



QUARTZLOCK INSTRUMENTS

Gothic
Plymouth Road
Totnes
Devon TQ9 5LH
England
Tel: 0803 862062
Fax: 0803 867962



Quartzlock

QUARTZLOCK INSTRUMENTS

Group products include SYNTHESIZED SIGNAL GENERATORS · RADIOTELEPHONY TEST SYSTEMS · PROGRAMMABLE ATTENUATORS & FREQUENCY STANDARDS



RADIO TELEPHONE TEST SETMANUALContents:

Section 1	Equipment description
Section 2	Specification
Section 3	Initial Setting Up
Section 4	Operating Instructions
Section 5	Application Notes
Section 6	Technical Description
Section 7	Test & Calibration
Section 8	Fault Finding
Section 8A	Sinad
Section 9	Mechanical Assembly Details
Section 9A	Appendix 1 2 3 4 & 5
Section 9B	TO FOLLOW (SEE ALL W.C.L.)
Section 10	Parts Lists
Section 11	Circuit Diagrams

Radiotelephone Test Set Type 282A

Introduction.

The Test Set 282A is a complete system for the maintenance and checking of all standard radiotelephones in both fixed and mobile installations. Selectable mains or battery operation make it ideally suitable as a field test unit by engineers in remote areas.

The Set permits for duplex testing of receiver and transmitter.

The 282A contains the following functions:-

- 1) Precision Signal Generator 65-180Mhz, 420-510Mhz with CW, AM, FM or PM capability from internal or external audio.
- 2) Frequency Counter Accepts inputs from 50Hz to 510Mhz.
- 3) Power Meter Covers measurements from 100mW to 300W over the frequency range.
- 4) Modulation Meter Reads AM FM and PM characteristics on both the internal signal and the applied transmitter signal.
- 5) I.F. Oscillator Four selectable internal crystal frequencies (10.7Mhz standard) to customer requirements with an external crystal socket. Range 100KHz-22Mhz.
- 6) A.F. Oscillator 100Hz to 9.9KHz sinewave oscillator with 100Hz frequency increment for internal modulation and/or external use.
- 7) Selcall Any one standard to customers requirements, with microprocessor controlled Selcall Board available.

The equipment may be operated from a 50-60Hz, 110V or 240V nominal supply, or 12V DC. It is a fully protected for transmitter inputs to 1000W, although power levels in excess of 60 watts must be time limited.

The unit may be used manually between transmitter and receiver functions or on automatic when transmitter powers greater than 100mW will select transmitter tests.

The unit is constructed in readily accessible printed circuit board format, for ease of servicing, whilst still retaining the ruggedness necessary for field operations.

The equipment is fully protected such that transmitters up to 1000W can be fed into the load for short periods. The system may be used manually with selection of receiver (Rx) or transmitter (Tx) test functions, or in an automatic mode (TRx) when a carrier greater than 100mW will switch the system to transmitter tests.

The system is built up in module form for ease of servicing.

SECTION 1

Equipment Description

The Radiotelephone Test Set type 282A is a complete system for all normal measurement and setting up procedures on modern radiotelephone fixed and mobile stations. Its portability and battery operation capability make it very suitable as a mobile test station.

The test set consists of:-

- 1) Signal Generator A low noise analogue V.F.O. digitally controlled over the ranges 65-109.9999MHz, 110-180MHz, and 420-510MHz. Output level 0.5uV-50mV rms (emf), 1uV-100mV rms (pd) at the signal generator (BNC) output, with A.M., F.M. and P.M. capability from internal or external audio source. The signal is attenuated by 40dB at the Radio Telephone (type 'N' connector) output when an external link is connected.
- 2) A.F. Oscillator A 100Hz-9.9KHz sine wave oscillator with thumbwheel switch frequency selection and 100Hz incremental setting. Output level 1mV-1V e.m.f. into 600ohms available for Rx/Tx AF response test, counter frequency setting, or other use.
- 3) I.F. Oscillator A crystal controlled oscillator, range 100kHz-22MHz, with 10.7MHz fitted as standard. Four selectable crystal positions to suit customers requirements and an external socket are provided.
- 4) Counter 50Hz-510MHz in two ranges. 50mV-2V operating range. 3 parts in 1000 million oven controlled crystal reference. External input or internal switching to Signal Generator or Power Meter R.F. tap.
- 5) Modulation Meter Automatic locking to Signal Generator or incoming carrier. A.M., F.M. * P.M. peak and trough readings. A.F. * I.F. outputs, and external input available.
- 6) Power Meter 100mW-300W over the range 10-510MHz with 10% accuracy. R.F. tap of incoming carrier provides inputs to Frequency Counter and Modulation Meter. Further tap available as a 40dB power attenuator.
- 7) Power Supply A 110V * 230V 50-60Hz mains input supply with a 12V DC inverter built in.

SECTION 2

SPECIFICATION

(a) SIGNAL GENERATOR

Frequency Range	60 - 180Mhz 420 - 510Mhz
Frequency Increment	100Hz
Frequency Stability	Determined by internal standard, temperature drift: 1×10^{-7} over working range. Warm up time: 5 mins @ 20 C ambient : 10 mins @ 0 C ambient Ageing : 1×10^{-7} / month
Output Signal	3.2uV - 100mV pd at High Level output. Selected by 10 x 10dB steps and 10 x 1dB steps on calibrated attenuators. Fixed -40dB output w.r.t. High Level.
Output Level Accuracy	2dB absolute, 0.5dB incremental
Harmonics	> 30dB below main carrier
Spurious Output	> 60dB below carrier
F.M. Noise (3kHz BW)	< 20Hz
A.M. S/N Ratio (3kHz BW)	> 40dB

All r.f. inputs and outputs are 50ohms @ 10%
The Test Set will withstand 60 Watts RF at the transmitter
input indefinitely, and is fully protected to 1000 Watts.

(b) AMPLITUDE MODULATION

Modulation Depth	0 - 90% with meter indication
Accuracy	5% max. at 30% depth, 3% typical
Frequency Range	60Hz - 10kHz
Waveform Distortion	3% max.

(c) FREQUENCY MODULATION

Deviation	0 - 20Khz with meter indication
Accuracy	5% fsd max., 1.5% typical
Frequency Range	60Hz - 10kHz
Modulation Distortion	3% max.

(d) PHASE MODULATION

Deviation	F.M. with 6db / octave pre-emphasis 0 - 5 Radian
Deviation Accuracy	5% fsd max., 1.5% typical
Frequency Range	300Hz - 10kHz
Modulation Distortion	3% max with 6db / octave filter

(e) A.F. OSCILLATOR

Frequency Range	100Hz - 9.9kHz
Setting Accuracy	1 part in 10^{-6} / month
Waveform Distortion	1%
Output	1mV - 1V emf 600ohms. Meter indica- tion

(f) FREQUENCY METER

Frequency Range 10Hz - 510Mhz
Sensitivity 100mW RF at Transmit Input
50mV internal, 100mV external input
Display 9 Digit, 100,10,1Hz resolution
Stability As Signal Generator in 1 (a)
Control May be set to read External or Internal signal, manually or automatically.

(g) MODULATION METER

Carrier Frequency 10Mhz - 510Mhz. Automatic Frequency setting
Sensitivity 100mW at Transmitter input or 50mV internal, 100mV external input
Ranges:-
i) F.M. 0-5kHz, 0-20kHz
ii) P.M. 0-2 RAD, 0-5 RAD
iii) A.M. 0-50%, 0-100%
Filter NB 300Hz-3kHz, WB 60Hz-15kHz positive or negative modulation
Accuracy 5% fsd, 3% typical all modes
Recovered A.F. Output 300mV emf into 600ohms for fsd

(h) POWER METER

Frequency Range 2Mhz - 520MHz
Ranges 1,3,10,30,100,(300) Watts fsd
Accuracy 10% over full range, 5% below 200MHz
Input Impedance 50ohms @ 5% VSWR 1.3:1 max. at 510MHz

(i) A.F. LEVEL METER

Frequency Range 60Hz - 10kHz
Input Impedance 20k ohms RF protected (C=1000pF)
Amplitude Ranges 3mV, 10mV, 30mV, 100mV, 300mV, 1V, 3V fsd
Accuracy 0.2dB

(j) POWER SUPPLIES

115V or 240V 50-60Hz
12V DC at 3A

(k) TEMPERATURE RANGE

0 C - 40 C ambient

SECTION 3

Initial Setting Up

3:1 Power Supply

The built in power supply is designed to cover all normal mains fluctuations. It is fitted with a selector for 230/110V operation. When the equipment is delivered the selector will be set to 230V or 110V as appropriate. This MUST be checked before first switching on. A built in inverter is fitted to operate the equipment from a standard 12V car battery.

3:2 Battery Operation

To operate the equipment from DC, connect a lead capable of carrying 4 amps to the terminals on the back of the power supply, positive to red. The main front panel ON/OFF switch now operates the opposite way. (ie. ON for DC is OFF for AC.) No harm can thus result from connecting to a battery while mains voltage is applied.

SECTION 4

Operating Instructions4.1 Switching on

The mains switch is located underneath the right hand edge of the Frequency Meter. To switch on simply press the button. The Counter will illuminate.

For battery operation or a mains voltage change, consult section 3 of this hand book.

4.2 Front panel controls, indicators and connectors.

4.2.1 Signal Generator

a) RX range

The VFO ranges are automatically changed electronically by the action of selecting the desired frequency on the seven position multilever switches.

b) RX Tune

The VFO is automatically tuned by the operation of selecting the desired frequency.

c) A.M. C.W. F.M. P.M. (Signal Generator mode)

This four position rotary switch is used to select the Signal Generator mode. C.W. position mutes all modulation to the VFO.

A.M. F.M. * P.M. positions are selected as required.

d) Modulation

The mode of modulation is set as in (c) above. The modulation depth is set by level controls for each of the following:

Modulation Oscillator
Pilot Tone Oscillator
Selcall

e) Modulation Oscillator

A two position bank of thumb-wheel switches gives a direct readout of modulation frequency. The minimum increment is 100Hz.

f) Pilot Tone Oscillator

A four position bank of thumb-wheel switches selects Pilot Tone frequency from 10Hz to 750Hz. The minimum increment is 0.1Hz.

g) AF Output level

This control is used to set the Modulation Oscillator output level. (This in turn determines the depth of modulation of the Signal Generator).

h) Int/Ext. 0dB - 20dB

With the toggle switch set to INT the Modulation Oscillator output is available at the BNC AF output. This may be attenuated with the 0dB-20dB switch.

With toggle switch set to EXT the AF output BNC becomes an external input socket. The attenuator switch does not operate in this position.

i) RX Level

Two ten step attenuators to reduce the carrier to 0.5uV from the normal 50mV output from the Signal Generator. The attenuators are marked in dB and simply added to obtain the total attenuation. See appendix 5 for conversion chart dB to uV.

j) A.F. Level (Range) 3mV to 10V

This seven position rotary switch selects the gain of the A.F. Level Meter.

k) I.F. Oscillator (Range)

A six position switch selects the I.F. frequency. The first position allows any crystal in the range 100kHz-22MHz to be plugged into the external socket. The second position is fitted with 10.7MHz as standard. The remaining positions can be fitted with any crystal within the above range to suit the users requirements.

4:2.2 Counter

a) EXT, TRx, Rx

This is effectively the systems function switch. As well as controlling the Counter mode of operation it also performs all the necessary switching of RF paths to connect the Modulation Meter and Power Meter to the Counter and Signal Generator.

EXT makes the Counter available via the adjacent BNC socket.

Rx sets the Counter and Modulation Meter to monitor Signal Generator frequency and modulation.

TRx is the automatic mode which normally monitors the Signal Generator, but switches to any carrier greater than 100mW applied to the load.

i) Prescaler Switching

The switch is marked with the counter capability, 50Hz-10MHz * 10-510MHz. When selected for external low frequencies the decimal points on the display are extinguished and the display reads directly in Hz. The input impedance in this position is nominally 10k ohms. When TRx is selected the prescaler is switched to 10-510MHz. The decimal point indicates MHz. The input impedance is 50ohms in this position.

ii) Resolution

The Prescaler is electronically interlocked to give the correct resolution when prescaling is taking place. The gate times are increased by a factor of 10 when the 10MHz-510MHz range is selected.

The TRx 1Hz position would only be used for special purposes, and gives a 10 second gate time. For carrier frequency measurement the 100Hz or 10Hz positions are recommended.

iii) Gate Times.

<u>Resolution</u>	<u>50Hz-10MHz</u>	<u>10MHz-510MHz</u>
1 Hz	1 sec	10 sec
10 Hz	100 m sec	1 sec
100 Hz	10 m sec	100 m sec

b) Tx PT Freq

Depressing this push button switches in the x100 frequency multiplier between the output of the modulation meter and the low frequency input to the counter. Other inputs to the counter are muted and the resolution is 0.01Hz with a 1 second gate time when 10Hz resolution is selected.

4:2.3 Modulation Meter

a) Range

The Modulation Meter being fully automatic leads to a great simplification of controls. The Range control is a two position toggle switch which is marked with the full scale indication of the meter.

b) CW, AM, FM, PM (Function)

As described in the Signal Generator section, this control is used to select the type of modulation to be read.

c) +/- Switch

Positive and negative modulation can be compared to show up any distortion in the demodulated signal.

d) Filter

A wide and narrow band filter is provided. The narrow band is particularly useful in the PM position in removing very low frequency modulation which, due to the principle of de-emphasis fundamental to phase modulation, is accentuated.

It is operational on all modes of modulation and may be used at any time to reduce noise on signals.

e) Lock

A Light Emitting Diode is provided which illuminates when there is sufficient carrier for the Modulation Meter to work correctly. Normally this lamp will show continuously as the meter will lock onto the Signal Generator.

f) Mod Monitor

The demodulated output is available from this BNC. The output impedance is 600ohms and is suitable to drive an oscilloscope or high impedance ear piece. There is insufficient output to drive a loudspeaker, and the circuit is short circuit protected.

4:2.4 Power Meter (R.F. Wattmeter)

a) Range

A simple six position switch to scale the meter as required. The instrument is fully protected and no damage will result from applying maximum power even in the 1W position.

b) Zero

This control is adjusted for Zero indication on the meter. When turned clockwise until the internal relay just operates the Tx mode is selected. Further adjustment of the control reduces the accuracy of the indicated power reading.

If a high power has been dissipated for any length of time and the load is hot, it is recommended that Zero be reset if high accuracy is required.

c) Radiotelephone (main input/output socket)

In the Rx mode a maximum carrier level of 0.5mV pd is available from the 'N' type connector. In the Tx mode the transmitter power is dissipated in the dummy load and the power indicated on the meter above. The Test Set carrier is still available at this socket even with power applied, thus making possible receiver sensitivity checks with the transmitter keyed.

d) Rx Signal

A high level output of 50mV pd is obtained from this BNC. In normal use it is linked across to the adjacent BNC.

4:3 Rear Panel Connections

4:3.1 Modulation Meter

a) RF Input

This BNC enables the Modulation Meter to be used on signals too small to operate the auto switchover circuits. The sensitivity is typically 10mV pd. When this input is in use select Tx on the Zero RF Power control.

b) IF Output

The 432kHz Intermediate Frequency of the Modulation Meter, at a level of 100mV rms, is available at this socket. With the tracking nature of the Modulation Meter, and using the auxillary RF input mentioned above, any external signal in the range 10-510MHz may be analysed, at a constant frequency, at this output.

SECTION 5

Application Notes

5:1 Introduction

The facilities built into the 282A and the combinations of operation available make it virtually impossible to document all the possibilities.

To enable the operator to become familiar with the instrument the following application notes have been gathered together covering some of the most usual radio-telephone measurement procedures.

In the procedures, Controls, Indicators and Connectors are signified by block capitals with the wording as seen on the front or rear panel.

All the procedures are described with the system in the automatic mode i.e. Counter function switch in TRX position, if desired they may be performed manually by selection of Rx or Tx positions as appropriate.

5:2 Receiver Bandwidth Measurement

- a) Connect the receiver aerial to the RADIOTELEPHONE Type 'N' socket, and the receiver audio output to AF LEVEL/SINAD input sockets.

Dial the Rx centre frequency.

- b) Switch in maximum attenuation and note the reading of the A.F. Level Meter.
- c) Increase the sensitivity of the A.F. Level Meter by 10dB (1 step anti clockwise). Adjust the R.F. attenuators for 10dB reduction in noise level with meter needle in equivalent position to (b). Check carrier is still centred in passband by adjusting selected frequency for peak reading on AF Level Meter.
- d) Switch out 6dB on the right hand attenuator.
- e) Adjust selected frequency upwards for the same AF LEVEL reading as (c). Do not adjust carrier level. Note frequency reading.
- f) Adjust selected frequency downwards for the same A.F. LEVEL. Note frequency and subtract from value obtained in (e). The result is the receiver bandwidth.

5:3 Receiver Sensitivity Measurement

- a) Connect the receiver aerial to the RADIOTELEPHONE Type 'N' socket, and the receiver audio output to AF LEVEL/SINAD input sockets.
- b) Select FM, 5KHz range. Set MODULATION OSCILLATOR TO 1.0kHz and adjust OUTPUT LEVEL for 2.8kHz deviation.

- c) Set RX LEVEL attenuators for 60dB. Select Receiver carrier frequency.
- d) Measure the received AF level.
- e) Switch modulation to EXT and increase the AF Level Meter sensitivity by 20dB, two steps anti-clockwise.
- f) Add carrier attenuation until noise level is 20dB below modulation level. i.e. The AF LEVEL meter needle is in the equivalent position as (d).
- g) Switch Signal Generator to CW and add attenuation from step attenuators to read sensitivity. Use chart in Appendix 5 to convert to uV if required.

Note: The above procedure describes the tests for a typical FM receiver. The same procedure is used for AM or PM, the Signal Generator and Modulation Meter function and ranges being selected accordingly. The depth of modulation will be as defined by the radiotelephone manufacturer for that model.

5:4 Receiver Signal to Noise Ratio

- a) Connect the receiver aerial to the RADIOTELEPHONE Type 'N' socket, and the receiver audio output to AF LEVEL/SINAD input sockets.
- b) Select FM, 5KHz range. Set MODULATION OSCILLATOR to 1.0kHz and adjust OUTPUT LEVEL for 2.8kHz deviation.
- c) Set RX LEVEL attenuators for 40dB. Select Receiver carrier frequency.
- d) Measure the receiver AF level.
- e) Switch modulation to EXT and increase the AF LEVEL meter sensitivity until equivalent meter deflection is obtained. Calculate the increase in gain, 10dB=1 switch step, this is the signal to noise ratio.

5:5 Receiver Squelch Threshold.

- a) Connect the receiver aerial to the RADIOTELEPHONE Type 'N' socket.
- b) Set RX LEVEL attenuators for 40dB. Select Receiver carrier frequency.
- c) Reduce the carrier level with the step attenuators until the receiver noise level is heard to be increasing. Apply 1 dB steps until squelch operates.
- d) Remove 1dB steps until squelch opens then increase attenuation to within 1dB of operating point.
- e) Add total attenuation reading and 40dB. Convert to threshold voltage using chart in appendix 5.

5:6 Receiver Audio Frequency Response (AM & FM)

- a) Connect the receiver aerial to the RADIOTELEPHONE Type 'N' socket, and the receiver audio output to AF LEVEL/SINAD input sockets.
- b) Select AM or FM and modulation range required. Set MODULATION OSCILLATOR to 1.0kHz and adjust OUTPUT LEVEL for modulation depth required.
- c) Set RX LEVEL attenuators to 40dB. Select Receiver carrier frequency.
- d) Set the modulation AF FILTER to 50Hz-15kHz. Note reading of AF Level Meter.
- e) Dial up LF & HF CORNER frequencies on the MODULATION OSCILLATOR thumbwheels to give 3dB lower readings on the AF LEVEL meter.

5:7 Transmitter Frequency & Power

- a) Connect the transmitter to the type N socket RADIOTELEPHONE. Select the power range required and check the meter zero, adjust ZERO if necessary.
- b) Set Counter function switch to TRx, 10Hz resolution.
- c) Switch on transmitter and read the power dissipated, and the carrier frequency directly.

Note: On higher power transmitters at certain frequencies the counter may be overloaded. In this case a 'sniffer' may be used to measure frequency.

5:8 Transmitter Deviation, FM on AM

- a) Connect the transmitter aerial to the RADIOTELEPHONE Type 'N' socket.
- b) Set Modulation Oscillator OUTPUT LEVEL to manufacturer's specified value at 1kHz, monitored on AF LEVEL METER. For levels less than 50mV switch in -20dB attenuator.
- c) Switch on transmitter. Select FM, appropriate range, and read off deviation, or FM on AM, directly.

5:9 Transmitter Audio Frequency Response FM & AM

- a) Connect the transmitter aerial to the RADIOTELEPHONE Type 'N' socket.
- b) Switch on the transmitter and adjust modulation OUTPUT LEVEL for a convenient reading on the AF Level Meter dB scale, at 1kHz. Ensure modulation depth is within the transmitters normal operating range.

- c) Set Modulation Meter filter to 50Hz-15kHz. Step the AF band with the MODULATION OSCILLATOR thumbwheels to determine the upper and lower 3dB (6dB) points, as required by the radiotelephone manufacturer's specification.

5:10 Transmitter Call Tone Frequency

- a) Connect the transmitter aerial to the RADIOTELEPHONE Type 'N' socket.
- b) Set Counter to EXT, 50Hz-10MHz. Link between counter INPUT socket and Modulation Meter MOD MONITOR.
- c) Switch on the transmitter and operate the call tone. Select AM FM or PM as required and 5KHz range. Read off the call tone directly from the Counter.

NOTE: The Counter gate time is 1 sec so it is advised that the first reading be ignored.

- d) For call Tones (CTCSS/Pilot Tone) lower than 750Hz simply depress the TX PT FREQ button, no external connection between Counter and Modulation Meter is required. When TRx, 100Hz resolution, is selected the display will be 0.1Hz resolution with a 0.1 second gate time.

SECTION 6

Technical Description

6.1 Block Diagram.

The system consists of five basic blocks. These are the Signal Generator, Counter, Modulation Meter, RF Power Meter and Power Supply. The Counter and Modulation Meter, being common instruments for both transmitter and receiver tests, have their RF inputs co-axially switched by the Power Meter switching circuits. The Power Meter, as well as monitoring transmitter power, also acts as the radiotelephone interface. Its dummy load is tapped to give a sample of transmitter power for Counter and Modulation Meter operation, and acts as protection for the Signal Generator. The Signal Generator output is also fed through the load which gives further attenuation, in addition to the step attenuators, to bring the signal level down to typical aerial values, even with maximum output from the Signal Generator. This ensures receiver stages are protected from overload.

The 282A system is shown diagrammatically in Fig.A. The signal generator section has two buffered outputs. One feeds the precision switchable attenuators and the second is used for internal frequency and modulation checking in the 'receive' mode.

A range of modulation levels and frequencies may be applied to the signal generator from either the internal or external sources.

An external link enables the main transmit/receive socket to be fed from the attenuator output via a fixed -40dB pad.

The non reactive transmitter load will handle input powers up to 60 watts continuously and provides a transmitter input sample both to the R.F. power meter, and, either manually or automatically, to the counter and modulation meters.

6.2 Signal Generator

- a) A block diagram of the R.F. generation is given in Fig.B and the full circuit in Figs. C & D. All the circuitry is contained in a low microphonic, double r.f. screened, housing.

The frequency range of the 282A is covered by the three separate, low level, voltage controlled oscillators (VCO's). The required VCO is automatically selected from the setting of the front panel multilever switches.

The appropriate VCO output is amplified first in common head amplifier IC2, to approximately 20mV rms, and then in a constant output level amplifier IC4, to pass via PL2 to the front panel attenuators.

The counter and modulation meter signals are derived from a separate amplifier, IC3, to prevent load variations affecting the main output. The VCO signal is then digitally processed. The complete board is sited in a double screened r.f. box to reduce r.f. leakage at the fundamental frequency.

b) VCO/Head Amplifier (Fig.C)

The three VCO's use bipolar devices in a Colpitts circuit, in grounded base configuration. VCO I, (Tr1), utilises a lumped inductance and VCO II, (Tr2), VCO III (Tr3), use trough line inductors.

Tr1 covers the range 65-109.9999MHz determined by L1 and the total fixed parallel capacity, plus the capacity associated with the variable capacity diodes D2, D3. The frequency range is covered with the bias limits (CONTROL VOLTAGE) of 0.8-18.0V.

F.M. of P.M. are applied as an audio frequency signal to the variable capacity diode D4 which has only a limited effect on the resonant frequency via C8.

The VCO I output is the amplified in IC2 to 20mV rms.

Tr2, and Tr3, operate as Tr1 but over the ranges 110-185MHz, and 420-510MHz. Diodes D5, D6, and D8, provide the frequency coverage and D7, and D9, in conjunction with C16, and C27, provides the FM and PM. The output of VCO II, and VCO III, are inductively coupled to the common head amplifier IC2.

The VCO output level from IC2 is adjusted by the coupling into L1, L2, or L3 to be approximately 20mV rms on all ranges.

The three VCO's have residual F.M. and noise filtering on all variable capacity diode supplies.

Note: The F.M. deviation is indicated on the front panel and must be set to the required value at the frequency in use.

IC1 demultiplexes the binary coded switch data to three lines and routes the VCO supply voltage from D1 to the selected VCO.

The VCO output at 20mV rms is followed by three independent buffer amplifiers IC3, IC4, and IC7 (Fig.D). The levelling amplifier, IC3 provides a constant signal generator output to the attenuators; IC4 gives a constant level to the internal frequency counter and modulation meter, and the dual modulus divider IC8, IC9 is supplied via IC7.

The amplifiers IC3, IC4, and IC7 are wideband hybrid amplifiers with a fixed voltage gain of 27dB over the full VCO range.

c) Level Control and Amplitude Modulator.

The VCO output signal is coupled via R31 to a P.I.N. diode attenuator network comprising D10, D11, D12 and IC4. The attenuation level is controlled by the DC voltage applied via the RF isolation chokes Ch3 & Ch4.

The RF output of IC4 is sampled and peak rectified with C53 and D13. The resultant DC level is amplified and inverted in IC6, which has a fixed gain of 15dB. D13 has approximately 120mV of forward bias to reduce AM distortion effects.

IC5 is used as a wideband comparator. The output of IC6 is compared with a level which is preset by R48. R48 is adjusted to give 50mV rms at the RX SIGNAL output with zero attenuation selected. The audio for AM is also supplied via R48 to maintain a constant modulation depth/carrier level characteristic.

The P.I.N. diodes are arranged in a constant impedance versus attenuation network. Consider a decrease in VCO level at PL2. The voltage at IC6 inverting input will increase positively giving a negative swing at its output. This is again inverted in IC5 to give a positive going voltage to the P.I.N. diode network. D11 will now increase in conduction, D10 and D12 will be biased towards cut-off, thus reducing the attenuation to maintain a constant output at PL2.

The attenuator operates at a low signal level (approximately 20mV), to minimise waveform distortion by the diode characteristic.

The output signal at PL1 will also be at a constant, approximately 6dB higher, level to drive the frequency counter and modulation meter.

d) Dual Modulus Prescaler.

IC7 amplifies the VCO output to 400mV rms to drive the ECL dividers IC8 & IC9. IC8 is a high speed programmable divide by 10/11 stage and IC9 is a conventional high speed 10 stage. IC8 is converted from an 11 to a 10 counter when either or both enable inputs PE are in the high ECL stage.

Tr6 is an ECL/TTL converter to drive the following N dividers.

e) Programmable Counter and Phase Comparator (Fig.E)

Programmable Counter:

The prescaler output from the board is fed via pin 5 of the board edge connector the parallel clocked counter comprising IC13 - IC19. A 'Swallow' counting technique is used with IC13 and IC14 forming the swallow counter and IC15 - IC19 providing the main N counter to give a final output with P.R.F. of 100Hz.

Counter programming for frequency selection is controlled from the front panel multilever switches. The parallel PCD data is fed to latches IC5 - IC11 which are strobed by the demultiplexed digit select output of IC12 to set multilever switch data into both the swallow and N counters. IC13-19 are arranged in the count down mode. On completion of the preset count in IC13 * IC14, the swallow counter is inhibited from further counting by Pin 8 of IC24 holding count enable P high. The N counter continues counting down until the 'carry out' of the IC19 indicates end of preset count. This 'carry out' has two functions, it a) resets and loads all counters to preset numbers, and b) provides a signal at 100Hz for the phase comparator.

Phase Comparator:

100Hz pulses, derived from the precision 10MHz crystal reference in the frequency meter section, are applied to IC26 via edge connector Pin 20. The 74C932 phase comparator compares the phase relationship between these standard 100Hz pulses, and the 100Hz pulses from the N counter, and produces a DC level dependent on the relative phases. This DC level is amplified and smoothed in IC25 to give a 0-19V maximum output with a fast response time. This voltage is applied as the VCO control voltage.

f) VCO Select

The two MSB counter preset inputs are converted from BCD to decimal in IC20 * IC21 and further gated to provide the data A and B for VCO selection (see section 6:2.b)

g) Multiplex and 100Hz Reference (Fig.C)

100Hz Reference:

A 1MHz signal from the 10MHz precision reference in the frequency counter is supplied via Pin 31 on the edge connector to two cascade dividers IC3 * IC4 to give 100Hz. The 100Hz output is fed via edge connector Pin 17 to the phase comparator (see Section 6:2.b) and a second output at 1kHz is taken from IC4, to provide the multiplex waveform for the switch multiplex circuit.

Multilever Switch Multiplexing:

The frequency selected on the front panel switches is strobed in BCD form by the outputs of the BCD/decimal decoder IC1 on the Multiplex board. The digit selection is buffered by Tr1, Tr2, and Tr3 to drive IC12 on the N board.

i) Modulation Oscillator.

The oscillator provides a sine wave output of up to 1V emf into 600ohms, with distortion less than 1%. The frequency is set by a 2 decade thumbwheel switch, incorporating an engraved numerical display, setting resolution is 100Hz.

The circuit is basically a Wein Bridge Oscillator. The required gain is provided by the operational amplifier type 709, and the Wein feedback network comprises 2 or 3 fixed capacitors, and 2 resistors which are switched for frequency selection.

The amplifier output is fed through a buffer stage to ensure a very low impedance input to the Wien network. From the output of this buffer a negative feedback network, consisting of a thermistor and 150ohms to earth, defines the amplifier overall gain and gives AGC action. On switch on, the amplifier output rises to a value of about 2V. There is then about 1.3V across the thermistor, which reduces its resistance to about 300ohms, giving a gain of 3, which just matches the loss in the Wien network. Any further voltage increase produces a reduction in the thermistor resistance, and hence in amplifier gain, so that the output amplitude is stabilized at about 2V.

The Wien network output is fed to the non-inverting input of the amplifier, so that the loop oscillates at the frequency at which the phase shift across the Wien network (and hence round the whole loop) is zero.

The frequency of oscillation is determined by the values of C and R. The value of C is fixed in this case and frequencies are selected by varying both resistors simultaneously. The frequency is inversely proportional to resistor values. So if resistors are switched into circuit with values following, in inverse ratio, binary coded decimal, the resultant frequency will directly follow that sequence. This switching is achieved by the BCD panel switches. Each single pole switch energises a relay, bringing in two resistors. Overall frequency accuracy is set by adjusting one of the C values and using close tolerance resistors.

j) Function/Range Switching.

Audio frequency from the Modulation Oscillator is attenuated by the modulation range switch. It is routed to the correct attenuator for AM, FM or PM, as each range is different, by one contact of SW1. The attenuated outputs for AM and FM are routed directly to the levelling amplifier and VFO respectively. Phase modulation is performed by applying a 6dB/octave pre-emphasis to the audio before frequency modulating the VFO. This is accomplished by passing the audio frequency through C1, the value of which is chosen so that its reactance at 10kHz is 15k ohm, the same as the input impedance of IC2. This ensures that the 6dB/octave slope is maintained up to 10kHz. Above this frequency the slope reduces until the corner frequency is reached at 20kHz. The gain of IC2 is set to compensate for transmission loss through C1 at 1kHz and the output is then fed to the FM inputs of the VFO.

The tap is connected via solid co-axial links to the measurement circuitry and Signal Generator output. Power measurement is performed with a simple peak detector circuit. To ensure low level operations the diode D1 is lightly biased via R3. The DC level appearing across C1 and C2 is measured by the display meter, FSD for each range being set by trimmers R8-R11, R16, and R20.

To back off the slight DC pedestal caused by the biasing of D1, the meter +ve terminal is referenced via the set zero potentiometer to positive level generated across D4. Overload protection of the meter is provided by D2 and D3. Transmitter power detection is accomplished by the operational amplifier IC1. The +ve summing junction is referenced slightly -ve to the meter +ve by potentiometer chain R14 and R15. With no carrier power the voltage across the meter is zero, hence the input to the -ve summing junction is approximately zero, so IC1 output is switched -ve by the +ve input. As power increases the output of the detector goes -ve until the point where the -ve input of IC1 is greater than the bias of the +ve input. The amplifier then switches +ve. No negative feedback is employed so saturation occurs.

The output of IC1 is fed via D6 to the emitter follower Tr1. This gives the current capability to drive the relay coils. Catching diode D7 is incorporated to protect Tr1 from inductive spikes. Automatic switching is overridden via input pin 5. When Rx is selected -12V is applied to the base of Tr1 via 560ohm. This switches Tr1 on and D6 hard off irrespective of IC1 output. When Tx is selected 0V is applied direct to the base of Tr1. Output from IC1 is grounded and Tr1 remains hard off.

Tr1 switches five relays, two in the Counter, one each in the VOC and Modulation Meter, and the fifth in the 40dB box. With this relay energised, (Rx position) inputs from the Modulation Meter and Counter are open circuited and the two arms of the 6dB splitter terminated. This action together with similar isolation in the Counter, VCO, and Modulation Meter ensures that no carrier frequency signal can bypass the Signal Generator attenuators.

In the Tx position the RF tap on the load is connected via the splitter pad to Modulation Meter and Counter inputs, providing input signals to both. The Signal Generator output is connected through a 13dB pad consisting of R30, R31 and R33 to the load resistor tap. This gives an attenuation of 40dB from the type 'N' Connector to the high level Signal Generator socket. Trimming of the 40dB is accomplished by R32 to compensate for differences in individual load units.

6:6 Power Supply

The power supply uses integrated circuit regulators to provide positive and negative 20 volts, 12 volts, and a +5 volt rail. There is also an unregulated nominal +10 volt rail which supplies the crystal oven and +5 volt regulator in the frequency counter. The 20 volt rails are adjusted by preset 5k potentiometers built into the power supply unit. A multiway plug and socket is used to connect the voltages to the test-set.

A feature of the power supply is the built in inverter. A low voltage set of primaries is incorporated in the transformer. One set of windings is connected in series, and driven in push pull by Tr8 and 9. Feed back to enable the circuit to oscillate is provided by windings feeding the bases of Tr8 and 9.

The action is as follows: Assume Tr8 has just turned hard on hence current starts to flow through the upper half of the primary into the collector. Since the current is changing a voltage is induced in the two feed back windings such that +ve appears on the base of Tr8 and -ve at the base of Tr9 thus driving Tr8 hard on and Tr9 hard off.

When the current through Tr8 reaches a steady state (the time determined by the inductance of the primary) the voltage on the base windings drops to 0V. The current in the primary starts to decay inducing opposite polarity voltages on the transistor bases thus turning Tr8 harder off and Tr9 on. This in turn causes current to build up in the lower half of the primary, reinforcing the base voltage. When the current in Tr9 reaches its maximum the feed back voltages again reverse and the cycle repeats. Resistors R15 and R16 are included to ensure that at no time can both transistors switch off.

SECTION 7

Test and Calibration

7:1 General

The system is built up of modules and so the following procedures are divided into modules with a test equipment list for each. Any equipment of equivalent specification may be used if available. Each test step is given a paragraph reference eg. 7:3:1(c). If any step fails, refer to the same paragraph in the fault finding procedure, section 8.

In the instructions, controls and sockets are indicated by their legend and are written in block capitals.

7:2.1 Contents

2.2	Equipment Required
3.1	Modulation Oscillator
3.2	IF Oscillator
3.3	VCO
3.4	AF Level Meter

7:2.2 Equipment

	3:1	3:2	3:3	3:4
HP 8558B Spectrum Analyser				
0-1500MHz			x	
Green 270 Automatic Mod Meter				
0-500MHz			x	
Green 2700 Manual Mod Meter				
0-500MHz			x	
Boonton RF Millivolt Meter				
0-500MHz, 50mV		x		
Green MH100 Counter 0-500MHz	x	x	x	
Fluke 8000A Multimeter	x	x	x	
Green Standard AF Level Meter				
3mV-2V	x		x	x
Solartron CD1400 Oscilloscope				
10MHz BW 10mV sensitivity			x	
Crystals 100kHz, 10.7MHz		x		
A.F.Oscillator 2kHz 0.5V rms				
SMA to BNC Cable, 2 off			x	
BNC to Banana plug cable	x			x
50ohm termination			x	
BNC 'T' piece	x			

7:2.3 Procedure

3:1 Modulation Oscillator (to follow)

3:2 IF Oscillator.

a) Check with the multimeter set to resistance for shorts to 0V on +12V rail.

- b) Connect supply and switch on. Select XTAL position and check with the multimeter for no voltage out of the crystal socket.
- c) Plug in the 100kHz standard crystal and connect the counter and RF millivolt meter to O/P. Check for satisfactory counter reading and level of 300mV rms. Change the crystal for 10.7MHz and repeat, check level is 300mV +/-50mV.
- d) Select 10.7MHz position and adjust C2 for a reading of 10.700000 MHz.
- e) Select position 1,2,3 and off and check no reading occurs unless crystals are fitted.

3:3 VCO

The board should be assembled with R5, R29, R66 omitted. If the board has been previously calibrated these values will probably not need changing.

DC Checks

- (i) With board disconnected at 14 pin P.I.L. plug/socket, measure resistance to chassis (AVO 8, ohms range, -ve lead to chassis).

+12V Pin 7.....	1k ohm)	
+5V Pin 4.....	700 ohm)	approx.
+20V Pin 1.....	500 ohm)	
-12V Pin 10.....	10k ohm)	

- (ii) Plug in power lead and apply power:
Voltage at pin 13 of I.C.1 should be 9.7-10.3V
- (a) Select 80MHz.
Voltage at pin 11 of IC1 should be 9.1-9.5V
Voltage across R4 should be 0.25V-0.95V
- (b) Select 180MHz:
Voltage at pin 12 of IC1 should be 9.1-9.5V
Voltage across R14 should be 0.75-1.45V
- (c) Select 480MHz:
Voltage at pin 15 of IC1 should be 9.1-9.5V
Voltage across R27 should be 1.15-1.85V
- (d) Voltage between pins 16 and 8 of IC8 should be 4.85V

RF checks

Monitor output of Levelling Amp. at PL2 with suitable oscilloscope or spectrum analyser, and PL1 with frequency meter.

Monitor control voltage on pin 14 with AVO or similar meter on 25V range.

- (i) Select 65MHz on switches. Adjust L1 to give meter reading >0.2V <1.2V. Counter should read 65.0000MHz.

- (ii) Select 109.9999MHz. Check meter reading 18v and counter reads 109.9999MHz. Select minimum value of R5 to give output level at PL2 of 100mV rms into 50ohm with R48 set for max. output.

Check a +ve TTL pulse at 1.0MHz appears at 100/101 feedthrough. Select 100.0011MHz and check a - ve TTL pulse, 11us wide appears at pin 1 of divide by N board. The 7th digit switch should increment this in 1us wide steps. The 6th digit switch should increment in 10us wide steps.

- (iii) Select 110.000MHz and check counter reads 110.000MHz. Meter should read >0.5V <2V. Add capacity parallel to C14 (15pf) to achieve correct control voltage. (typical value added 6.8pf).
- (iv) Repeat (ii) for 180.0000MHz and R29.
- (v) Select 420.0000MHz and check counter reads 420.000MHz. Meter should read >0.35V <0.8V. Adjust tapping point of C68 to achieve this value.
- (vii) Select 510.0000MHz and check counter reads 510.0000MHz. Meter reading should <18.0V.
- (viii) Adjust R66/R65 to give 100mV rms at PL2.

3:4 A.F. Level Meter

- a) Connect a BNC 'T' piece to the AF output and link the standard AF level meter and internal level meter to its arms. Set MODULATION OSCILLATOR to 1kHz and set the two meters to the 3V range. Adjust OUTPUT LEVEL for 2V on the standard meter.
- b) Adjust R6 for 2V indication. Reduce OUTPUT LEVEL and step ranges as table 6. Check the meters stay within +/-0.5dB

TABLE 6

Output level	2	1	1	0.3	0.1	30mV	10mV	3mV
Range	3	3	1	0.3	0.1	30	10	3
Reading	2	1	1	0.3	0.1	30	10	3

- c) Set 0dB at 1kHz and step MODULATION OSCILLATOR from 100Hz to 9.9kHz. Check the reading of the two meters stays within +/-0.5dB.

SECTION 8

Fault Finding Procedure8:1 General

With a system of this complexity it is impossible to define every fault condition. In the following procedures faults defined in the Test and Calibration procedures of section 7 are further investigated and localised to most likely components. It is assumed that the test personnel are familiar with systematic trouble shooting from then on.

8:2.1 Signal Generator - Modulation Oscillator

<u>Fault</u>	<u>Action</u>	<u>Likely Component</u>
a) + or -12V short circuit.		
b) No output	Check with CRO for sine wave on IC1 pin 10 if OK follow Through Tr3 and 4.	IC1, Tr1, C1, TH1 Tr3, Tr4, C4, C5.
Output square wave		TH1
Output will not adjust frequency.		Bad connection C6-C9.
c) Sequence not followed	Measure resistance between BCD switch common and earth. Then BCD switch and pin. Step decade and find resistance out of sequence.	Refer to circuit diagram.
d) Step will not trim		Step resistor out of tolerance.
e) Level out of spec Frequency out of spec.	Readjust frequencies	
f) Attenuators not 20dB. Output will not reduce.		R68, R69, R70. Output level pot.

8:2.2 I.F. Oscillator

a) + 12V short circuit	C7
b) Voltage appears at socket	C1

- | | | | |
|----|-----------------------|--|------------------|
| c) | No output or low | Check with CRO for sine wave at Tr1 drain. If OK follow through Tr2 and 3. | Tr1
Tr2, Tr3. |
| d) | Crystal will not pull | | C2 inoperative |
-

8:2.3 V.F.O.

8:2.4 AF Level Meter

- | | | | |
|----|--------------------------|---|-------------------------------|
| a) | All ranges out of spec | | R6 wrongly adjusted |
| b) | One range out of spec | | Range resistor for that range |
| | 3mV range out of spec. | Check with CRO for oscillation at output of IC1 | IC1 |
| c) | Frequency response poor. | | C1,C2,C3,C4,C5,C6. |
-

8:3 Modulation Meter

8:5 RF Power Meter

8:5.1 Calibration Board

- | | | | |
|----|---------------------------------|--|-----------------------|
| a) | Short circuit + or -12V or -20V | | C3, LC1 |
| b) | Zero control inoperative. | Check for +0.6V on pin 2. If Ok | D2
RV5 |
| | Relay inoperative | Check for + 12V swing on IC1 pin 6. If OK check for oscillation on Tr1 emitter | IC1
Tr1 |
| | Relay operates out of limits | | IC1 (voltage off set) |
| c) | Relay not inhibited | | Pin 5 not connected |
-

8:5.2 Load

- | | |
|----------------------------|-------------------------------|
| a) Load not 50ohm | Load resistor damage |
| b) One range will not set | Range trimmer or pot resistor |
| c) All ranges will not set | D1 |
| d) Output incorrect | R17, 18, 19 Load resistor |
| e) Load not 50ohm | Load resistor damage |
| f) VSWR high | Load resistor, input type N |
-

8:5.3 Frequency response and Calibration

- | | |
|--|----------------------------|
| a) 40dB will not set | R19 |
| b) Frequency response poor | Load resistor, R17, 18, 19 |
| c) Frequency response will not compensate. | Load resistor |
-

8:6 Power Supply

SECTION 8B

SINAD Meter

8B:1 General Description

The SINAD meter is a specialized distortion meter for making SINAD measurements on radio receivers. Special circuit design speeds and simplifies the SINAD measurement by eliminating all distortion meter adjustment.

The null circuits of the SINAD meter are internally set to the 1kHz tone used in SINAD measurements, and an automatic gain control eliminates the need for setting input gain to the meter.

The automatic gain control feature permits the SINAD meter to be used as a receiver alignment tool, providing rapid alignment of receivers for optimum performance.

8B:2 Circuit Description

The input circuits of the SINAD meter are connected to the audio output circuits of the receiver being tested. The signal appearing at the input to the SINAD meter consists of the wanted 1kHz signal frequency, and other frequencies representing the noise and distortion created in the receiver. This composite Signal, Noise, and Distortion signal is amplified by two cascaded AGC amplifiers. The output of the second AGC amplifier is a replica of the input signal, but is at a constant average level, regardless of input signal level changes from 20 millivolts to 4.25 volts rms.

The composite, constant level signal, is then fed into a 1kHz bandstop filter, which removes the 1kHz signal component, leaving only the Noise and Distortion components. These components are amplified and rectified by a precision average value rectifier circuit and then used to drive the indicator meter. Since the input signal to the bandstop filter is held constant, the meter is directly calibrated in SINAD values.

Normally the SINAD meter is connected to the loudspeaker terminals of the receiver under test. The 4.25 volts RMS maximum input will accommodate audio power levels up to 5.6 watts into a 3.2 ohm speaker. Since 4.25 volts rms amounts to 12 volts peak-to-peak levels greater than this voltage are not expected in radios operating from 12 volt supplies. On the low side, the 10 millivolts rms permits the connection to be made as early in the circuit as the discriminator output. For quantitative SINAD measurements, the connection must be made after the de-emphasis circuit, but connections ahead of the de-emphasis circuit will still give meaningful relative readings.

8B:3 Operating Instructions

Before using the SINAD meter with a specific signal generator, check the 1kHz modulating tone of the SINAD meter's null circuit. If the generator makes the modulating signal available on an output jack, simply connect it to the SINAD meter, and see if the SINAD meter reads hard left on the scale. If the generator you are using is not close enough, it will be worth while correcting it. Commonly used FM monitors have very accurate 1kHz sources, and you can depend upon them being correct.

Some signal generators have a front panel dial for adjusting the modulating signal frequency. If yours is this type, tune it for minimum indication on the SINAD meter and mark the spot on the dial for future reference.

Connect the SINAD meter to the loudspeaker output of the receiver. Connect the signal generator to the receiver aerial and set modulation and frequency. The SINAD meter is now measuring SINAD.

If you turn the signal generator up to a strong, noise free signal, if the receiver has low distortion, and if the generator and receiver agree on channel frequency, the SINAD meter indicator will swing left on the meter scale. If you remove the signal from the receiver, and set the squelch control to let the set roar, the SINAD meter will swing right of the meter. To determine the 12dB SINAD sensitivity of the receiver, adjust the signal generator output attenuator until the SINAD meter indicates 12dB. The microvolts output of the signal generator is the 12dB SINAD sensitivity of the receiver.

8B:4 Using the SINAD meter for Receiver Alignment

Set the signal generator level so the SINAD meter reads about 12dB. Then adjust the various front end adjustments to make the meter swing as far to the left as you can. If you get below the 20dB mark, reduce signal generator output to bring the meter reading back to about 12dB. Even though a receiver has been accurately aligned using the traditional limiter meter methods, this touch-up of the front end section will typically gain an improvement in sensitivity.

Set the signal generator to the 12dB SINAD meter reading, and adjust the alignment screws. If you don't leave the AFC voltage properly centered, the receiver may "rest" off to one side of the channel.

8B:5 SINAD Measurements

The term SINAD is an abbreviation of the ratio:

Signal plus Noise + Distortion : Noise plus Distortion

The signal level at which a receiver produces a 12dB SINAD ratio is referred to as the 12dB SINAD sensitivity of the receiver. In practice, a 12dB SINAD signal is a reasonably intelligible and useful signal for speech transmission.

Since a SINAD measurement gives a more meaningful measure of a receiver's useful sensitivity than is obtained by other methods. It has become the preferred method of specifying and measuring receiver sensitivity in FM receivers used in land mobile and marine services.

The exact method of measuring 12dB SINAD sensitivity is given in the Electronic Industries Association's Standard RS-204-A, which is quoted here:

A 1000 microvolt test signal from a standard input signal source with standard test modulation shall be connected to the receiver antenna input terminals. A standard output load and a distortion meter incorporating a 1000 hertz band elimination filter shall be connected to the receiver audio terminals. The receiver volume control (low level) shall be adjusted to give rated audio output. The standard input signal level shall be reduced until the SINAD is 12dB. At this value of signal input, the audio output shall be at least 50% of the rated audio output without readjustment of the volume control. If the audio output is less than 50% of rated audio output, the input signal level shall be increased until 50% of full rated audio output is obtained, and this value of input signal level shall be used in specifying sensitivity.

NOTE: A receiver with more than one volume control shall be adjusted utilizing a control preceding the audio power amplifier.

Standard RS-204-A specifies that the receiver shall be operated into a resistive load equivalent to the load into which the receiver normally operates. It also specifies standard test modulation as being 60% of the peak modulation used. (3kHz peak, for typical communications systems using 5kHz maximum peak modulation).

Since the SINAD definition includes the distortion created by the receiver's audio output stage, a precise measurement of SINAD should be made at the rated audio output. However, in typical equipment with low distortion amplifiers, a reasonably accurate SINAD measurement can be made with the audio output merely set at a comfortable listening level, using the loudspeaker of the receiver as the audio load.

8B:6 About Accuracy

For a precise determination of the rate implied by the SINAD definition, the measurement circuits of the distortion meter should measure the rms values of the composite signal, noise and distortion waves. However, almost all commercially available distortion meters are based upon average measuring, but rms calibrated, metering circuits. At the low distortion and noise percentages involved in the typical 12dB SINAD measurements, the error created by the use of average metering circuits instead of rms metering circuits is negligible. The metering circuits of the SINAD meter are average measuring in nature, to provide optimum correlation with commonly used distortion meters.

The width of the null in commercial distortion meters varies considerably from one model to another. While this will not create any discrepancy in simple distortion measurements, the width of the null will affect readings on noise measurements. Therefore perfect correlation between SINAD indications may not be obtained between different model distortion meters, although they agree perfectly on ordinary distortion measurements.

Although different model distortion meters may give slightly different SINAD readings on the same composite signal, the SINAD method of measuring receiver sensitivity is remarkably precise. This is because the 12dB SINAD performance of a typical FM receiver falls in a place on the FM improvement curve where a small percentage change in incoming signal will create a large change in SINAD reading. Thus, distortion meters differing by two or three dB in their SINAD reading will result in 12dB SINAD sensitivity measurements which correlate to better than 1dB. 12dB SINAD sensitivity measurements made with the SINAD meter will correlate within 1dB to the sensitivity measurements obtained by the use of the most popular distortion meters.

8B:7 Calibration Checks

The following procedure can be used to check the calibration of the SINAD meter:

Connect the SINAD meter input to a 2kHz audio source. The SINAD meter will read fsd and should stay there as the voltage of the audio source is varied from 10 millivolts to 4.25 volts rms. If not adjust RV1 to set the meter to the right with the input signal set at about 1 volt.

Connect the SINAD meter input to a 1kHz source. This source must be accurate to within 5Hz. Adjust the source to 1 volt rms output. The SINAD meter indicator should go to the left of the scale. If not, adjust RV2 and RV3 for minimum meter deflection.

8B:8 About the Meter Flicker

The flickering of the meter pointer is caused by the statistical nature of the noise in the receiver output. Since this flickering is a basic fact of nature, the only way to reduce it (and still make a true SINAD measurement) would be to slow down the meter response time. This response is, in fact, slowed down by C31 in the meter circuit, but further slowing would result in an unacceptable lag between an adjustment on the radio and the resulting meter indication.

When the SINAD meter is used as a receiver alignment aid, the amount of flicker can be greatly reduced by the use of an auxiliary filter circuit, connected between the loudspeaker terminals and the SINAD meter input. This filter circuit reduces the lower frequency noise components, which contribute most of the flicker. When the circuit is in use, however, the SINAD meter calibration should be considered only relative, and the circuit should be removed for any quantitative measurements.

SECTION 9

Mechanical Assembly Details

9:1 General

For all normal calibration procedures it is unnecessary to dismantle any module with the exception of VFO. All controls are accessible directly or through access holes. In the case of the VFO, the level potentiometer is adjusted by removing the VFO box lids, two screws in each.

Servicing of the Signal Generator module and Power Meter is quite possible in situ. The Counter, Modulation Meter, and PSU are best removed, an extension board is available for the five plug in boards.

The following procedures outline the easiest way of removing a given module for service.

9:2 Signal Generator (To follow)

9:3 Modulation Meter

Remove both cover fixing screws and slide out covers, then remove the power supply (see 9:6). Remove the side M3 fixing screw and the two M3 pan head screws adjacent to the BNC sockets (Viewed from rear). Disconnect all co-axial links to the Modulation Meter box.

Slide the box forward and up. Remove the six box lid screws and extract the PCB, fixed to the lid, on its umbilical cord.

Replace the empty box and reconnect the solid co-axial links. The Modulation Meter may now be tested outside its box.

9:4 Counter

Remove both cover fixing screws and slide out covers, then remove the top extrusion, eight M3 pan head screws and two M4 countersunk head screws.

Remove the six Counter box lid screws and taking care not to foul the displays on the inside lip remove the counter PCB, fixed to the lid, on its umbilical cord.

The Counter may now be serviced outside the box.

9:5 Power Supply

A service loop is provided so that it is unnecessary to disconnect the PSU from the system wiring if test under load are required.

Remove the six fixing screws on the back panel.

Unscrew mains switch push rod and remove module through back panel.

SECTION 9B

APPENDIX 1

Residual FM Measurement

Connect the RX SIGNAL high level output to the manual modulation meter and the AF output of the manual modulation meter to the AF/SINAD input.

Select FM 5kHz on Signal Generator. Tune mod meter in SET FS position for peak meter reading. Set mod meter to FM 5kHz and adjust signal generator for 4kHz deviation at 1kHz.

Note the AF level meter reading in dB. Remove the modulation and set the mod meter to narrow band. Increase the sensitivity of the AF level meter until a reading greater than -10dB is obtained. Calculate the increase in gain from the initial reading. (two switch positions = 20dB) and check the residual FM according to table 1.

TABLE 1

Increase from initial reading in dB	Residual FM
0	4kHz
10	1.2kHz
20	400Hz
30	120
31	108
32	96
33	83
34	76
35	67
36	60
37	53
38	48
39	43
40	40Hz
41	34
42	32
43	28
44	25
45	22
46	20
47	18
48	16
49	14
50	12Hz

Residual AM measurement

Connect up equipment as before.

Select AM 50% and adjust signal generator for 33% AM at 1kHz.

Note the AF Level Meter reading in dB. Remove the modulation and increase the sensitivity of the AF Level Meter until a reading greater than -10dB is obtained. Calculate the increase in gain from the initial and add 10dB to reference the reading to 100% depth.

APPENDIX 2

Frequency response of 40dB pad

If a power meter, spectrum analyser or RF millivoltmeter of known flatness is not available the following procedure may be used to reduce the errors of measurement.

Remove the EXTERNAL LINK between the power meter BNC sockets. Connect the measuring instrument to RX SIGNAL socket and set 40dB attenuation on RX LEVEL.

Select 65MHz. Select a suitable amount of attenuation for the measuring instrument used. Attempt to keep AF LEVEL meter on scale.

Transfer measuring instrument to RADIOTELEPHONE type 'N' socket and replace link. Remove 40dB attenuation and adjust 1dB attenuator for reference point. Add or subtract 1dB from 40dB to give attenuation at that frequency.

Continue at frequencies up to 510MHz. This technique relies solely on the flatness of the system attenuator which is quoted as $\pm 0.5\text{dB}$.

APPENDIX 3

Wattmeter Frequency Response and Calibration

Frequency response

Select RANGE 10W and adjust ZERO as necessary. Connect 1000uF, 10V working capacitor between D1 anode and OV, +ve terminal to OV. Measure DC resistance of load with DMM and apply AC variac according to table 1 below.

TABLE 1

Resistance of Load in ohms	Voltage
48.00	21.91
48.50	22.01
49.00	22.15
49.50	22.26
50.00	22.35
50.50	22.46
51.00	22.59
51.50	22.70
52.00	22.80

Adjust R10 for 10W reading. Remove 1000uF capacitor and variac. Connect RF power source and thru-line watt meter to type 'N' socket. Set 50MHz and adjust power source for 10W according to calibration. Note reading of Power Meter.

Take reading at 100, 150, 200, 250, 300, 350, 400, 450 and 500MHz. Above 200MHz it is usual for power meter to read high. Adjust power source for FSD on Power Meter and calculate the % reduction in power source output, this is the % error high of the Power Meter.

Calculate the % error of each step and check if these are within the specification +/-5% up to 200MHz, +/-10% above 200MHz.

It is likely that 500MHz will be too high. If so check with table 2 and solder a correction capacitor between D1 cathode and OV. Re-check readings at 200, 400 and 500 MHz.

If an excessive dip appears at 400MHz select the next preferred value up and add a 10ohm series resistor to it. Solder this combination in place of a single capacitor.

TABLE 2

%high	5%	10%	15%	20%
Capacitor	1.1pF	2.2pF	3.9pF	5pF

Capacitors to be ceramic or silver mica type and the leads must be kept as short as possible.

Calibration

When the frequency response has been optimised decide if any advantage may be gained in shifting the calibration to straddle the error about 0%.

Calculate the % error at 200MHz. Set the power source to 200MHz and adjust the output for 1W. Adjust R8 for 1W reading +/- error at 200MHz. Repeat with 3, 10, 30, 100, and 300W ranges.

Set 10W reading on Power Meter on 30W range. Select 10W range and check for 10W reading. Set 3W and repeat with 3W range. Finally set 1W and repeat to check range to range accuracy.

APPENDIX 4AM • FM Calibration with Spectrum Analyser

Due to the high dynamic range of modern spectrum analysers it is possible to resolve carrier side bands down to a very low level. This gives the opportunity to set AM and FM depths by side band measurements and 'Bessel Zero' methods to very small depths of modulation.

AM Calibration

Connect the RF output of the Signal Generator to the spectrum analyser input. Select 100 MHz. Adjust spectrum analyser for 1kHz per division dispersion

Switch to AM and set 3kHz modulation frequency. Adjust the AM depth for side bands 12dB down on carrier. Adjust Modulation Meter RV92 for 50% reading.

FM Calibration

Connect the spectrum analyser as before and adjust spectrum analyser for 5kHz per division dispersion.

Switch to FM and set modulation frequency to 2.8kHz and increase modulation depth until carrier is seen to disappear.

Adjust modulation meter RV25 for 5kHz deviation on 5kHz range.

APPENDIX 5

dB to uV conversion chart

Attenuator setting dB	Output from RX SIGNAL BNC uV	Output from RADIO TELEPHONE Type N. uV
0	50,000	500.00
1	44,560	445.60
2	39,720	397.20
3	35,400	354.00
4	31,550	315.50
5	28,120	281.20
6	25,060	250.60
7	22,330	223.30
8	19,910	199.10
9	17,740	177.40
10	15,810	158.10
11	14,090	140.90
12	12,560	125.60
13	11,190	111.90
14	9,976	99.76
15	8,892	88.92
16	7,924	79.24
17	7,063	70.63
18	6,295	62.95
19	5,610	56.10
20	5,000	50.00
21	4,456	44.56
22	3,972	39.72
23	3,540	35.40
24	3,155	31.55
25	2,812	28.12
26	2,506	25.06
27	2,233	22.33
28	1,991	19.91
29	1,774	17.74
30	1,581	15.81
31	1,409	14.09
32	1,256	12.56
33	1,119	11.19
34	997.6	9.98
35	889.2	8.89
36	792.4	7.92
37	706.3	7.06
38	629.5	6.29
39	561.0	5.61
40	500.0	5.00
41	445.6	4.46
42	397.2	3.97
43	354.0	3.54
44	315.5	3.15
45	281.2	2.81
46	250.6	2.51
47	223.3	2.23
48	199.1	1.99
49	177.4	1.77
50	158.1	1.58
51	140.9	1.41
52	125.6	1.26
53	111.9	1.12

54	99.76	1.00
55	88.92	0.89
56	79.24	0.79
57	70.63	0.71
58	62.95	0.63
59	56.10	0.56
60	50.00	0.50
61	44.56	0.45
62	39.72	0.40
63	35.40	0.35
64	31.55	0.31
65	28.12	0.28
66	26.06	0.25
67	22.33	0.22
68	19.91	0.20
69	17.74	0.18

Selcall Operation

The selcall facility on the 282A though simple to use requires some explanation.

By operating the +/- buttons on the selector switches it will become apparent that the various positions are 0-9 and A-F.

0-9 and A-F correspond to various audio tones (see tone table) and F is a no-tone position. Character E is used where successive digits are identical and replaces the second digit. Therefore if E is selected it is sent as a repeat of the previous digit. Data selected 128E8 is sent as 128E8 and displayed 12888. Character A is known as "Group"

A small modification is available for auto repeat such that when 12888 is selected it will be sent as 128E8

Tone Table

	CCIR/EEM	ZVE1
0	1981	2400
1	1124	1060
2	1197	1160
3	1275	1270
4	1358	1400
5	1446	1530
6	1540	1670
7	1640	1830
8	1747	2000
9	1860	2200
A	2400/1055	2800 "Group"
B	930	810
C	2247	970
D	991	886
E	2110	2600 Repeat
F	No tone	No tone

The display will automatically give a read out of any selcall sent either from the test set or from an external transmitter. To transmit a selcall sequence press the TX button and hold it in until the display illuminates. Press the CLEAR button to reset the displayed digits. To use the selcall on revert/answerback it is simply a matter of sending the selcall from the test set in the usual way and as soon as the display lights clear it in order that the reverted selcall can be displayed.