Chapter 5
TECHNICAL DESCRIPTION

Contents

List of figures

Overview

This simple description is provided to give the user an insight into the working of the instrument at the block diagram level. Block diagram Fig. 5-2. Simplified block diagram, will help to follow the description.

The power supply and display unit are described first. The functional circuit blocks of each test mode are then described in sequence.

The instrument is of modular construction comprising of at least 15 printed circuit boards, (depending on options included), housed in two sub-assemblies, along with attenuators, power supply unit, front panel, rear panel and display unit modules. The instrument is microprocessor controlled and is software driven.

Power supply

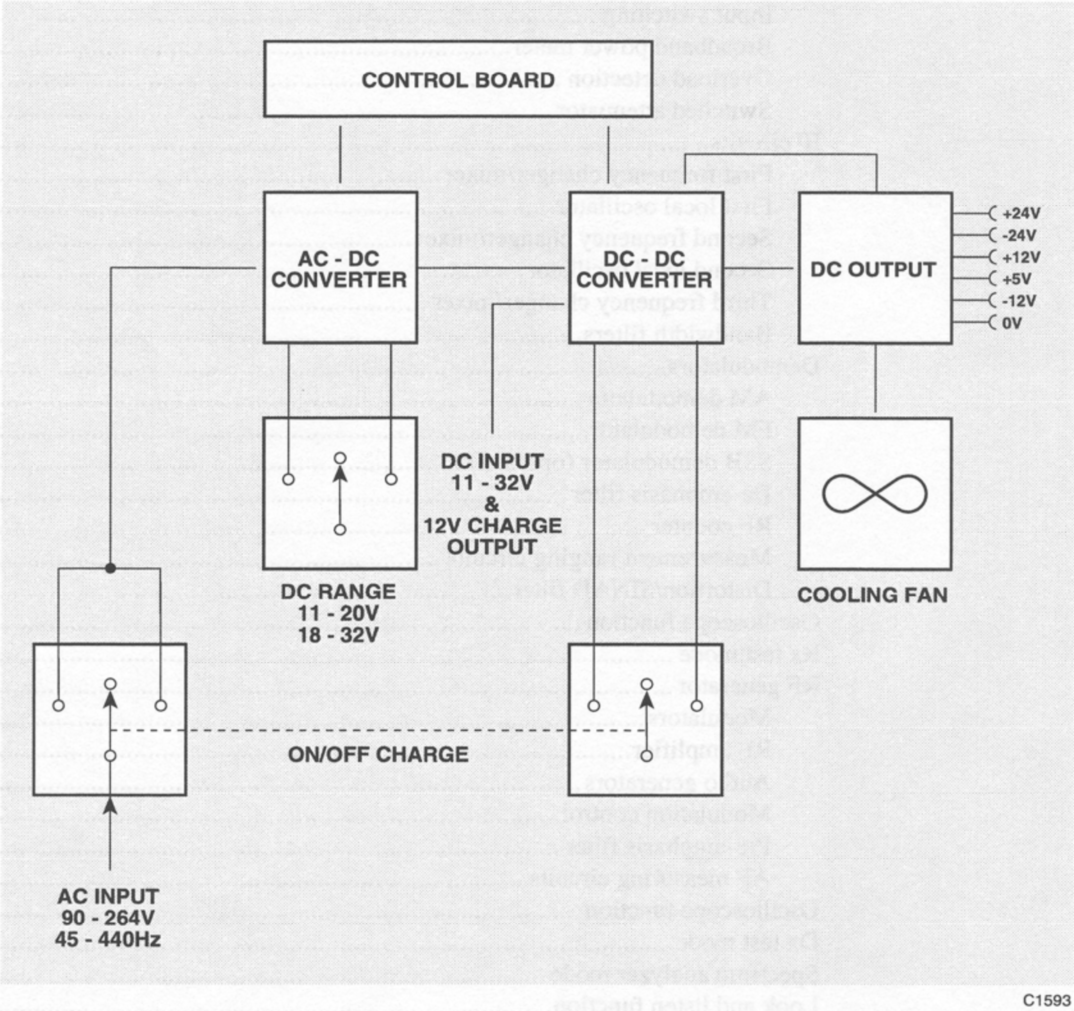

Fig. 5-1 Block diagram of power supply module

The power supply module is a switched mode design which operates from both an AC supply of 94 to 264 V, 45 Hz to 440 Hz. or a DC supply of 11 to 32 V.

The circuits of the instrument require supplies of:

+5 V	3.0 A
+12 V	2.5 A
-12 V	1.2 A
36 V	100 mA output

An additional requirement is for a charging facility to provide a trickle charge to the DC supply when the instrument is working from the AC supply and a recharge facility from the AC supply when the instrument is not operating.

The AC supply enters the instrument through a connector on the rear panel and passes through a fuse and two poles of a triple pole, double throw switch. This switch selects the operate condition, the charge condition or off. The supply then enters the power supply module where it is fed to a bridge rectifier in the AC-DC converter to produce an unregulated DC supply. The voltage of this will depend on the supply voltage as the full range of AC input voltage is covered without range switching.

The second stage of the AC-DC converter produces semi-regulated DC supplies of 12 V or 24 V using a 60 kHz switched mode oscillator and transformer coupling. This transformer also provides the safety isolation barrier.

The DC external or the DC supply from the AC-DC converter is used to drive the DC-DC converter.

The DC output circuits producing the four output supplies are each fed from an individual winding on the DC-DC converter output transformer.

Regulation is applied to the DC-DC converter from the output current and voltage sensing circuits.

The charging supply circuits are contained within the DC-DC converter.

Current monitoring to provide regulation is obtained from the three common-return supplies and voltage monitoring from the +5 V supply.

The 36 V is generated by adding a 24 V floating supply onto the +12 V supply rail.

The floating 24 V supply has a voltage regulator configured within it.

A control circuit PCB contains the components for frequency control and regulation of both converters.

The third pole of the power on-off and charge switch is connected to the DC-DC converter circuits through plug and sockets. The DC voltage range selector switch, fitted to the rear panel, is similarly connected.

In the 'charge' position the DC-DC converter is turned off, allowing the full output of the AC-DC converter to be available for charging a 12 V lead-acid battery.

The display

The display device is a module containing:- a liquid crystal display with an active viewing area 156 mm X 78 mm; a logic board which processes data from the microprocessor to assemble the display information; and a backlighting system to provide illumination for the viewing area.

The viewing area is composed of a 400 X 200 dot matrix with a white background which turns blue where activated. The logic within the display assembly, using latches and shift registers, addresses the 80,000 pixels of the display from 3 control lines and 4 data lines.

The display contrast is dependent on the voltage supplied to the liquid crystal display matrix. This AC voltage is derived within the module from a DC voltage supplied from the microprocessor board B2. It is an infinitely variable voltage fed from a digital to analogue converter, allowing the contrast to be set for optimum viewing.

Illumination for the display is provided by a cold cathode fluorescent tube built into the display module. The supply for the backlight is from three op-amps located on the microprocessor board B2. The op-amps are gated by the microprocessor through a latch to provide four levels of brightness and an off condition.

The DC supply is fed to a CCFT invertor which provides the control voltages for the tube.

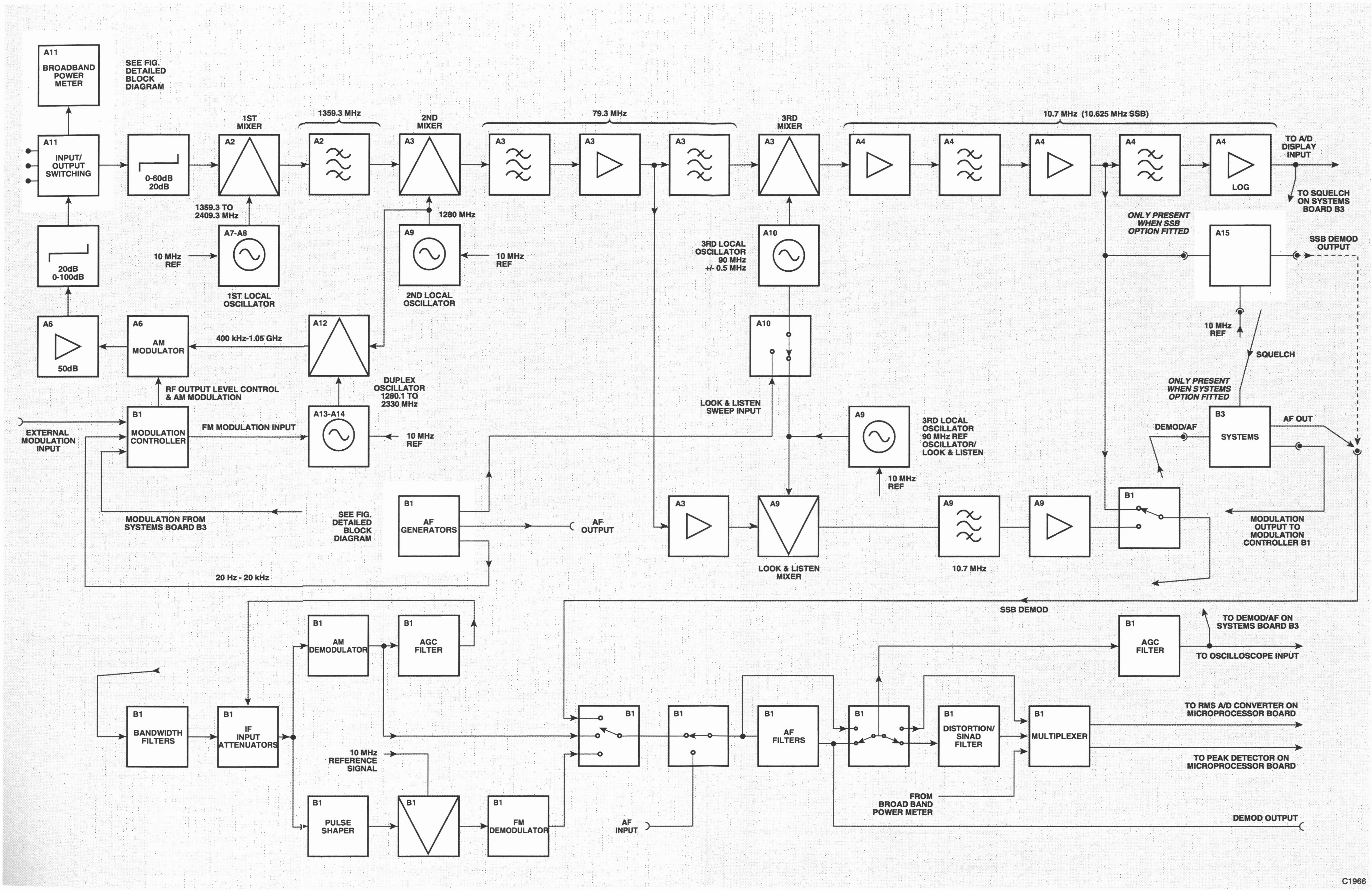

Fig. 5-2 Simplified block diagram

Tx test mode

When operating in the Tx test mode the 2945 monitor has to provide a source of modulation for the transmitter being tested and also analyse the RF output signal from the transmitter.

Modulation sources

The modulating signal is provided by one or both of the audio generators or the data generator and is taken from the AF output connector on the front panel.

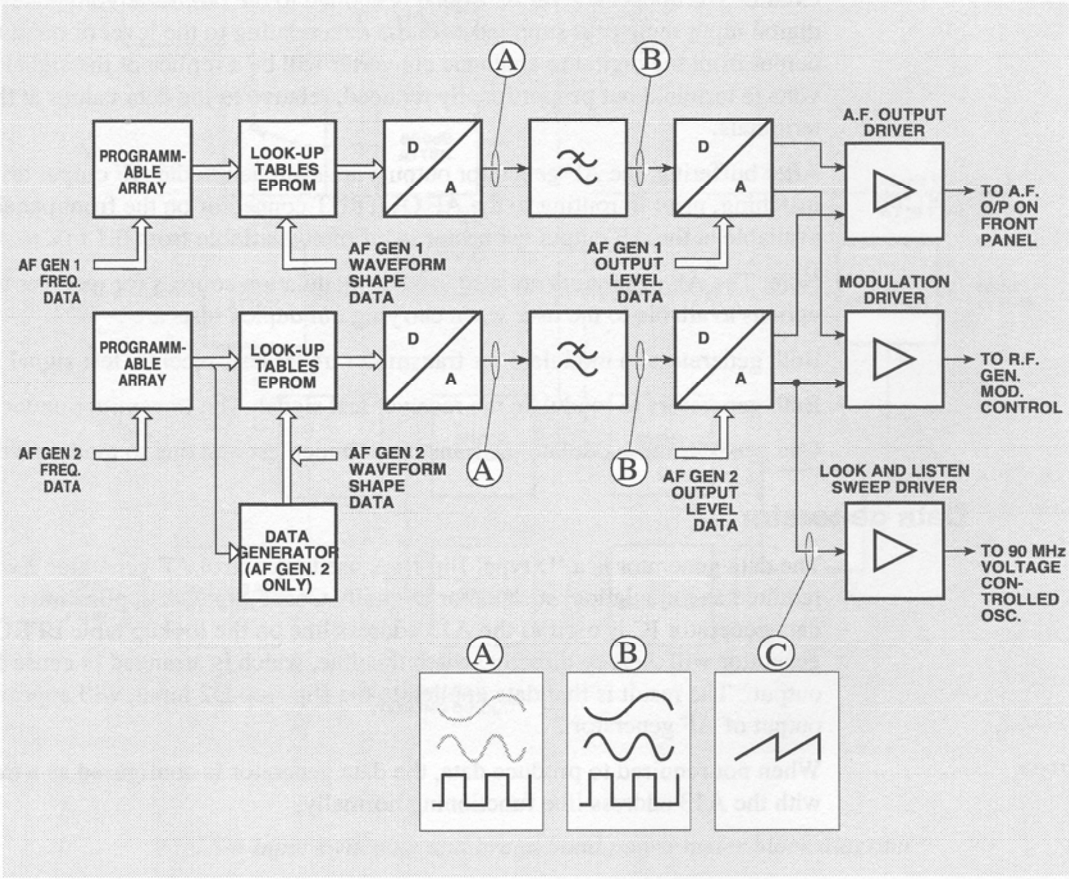

Fig. 5-3 AF generator detail block diagram

Audio generators

Included in the monitor are two audio generators, shown as 'AF generators' on the simplified block diagram. They are used as modulation sources for the Tx, Rx and Dx test modes and as audio test signal generators in the AF TEST mode. A detailed block diagram is given in Fig. 5-3 AF Generator detail block diagram. The generators have a frequency range of 20 Hz to 20 kHz. The output waveform, of either generator, is independently switchable between sinewave or squarewave. Both generators are of similar design, but there are slight departures from exact duplication. The generator designated 'GEN 2' is also used for other functions which do not conflict with its functions as an audio generator. These uses will be mentioned where relevant.

Each of the circuits function in the following manner:-

Instruction as to the frequency of the required signal is latched into a programmable array device, which generates a repetitive digital output sequence recurring at the required frequency. The digital output from the programmable array is transferred as a stream of 13 bit parallel data into an EPROM. This holds look-up tables containing shape details of sinewave and squarewave signals. Output from the EPROM is as 8 bit parallel information corresponding to the selected shape and at the repetition frequency instructed by the information latched into the programmable array device.

The EPROM output is applied to a digital to analogue converter which, by converting each digital value to the corresponding analogue level, produces the required signal. The mean output level from the digital to analogue converter is constant. The analogue output is filtered by a 50 kHz low pass active filter, to remove any spikes created by the digital generation process. The output from the filter has a peak to peak level of 5.7 V.

Output level is controlled by a digital to analogue converter, configured as a digital level control circuit. The constant level AF signal is applied to the reference voltage level input, while the digital input register is supplied with the data relating to the level of output signal required. The output from the digital to analogue converter will be a replica of the signal at the reference voltage terminal but proportionally reduced, relative to the data values at the digital input terminals.

After buffering, the AF generator outputs are switched to the AF output drivers for impedance matching, prior to routing to the AF OUTPUT connector on the front panel. The output level available at the AF output connector is infinitely variable from 0.1 mV to 4.0 V RMS.

Note; The AF generators are also used as modulation sources for receiver testing. Therefore the options available to the user when carrying out duplex tests are :-

Both generators to modulate the transmitter under test, receiver test signal not modulated.

Both generators to modulate the receiver test signal, The transmitter under test not modulated.

One generator to modulate the transmitter under test and one to modulate the receiver test signal.

Data generator

The data generator is a 'D type' flip-flop, used to control AF generator 2 when pulsed tones are required as modulation, such as for Digitally Coded Squelch applications. The Q1 output of the data generator IC is used as the A13 address line on the lookup table EPROM. The data generator will thereby directly switch this line, which is arranged to cause full output or no output. The result is that data applied to the flip-flop D2 input, will appear as tone pulses at the output of AF generator 2.

When not required to produce data, the data generator is configured as a transparent flip-flop, with the A13 address line functioning normally.

Receiver circuits

Input switching

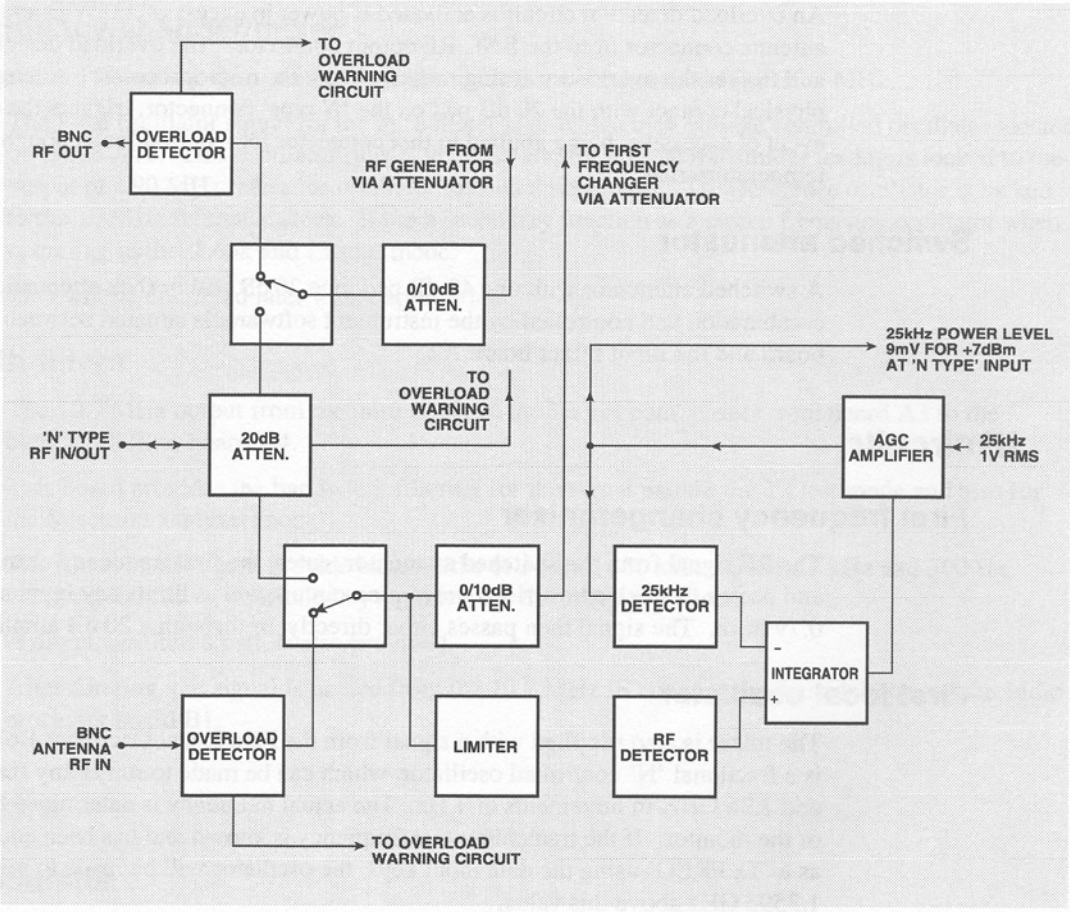

Fig. 5-4 Input switching and broad band power meter block diagram

The RF signal from the transmitter enters the monitor at either the BNC antenna input or the 'N Type' connector on the input/output switching board. A detailed block diagram of the input switching board is shown in Fig. 5-4 Input switching and broad band power meter block diagram.

The 'N type' connector, which is also used as an output for receiver testing, has a 20dB power attenuator, 20dB between it and the input/output switching circuits.

The RF signal, from the transmitter under test, can be within the frequency range of 100 kHz to 1.05 GHz. A 10 dB attenuator pad can be switched into the transmitter test RF path by the instrument software.

Broadband power meter

A proportion of the signal is fed directly to the broadband power meter circuits. The RF signal is passed through a diode detector and the resultant DC signal integrated with a similar signal derived from a 25 kHz signal from board B2. As the integration is carried out using the inverting and non-inverting inputs of an operational amplifier, a stable condition will result when the two inputs are of the same value.

The output from the integrator is used as a control signal for an AGC amplifier acting on the 25 kHz signal, with the output from the AGC amplifier supplying the integrator. The loop will therefore remain stable with the AGC amplifier output voltage exactly equalling the voltage of the

RF input to the detector. This voltage is taken to the voltmeter ranging circuits on the AF Analyzer Board B1 and then to the AF voltmeter circuit on the microprocessor board.

Overload detection

An overload detection circuit is activated if power in excess of 1.0 W is applied to the BNC antenna connector or to the BNC RF output connector. The overload detect lines are activated and trigger the overload warning message from the microprocessor. A temperature sensor, in physical contact with the 20 dB pad on the 'N type' connector, triggers the overload circuit in the event of excessive being applied to that connector for a period long enough to cause an excessive temperature rise

Switched attenuator

A switched attenuator with one 40 dB pad, one 20 dB pad or 0 db attenuation, selectable in any combination and controlled by the instrument software, is situated between the input switching board and the input mixer board A2.

IF circuits

First frequency changer/mixer

The RF signal from the switched attenuator, enters the first frequency changer/mixer board A2 and passes through an overload prevention circuit, which limits any input signal to approximately 0.7v peak. The signal then passes either directly, or through a 20 dB amplifier, to the 1st mixer.

First local oscillator

The mixer is also supplied with a signal from the First Local Oscillator Board A8. This oscillator is a fractional 'N' controlled oscillator, which can be made to run at any frequency between 1.36 and 2.36 GHz, in increments of 1 Hz. The actual frequency is determined by the control system of the monitor. If the transmitter test frequency is known and has been entered into the monitor as a 'Tx FREQ' using the data input keys, the oscillator will be made to run at a frequency 1.3593 GHz above this value.

By mixing this signal with that from the input circuits, the output from the mixer will contain a signal of 1.3593 GHz.

Where the required frequency of the monitor receiver circuits is to be established by the 'Auto Tune' function, the variable oscillator is made to sweep through its operating range by the instruments software. When a signal is detected at the demodulators, the sweep rate is slowed and locked.

Filtering in the mixer output removes the upper frequency components of mixing process

Second frequency changer/mixer

The signal from the first mixer is further reduced in frequency by a second frequency changing mixer which has an output of 79.3 MHz. This is on board A3. The signal arriving at board A3 is first passed through a 1.3593 GHz bandpass filter and is then applied to the input of the second mixer.

Second local oscillator

The local oscillator signal for the second mixer has a frequency of 1.280 GHz and is generated on board A9. This oscillator is a phase locked loop device, locked to the instruments 10 MHz reference oscillator.

The output from the second mixer is passed through a 79.3 MHz bandpass filter, to remove the unwanted products of the mixing process, before being given 20 dB amplification.

The 79.3 MHz IF signal is split and fed to two independent mixers. The secondary feed supplies the spectrum analyzer 'Look & Listen' 3rd mixer which is described later. The primary path is through a band pass filter with 5 MHz bandwidth to the main 3rd mixer, also on board A3, for the Tx test circuits.

Third frequency changer/mixer

A third frequency change is made to the signal to achieve a final IF of 10.7 MHz.

The local oscillator signal for the third mixer is provided by a voltage controlled oscillator located on board A10. This oscillator runs at 90 MHz and for normal transmitter testing is locked to the output of a 90 MHz reference oscillator located on board A9. This reference oscillator is locked to the 10 MHz reference clock. It has a secondary function as a sweep frequency oscillator when operating in the 'Look and Listen' mode.

This will be described later where appropriate.

Bandwidth filters

The 10.7 MHz output from the third mixer in the Tx test path, passes from board A3 to the bandwidth filter board A4.

This board provides the bandwidth filtering for the signal path in the Tx test mode and also for the Spectrum analyzer mode.

The filters on the board provide bandwidths of 3 MHz, 300 kHz, 30 kHz, 3 kHz and 300 Hz, using crystal filters, controlled by signals from the micro processor.

A direct, unfiltered path is also provided.

After filtering, the signal is passed from the 10.7 MHz IF board to the demodulators on the audio processor board B1.

Demodulators

AM demodulator

The demodulators are located on the audio processor board B1. The 10.7 MHz IF from the bandwidth filter board, is fed to a phase splitter circuit which provides anti-phase outputs for the AM demodulator. The outputs from the phase splitter are taken to the positive and negative inputs of the balanced demodulator. The demodulator is also fed with balanced unmodulated inputs, obtained from the modulated 10.7 MHz signal, by way of a phase-splitting limiter.

The demodulator produces a balanced output equal to the difference between the two input signals. This will have an AF component equalling the modulation signal and a DC component relating to the level of the IF signal. The modulation is fed to the AF switching circuits while the DC component is used for automatic gain control.

FM demodulator

FM demodulation is performed by a pulse width discriminator operating at 700 kHz. The signal for this is obtained by mixing the 10.7 MHz output from the limited signal fed to the AM demodulator, with the 10.0 MHz reference frequency and passing the resultant signal through a low-pass filter.

The 700 kHz signal containing the FM information is fed into a both halves of a dual monostable flip-flop. By putting this signal to A1 and B2 inputs, the Q- outputs from the monostables will be anti-phase. By summing the two output signals the resultant signal will be a true representation of the modulation.

SSB demodulator (optional)

The single sideband demodulator circuits are all contained on printed circuit board A15.

When the SSB demodulation function is selected the first local oscillator of the 2945 is set to a frequency which will produce a final IF of 10.625 MHz (from an input frequency equal to the carrier frequency) rather than the 10.7 MHz IF produced for all other modes. The IF signal for the SSB board is obtained from the third mixer on A3, through a 10.7 MHz low pass filter on A4.

It is applied to a variable gain circuit which is used to control the input level for the SSB demodulator circuits.

After leaving the gain control circuit the signal is then mixed in a double balanced mixer with a 10 MHz signal from the instrument reference oscillator. The output from the mixer will contain a 625 kHz component. This is passed through a 625 kHz low pass filter, to one input of another double balanced mixer. The second input is fed with a reference signal of 625 kHz derived from the 10 MHz reference through a 'divide by 16' circuit. The output from the double balanced mixer will be zero when no modulation is present on the input signal. When modulation is applied, the output signal will equal the difference in frequency between the original carrier frequency and the original sideband frequency. Either an upper sideband signal or lower sideband signal will produce an output. This will equal the frequency of the applied modulation. The demodulated signal is fed to the input of the audio routing circuits.

De-emphasis filter

The output from the discriminator passes through a 163 kHz low-pass filter and then the 750 µs de-emphasis filter before being routed by the demodulation selection switches. The de-emphasis filter can be by-passed as part of the test set-up.

RF counter

A sample of the 10.7 MHz IF signal is taken from one output of the phase splitter/limiter and supplied to the IF counter circuit also located on board B1.

This counter measures the mean frequency of the IF signal and the result is written into memory. By making a calculation using the reading from the RF counter and the division ratios from the three local oscillator control loops, the instrument software can establish the mean frequency of the transmitter output.

Measurement ranging circuits

The evaluation of RF level, modulation depth, modulation deviation, distorted levels etc. are all made using a metering circuit on the microprocessor board B1. Before the various levels can be measured, each must be conditioned so as to bring the minimum and maximum levels of each parameter within the range of the metering circuit. The signals to be measured are all brought to the analyzer ranging circuits on the audio processor board B1. Signals relating to RF power input to the instrument and power readings from an auxiliary powerhead are passed through various switched gain amplifiers before leaving the board to be measured.

Measurements to the demodulated AF signals are made after filtering to the selected AF filter passband. The AF filters are located on the audio processor board and offer the choice of 300 Hz-3.4 kHz bandpass; 15 kHz lowpass; 300 Hz lowpass and the full bandwidth of 50 kHz. The selected filters are switched into the AF circuit before the ranging amplifiers.

Distortion/SINAD filter

The 1.0 kHz active notch filter, used to make distortion percentage and SINAD measurements, is also on the audio processor board. This filter is switched into circuit to make the above mentioned measurements as a comparison to the unfiltered path.

Oscilloscope function

The oscilloscope function when used within the Tx test mode displays the waveform of the demodulated signal. The signal for this is taken from the AF filter output and after passing through level converting amplifier circuits is fed to an analogue to digital converter located on the microprocessor board B2. The digital levels relating to the waveform are written into a digital signal processor which generates the oscilloscope display. The values are incorporated into the display and updated continually.

Rx test mode

The receiver test mode requires an RF signal, modulated to precise limits, to be fed to the receiver. The AF signal, produced by the demodulator within the receiver, is analysed to produce results of the test.

Implementation of the Rx test mode does not disable the functions of the Tx test mode. The receiver circuits remain active at their last settings. The AF generators will also continue operating at their last settings unless either is enabled as a modulation generator. Calling up one modulation generator will allow the other to function as an AF generator for Tx testing, but using both as modulation sources will remove both from Tx test use.

RF generator

The RF signal is produced within the monitor by a Fractional N controlled oscillator with a range of 1,280.1 MHz to 2,280.0 MHz. This is located on Local Oscillator Board A13. The oscillator and its control system is of a complex design in order to meet strict requirements of frequency stability, low phase noise and very fast settling after a change of frequency. The output from this oscillator is fed to the duplex mixer board A12 where it is combined with a signal taken from the output of the 'Second Local Oscillator' on board A9.

The mixer output is filtered by a 1050 MHz low pass filter to remove all frequencies, other than the difference frequency of the two mixer input signals, before passing to the output amplifier board A6.

Modulators

The receiver test signal can be either amplitude modulated or frequency modulated.

The selected modulation signal, from either or both of the AF generators, from the data generator or from an external source, is conditioned and level corrected within the modulation control circuits on the Audio Processor board B1.

Frequency modulation is applied by injection into the fractional N control loop, thereby influencing the generated frequency. When the signal is FM modulated, the AM modulator is held in a 0% modulation state.

AM modulation is applied to the signal using a pin diode modulator, located within the output amplifier circuits on A6. The output level of the receiver test signal is also controlled using the pin diode modulator.

The signal controlling the attenuation level of the pin diode modulator, is a composite signal containing the amplitude modulation component obtained from the modulation source and a DC component representing the required output level.

They are combined into one modulation signal using a digital to analogue converter on the audio processor board B1

RF amplifier

The signal level from the AM modulator is increased by 50 dB by a three stage RF amplifier before passing through the output control attenuator to the RF switching unit and the RF output sockets.

Audio generators

The audio generators on the audio processor board B1 are used to provide AF Modulation to the RF test signal generated on the duplex local oscillator board A13. The operation of the generators is as described for the Tx TEST mode but rather than the output level being called up as an output voltage, this is specified as a modulation level. The necessary calculations are performed by the instrument software.

The DATA GENERATOR facility is available in the Rx TEST mode.

Modulation control

The output from each generator is taken through selector switches to a summing amplifier at the input to the modulation control circuits. The signal from an external modulation source or from the modulation options circuits are also summed in at this point. An external modulation source can be connected to the EXTERNAL MOD IN connector on the rear panel and is passed through a level control circuit of the same type as that in the AF generator circuit, incorporating a digital to analogue converter, with the signal input to the voltage reference point and the level set by the value on the digital input.

The summed modulation signal is taken through a modulation correction level control circuit before being routed to either the FM attenuator digital to analogue converter or to the RF level digital to analogue converter. This device provides fine level control of the RF signal by applying a DC level to the AM modulator as described earlier.

Pre-emphasis filter

A 750 μs pre-emphasis filter is included on the Audio Processor board and is switched into the FM modulation path when selected as part of the Rx TEST set-up.

AF measuring circuits

Measurements are made to the AF signal demodulated within the receiver under test, taken from its AF output circuits and fed into the AF INPUT connector of the 2945. The input signal is directly fed to the audio processor board B1 and applied to a switched ÷2/÷20 circuit before being routed in through two paths, one to the AF filtering and measuring path used by the demodulated signals in the TX test mode, the other to the oscilloscope input circuits, again as used for the Tx TEST mode.

Oscilloscope function

The oscilloscope function when used within the Rx TEST mode, displays the AF input signal. The signal is routed as described above and is passed through a sensitivity control circuit for scope calibration before following the same path as used in the Tx Test mode. The display is calibrated to indicate the voltage as present at the AF input connector.

Dx test mode

The Dx test mode uses all the circuit elements described in the proceeding sections and the technical description is valid for all three modes. The display presentation allows parameters applicable to transmitter testing and receiver testing to be seen simultaneously.

Spectrum analyzer mode

Data to be presented as the active trace on the spectrum analyzer display is obtained through the following circuits:-

The input frequency of the 2945 is made to sweep through the frequency range selected on the display by sweeping the first local oscillator, located on board A7. Any signals which fall within the sweep range will pass through the IF circuits of the 2945.

The output from the third mixer is amplified and filtered on board A4 and fed to a logarithmic amplifier. Within this amplifier the 10.7 MHz signal is detected to produce a DC signal with a level relative to the level of the RF signal input. The DC voltage is digitised by an analogue to digital converter on the Microprocessor board B2. The digital value obtained is stored in RAM at a memory location which is related to the sweep position and to the value.

Each time the display is refreshed, the contents of each display location address will provide the latest data, thus updating the display. The refresh rate is approx. 11 per second.

Look and listen function

When the look and listen function of spectrum analyzer mode is selected, the operation is modified. In order to demodulate the centre frequency of the span, the signal fed to the demodulator must be obtained from a fixed frequency point. As the frequency span in the look and listen function is limited to 2 MHz, the frequency sweep can be applied at the third mixer stage. A ramp voltage is generated within AF generator 2 on the AF board B1 and applied to the 90 MHz voltage controlled oscillator on board A10. The 10.7 MHz IF signal will thus have swept over the selected range to produce a 'Frequency/Signal Level' display.

The signal fed to the modulator meter is obtained from the 'Look and Listen' third mixer located on the second and third local oscillator board A9. The demodulated AM or FM signal is amplified to provide a low impedance output which is fed to the loudspeaker and to the audio output connection on the accessory socket.

A 90 MHz reference oscillator on board A9 provides the local oscillator signal for this mixer and also provides a 90 MHz reference for the voltage controlled 90 MHz swept oscillator on A10.

AF test mode

The AF test mode requires a signal source to apply to the circuit or equipment under test and a measuring facility to analyse the resultant output signal.

The signal source is provided by the audio generators as for Tx testing and the AF measuring circuits configured as for receiver testing. The RF generator and IF local oscillators are disabled. The power metering and modulation metering functions are also disabled.

Systems mode

The systems mode of the 2945 allows the instrument to test communications equipment which is designed for operation on dedicated systems such as cellular mobile radio telephone systems and trunking radio telephone systems. Automatic testing is performed using various test programs. These can be made to check all functions of the system, the signalling only or any intermediate choice of functions, depending on the user's requirements.

The data processing needed to carry out these tests is handled on board B3 by a 68000 microprocessor and three Digital Signal Processors (DSPs).

The board has 1 M byte of EPROM which contains the cellular systems software and the built-in test sequences.

The user defined sequences and user set-ups are held in 256 k byte of NOVRAM.

One of the DSPs generates the signals required to simulate the system signals, the other two handle the signals received from the mobile.

A gate array is used for communication between the 68000 microprocessor and the DSPs.

Interfacing between the digital circuits of the B3 board and analogue circuits of the 2945 is handled by a dual 18-bit digital to analogue converter for the test set to mobile signals and by a 12-bit analogue to digital converter for signals from the mobile.

Appendix A
DIRECTIONAL POWER HEADS

Contents

List of tables

List of figures

Precautions

WARNING **CAUTION** **Note**

These terms have specific meanings in this manual:

WARNING information to prevent personal injury.

CAUTION information to prevent damage to the equipment.

Note important general information.

Hazard symbols

The meaning of hazard symbols appearing on the equipment is as follows:

Symbol	Nature of hazard	Reference in manual
	Static sensitive component	Page App. A-2

Operating precautions

This product has been designed and tested in accordance with IEC Publication 348 - 'Safety Requirements for Electronic Measuring Apparatus'. To keep it in a safe condition and avoid risk of injury, the precautions detailed in the WARNINGS below should be observed. To avoid damage to the equipment the precautions detailed in the CAUTIONS should also be observed.

WARNING

RF and standing wave hazards

Under certain operational conditions using the Directional Power Head accessory, high RF potentials may exist and contact with them could result in shock and burns. The power head should NEVER be used with the covers removed; if removal of the covers is necessary, the power head must first be disconnected from any source of RF power. Failure to correctly terminate the RF line under test will cause standing waves to be set up and hazardous voltages may be present.

WARNING

Other hazards

Parts of the Directional Power Head accessory are made from metal pressings, therefore it should be handled with due care to avoid the risk of cuts or scratches.

Some of the components used in this equipment may include resins and other materials which give off toxic fumes if incinerated. Take appropriate precautions, therefore, in the disposal of these items.

CAUTION

Static sensitive components

This equipment contains static sensitive components which may be damaged by handling - refer to the Service Manual for handling precautions.

Features

This accessory for MI instruments is used to measure forward power, reverse power and VSWR in coaxial RF transmission lines and antenna systems. There are two versions as follows:-

Frequency range	Part no.
1 to 50 MHz (HF)	54421-002L
25 to 1000 MHz (UHF)	54421-003J

There are no controls fitted to the Directional Power Head. There are RF line input and output connectors and a DIN socket for the lead to the test set. Various Lead Assemblies are supplied for connecting to the relevant test set. A 1 m Lead Assembly is available as an optional accessory. As the Directional Power Head is bi-directional, it can be connected either way round in the RF line.

The Directional Power Head is able to measure CW power or give an indication of peak envelope power (PEP) for AM and SSB. Selection between CW or PEP mode is made by a Test Set front panel key. A very wide measurement range is available, from 10 mW to 400 W under certain conditions, for both forward and reverse power. Range selection is automatic under software control, so no range switching is required of the operator.

A system of compensated peak responding detectors is employed to ensure fast response times and a wide dynamic range. It should be noted that the instrument is accurately calibrated for signals with low harmonic content and noise.

Performance data - power head only

	HF version	UHF version
Frequency range:	1 MHz to 50 MHz.	25 MHz to 1000 MHz.
Power measurement (either direction)	See Fig. 1-2.	See Fig. 1-3.
Indication range for CW:	5 mW to 400 W.	5 mW to 400 W at 25 to 520 MHz, 5 mW to 200 W at 1000 MHz.
Indication range for PEP:	1 to 400 W.	1 to 400 W at 25 to 520 MHz, 1 to 200 W at 1000 MHz.
Maximum applied PEP:	1 kW.	1 kW at 25 to 100 MHz, 200 W at 1000 MHz.
CW power accuracy	The quoted figures apply when the Power Head is terminated by a load which has a VSWR of 1.1:1 or better and within the temperature range 18 to 26°C.	
Calibration at 1 W (with harmonics <-50 dBc):	±4.7% (±0.2 dB) at 30 MHz.	±4.7% (±0.2 dB) at 100 MHz.
Flatness:	±3.6% (±0.155 dB) at 1 to 50 MHz.	±5.9% (±0.25 dB) at below 520 MHz, ±9.6% (±0.4 dB) at 520 to 1000 MHz.
Linearity, relative to 1 W:	±3.5% (±0.15 dB) ±0.003% of maximum power of Head, at 10 mW to 400 W.	3.5% (±0.15 dB) ±0.01% of maximum power of Head.
Calibration, flatness and linearity combined (root of sum of squares):	±7% (±0.29 dB) ±0.003% of maximum power of Head.	±8% (±0.35 dB) ±0.01% of maximum power of Head, at 25 to 520 MHz, ±11% (±0.5 dB) ±0.01% of maximum power of Head, at 520 to 1000 MHz.
Effect of temperature outside 18 to 26° C on calibration, flatness and linearity:	<±0.2%/°C (±0.008 dB/°C).	<±0.3%/°C (±0.015 dB/°C) at below 520 MHz, <±0.5%/°C (±0.02 dB/°C) at 520 to 1000 MHz.
VSWR measurement	See Fig. 1-3.	See Fig. 1-3.
VSWR indication:	1.0 to 99.9.	1.0 to 99.9.
VSWR accuracy at 18 to 26°C:	±12.5% for 1.1:1 to 2:1 (typically 3%), ±15% for 2:1 to 3:1 (typically 4%).	±16% for 1.1:1 to 2:1 (typically 5%), ±20% for 2:1 to 3:1 (typically 6%).
Effect of temperature outside 18 to 26°C:	<±0.4%/°C for 1.1:1 to 2:1, <±0.6%/°C for 2:1 to 3:1.	<±0.3%/°C for 1.1:1 to 2:1, <±0.6%/°C for 2:1 to 3:1.

RF connectors		
Type:	N sockets.	N sockets.
Characteristic impedance:	50 Ω nominal.	50 Ω nominal.
Insertion SWR:	<1:1 (return loss >26.4 dB) at 1 to 50 MHz.	<1:1 (return loss >26.4 dB) at 25 to 1000 MHz.
Insertion loss:	<0.05 dB.	<0.35 dB at up to 520 MHz, <0.65 dB at 520 to 1000 MHz.
Output connector		
Type:	DIN 7-pin socket, standard Lead Assembly (3 m) to ACCESSORY socket on test set.	
Dimensions and weight		
Height:	52 mm.	52 mm.
Width:	108 mm.	108 mm.
Depth:	114 mm.	114 mm.
Weight:	645 g.	850 g.
Radio frequency interference:	Complies with the requirements of EEC Directive 76/889 as to limits of RF interference.	
Safety:	Complies with IEC 348.	
Environmental		
Rated range of use:	0 to 50°C.	
Limit range of operation:	0 to 55°C.	
Conditions of storage and transport		
Temperature:	-40 to +70°C.	
Humidity:	Up to 90% RH.	
Altitude:	Up to 2500 m (pressurized freight at 27 kPa differential (i.e. 3.9 lbf/in^2).	

Performance data - in conjunction with 2945

When the Power Head is used in conjuction with the Radio Test Set 2945, the performance is identical to that of the Power Head alone with the exceptions and additions given below.

Power measurement

	HF version	UHF version
Resolution:	1 mW or 0.1 dB	
Indication:	3 digits	
Setting:	Automatic ranging using 0 to 1, 0 to 3 and 0 to 10 scales.	
Accuracy (including errors due to frequency response, linearity and calibration uncertainties combined (root of sum of squares)):	±8% (±0.003% of maximum power of Head).	±9% (±0.01% of maximum power of Head) at 25 to 520 Mhz, ±12% (±0.01% of maximum power of Head) at 520 to 1000 MHz.
Effect of temperature outside 18 to 26°C:	<±0.2%/°C.	<±0.3%/°C at 25 to 520 Mhz, <±0.5%/°C, at 520 to 1000 MHz.
VSWR measurements		
Resolution:	0.01	
Indication:	3 digits and analogue display.	
Setting:	Automatic ranging, analogue scales 1 to 2, 1 to 4 and 1 to 11.	

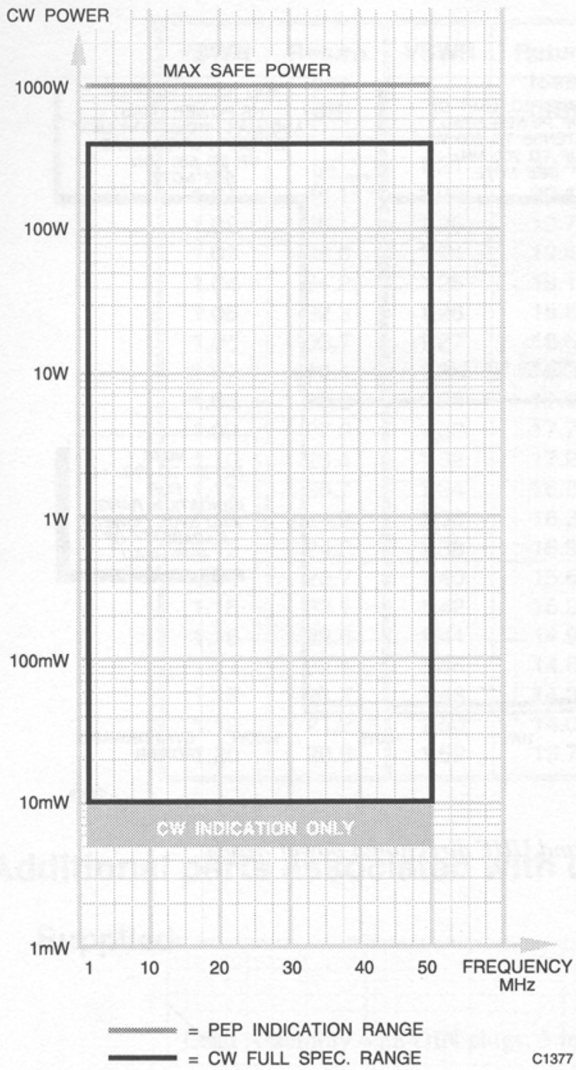

Fig. A-1 Power range of HF directional power head

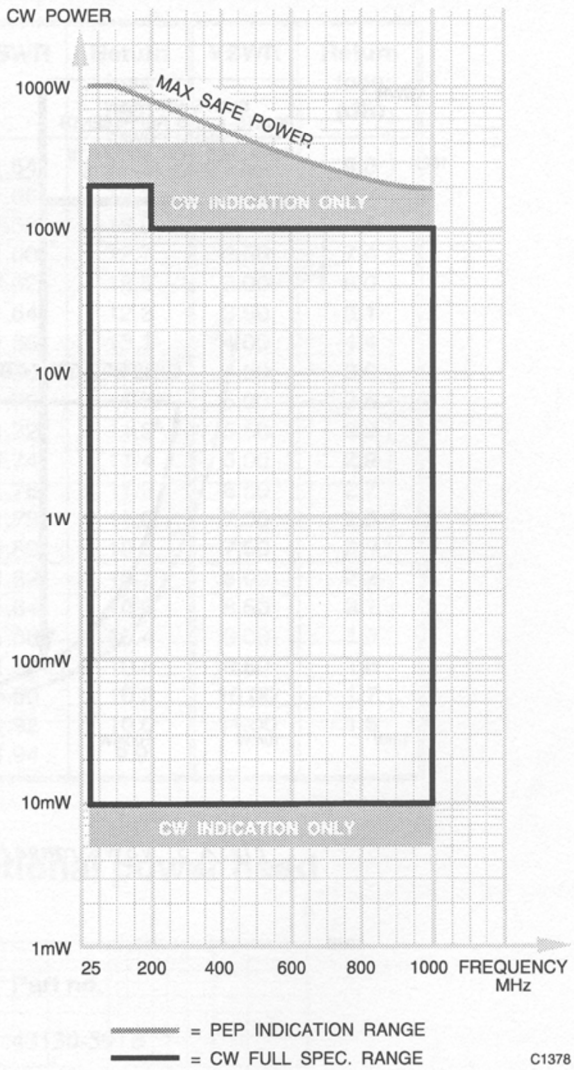

Fig. A-2 Power range of UHF directional power head

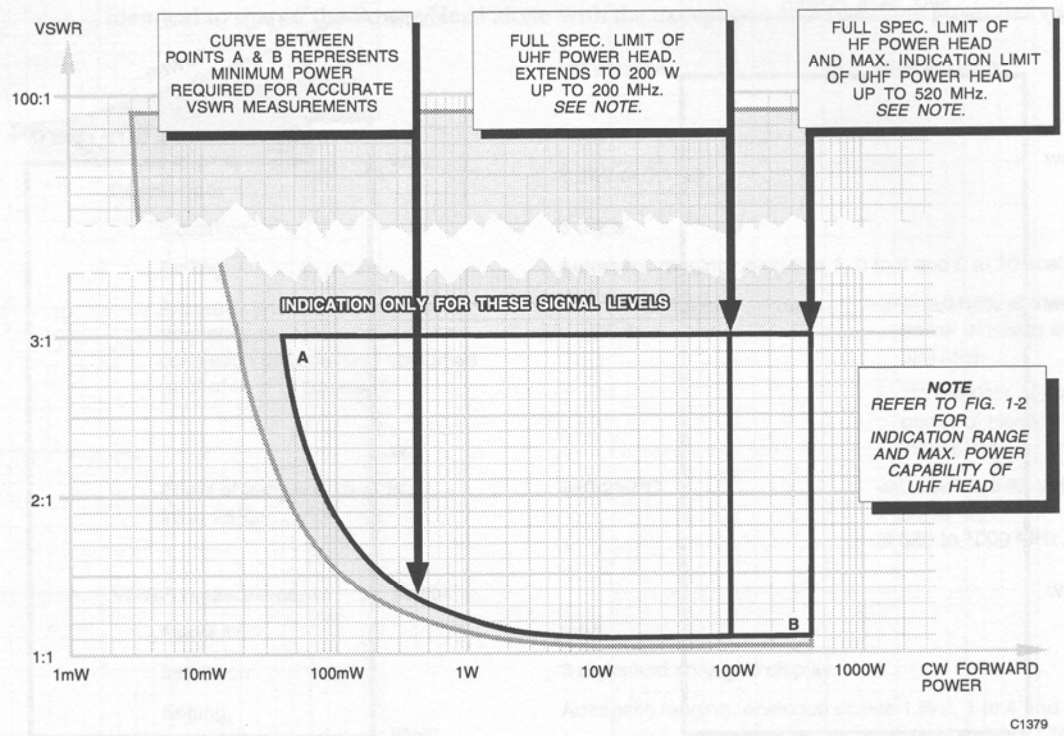

Fig. A-3 VSWR range for HF and UHF directional power heads

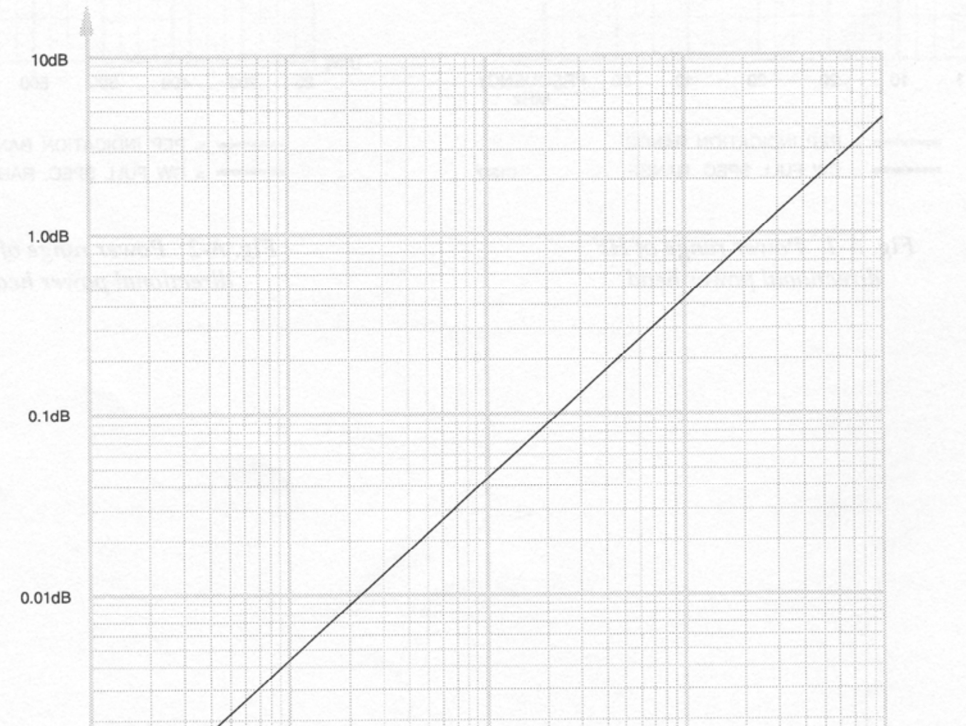

Fig. A-4 Percentage to dB error conversion

Table A-1 Conversion of VSWR to return loss

VSWR	Return loss (dB)	VSWR	Return loss (dB)	VSWR	Return loss (dB)	VSWR	Return loss (dB)
1.00	∞	1.21	20.4	1.54	13.4	1.96	9.8
1.01	46.1	1.22	20.1	1.56	13.2	1.98	9.7
1.02	40.1	1.23	19.7	1.58	13.0	2.00	9.5
1.03	36.6	1.24	19.4	1.60	12.7	2.50	7.4
1.04	34.2	1.25	19.1	1.62	12.5	3.00	6.0
1.05	32.3	1.26	18.8	1.64	12.3	3.50	5.1
1.06	30.7	1.27	18.5	1.66	12.1	4.00	4.4
1.07	29.4	1.28	18.2	1.68	11.9	4.50	3.9
1.08	28.3	1.29	17.9	1.70	11.7	5.00	3.5
1.09	27.3	1.30	17.7	1.72	11.5	5.50	3.2
1.10	26.4	1.32	17.2	1.74	11.4	6.00	2.9
1.11	25.7	1.34	16.8	1.76	11.2	6.50	2.7
1.12	24.9	1.36	16.3	1.78	11.0	7.00	2.5
1.13	24.3	1.38	15.9	1.80	10.9	7.50	2.3
1.14	23.7	1.40	15.6	1.82	10.7	8.00	2.2
1.15	23.1	1.42	15.2	1.84	10.6	8.50	2.1
1.16	22.6	1.44	14.9	1.86	10.4	9.00	1.9
1.17	22.1	1.46	14.6	1.88	10.3	9.50	1.8
1.18	21.7	1.48	14.3	1.90	10.2	10.00	1.7
1.19	21.2	1.50	14.0	1.92	10.0	11.00	1.6
1.20	20.8	1.52	13.7	1.94	9.9		

Additional parts associated with directional power head

Supplied

	Part no.
Lead Assembly with DIN plugs, 3 m	43130-591B
Carrying Case HF version	46662-190V
Carrying Case UHF version	46662-189W

Optional

Lead Assembly with DIN plugs, 1 m	43130-590R
Dual DIN Connector Assembly	44990-814K

Using the directional power head accessory

General

The supplied accessory consists of the Power Head together with the 3 metre Cable Assembly.

Power supply

No additional power supply is required. 12 V DC is supplied to the Power Head from the 2945 through the Cable Assembly.

Procedure

WARNING **RF HAZARD. No attempt should be made to connect the Directional Power Head to an RF line until the "Operating Precautions" on page v have been noted.**

Connect the accessory cable between the seven pin ACCESSORY IN/OUT socket on the 2945 front panel, and the seven pin DIN socket on the Power Head. These connections can be made with the instrument powered up.

Select either the Tx or Dx operating mode by pressing the appropriate mode key.

Press the [Tx Freq] key which will display the screen shown in (2.1) or (4.7).

Press the [Dir Power] key. The screen shown in Fig.A-5 will be displayed.

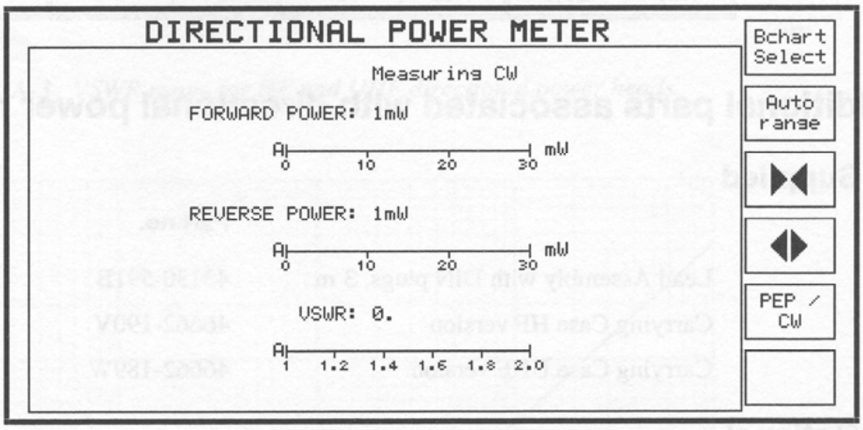

Fig. A-5 Directional power head screen

The Power Head is now installed and the 2945 ready to make directional power measurements.

Ensure that transmitter power is OFF and an antenna or load is connected to the transmitter.

Connect the Power Head in series with the transmitter output using either of the N sockets for input or output.

The Directional Power Head is able to operate in two modes, CW and PEP (when using AM or SSB). When the DIRECTIONAL POWER METER display first appears, it is in CW mode.. Select CW or PEP as appropriate, using the *[CW/PEP]* key.

Switch on the transmitter under test. Readings appear for forward power, reverse power and VSWR. The values appear on three horizontal bar charts.

The forward and reverse power levels and the VSWR level, are each displayed as digital readouts with a maximum resolution of three figures. Below 10 mW the power readings are reduced to a single figure, with two digits resolution up to 99 mW.

The bargraphs can be set for autoranging or manual range selection. Repeated presses of the *[Bchart Select]* key selects each bargraph in turn. The selected bargraph is indicated by the uppercase letter A or H being displayed in inverse video at the left end. Repeated presses of the *[Autorange]* key will toggle between autoranging, indicated by the uppercase 'A' and manual range selection (range held), indicated by an uppercase 'H'.

To manually change the range of a 'held' bargraph, first select it, using the *[Bchart Select]* key. Then, to step to a higher range, press the *[><]* key. Each press will adjust the maximum reading by one range. To step to a lower range, press the *[<>]* key.

The bargraph indications of the power measurement range is covered in the following 11 steps:-

0 - 30 mW..........with 10, 20 mW divisions
0 - 100 mW.......... with 20, 40, 60, 80 mW divisions
0 - 300 mW..........with 100, 200 mW divisions
0 - 1 W.......... with 0.2, 0.4 0.6, 0.8 W divisions
0 - 3 W..........with 1, 2 W divisions
0 - 10 W..........with 2, 4, 6, 8 W divisions
0 - 30 W..........with 10, 20 W divisions
0 - 100 Wwith .... with 20, 40, 60, 80 W divisions
0 - 300 W.......... with 100, 200 W divisions
0 - 1 kW..........with 0.2, 0.4 0.6, 0.8 kW divisions

The 2945 has the capability to adjust power readings to indicate the input power to external attenuators. The value of any external attenuation is entered in set-up screen 1.

This facility remains active when the directional power head is in use and for this purpose,four high power ranges are included.

0 - 3 kW..........with 1, 2 kW divisions
0 - 10 kW.......... with 2, 4, 6, 8 kW divisions
0 - 30 kW..........with 10, 20 kW divisions
0 - 100 kW..........with 20, 40, 60, 80 kW divisions

The directional power head is able to measure RF powers over a large dynamic range, from 5 mW to 400 W. The measuring circuits integrate readings over a finite period and therefore the accuracy of the readings obtained from amplitude modulated signals would depend on the content of the signal being measured.

For making measurements on CW, FM and phase modulated signals the CW measuring system is selected.

When it is required to make power measurements on amplitude modulated or single sideband signals the PEP (Peak Envelope Power) system is selected. The range of measurement covered by the PEP system is from 1 W to 400 W.

The selection of CW or PEP measurements is made using the *[CW/PEP]* key. The selection is indicated by the legend *Measuring CW* or *Measuring PEP* displayed above the forward power measurement.

VSWR is shown digitally and also on a bargraph at the bottom of the display. The VSWR range is covered in two steps as shown below:-

1.0 (:1) to 2.0 (:1).......... with 1.2, 1.4, 1.6, 1.8 (:1) divisions.
1.0 (:1) to 4.0 (:1)..........with 2, 3 (:1) divisions.

Technical description

Directional coupler assembly

The directional coupler is connected in series with the RF line under test and senses forward and reverse RF power. The coupler has two outputs, one for forward power and the other for reverse power. Because the coupler can be connected in either direction on the RF line, either output could represent forward or reverse power. Each output from the coupler is routed to an RF detector.

Channel circuit

There are two channel circuits, each comprising an integrator, AGC circuit and a peak buffer. Both channel circuits are identical to each other, therefore only channel 1 is described below.

CW operation

With reference to Fig. A-6 the RF detector output is connected to one input of the integrator. The output from an LF detector is connected to the other input of the integrator. The integrator output controls the gain of the AGC circuit which controls the level of a 1 kHz signal to the LF detector.

When RF power is detected, an increased offset voltage exists at the integrator input which causes the AGC to compensate by increasing the level of LF voltage to the LF detector. The increase in LF level at the AGC circuit is routed to the test set and is directly proportional to the increase in RF sensed by the directional coupler.

The error correcting action of the AGC/LF detector loop circuit corrects for law variations in the RF detector, thereby extending its linear output range.

The RF and LF detector diodes for each channel have matched characteristics and are mounted close together to ensure thermal equilibrium. However, DC level differences due to temperature are compensated by a unique auto-nulling scheme (patent applied for) which further extends the detector dynamic range.

PEP operation

The integrator and AGC/LF loop circuit is not suitable for AM signals therefore for PEP operation they are switched out of circuit. The RF detector output is routed to a peak buffer which in channel 1 outputs a positive voltage and in channel 2 outputs a negative voltage proportional to the forward and reverse peak envelope voltage on the RF line under test.

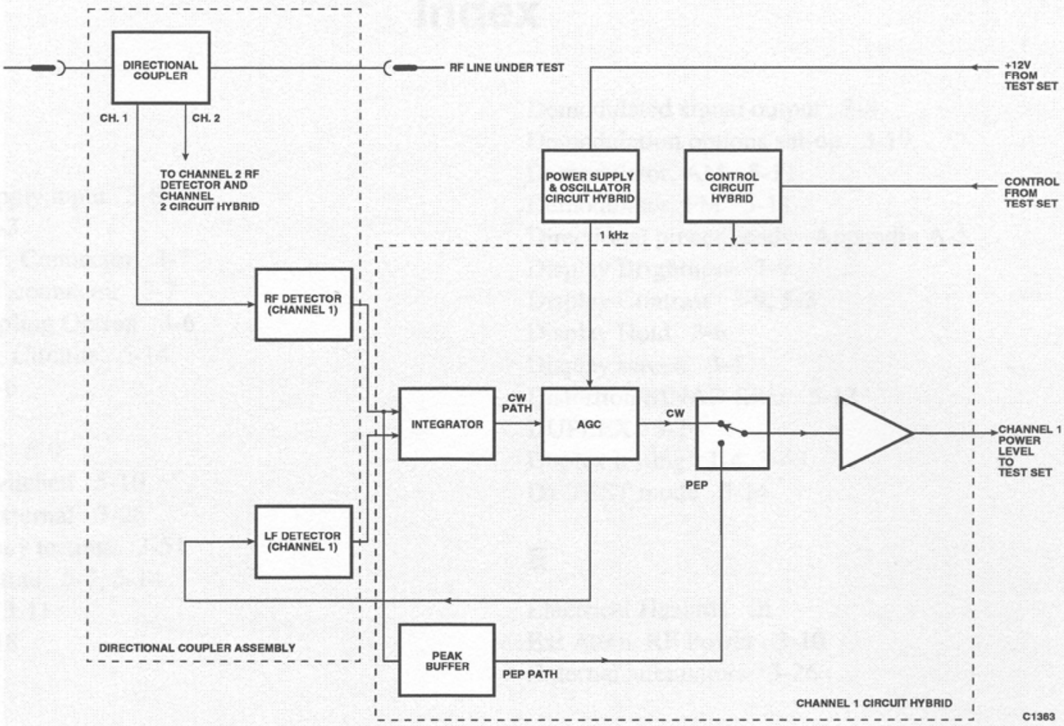

Fig. A-6 Simplified block diagram of HF or UHF power head

Control circuit

Signal switching for CW/PEP signal paths is controlled by the test set via a control circuit hybrid in the power head. The control circuit directly controls the operation of the zero-loop circuit.

Power supply and oscillator

A power supply and oscillator circuit hybrid in the Power Head is powered by +12 V DC from the test set and provides the nominal 1 kHz signal to each channel AGC circuit and also ±6.5 V DC supplies to the Power Head circuits.

Index

V

W