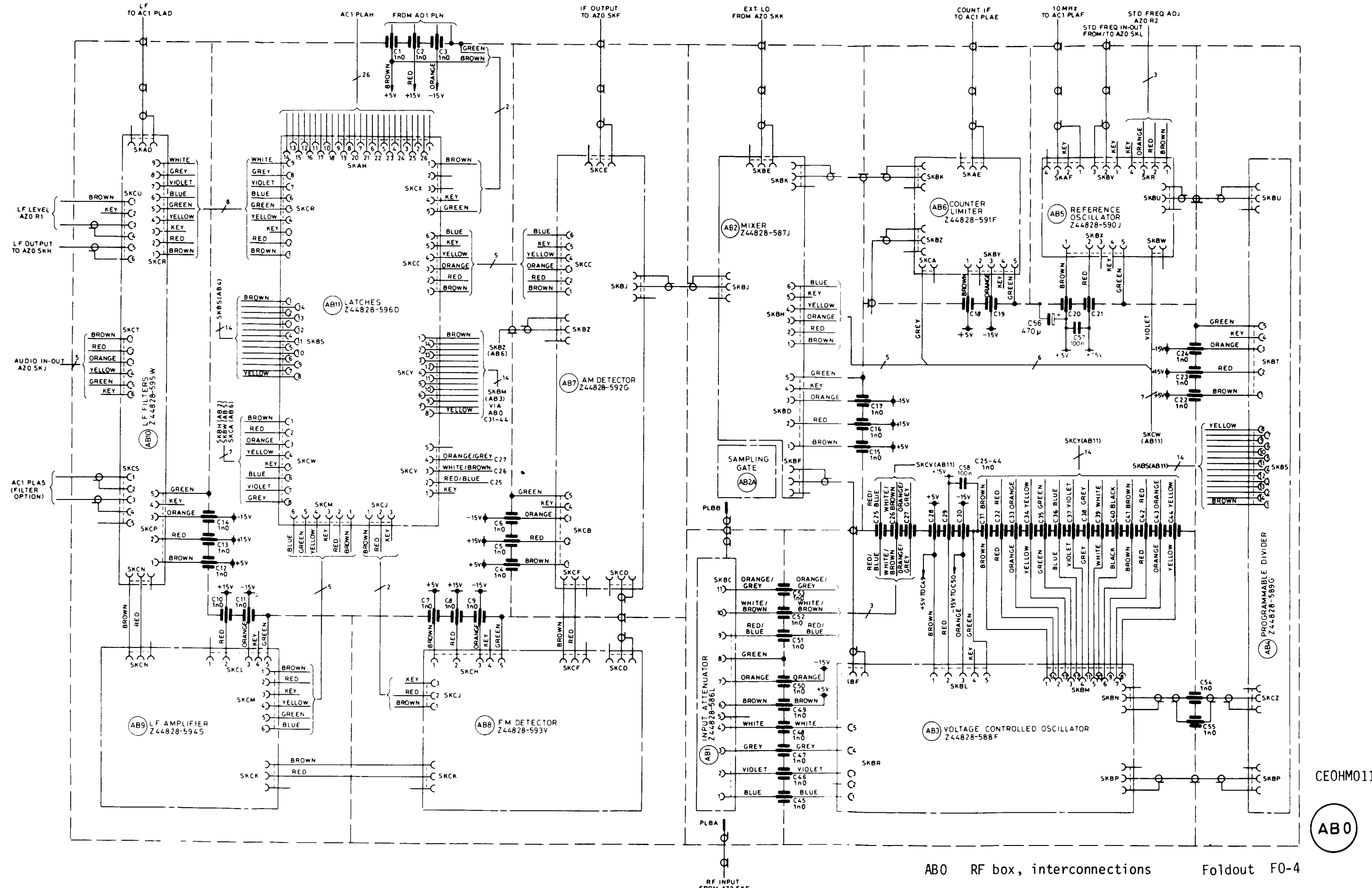
Foldout FO-2





AA2 Display, circuit diagram

Foldout FO-3



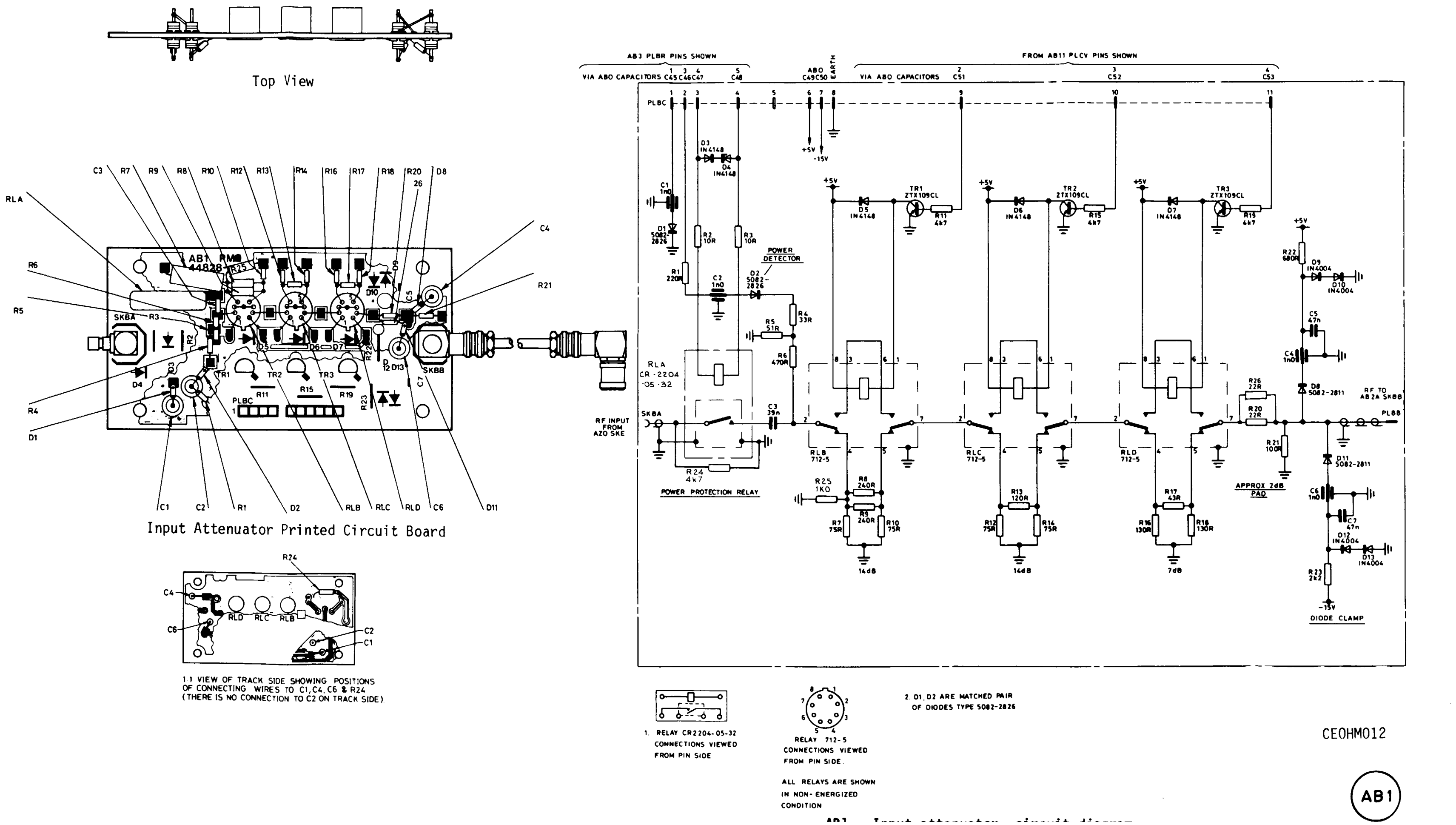
NOTES:

1 MATING PLUGS & SOCKETS HAVE SAME IDENTIFICATION FOR EXAMPLE PLBA CONNECTS TO SKBA CONNECTOR NUMBERS CORRESPOND IF SOCKETS AT BOTH ENDS OF A CONNECTOR ASSEMBLY HAVE SAME IDENTITY

2 WIRE FOR ALL LEAD THROUGH CAPACITOR INTER-CONNECTIONS IS TO M15410-181 (+5V BROWN, +15V RED, −15V ORANGE)

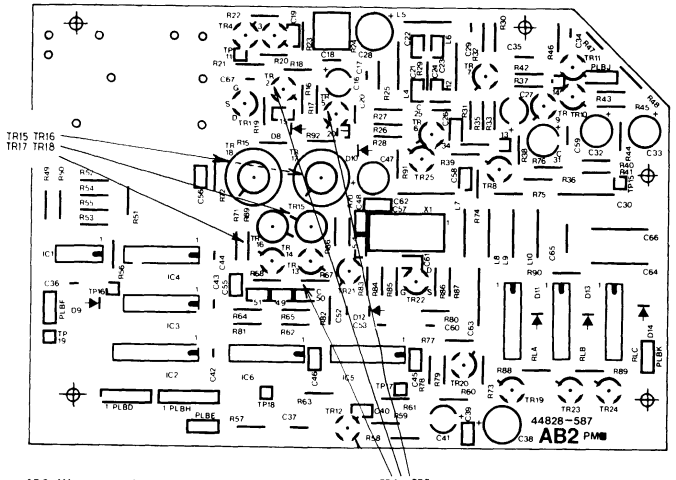
ABO RF box, interconnections

Foldout FO-4

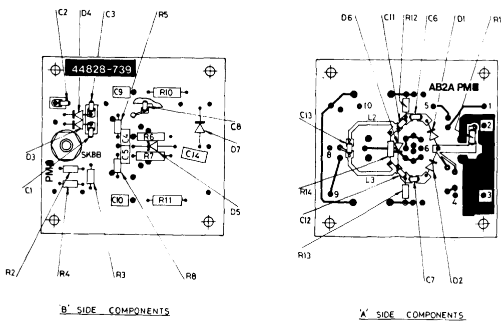


AbI Input attenuator, circuit diagram

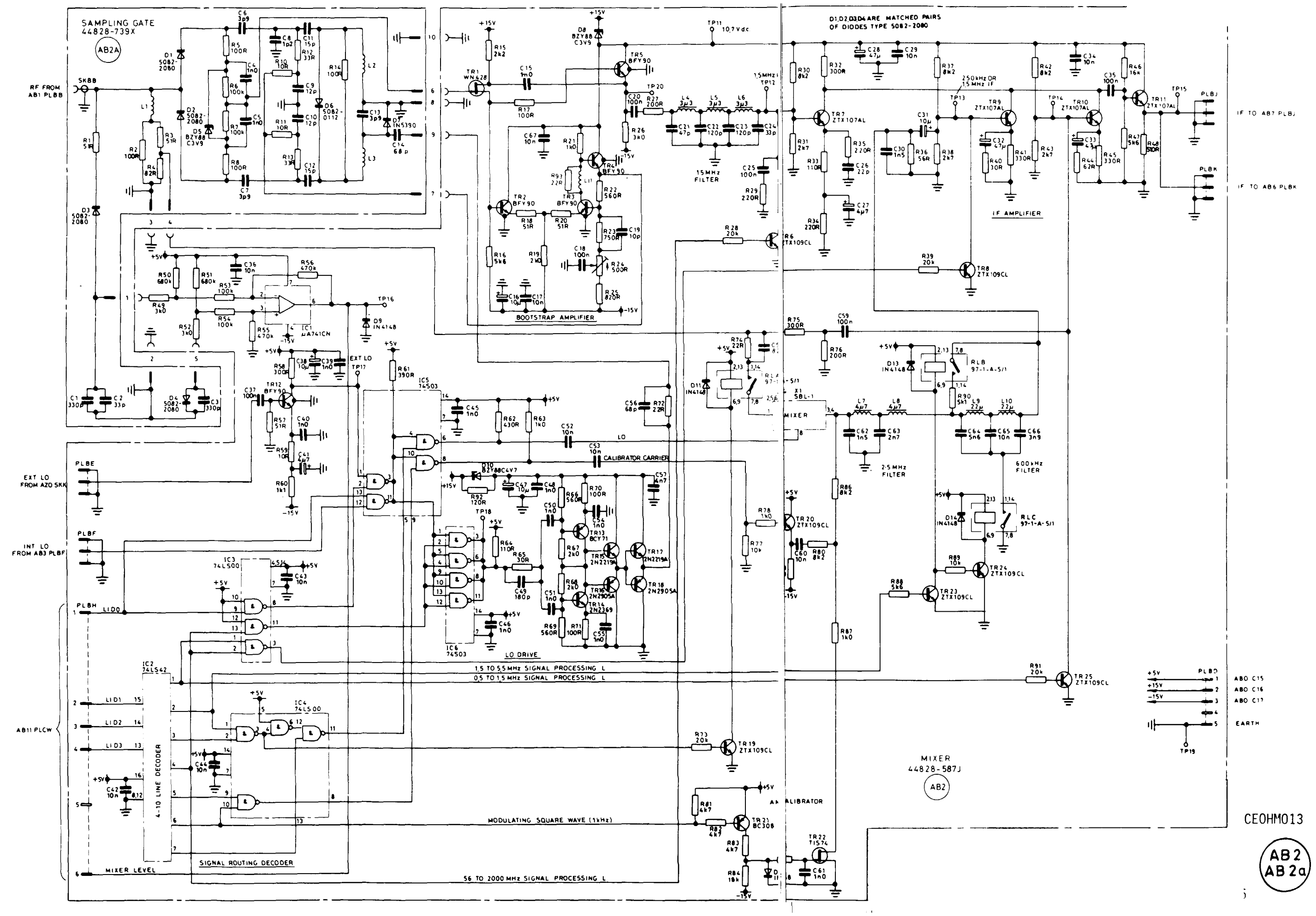
Foldout FO-5



AB2 Mixer, printed circuit board

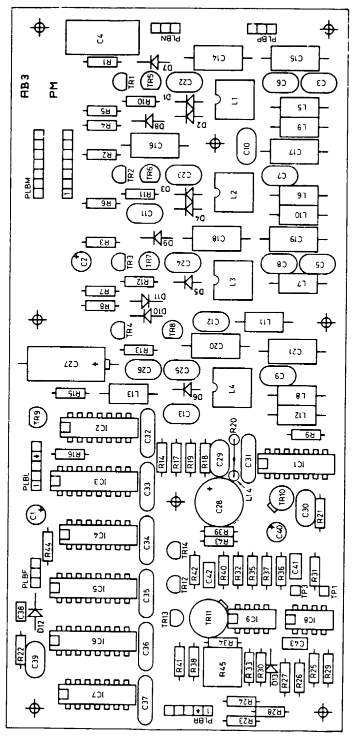


AB2a Sampling Gate, printed circuit board

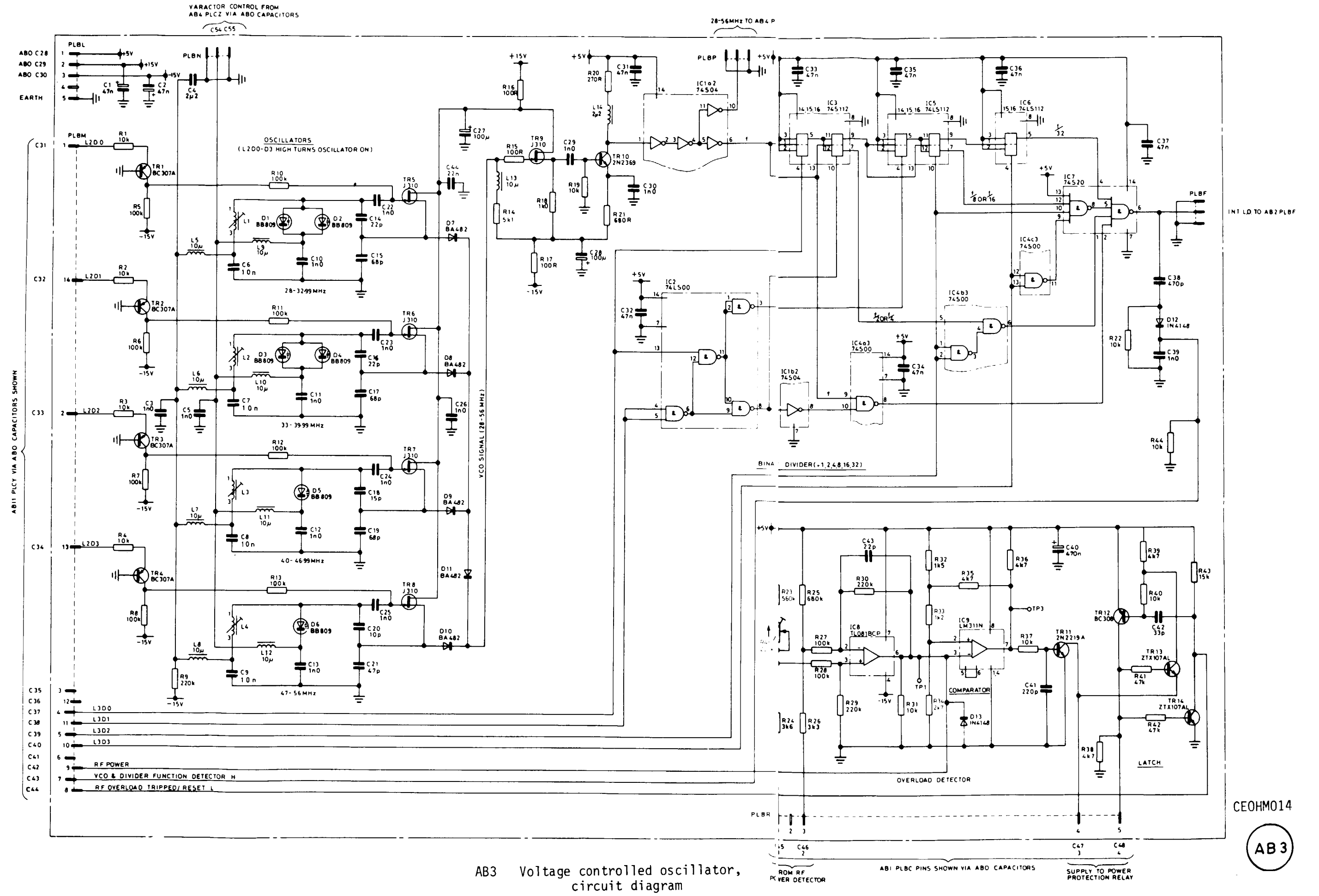


AB2 Mixer and AB2a Sampling gate component layout and circuit diagram.

Foldout FO-6



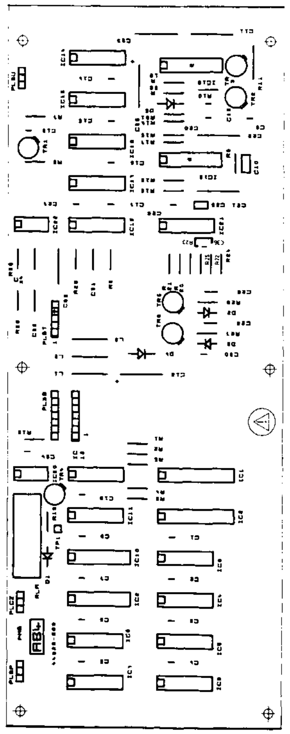
Voltage Controlled Oscillator, printed circuit board.



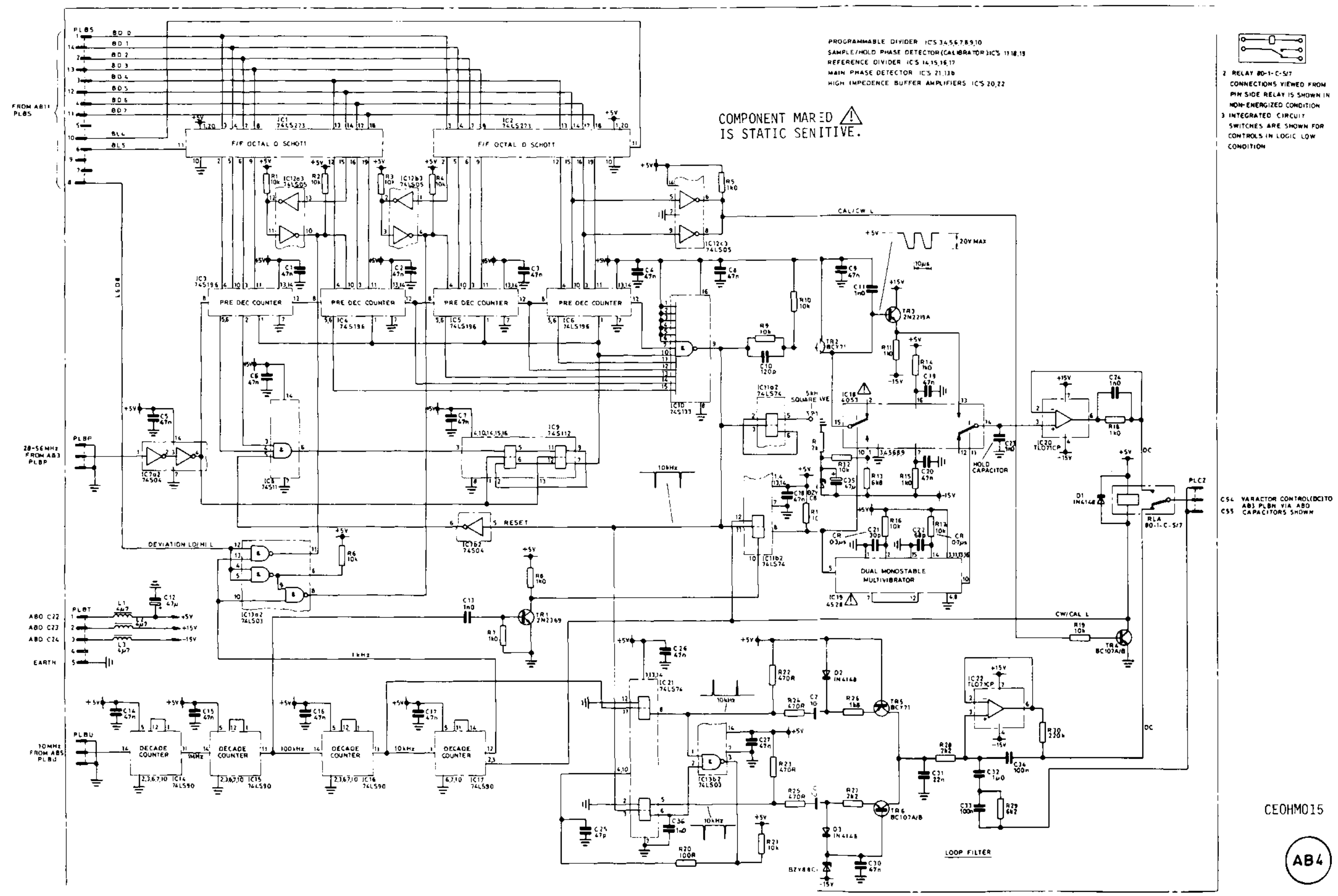
AB3 Voltage controlled oscillator, circuit diagram

AB3 Voltage controlled oscillator, circuit diagram

Foldout FO-7

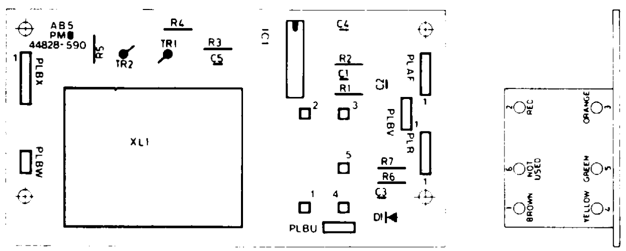


AB4 Programmable Divider, printed circuit board.

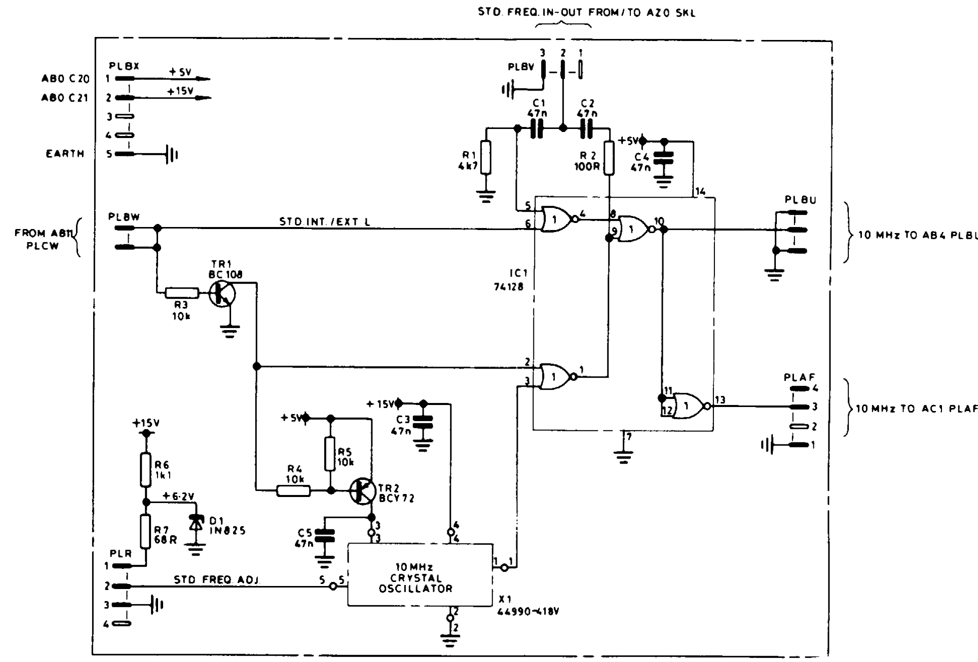


AB4 Programmable divider, circuit diagram

Foldout FO-8

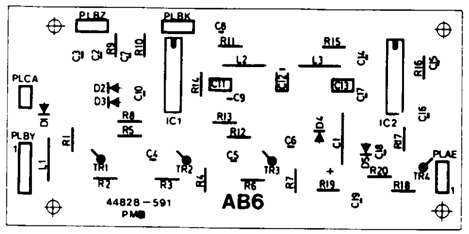


AB5 Reference Oscillator, printed circuit board.

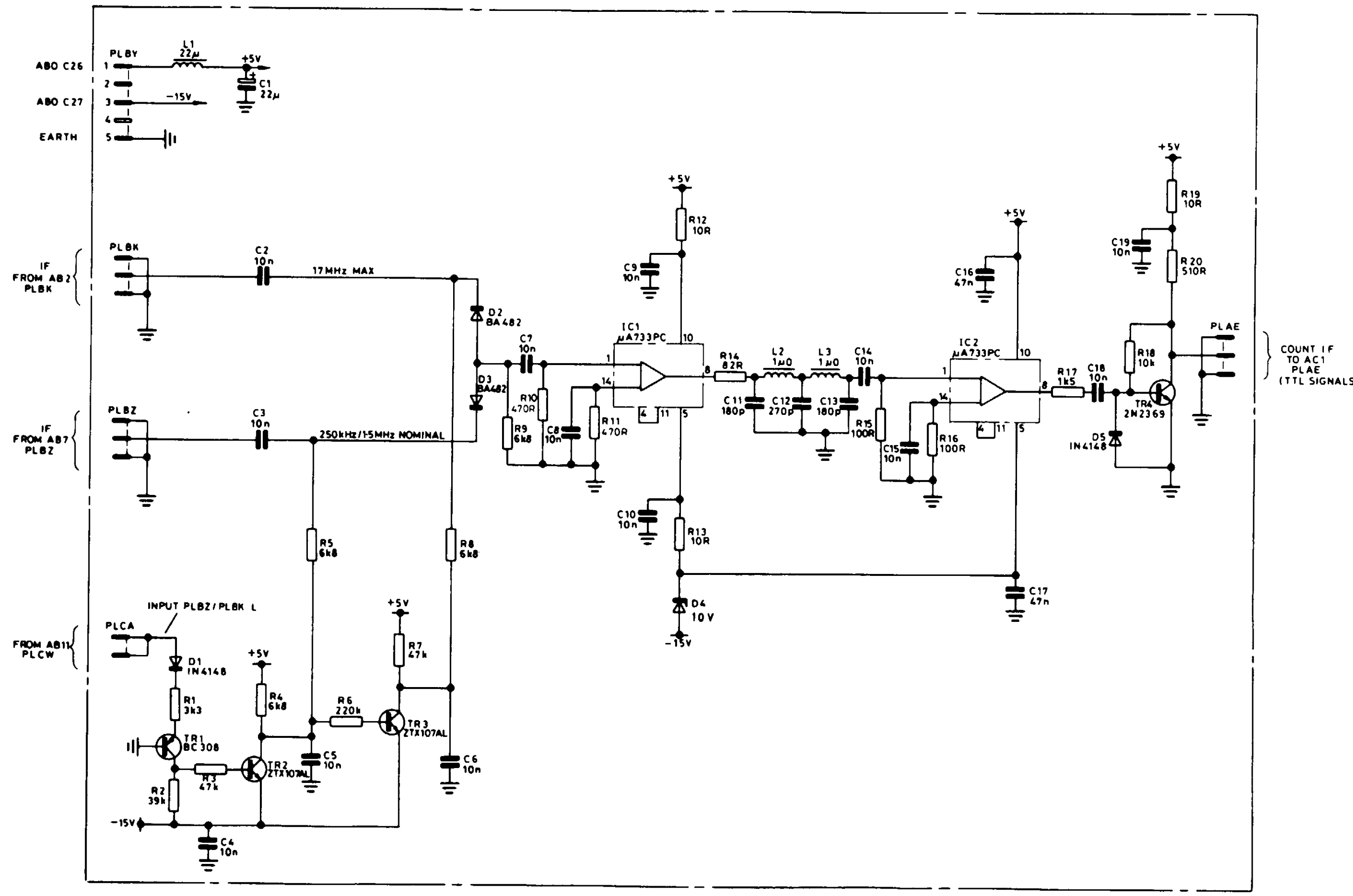


AB5 Reference oscillator, circuit diagram

Foldout FO-9



AB 6 Counter Limiter,
printed circuit board



CEOHM017

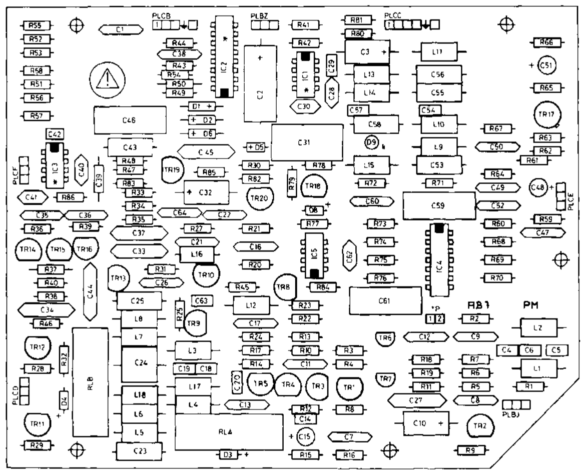
AB6 Counter limiter, circuit diagram

Foldout FO-10

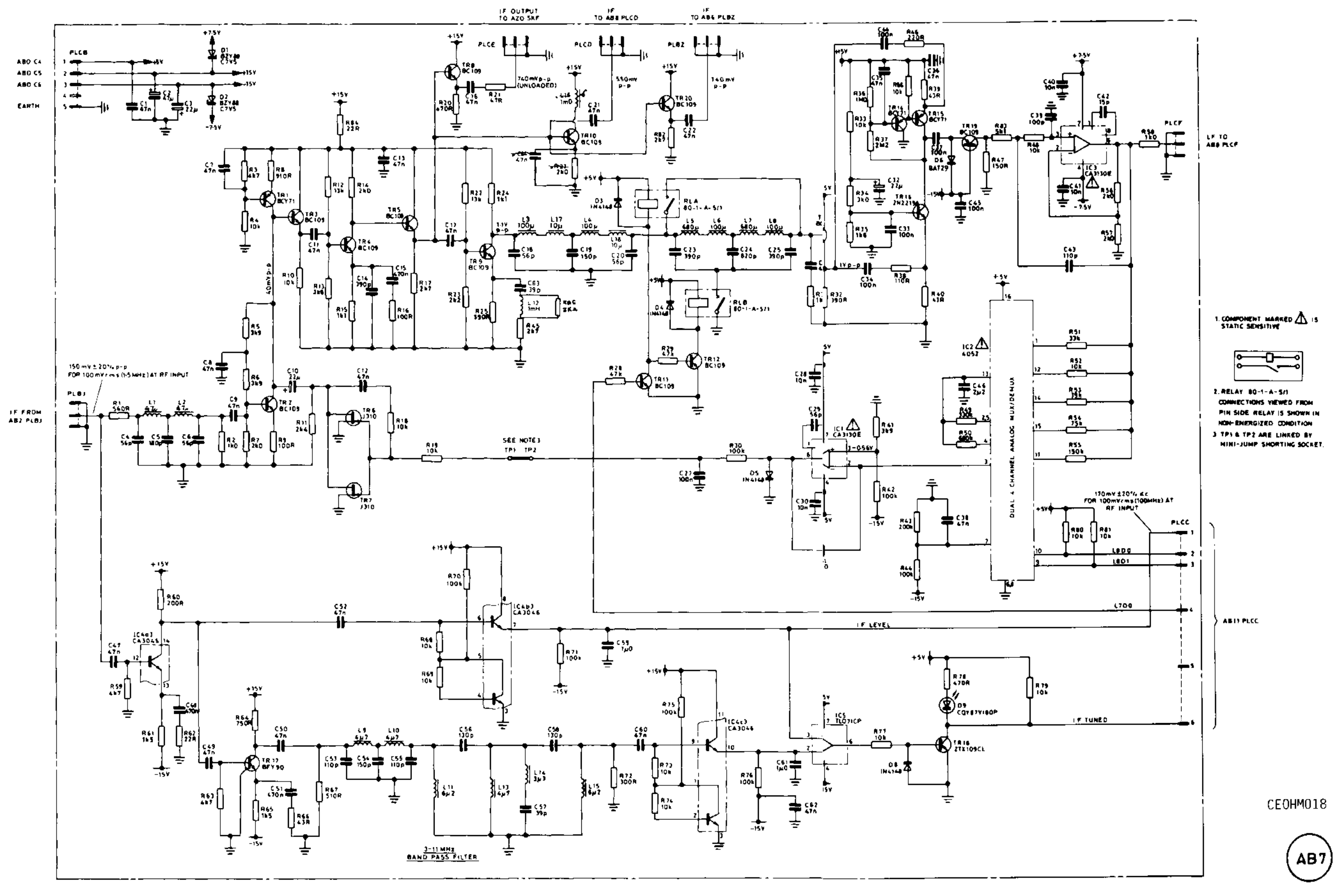
Notes...

(1) In early instruments a single transistor amplifier (TR10) was fitted to buffer the i.f. output to AB8. This has been removed from later instruments to reduce f.m. distortion at high deviation/modulation frequencies. Instruments with serial number prefixes of 169812 and below will have been modified by the partial or total omissions of TR10 and associated components with a hand-wired link added between collector and base connections. Later instruments have a redesigned circuit board.

(2) In early instruments, C15 was a tantalum bead capacitor and the 2K0 resistor shunting L12 (R85) may not have been included or may be mounted on the track side of the board. This change was introduced to reduce the residual spurious f.m. on a.m.



AB7 AM Detector, printed circuit board

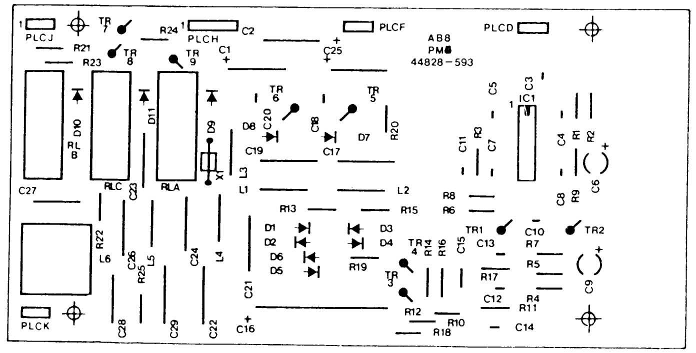


AB7 AM Detector, circuit diagram

Foldout FO-11

AB7 AM Detector, circuit diagram

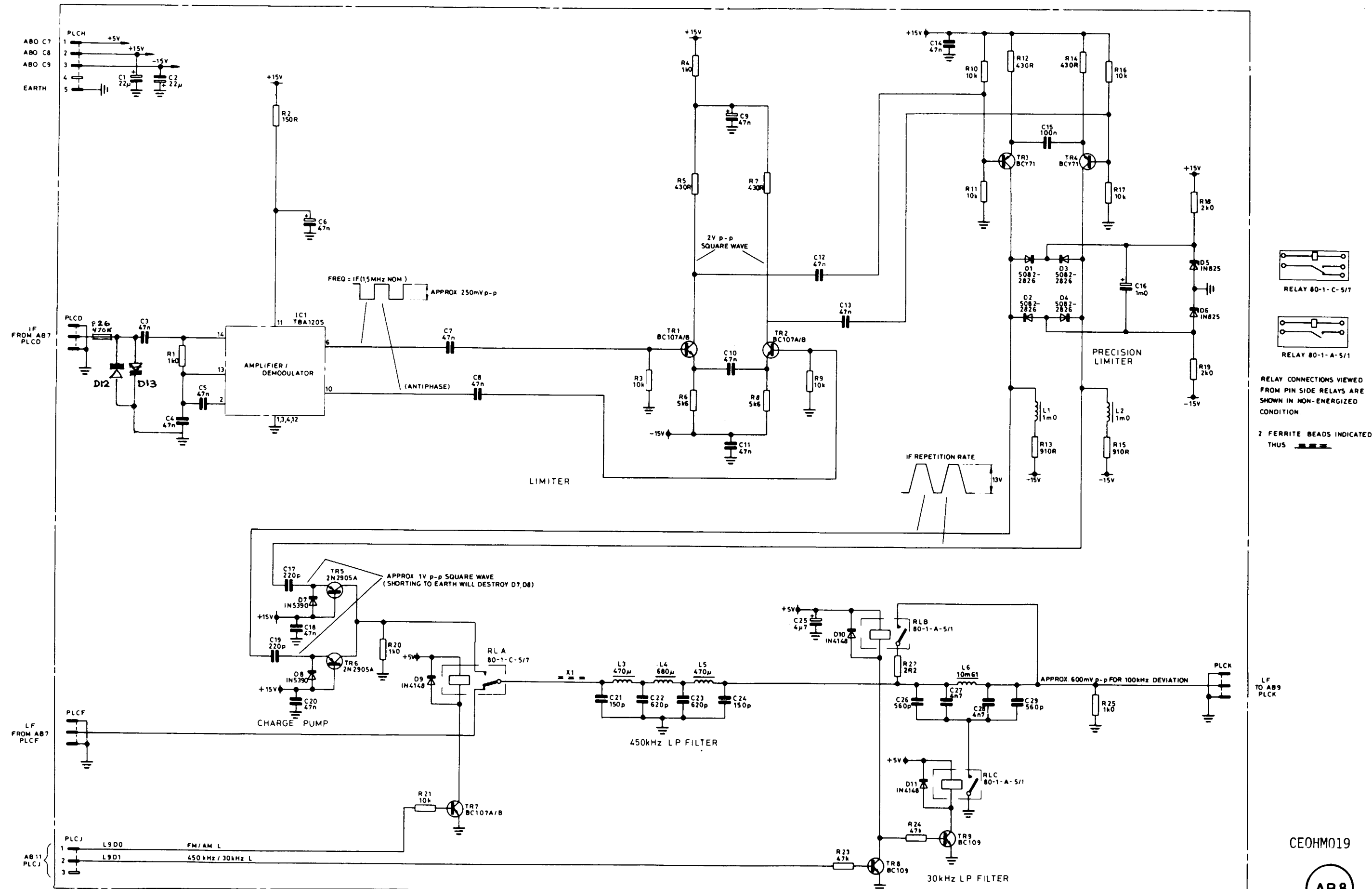
Foldout FO-11



AB8 FM Detector, printed circuit board.

Note...

Early instruments may not incorporate the clamping circuit R26, D12 and D13 or may have it fitted with the components mounted on the track side of the board.

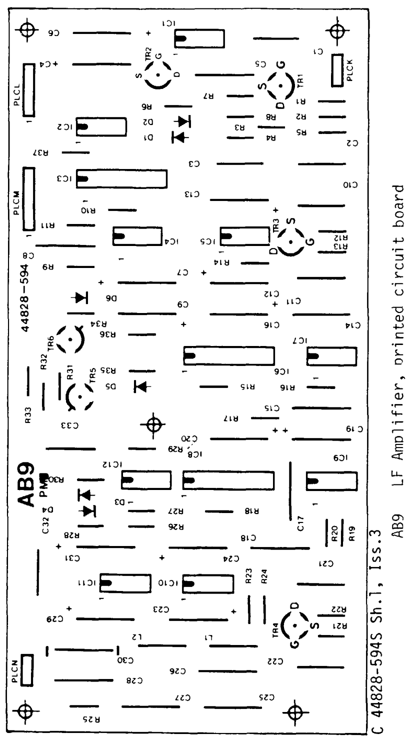


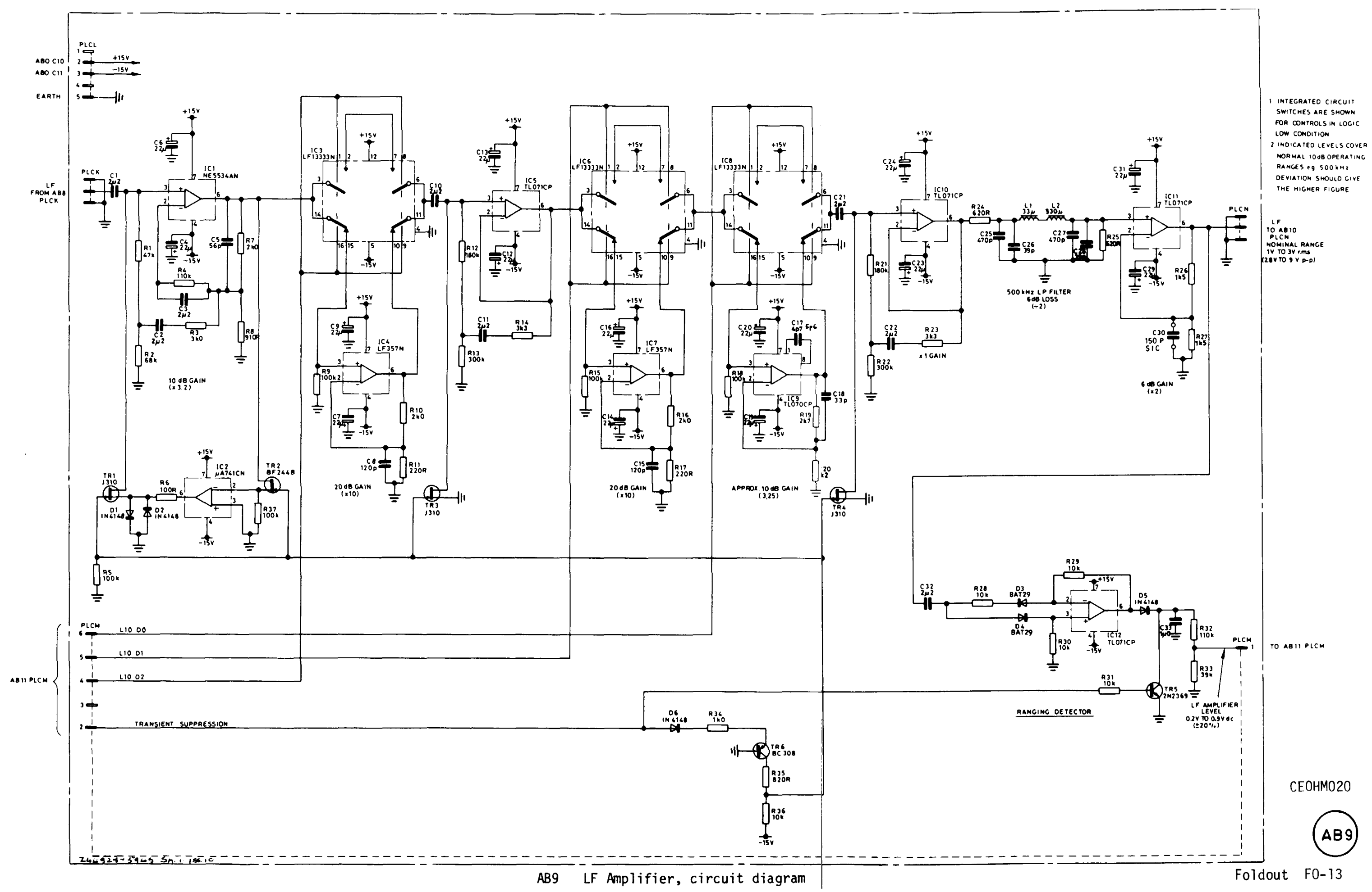
AB8 FM Detector, circuit diagram

Foldout FO-12

AB8 FM Detector, circuit diagram

Foldout FO-12

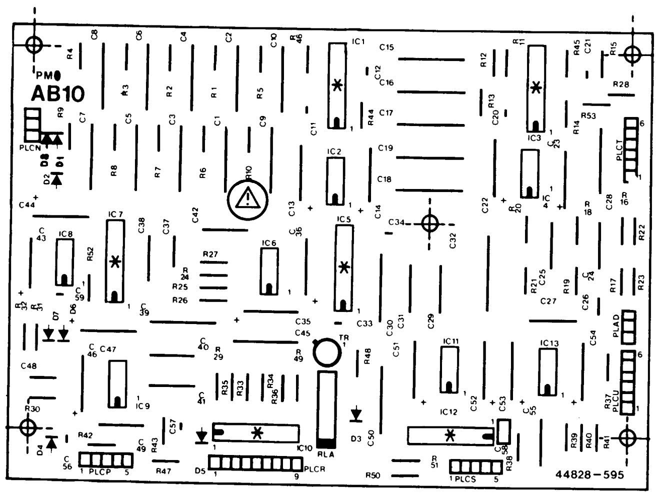




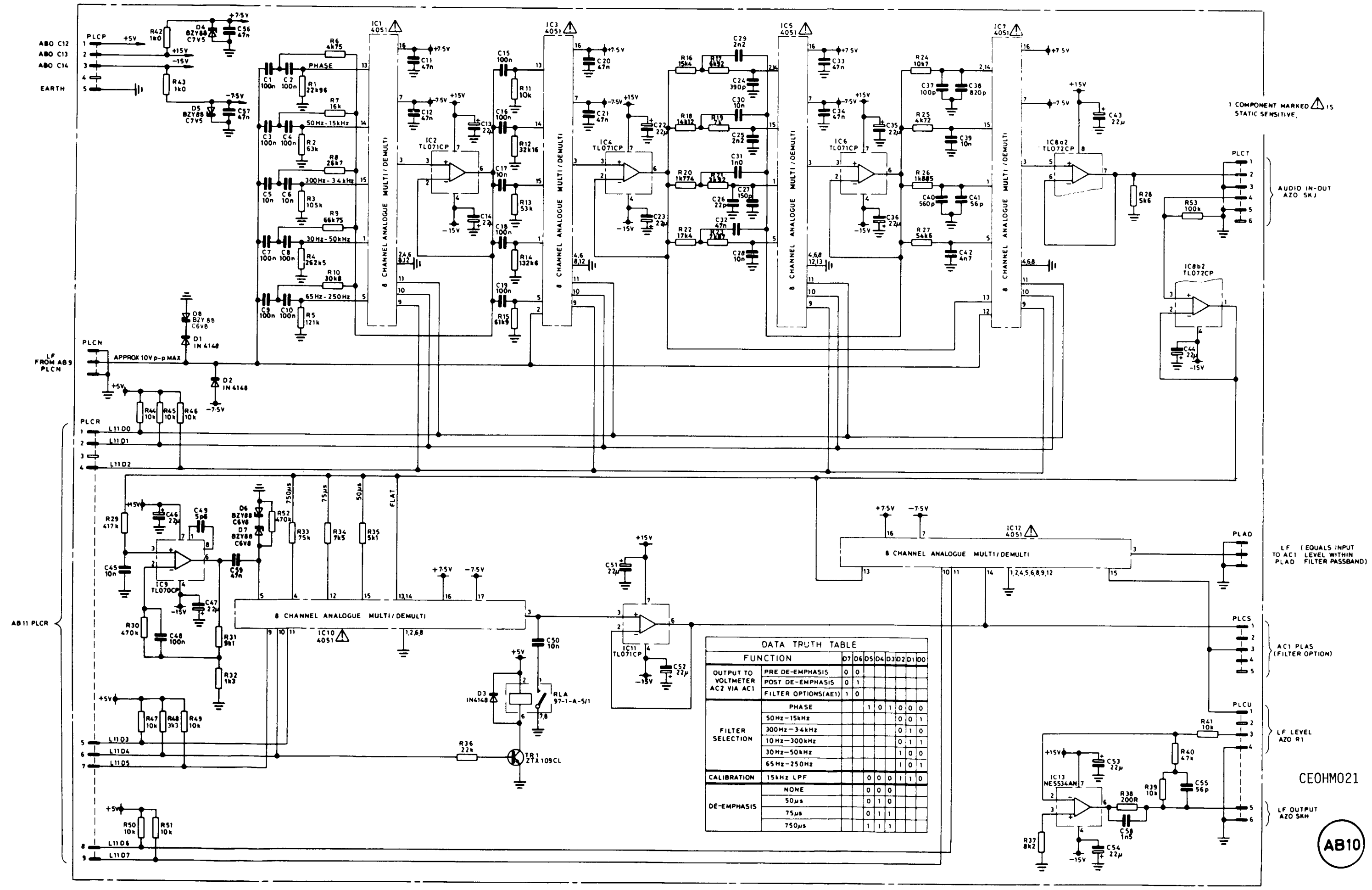
AB9 LF Amplifier, circuit diagram

Foldout FO-13

ALL IC'S INDICATED THUS '*' ARE STATIC SENSITIVE AND MUST BE ASSEMBLED AT A SAFEPOST

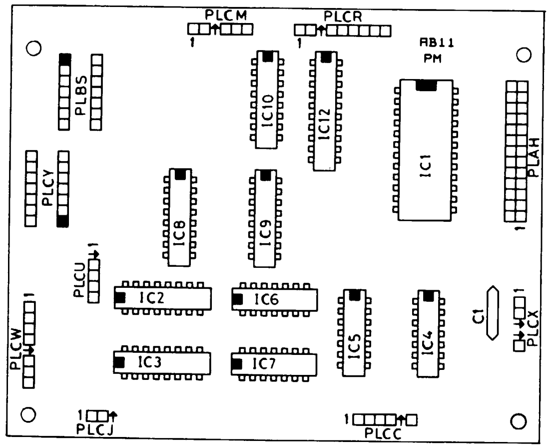


AB10 LF Filters, printed circuit board

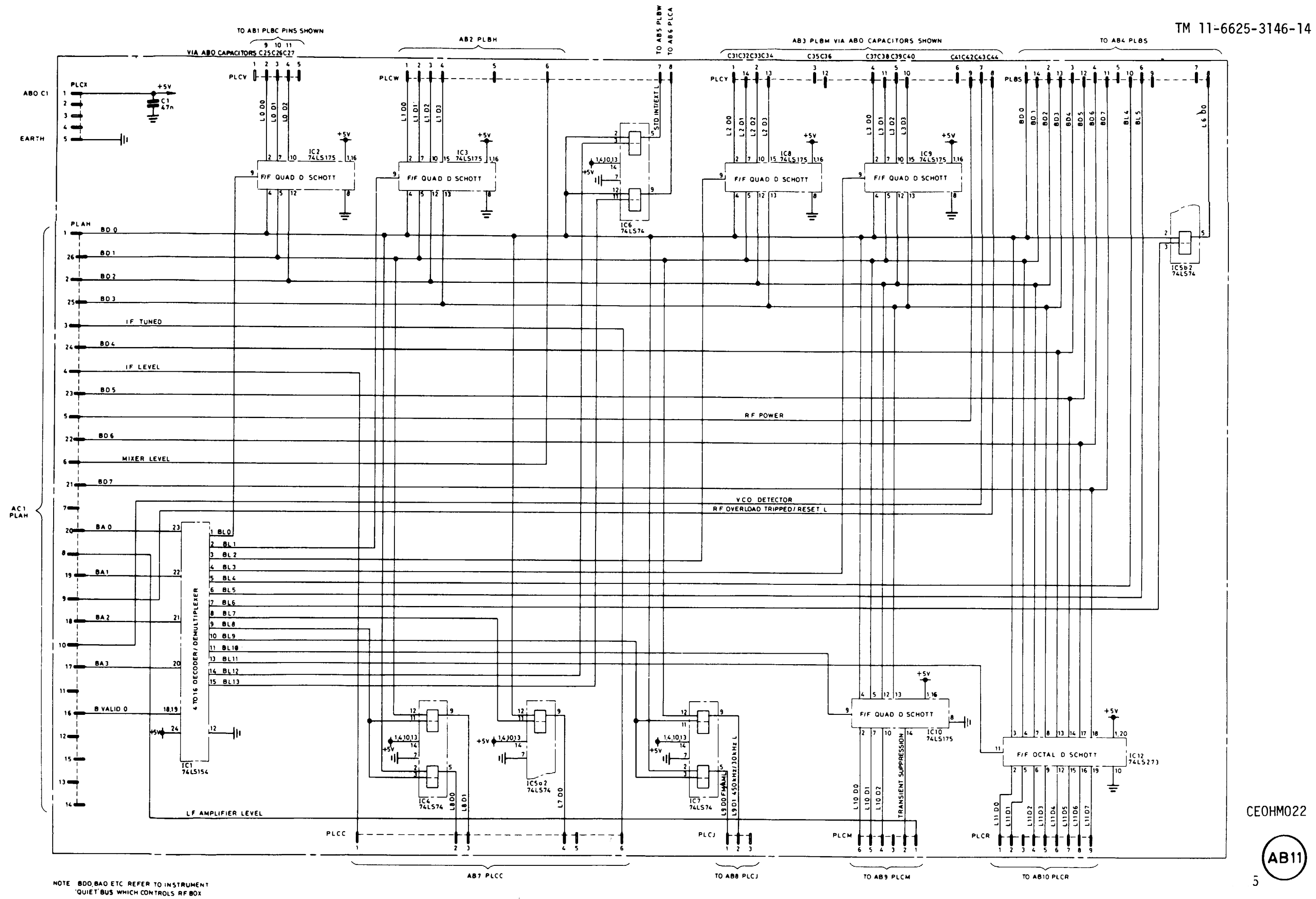


AB10 LF filters, circuit diagram

Foldout FO-14

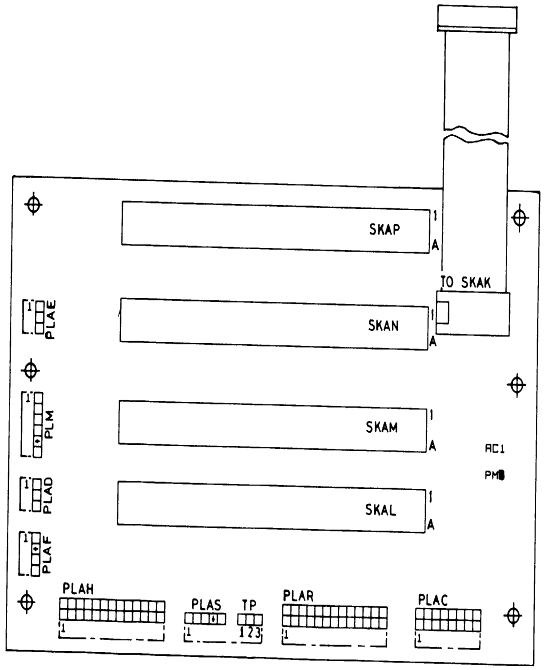


AB11 Latches, printed circuit board

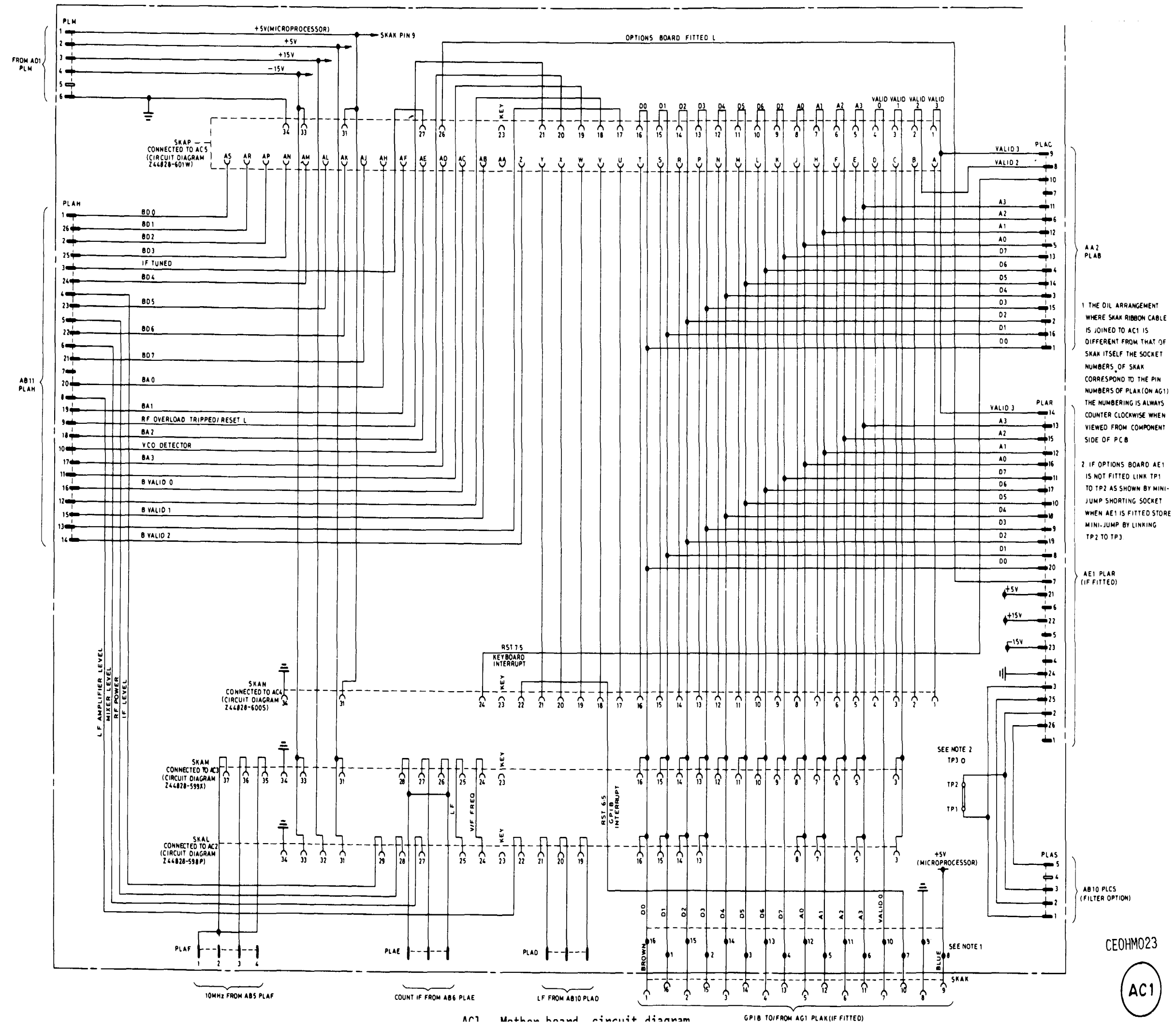


AB11 Latches, circuit diagram

Foldout FO-15



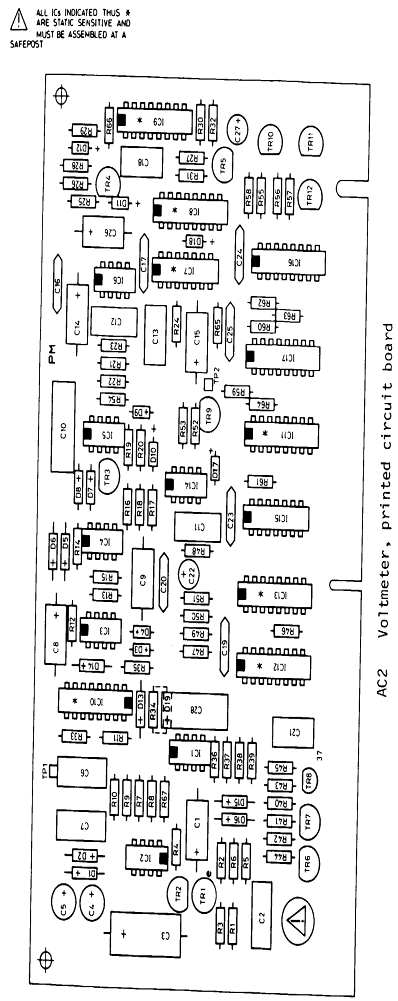
AC1 Motherboard, component layout

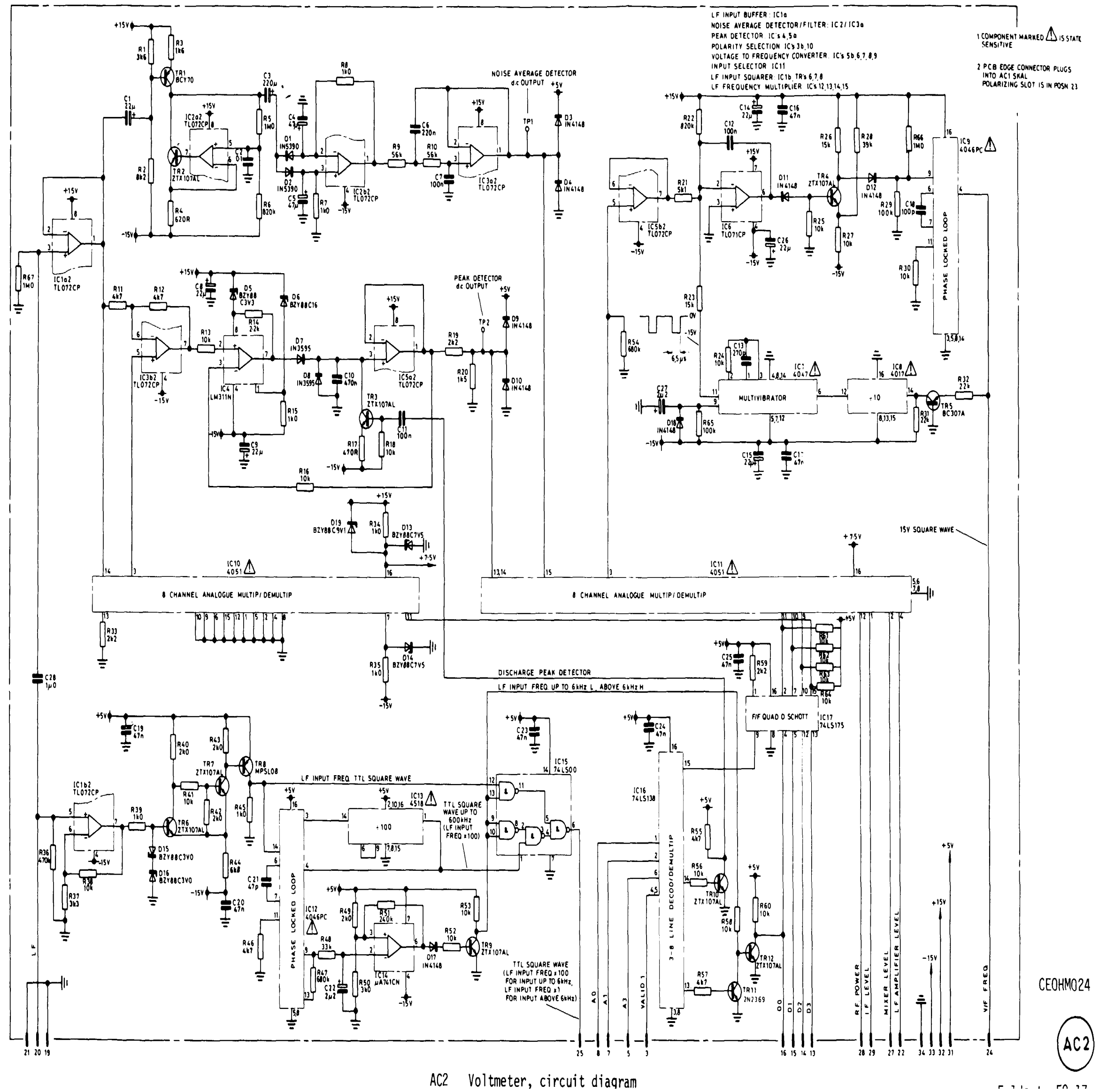


AC1 Mother Board, circuit diagram

Foldout FO-16

]

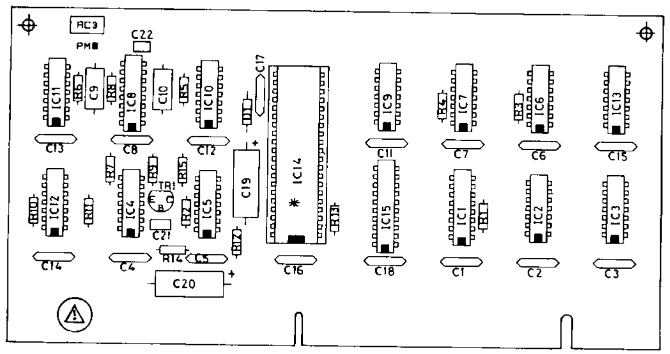




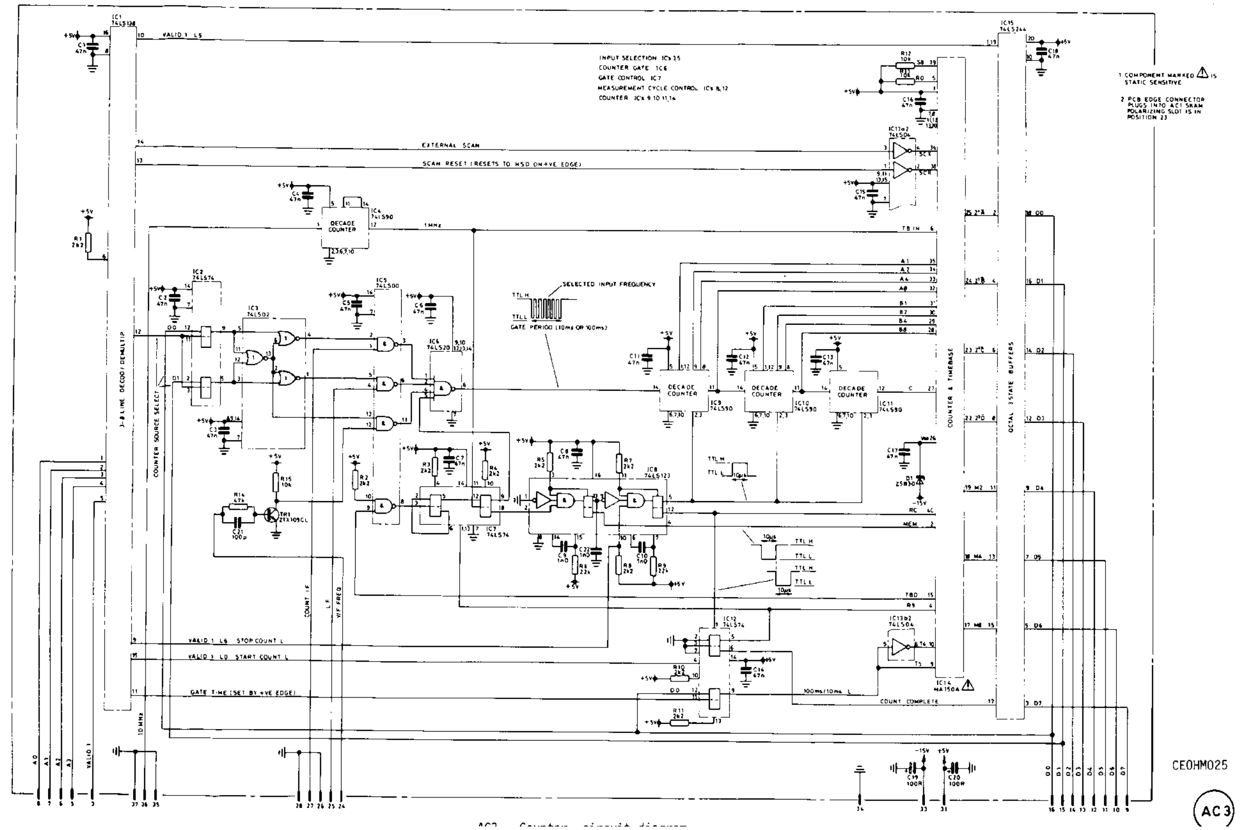
AC2 Voltmeter, circuit diagram

Foldout FO-17

⚠ ALL IC'S INDICATED THUS '*' ARE STATIC SENSITIVE AND MUST BE ASSEMBLED AT A SAFEPOST



AC3 Counter, printed circuit board



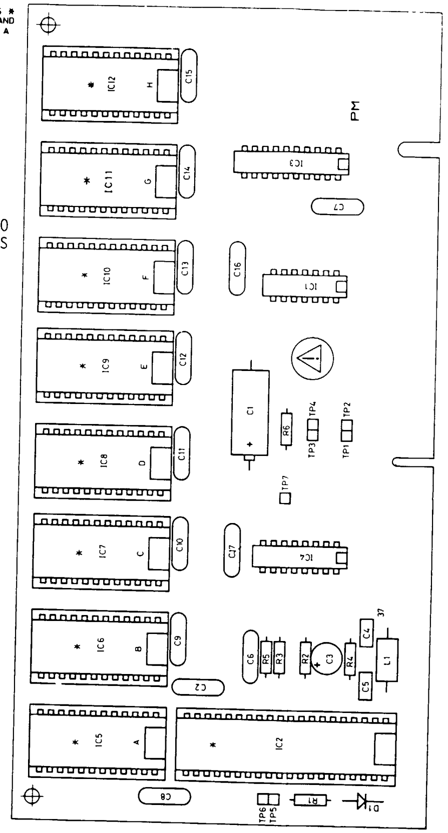
AC3 Counter, circuit diagram

Foldout FO-18

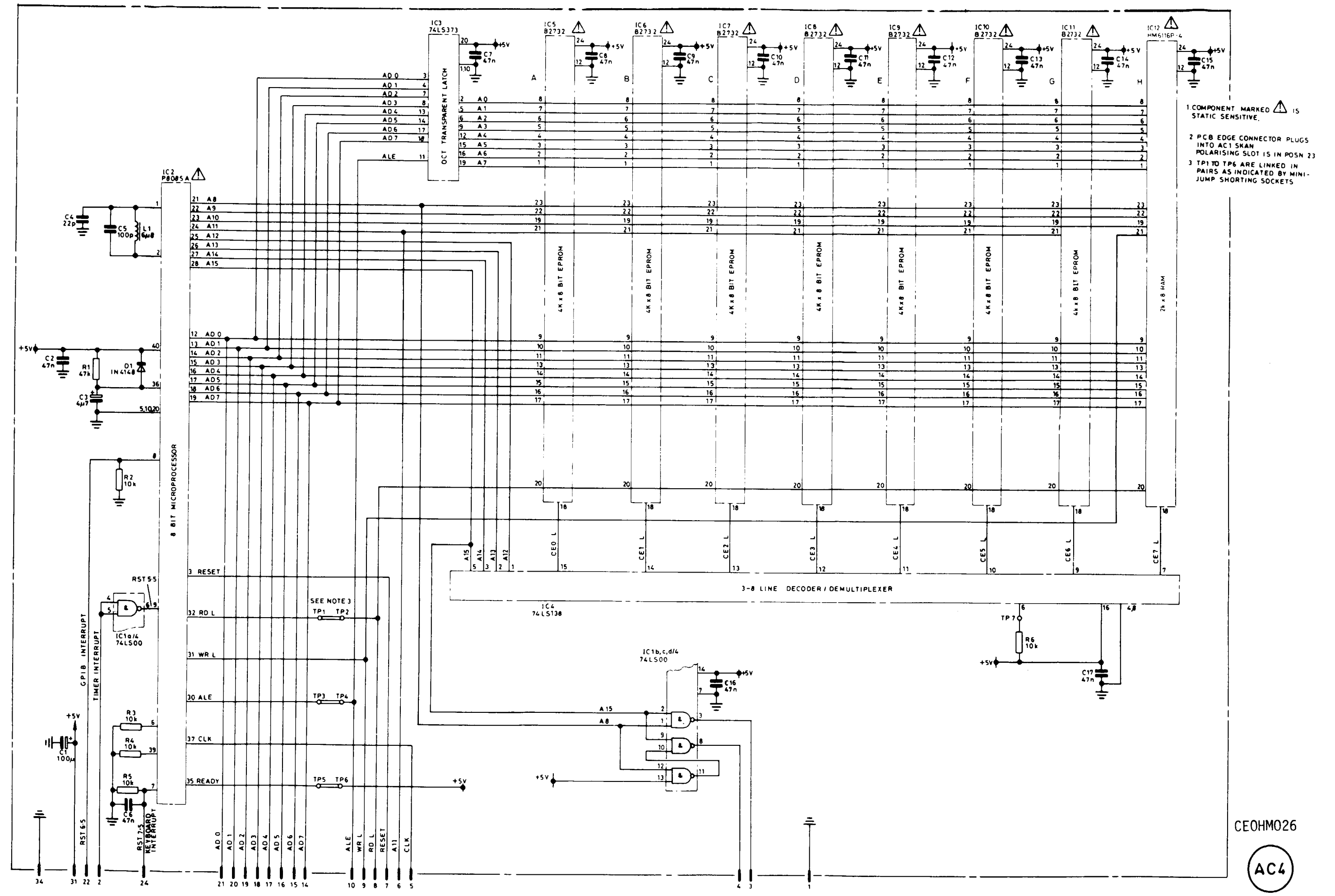
⚠ ALL ICs INDICATED THUS * ARE STATIC SENSITIVE AND MUST BE ASSEMBLED AT A SAFEPOST

INSERT EPROMS INTO SEVEN POSITIONS AS FOLLOWS:

44533-031 A INTO IC5 (A)
44533-031 B INTO IC6 (B)
44533-031 C INTO IC7 (C)
44533-031 D INTO IC8 (D)
44533-031 E INTO IC9 (E)
44533-031 F INTO IC10 (F)
44533-031G INTO IC11 (G)



Microprocessor (i), printed circuit board

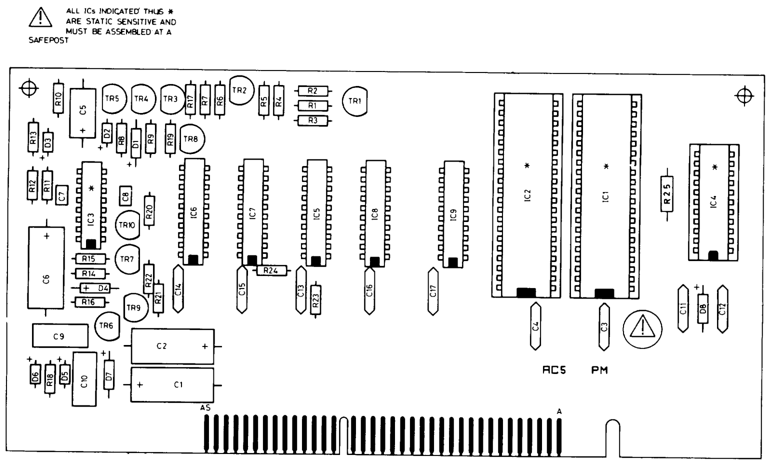


Microprocessor (i), circuit diagram

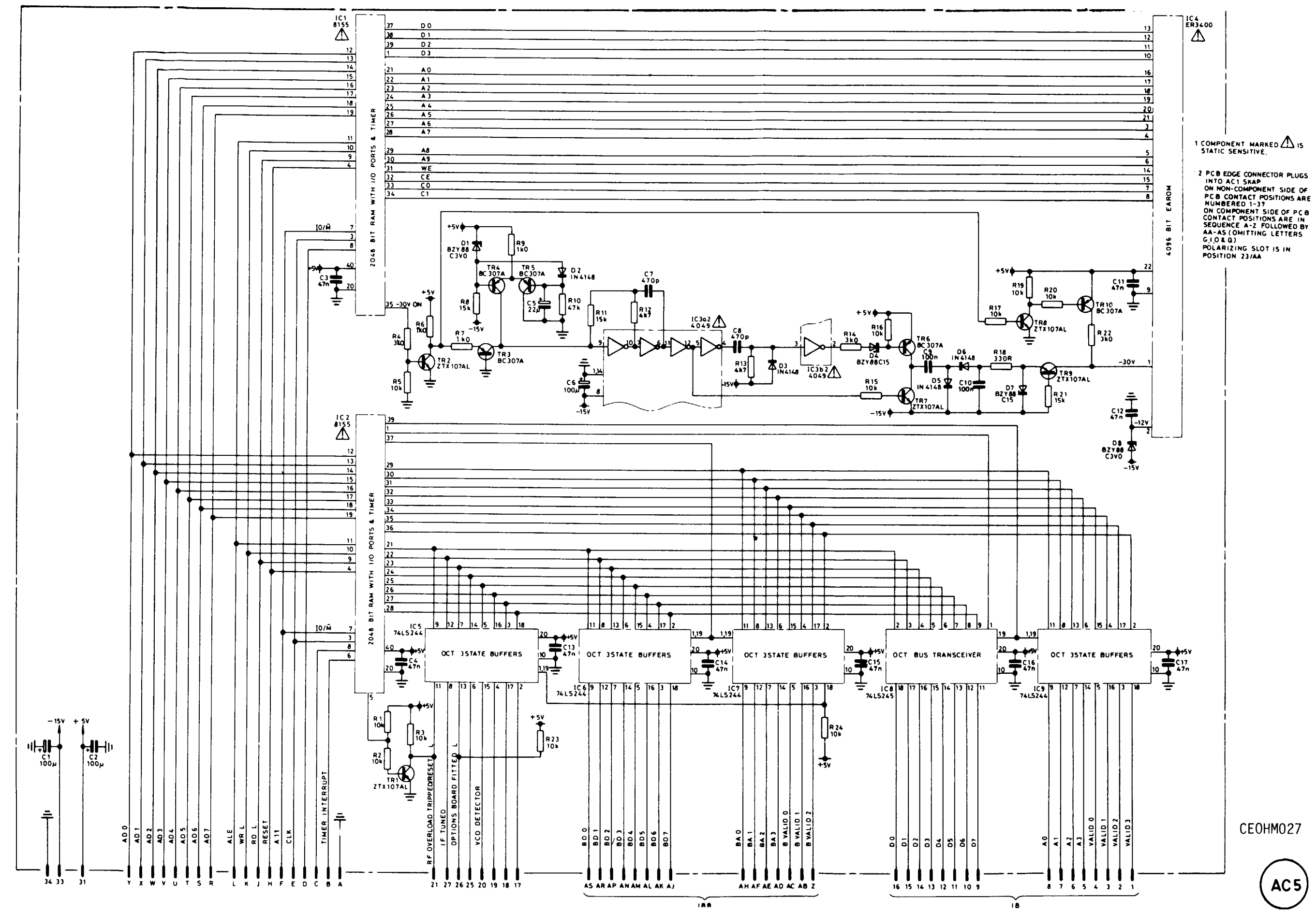
Foldout FO-19

Microprocessor (i), circuit diagram

Foldout FO-19

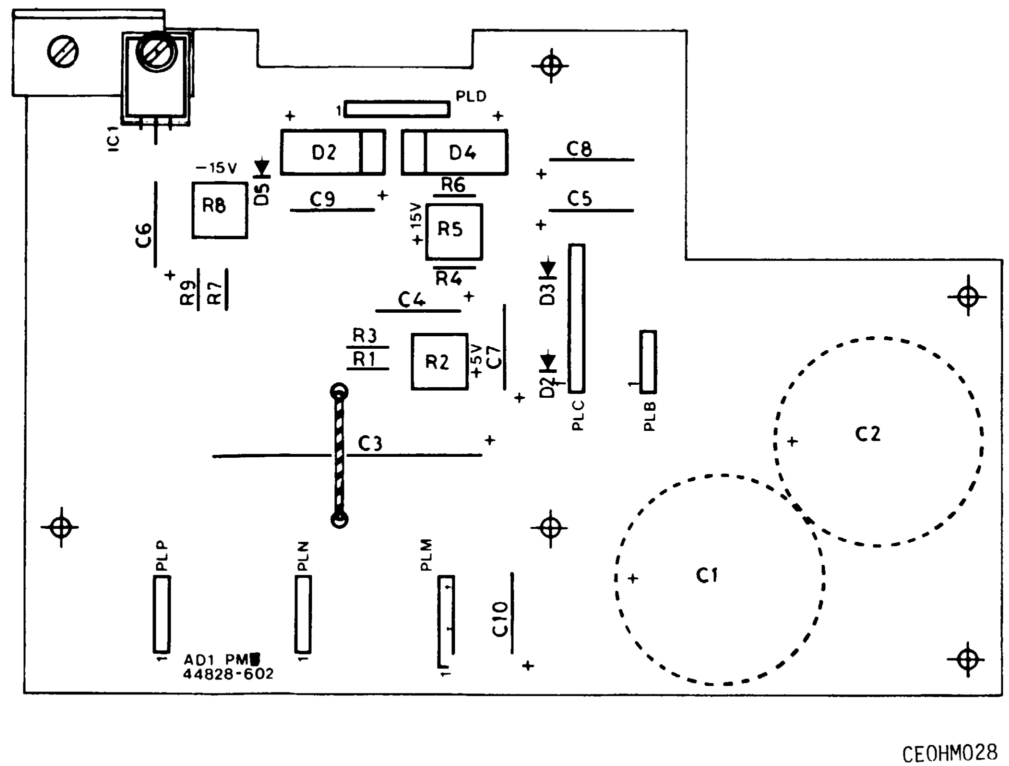


Microprocessor (ii), printed circuit board



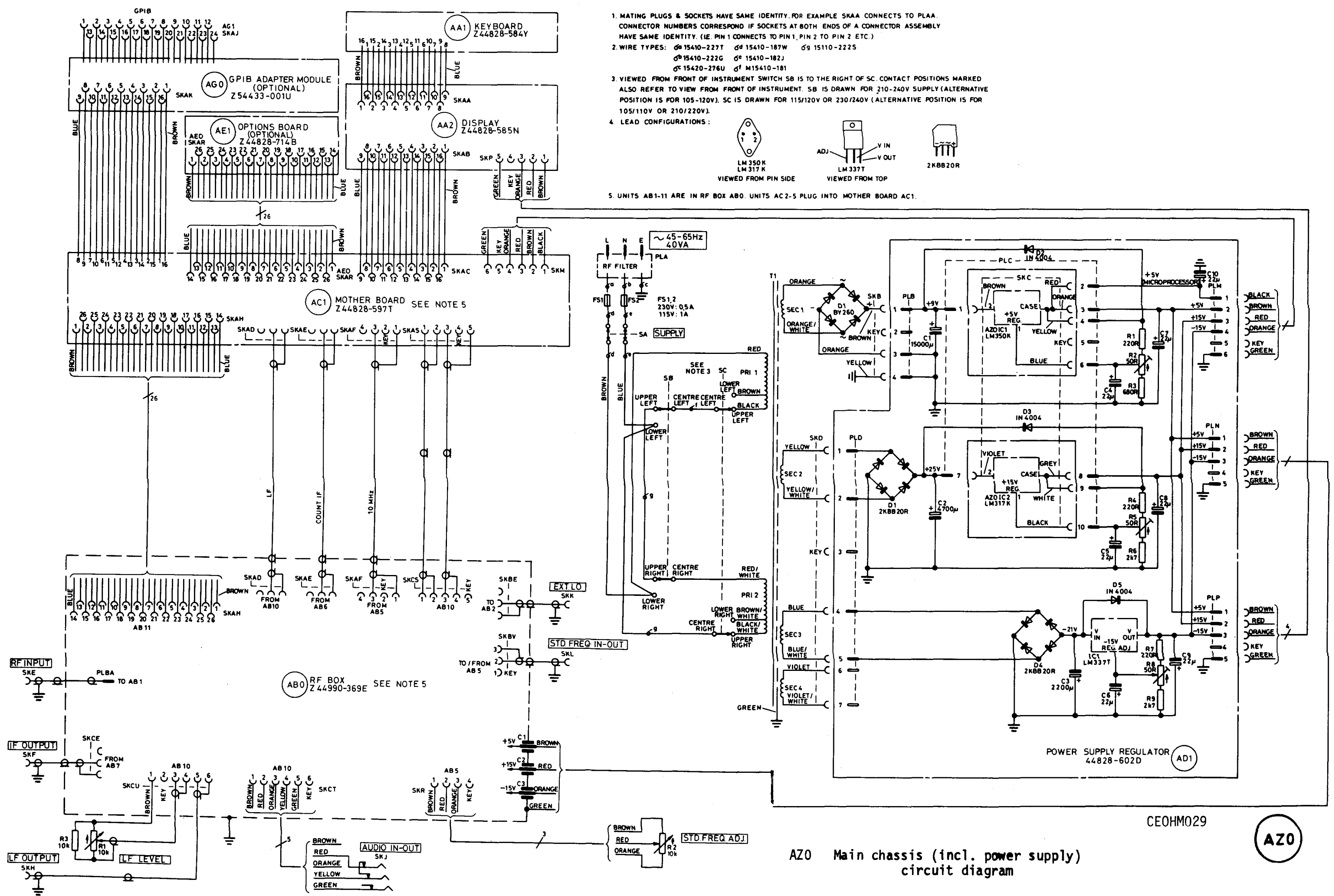
Microprocessor (ii), circuit diagram

Foldout FO-20



AD1 Power supply (stabilizer), component layout

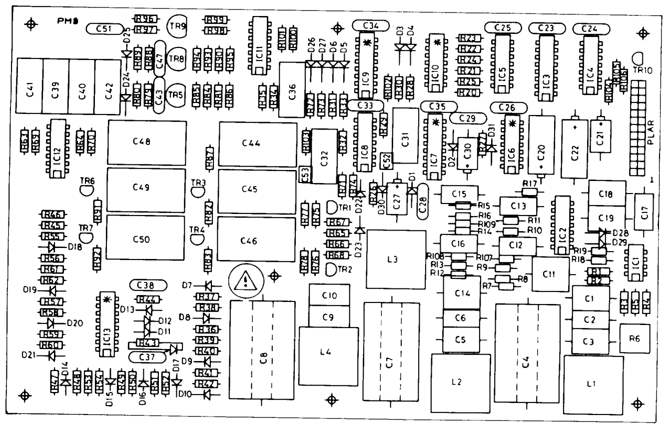
Foldout FO-21



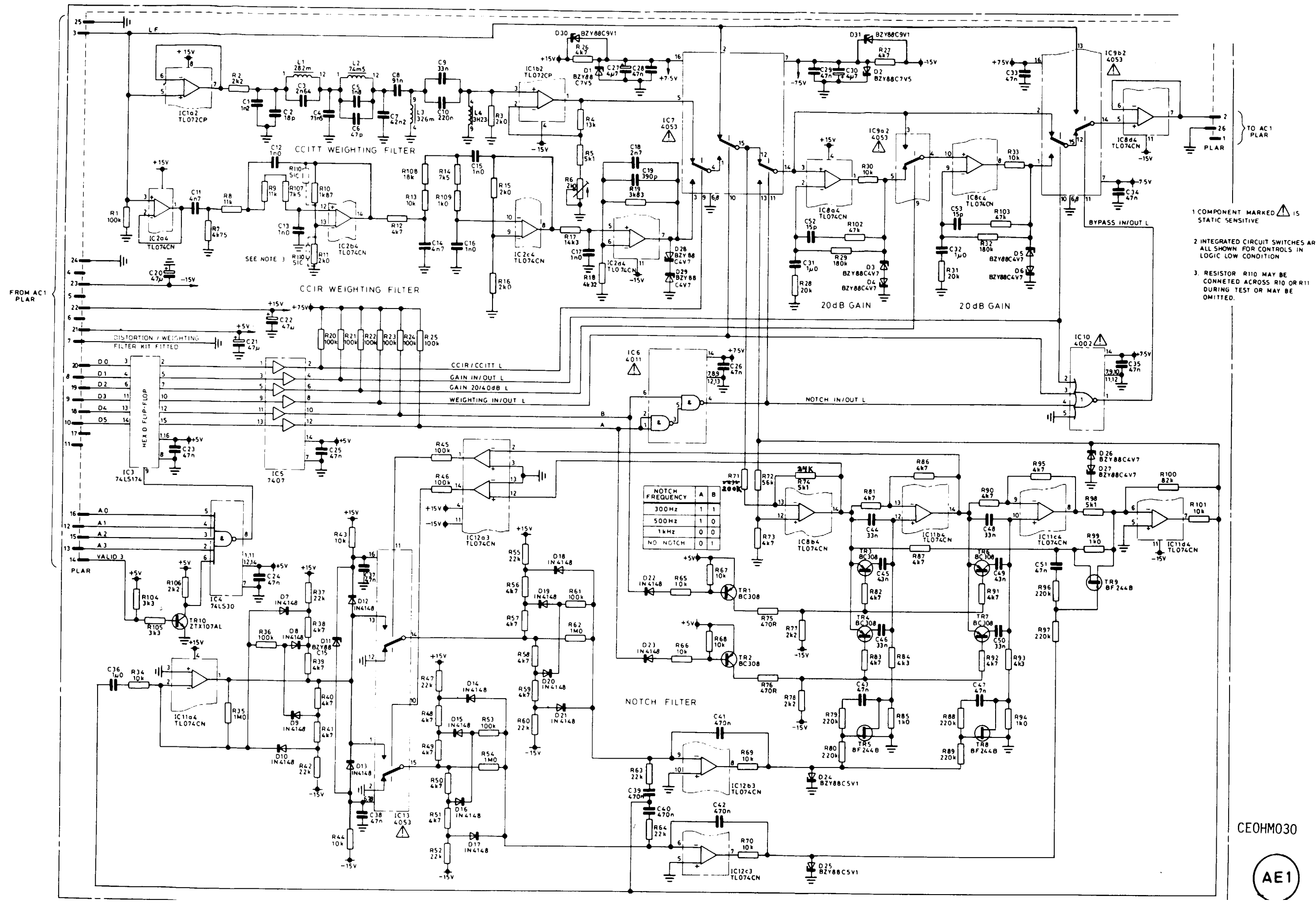
AZ0 Main chassis (incl. Power supply) circuit diagram

Foldout FO-22

⚠ ALL IC'S INDICATED THUS * ARE STATIC SENSITIVE AND MUST BE ASSEMBLED AT A SAFEPOST

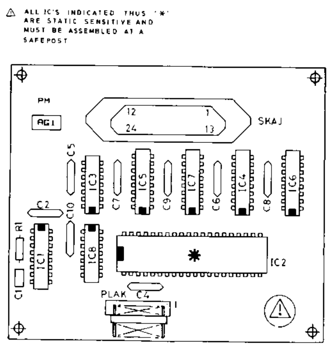


AE1 Distortion/Weighting filter, printed circuit board

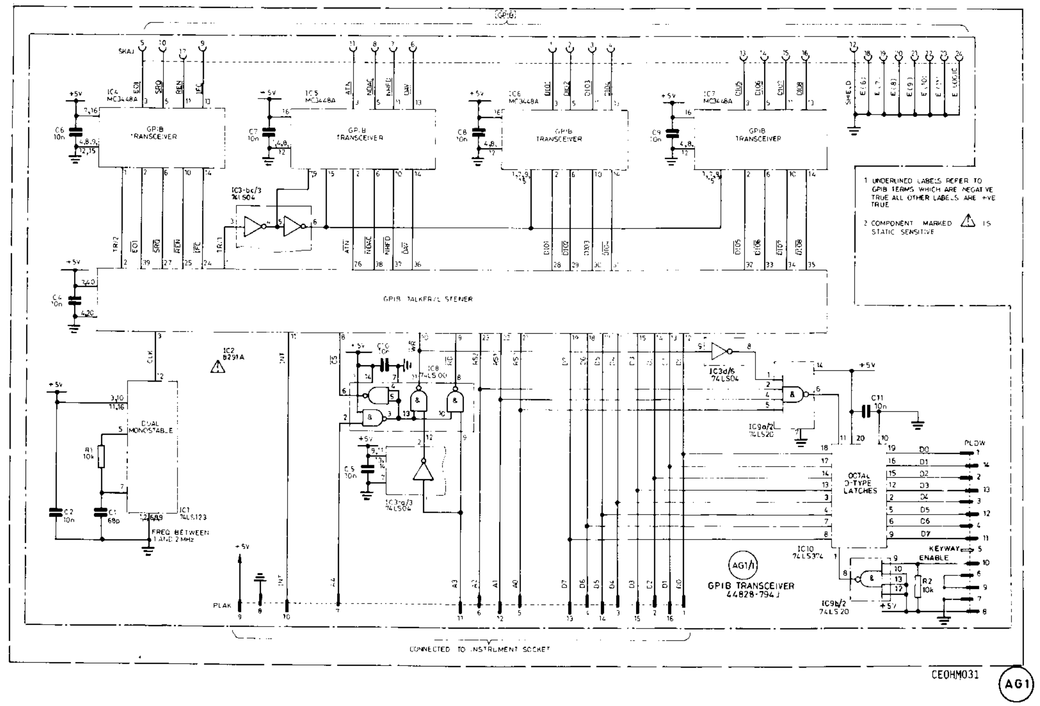


AE1 Distortion/Weighing filter, circuit diagram

Foldout FO-23

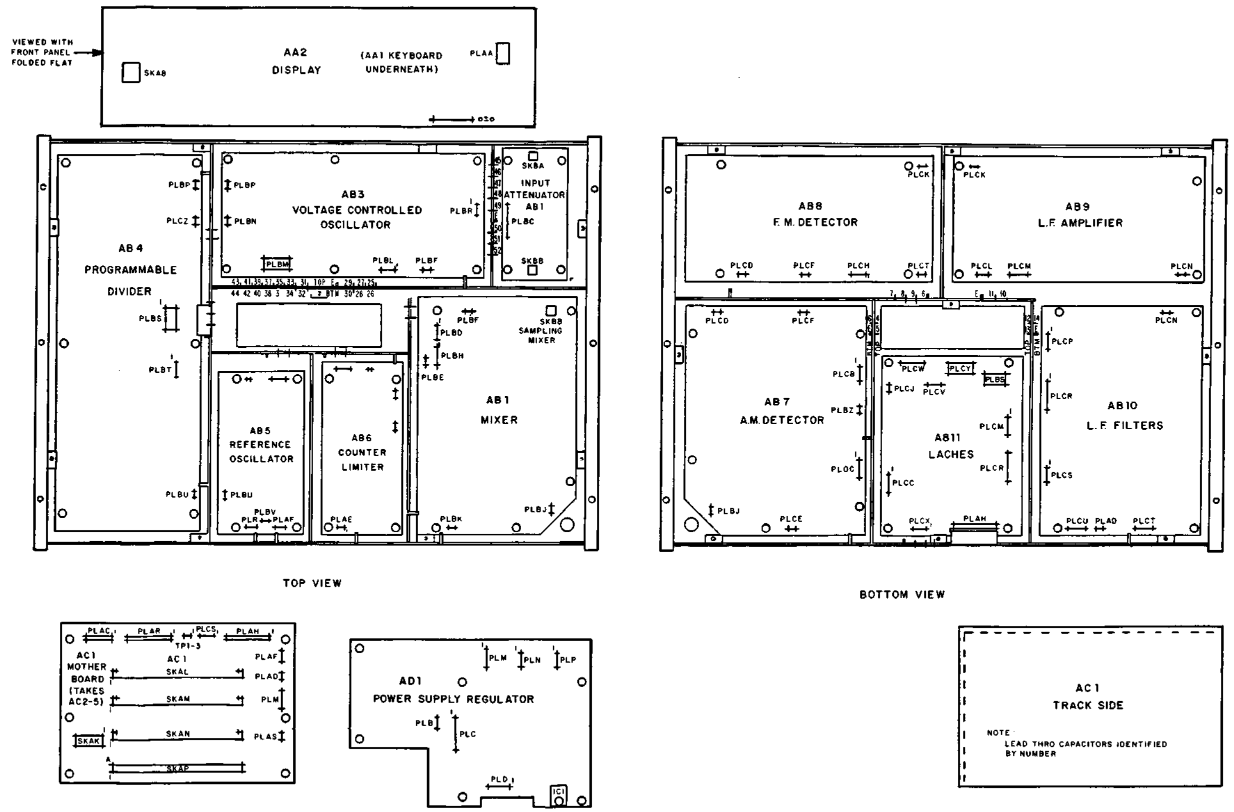


GPIB Transceiver, printed circuit board



AG1 GPIBB Transceiver, circuit diagram

Foldout FO-24



Board positions (top and bottom views) and interconnection detail

Foldout FO-25

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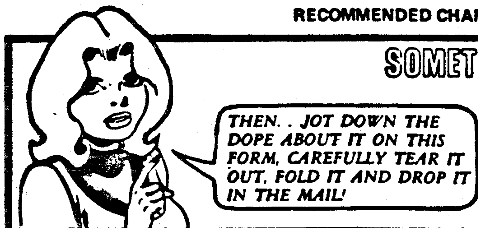

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