

DISTORTION AND NOISE METER

F242A

Applies to Serial No. 586 Onwards

Handbook 1-70542R
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PART 1GENERAL INFORMATION

This apparatus has been designed according to Class 1 of IEC Publication 348 Safety Requirements for Electronic Measuring Apparatus, and has been supplied in a safe condition. The present instruction manual contains information and warnings which shall be followed by the user to ensure safe operation and to retain the apparatus in safe condition.

1.1 INTRODUCTION

The AWA Distortion & Noise Meter F242A is suitable for the measurement of total harmonic distortion on balanced or unbalanced audio circuits including tape recorders. It features fully automatic fundamental rejection frequency tuning over the range 20 Hz to 20 kHz. The F242A will also measure both absolute and relative level, noise and hum-plus-noise in audio circuits in the frequency range 10 Hz to 100 kHz and sinad receiver sensitivity.

1.2 BRIEF DESCRIPTION

The F242A is a sensitive distortion and level meter which can be used to determine the performance of all types of audio amplifiers, oscillators, tape recorders, line equalizers and filters. Parameters which can be readily measured are: gain, frequency response, signal-to-noise ratio (weighted and unweighted) sinad receiver sensitivity and the distortion factor over a wide range of input levels.

Distortion measurements are referred to the incoming signal level and the meter is calibrated to indicate distortion factor either in dB or as a percentage. The fundamental rejection frequency is automatically tuned over the entire 20 Hz to 20 kHz operating frequency range, no manual selection or tuning being necessary. Residual distortion is typically less than -90 dB. An out of frequency range warning lamp indicates a frequency outside the operating range.

A simplified distortion calibrate control, independent of attenuator setting, enables easier calibration and rapid checking of calibration during measurements.

For level measurements, including noise, the meter is calibrated in dBm in 600 ohms (0 dBm = 1 mW) and V r.m.s. The meter circuit is true r.m.s. responding, necessary to produce accurate readings of the complex distortion waveforms and noise. The residual noise of the F242A is very low, being less than -110 dBm on full bandwidth.

Low-cut and high-cut filters are provided, and by the appropriate selection of these filters, noise above 20 kHz and mains hum-plus-noise below 400 Hz may be excluded. An optional programme weighting network complying with C.C.I.T.T. Recommendation J16 Annex, Geneva 1972, is available for weighted noise measurements.

1.3 PERFORMANCE

1.3.1 Environmental

Operating Temperature Range : 0 °C to 50 °C
Storage Temperature Range : -10 °C to 60 °C

1.3.2 Distortion Factor Measurement

Fundamental Frequency Range:

Balanced : 20 Hz to 20 kHz
Unbalanced : 20 Hz to 20 kHz

Harmonic Measurement Range : 100 kHz

Distortion Factor Range : Maximum -10 dB
Minimum determined by residual distortion of -84 dB balanced or unbalanced, but increasing to -60 dB at 30 Hz on balanced input. Typically better than -90 dB unbalanced.
For inputs below -10 dB ref. 0.775 V, minimum determined by residual noise of less than -74 dB. (100 kHz bandwidth), -84 dB (20 kHz bandwidth).

Accuracy of 2nd Harmonic Indication : +0, -0.5 dB

Input Level Range : -30 dB to +30 dB reference 0.775 V r.m.s.
2.5 mV to 30 V.

1.3.3 Level or Noise Measurement

Meter Ranges (For 0 dB Meter Indication) : -90 dBm to +30 dBm in 10 dB steps
(0.1 mV to 30 V FSD)

Level Accuracy at 1 kHz and 0 dB on meter : ± 0.2 dB (for any attenuator setting)

Absolute Level Accuracy 0 dBm at 25 °C and 1 kHz : ± 0.05 dB

Meter Indication : True r.m.s. responding

Meter Calibration : -30 dB to +2 dB, 0 to 3.2 and 0 to 10 for Volts or Percent

Meter Response : Response time to 99% of FSD in 250 \pm 50 ms

Meter Accuracy : $\pm 1\%$ of f.s.d.

RESIDUAL NOISE : Unbalanced : Less than -110 dBm (less than 2.5 μ V)

1.3.3.1 Relative Level Facility

Variable Gain : +22 dB to -38 dB

1.3.4 Input Impedance

Balanced and unbalanced : 600 Ω

Balanced Bridging : 50 k Ω (0.1 dB bridging loss)
10 Hz to 30 kHz

Unbalanced Bridging : 100 k Ω (10 Hz to 100 kHz)

RETURN LOSS OF TERMINATED INPUT

Balanced : 30 dB (10 Hz to 30 kHz)

Unbalanced : 40 dB (10 Hz to 30 kHz)

: 34 dB at 100 kHz

LONGITUDINAL SUPPRESSION OF
BALANCED INPUT

At least 40 dB with respect to transverse
: voltage (10 Hz to 30 kHz)

1.3.5 Frequency Response

Balanced Input : 10 Hz to 30 kHz ± 0.2 dB (typically less
than ± 0.3 dB to 100 kHz)

Unbalanced Input : 10 Hz to 100 kHz ± 0.2 dB

A.C. OUTPUT

: 2 Volts r.m.s. for FSD on meter
1 k Ω output impedance

1.3.6 Standard Filters

LOW CUT FILTER : ± 0.2 dB at 400 Hz
-45 dB at 50 Hz

HIGH CUT FILTER : Meets high frequency roll off
requirements of IEC Noise Filter
1 dB at 19 kHz
-18 dB at 32 kHz
-40 dB at 63 kHz

1.4 GENERAL INFORMATION

CONNECTORS

Standard Input Connector : Siemens Type 9, Relkli 6a 3-way
balanced or similar

POWER SUPPLY

Mains operation : 110 V - 120 V and 220 V - 240 V nominal, $\pm 10\%$
50 - 60 Hz

1.5 MECHANICAL DETAILS

Height	: 146 mm (including feet) 133 mm (with feet removed for rack mounting)
Width	: 430 mm
Depth	: 397 mm (including handles & rear feet) 345 (behind mounting face, when rack mounted)
Weight	: 7.1 kg.

1.6 ACCESSORIES PROVIDED

- 1 x Mains Cable
- 1 x Instruction Manual
- 1 x Mating Input Connector
(Siemens type Rel stp 6ac or similar)
- 1 x Spare Fuse

1.7 OPTIONAL ACCESSORIES

- | | |
|------------|--|
| Option 001 | CCITT PROGRAM WEIGHTING NETWORK complying with CCITT Recommendation J16 Annex, Geneva, 1972. |
| Option 002 | CCITT TELEPHONE WEIGHTING NETWORK complying with CCITT Green Book (1972) Vol V, Recommendation P53 |
| Option 003 | Alternative input connectors consisting of twin jacks for carrier or tip ring and sleeve plus an alternative rear panel connector. A mating connector for the latter is supplied. |
| Option 004 | Alternative input connector, 3 binding posts. |
| Option 005 | Rack mounting kit enabling the unit to be mounted in a standard 483mm rack, occupying 3 vertical units - 133mm total height. |
| Option 006 | Adaptor 3 pin male to BNC Female. |
| Option 007 | Adaptor 3 pin male to 3 binding posts. |
| Option 008 | A.M. Detector.

Distortion, less than 0.3% 500 kHz to 1.7 MHz
less than 1% 1.7 MHz to 36 MHz
for 2-10 Volt carriers at 30% modulation.
R.F. input connector, BNC female.
Plugs into standard 3 pin balanced input socket of F242A. |
| Option 009 | A.M. Detector
Specification as for Option 008
Mates with alternative input connector
Option 004, 3 Binding Posts. |

1.7 OPTIONAL ACCESSORIES (contd)

Option 010

"C" MESSAGE WEIGHTING NETWORK complying with
Bell Systems Technical Reference Publications
41009, May, 1975.

1.8 ORDERING INFORMATION

The instrument is described as A.W.A. Distortion & Noise Meter F242A,
Type 2A70542.

P A R T 2

I N S T A L L A T I O N

2.1 GENERAL

The F242A Distortion & Noise Meter is designed for bench operation or rack mounting and for operation from a.c. mains supply. For power and signal connections, see below.

The equipment should be inspected for any physical damage incurred during transportation. The accessories should be checked against the equipment schedule.

Whenever it is likely that the protection has been impaired, the apparatus shall be made inoperative and be secured against any unintended operation.

The protection is likely to be impaired if, for example:

- the apparatus shows visible damage;
- the apparatus fails to perform the intended measurements;
- after prolonged storage under unfavourable conditions;
- after severe transport stresses

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of mended fuses and the short-circuiting of fuse-holders shall be avoided. The fuse should be of the current rating as marked on the rear panel for the mains voltage selected.

2.2 MOUNTING

The F242A is fitted with bottom feet and a tilt bar for bench operation. The tilt bar enables the unit to be tilted upwards for easier operation.

2.2.1 Rack Mounting

If it is required to rack mount the F242A, Option 005, Rack Mounting Adaptor, must be ordered. This adaptor kit is designed to mount the F242A in a standard 483 mm (19 inch) rack.

To prepare the F242A for rack mounting, remove the top and bottom covers, held on by two screws at each end of each cover. Remove the front feet, tilt bar and rear feet from the bottom cover. Refit the bottom and top covers.

Next, peel off the adhesive trim strip on the side of the two front handles and remove the outer two screws from the handles. Using the screws provided in the Rack Mounting Adaptor Kit, screw the angle brackets onto the ends of the case, flange forward. The instrument is now ready for mounting into the rack.

The F242A does not require any cooling in ambient temperatures up to +50 °C however the usual care of not mounting above high dissipation equipment without adequate ventilation should be followed.

2.3 CONNECTIONS

2.3.1 Power

The F242A will operate from 110 V to 120 V and 220 V to 240 V nominal a.c. mains supply, 50 Hz - 60 Hz. The voltage range is selected by a slide switch on the rear panel of the instrument. This voltage range should be checked before connecting to the supply. Ensure that the correct fuse rating is fitted for the supply voltage range selected. These are shown on the rear of the instrument. For 110 V to 120 V range, a 200 mA Anti-Surge fuse should be used.

For 220 V to 240 V range, a 100 mA Anti-Surge fuse should be used.

An international mains socket is fitted on the rear panel of the F242A. The power cord supplied should be plugged into this and connected then to the mains power receptacle.

The mains plug shall only be inserted in a socket-outlet provided with a protective earth contact. The protective action shall not be negated by the use of an extension cord without protective conductor.

Warning!

Any interruption of the protective conductor inside or outside the apparatus or disconnection of the protective earth terminal is likely to make the apparatus dangerous. Intentional interruption is prohibited.

2.3.2 Input

The standard Siemens Halske Type 9 Rel kli 6a or equivalent input connector is a 3-contact in-line socket. The top contact is connected to chassis earth. Balanced input from a 600 ohm line to the other two contacts is normally bridged but may be terminated by selecting 600 ohm TERM. The bridging resistance is 50 kilohms. With unbalanced inputs the centre contact is "active" and the bottom contact is earthed internally. This condition is achieved when the push-button switch marked "BAL"/"UNBAL" is in the 'out' position. The unbalanced bridging input impedance is 100 kilohms.

2.3.3 Alternative Input Connectors

Optional twin jacks for carrier or ring tip and sleeve are available. This kit also provides an alternative rear-panel connector.

If this option is ordered with the instrument it will normally be factory fitted.

If the option is ordered separately, it is supplied with a set of fitting instructions, Modification Bulletin 70542/1, for Distortion & Noise Meter F242A, to enable the easy fitting of these alternative input connectors.

2.3.4 Output

An a.c. output is provided via two binding posts on the right-hand end of the front panel, so that the distortion products may be displayed on an oscilloscope. Two volts r.m.s. from this output correspond to full scale deflection of the meter. The source impedance of this output is 1 kilohm.

2.4 OPTIONAL PROGRAM WEIGHTING NETWORK

To fit the optional C.C.I.T.T. Program Weighting Network, remove the covers of the F242A, plug the Network into the socket on the main printed circuit board (centre left), with components side facing the front of the instrument. Fit clamp supplied over the Network and then replace the covers of the F242A.

2.5 OPTIONAL TELEPHONE WEIGHTING NETWORK

To fit the optional C.C.I.T.T. Telephone Weighting Network, carry out instructions as for 2.4.

2.6 OPTIONAL "C" MESSAGE WEIGHTING NETWORK

To fit the optional C.C.I.T.T. Message Weighting Network, carry out the instructions as for 2.4.

2.7 RE-PACKING FOR SHIPMENT

General guidance is furnished below in the event that re-packing of the instrument for shipment may be necessary at any time.

1. Should the original container be available, re-pack in the same manner as received. It is advisable to retain the original container and packing case for this purpose.
2. If the original container is not available, the unit should be wrapped in heavy paper or plastic sheet prior to placing in an inner container. Place liberal quantities of packing materials, which should be reasonably dust-free, on all sides of the container but DO NOT pack tightly. The instrument front panel side should receive extra attention when the container is being packed into the packing case.
3. Mark the case in which the instrument is shipped "DELICATE INSTRUMENT" or "FRAGILE".

PART 3OPERATION

Warning!

Any interruption of the protective conductor inside or outside the apparatus or disconnection of the protective earth terminal is likely to make the apparatus dangerous. Intentional interruption is prohibited.

The following controls are mounted on the front panel of the F242A.

3.1.1 Power Switch

This switch applies mains power to the instrument. For safety, both line and neutral are switched.

An associated red l.e.d. lamp indicates the presence of mains power.

Before switching on the apparatus, make sure that it is set to the voltage of the power supply.

3.1.2 Bal-Unbal Switch

This push button switch selects whether the input circuit to the instrument is balanced (button depressed) or unbalanced. In the balanced condition the two lower sockets of the input connector are active. In the unbalanced condition, only the centre socket is active and the lower socket is earthed.

3.1.3 600 Ω - Bridging Switch

With this switch in its non-depressed position, the instrument input will be in the bridging condition. The bridging impedance is 50 kilohms on balanced and 100 kilohms on unbalanced.

With the switch depressed the input will be terminated in 600 ohms.

3.1.4 Filters Switch

This is a bank of three push button switches. When all push buttons are 'out', then the response of the F242A will be flat. By depressing the 'wtg' button the CCITT Programme Weighting Network or CCITT Telephone Weighting Network will be selected, if either of these options are fitted. If neither of these options are fitted, no reading will be obtained on the meter. The 'Lo Cut' and 'Hi Cut' filters may be selected separately or together, again by depressing the appropriate button or buttons. When using the 'Lo Cut' and/or the 'Hi Cut' filters ensure that the 'Wtg' button is not depressed as this button over-rides the other two.

3.1.5 Function Switch

This is a bank of four interlocked push button switches. With the 'LEVEL dBm' button depressed the instrument may be used for absolute level and noise measurements. With the 'LEVEL rel' button depressed the instrument calibration level may be changed by use of the coarse and fine SET REF controls to allow measurements to be carried out relative to some reference input. The remaining two buttons are for distortion measurement. The 'DISTORTION cal' button is again

used in conjunction with the coarse and fine 'SET REF' controls, to set the reference level for distortion measurements. The calibration is carried out independent of the Meter Range Switch setting. Once the reference level has been set, the 'DISTORTION read' button should be depressed to obtain a distortion reading.

3.1.6 Distortion Calibrate Controls

These consist of a coarse and a fine control, the coarse control being switched. These are used when the Distortion Cal switch is depressed to set the reference level for distortion readings.

3.1.7 Meter Range Switch

This switch is used to adjust the meter range for both level and distortion readings.

3.1.8 Freq. Out Of Range Light

This indicator lamp will light on Distortion measurement only, if the fundamental frequency of the incoming signal is outside the range of the instrument.

3.2 LEVEL OR NOISE MEASUREMENTS

3.2.1 Absolute Level or Noise Measurements

Select the appropriate input configuration on the 'bal'-'unbal' and '600 Ω '-'bridging' switches. Next, if it is required to limit the frequency bandwidth, i.e., if noise above 20 kHz or hum and low frequency noise are to be excluded from the measurement, select 'Hi-Cut' and/or 'Lo-Cut' as required. If a weighted measurement is required and the optional weighting network is fitted, select 'Wtg'.

Select 'LEVEL dBm' on the function switch, set the meter range switch to the appropriate range and read the meter.

3.2.2 Relative Level or Noise Measurements

Select the appropriate input conditions and filters as for 3.2.1 Absolute Level and Noise Measurements.

Select 'LEVEL, rel' on the function switch, set the meter range switch to the 0dB position. The coarse and fine SET REF controls may now be used to adjust the meter reading to set the reference for other relative level or noise readings. The meter range switch operates normally enabling relative readings from 30 dB to -110 dB. The meter range switch may be set at other than the 0dB range for adjustment of the SET REF controls, however under these circumstances the operator must remember the range setting and subtract this from the relative measurements obtained from attenuator and meter. Example: If the SET REF controls are set with the meter range switch on -40 dB and another signal is fed in and reads -26 dB the true relative reading would be $(-26 \text{ dB}) - (-40 \text{ dB})$ i.e. $-26 \text{ dB} + 40 \text{ dB}$ giving a relative reading of +14 dB.

3.3 DISTORTION FACTOR MEASUREMENT

NOTE: The F242A measures distortion factor either as a percentage or in dB as follows:

$$\text{Percentage distortion factor} = 100 \frac{V_2^2 + V_3^2 + \dots V_n^2 + N^2}{V_1^2 + V_2^2 + \dots V_n^2 + N^2}$$

$$\text{Distortion factor in dB} = 10 \log \frac{V_2^2 + V_3^2 + \dots V_n^2 + N^2}{V_1^2 + V_2^2 + \dots V_n^2 + N^2}$$

where V_1 , V_2 , etc. represent the amplitudes of fundamental and harmonics, V_n represents the amplitude of the last harmonic in the admitted bandwidth, and N represents noise.

Select the appropriate input configuration on the 'bal'-'unbal' and '600 Ω ' - 'bridging' switches. If noise above 20 kHz or hum and low frequency noise are to be excluded from the measurement, select 'Hi-Cut' and/or 'Lo-Cut' as required. Note however, the use of the filters restricts the range of signal frequencies that may be used for accurate measurement. Next, select 'Distortion-Cal' and adjust the associated coarse and fine calibrate controls for a meter scale reading the 0dB or 10. The setting of the meter range switch is immaterial.

Select 'Distortion-Read' and adjust the meter range switch for optimum meter reading. The automatic frequency notch filter will start to null as soon as the Distortion-Cal button is depressed and in most cases, by the time the calibration controls have been set and the Distortion-Read button selected, the nulling will be complete. The higher the distortion, the more rapid the nulling time.

As the calibration procedure is independent of the meter range switch, the meter range may be left on the appropriate distortion range where a series of distortion measurements are being taken, thus avoiding the tedious winding back to 0dB/100 percent range for calibration and then back again to the required distortion range as on earlier generations of distortion meters.

PART 4TECHNICAL DESCRIPTION

4.1 PRINCIPLES OF OPERATION

Refer to Simplified Block Schematic drawing 70542-3-56.

The incoming signal feeds through the input circuit and then takes one of three routes to the main meter range attenuator/preamplifier. In the 'Level-dBm' mode, the signal feeds directly to the attenuator, in the 'Level-rel', 'Distortion-Cal' and 'Distortion-Read' modes the signal feeds through the coarse SET REF attenuator, SET REF amplifier and fine SET REF attenuator, thence directly to the main attenuator on 'Level-Rel' and 'Distortion-Cal' and via the automatic frequency notch filter on 'Distortion-Read'.

In all four modes signal path is common from the main meter range attenuator/preamplifier to the meter. The signal level is adjusted in the main attenuator and preamplifier and thence to the meter amplifier directly or via the selected filter/s. The output from the meter amplifier then feeds to the output on the front of the instrument and to the rms to d.c. converter, the output of which drives the meter.

4.2 CIRCUIT DESCRIPTION excluding auto notch filter

Refer to Circuit Drawing 70542-0-52.

4.2.1 Input Circuit

Capacitors C1, C2 block d.c. from the input circuit BUT DO NOT BLOCK d.c. FROM TERMINATING RESISTOR, hence d.c. should not be applied across input when using terminated input.

The maximum safe d.c. level unterminated is limited to ± 60 Volts.

Input mode is selected by switch SWA. Balanced signals are passed via a 1:1 transformer (TRI). For meter range settings of +20 dB and +30 dB a 30 dB pad is inserted in the balanced mode. This reduces the distortion generated by the transformer. The centre tap of the pad is a.c. grounded in order to maintain longitudinal suppression. If longitudinal suppression for high levels is unimportant this capacitor may be removed.

4.2.2 Attenuator & Preamplifier

Refer also to Level Diagram & Attenuator Control Circuit 70542-3-56. The level diagram shows for each input level the corresponding attenuation in the attenuator and the gain setting of the preamplifier. The attenuator has a constant 100 k Ω input impedance. Transmission gates IC1 select either 30 dB, 50 dB, 60 dB or 80 dB attenuation. As the transmission gates are in series with a high load impedance (100 k Ω) their on-resistance variation has negligible effect on accuracy. Transmission gates IC2 are used to prevent attenuator feedthrough. For meter ranges of -40 dBm and above transmission gate "6" is on and "12" is off and thus preventing relay (RLD) feedthrough. The preamplifier is a three-stage low noise amplifier. Q3 serves as a dynamic load for Q2 to attain high gain. Overall negative feedback, selected by RLA, RLB and RLC sets a gain from 6 dB to 36 dB in steps of 10 dB.

4.2.3 Program Filter

The LC-network shapes the frequency response to conform to the C.C.I.T.T. Recommendation J16 Annex Geneva, 1972. Feedback pair Q5, Q6 is used to achieve an overall gain of +12.2 dB at 6.3 kHz. The exact gain is set by RV401. For program filter characteristic refer to DWG 70550-3-26.

4.2.4 20 kHz Hi-Cut Filter

This filter is a five-pole active low-pass Chebyshev design. The first section contributes a complex pole and uses a complementary emitter follower with near unity gain. The second section provides a real pole as well as a complex pole pair. The roll-off meets I.E.C. noise filter specification with $f_m = 16000$ Hz. For Hi-Cut characteristic refer to DWG 70550-3-26.

4.2.5 400 Hz Lo-Cut Filter

This filter is a three-pole active high-pass Chebyshev design. It uses an operational amplifier to provide a unity gain stage. For high-pass characteristics refer to DWG 70550-3-26.

4.2.6 Meter Amplifier & 120 kHz Filter

This filter is a three-pole elliptical low-pass design. It attenuates out-of-band high frequency noise. The meter amplifier is a multistage, wideband negative feedback amplifier. An input differential stage is followed by two voltage gain stages and an output emitter follower. Q17 serves as a current source for Q16. L2 and C62 are used in the balanced mode to compensate for the high frequency response of transformer T1.

4.2.7 RMS-DC Converter

IC3 and associated components function as a full-wave rectifier. The four transistors of IC5 square the absolute value input signal and divide this by the output d.c.-signal. Zener diode D41 is used to protect the meter against heavy overloads.

4.2.8 SET REF Attenuators and Amplifier

The coarse SET REF control is used to provide from 20 dB of gain to 30 dB of attenuation in 10 dB steps to set the reference level in conjunction with the fine SET REF control RV301. The SET REF amplifier is a low distortion, high input impedance amplifier circuit with switchable gains of 23, 13 and 3 dB. Transistor Q302 is operated at constant collector-base voltage due to Q301 thereby minimising any source-impedance induced distortion effects. Q302 provides additional loop gain and Q304 and Q305 form a compound emitter follower. Feedback from Q305 emitter to Q302 emitter sets the amplifier gain.

4.2.9 Power Supply

The power supply circuit consists of a +12 V series regulated supply IC8 and a -12 V series regulated supply IC9. Both supplies are internally protected against short circuits and thermal overloads.

4.3 CIRCUIT DESCRIPTION OF AUTO NOTCH FILTER

Refer to Circuit Drawing 70542-0-55.

The automatic nulling circuit consists of 3 sections: the Wien bridge with associated amplifiers, a nulling circuit to control the variable resistors in the bridge and automatic bridge range control circuits.

4.3.1 Bridge Circuit

4.3.1.1 Bridge Preamplifier

The output from the calibrate control potentiometer RV315 is fed into the bridge preamplifier which has very high open loop gain and only 10 dB closed loop gain. This ensures that distortion produced by the instrument is kept to a minimum. Local preamplifier feedback is combined with overall nulling bridge feedback on one input of the amplifier.

4.3.1.2 Modified Wien Bridge Circuit

The bridge circuit used to remove the fundamental frequency signal in distortion mode is a Wien Bridge with a variable resistor PCC1 connected across the reactive arm series section resistor and part of the reactive arm parallel section resistor. The resistor ratios are chosen so that varying PCC1 changes the bridge rejection frequency without varying the bridge attenuation. Thus the bridge resistive arm need only have a fine adjustment which is done by PCC2.

To keep the signal across the PCC's down and hence to minimise PCC induced distortion the Wien Bridge needs sixteen separate ranges to cover the frequency band. Four major divisions are made by selecting one of four bridge capacitor sizes by relays RLK and RLJ. Each of these major frequency bands is further sub-divided by selecting one of four resistive ranges by relays RLL and RLM to make up the complete reactive arm of the bridge.

4.3.1.3 Bridge Postamplifier

The output of the Wien Bridge resistive and reactive arms are fed to opposite inputs of a differential amplifier to reject any common mode signal and amplify the difference. An emitter follower lowers the output impedance of the amplifiers. Feedback is taken from the postamplifier output via R153 to the preamplifier input to sharpen the rejection notch and set the gain for harmonics, which are not blocked, at 10 dB.

4.3.2 Nulling Circuits

4.3.2.1 Frequency Locked Loop. In Phase and Quadrature Generator.

To achieve the automatic nulling function the signal which appears across the Wien Bridge and postamplifier must be examined for phase shift. Any imbalance in the reactive arm of the bridge will result in fundamental appearing at the output phase shifted relative to the bridge input. Any imbalance in the resistive arm will result in an in-phase fundamental component referred to the input. To separate the bridge output signal into in-phase and out-of-phase components reference signals must be generated with zero phase shift (in-phase) and 90° phase shift (Quadrature) referred to the bridge input signal.

The outputs of the bridge preamplifier and the set reference amplifier are passed through isolation amplifiers IC24 which further amplify these signals and prevent switching transients from entering the bridge circuitry. According to the state of the Q output of the monostable 1/2 IC27, either of these signals is fed via an analog switch to an additional isolation amplifier IC25 whose output is squared by the comparator 1/4 IC32. D63 prevents excessive voltage swing from being applied to the comparator input. The comparator output is then buffered and inverted by 1/4 IC26. Pulses at twice the incoming signal frequency are created by exclusive OR gate, 1/4 IC26 with R273 and C131. These are fed to the frequency locked loop incorporating a retriggerable variable pulse width monostable as the oscillator. The output of the monostable at pin 13 of IC27 is a square wave at twice the incoming signal frequency. The square wave period is controlled by the variable current source Q43 and R300, which charges C133 until its voltage exceeds the reference voltage set by R278 and R279. At this point, comparator 1/2 IC32 changes state and resets the monostable via the reset line of 1/2 IC27. Q42 is then turned on and discharges C133. The monostable is now ready for the next input pulse. The mark space ratio of the monostable output is compared to unity by the integrator, 1/2 IC25, whose reference voltage is derived from the voltage divider R301 and R302. The integrator ramps up or down according to the error in the mark space ratio, and adjusts the charging current of C133 accordingly.

The frequency locked loop (f.l.l.) output frequency is halved by 1/2 IC30 and by the appropriate gating of signals, is phase shifted 90° by the other half of IC30. The IN Phase and Quadrature relationship of the output signal of IC30 with the bridge frequency is ensured by 1/4 IC35 by gating the bridge frequency with pulses provided by R303, and C136 at the derived bridge frequency. The IN Phase and Quadrature signals are then taken to the control loop integrator choppers.

Whenever unstable states are present on the frequency range relays, i.e. any one state does not exist sufficiently long for the bridge to null, pulses appear at pin 9 of IC21. Each pulse is used to trigger a monostable 1/2 IC27, C140, R305 which has a period of approximately 600 msecs. To ensure that each trigger pulse results in a full monostable period, the pulses from IC21 are blocked by a gating circuit IC35 with C139 and R304, for the discharge period of C140. This 500 msec pulse is used to change the state of the analog switch 1/3 IC12, which allows the f.l.l. to be fed from the set reference amplifier for this period, rather than the bridge preamplifier. This is done to assist the lock up of the f.l.l. onto the wanted fundamental frequency if another interfering signal was present in the nulling circuitry before the fundamental frequency was introduced into the instrument. Because of the lack of feedback around the bridge preamp and bridge, for the frequency being nulled, this frequency will appear at the preamp output selectively amplified over other frequencies present.

Thus, if, for example, the distortion of a 20 kHz signal were to be measured in the presence of severe hum, present in the bridge before the 20 kHz was introduced, the hum component would be amplified at the bridge preamp relative to the 20 kHz signal. This would deteriorate the lock-up behaviour of the f.l.l. However, once the coarse ranging circuitry has stabilised, the f.l.l. is fed from the bridge preamp, which transmits more accurate phase information to the IN Phase and Quadrature Generator about the state of null in the bridge, enabling faster nulls to be achieved.

4.3.2.2 Chopper Preamplifier

The bridge postamplifier output signal has to be amplified before it is dissected for information. Two conflicting requirements have to be met. For very low distortion signals, the preamplifier has to have very high gain so that error signals dominate integrator off-set voltages. For highly distorted signals, the high gain would cause clipping in the pre-amp.

To meet these requirements the amplifier gain is set according to the front panel attenuator switch. For attenuator settings of -30 dB or less, the gain is approximately 29 dB. When the attenuator is set to -20 dB or above, a transmission gate 1/4 IC11 is turned on, switching in a lower feedback resistor across the amplifier changing its gain to approximately 9 dB.

4.3.2.3 Chopper and Loop Integrators

The signal from the Chopper Preamplifier is switched through CMOS analog switches using the In Phase and Quadrature signals as control voltages.

The reactive arm balance is controlled by the Quadrature signal and is the critical path in the control loop. Any fundamental which is phase shifted with regard to the bridge input signal appears as a d.c. error signal after being chopped by the Quadrature signal.

The active integrator in the reactive arm constitutes a second order control loop so the steady state error signal is zero. Phase lead loop compensation is provided by R234 in parallel with C108. The integrator input offset error voltage is adjusted to zero by RV3.

The integrator output drives a loop filter which provides further loop gain and phase compensation required for loop stability. The loop filter output then drives a Darlington emitter follower which has the capacity needed to drive the control element LED. Q44 provides correction for nonlinearity in the control element characteristic.

The resistive arm loop is only a fine trim to make up for component tolerances. Therefore the resistive arm loop gain is lower and the integrator filter is simpler. After the Chopper Preamplifier output signal is chopped by the In Phase signals it is integrated through an RC low pass filter. The integrator drives an emitter follower which in turn drives the resistive arm control element LED.

The gain, of both the reactive and resistive arm integrators is increased, by reducing the input resistance via transmission gates IC11, when the front panel attenuator switch is set to -20 dB or above. This compensates for the reduction in gain of the chopper preamplifier, and maintains constant loop gains in both arms.

4.3.3 Automated Range Control

4.3.3.1 Principle of Operation

The d.c. error signal derived by the control loop to drive the bridge control elements is a function of the frequency difference between the bridge frequency and the input frequency. If the frequency difference is sufficiently large the bridge cannot null. To avoid this an approximate determination is continually made of the incoming frequency. This is compared with the range actually operating and if a difference of more than one range is detected the range is

changed. Operating in parallel with this system are two comparators that detect if the reactive arm control voltage exceeds its normal operating limits. This also causes the range to step in the required direction.

4.3.3.2 Coarse Frequency Measurement

Each bridge range covers a frequency ratio of approximately 1.55 to 1. Therefore the frequency of the nth range is $(1.55)^n$ times the frequency of the bottom range or -

$$T_{low} = \left(\frac{1}{1.55}\right)^n T_n$$

where T_n is the period of the incoming signal.

T_{low} is the longest period on the bottom range.

or rearranging
$$n = \frac{1}{\ln 1.55} \ln \frac{T_n}{T_{low}}$$

If a capacitor is charged to a voltage proportional to the period of the incoming signal and allowed to decay exponentially to a reference voltage then,

$$V_{ref} = V_p e^{-\frac{t}{RC}}$$

where V_{ref} is the reference voltage

V_p is the voltage proportional to input period

RC is the exponential delay time constant

or rearranging
$$t = RC \ln \frac{V_p}{V_{ref}}$$

If the delay time t is measured by a conversion clock whose period is T_c then,

$$n T_c = RC \ln \frac{V_p}{V_{ref}}$$

$$\text{or } n = \frac{RC}{T_c} \ln \frac{KT_n}{V_{ref}}$$

when n = number of clock cycles

$$KT_n = V_p$$

Thus if R, C and T_c are chosen so that $\frac{RC}{T_c} = \frac{1}{\ln 1.55}$ and the constant of proportionality K is chosen such that $\frac{V_{ref}}{K} = T_{low}$ then the number of cycles of the conversion clock is a direct digital indication of the required range.

In the circuit the voltage proportioned to signal period is derived from the Quadrature signal by a constant current generator consisting of IC28 and Q51 which charge C143 for one half period. Resistor R293 is switched across the capacitor by the CMOS analog switches 3/4 IC31. The exponential delay is always completed in less than one quarter of a period so for the last quarter period the capacitor is shorted to ground by the CMOS analog switch 1/4 IC31. This discharges the capacitor ready for the next cycle. The exponential delay capacitor is connected to a voltage comparator IC29 whose input offset voltage is nulled by RV6. After amplification by Q52 the exponential period is used to gate a clock oscillator consisting of IC16 and NAND gate 1/3 IC13 whose frequency can be adjusted by RV4. This adjustment also removes any errors in exponential delay time constant.

The clock output is taken to a four bit digital coarse ranging counter IC17 which counts to the required range before being reset ready for the next cycle. Before the counter is reset its output is compared with the output of a second counter IC18 which controls the bridge relays.

The comparison is performed by a four bit subtractor IC19 and exclusive OR gates IC23 whose outputs are NANDed. The least significant bit of the subtractor is ignored which permits the counters to differ by one bit without causing a range change. When the coarse range counter differs by more than one bit from the relay control counter a preset pulse is fed into an integrator delay circuit and then via the delay circuit 1/2 IC14 to the preset input of the relay control counter. This parallel loads the contents of the coarse ranging counter into the relay control counter.

The integrator delay circuit prevents the preset enable by disabling the delay circuit 1/2 IC14 until the coarse range error has been present for approximately 200 mS to avoid range changing due to heavy noise during SINAD measurements and during loss or break-up of signal on tape recorder distortion measurements.

A separate fine ranging control is generated by comparing the bridge reactive arm control voltage with two limit voltages via comparators 1/2 IC32. If the control voltage exceeds its normal operating limits clock pulses are generated via a free running multivibrator to clock the relay control counter in the required direction.

If the relay control counter is already at one extreme of its range then the "carry out" output of the counter paralyses the clock input via gate 1/3 IC13, and instead enables the "freq. out of range" LED.

The four outputs of the relay control counter operate four relay drivers which can feed the current needed to operate the relays.

In the event that no signal is present at the input to the bridge, transistor Q53 turns off and paralyses the fine ranging multivibrator, preventing unwanted range changes. Also if the frequency is outside the range of the bridge a signal from the carry output of IC18 is gated with the fine ranging error signal by transistors Q48 and Q49 to turn on the "freq. out of range" light D61.

PART 5MAINTENANCE

5.1 GENERAL

This is a high performance instrument and to maintain this performance level, periodic checks are advisable. Inspection should include checks on resistors to ensure that no signs of over-heating are evident. The wire used has an insulating coating of polyvinyl chloride, and the styrofoam capacitors also contain thermo-plastics which must not be subjected to excessive heat. Should servicing be required, take care against a hot soldering iron coming into contact with or being placed near the wiring forms or capacitors.

The opening of covers or removal of parts, except those to which access can be gained by hand, is likely to expose live parts, and also accessible terminals may be live.

The apparatus shall be disconnected from all voltage sources before any adjustment, replacement or maintenance and repair during which the apparatus shall be opened.

If afterwards any adjustment, maintenance or repair of the opened apparatus under voltage is inevitable, it shall be carried out only by a skilled person who is aware of the hazard involved.

5.2 SERVICE

It is important to note when servicing this instrument, that any replacement of circuit components may require a re-adjustment of the pre-set controls to restore the instrument to its original calibrated condition.

Service work of any kind, particularly on sub-miniature components, should be carried out with care. Transistors and diodes, when being replaced, should receive scrupulous care because permanent damage may be caused by the application of excessive heat.

Should it be found during inspections that dust accumulation has built-up inside the instrument this should be removed, preferably by a low pressure jet, or alternatively a soft brush may be lightly used.

Switch control cleaning and lubricating should always be done with a recommended agent and the use of abrasives should be avoided.

The following solution may be made up and applied with a fine brush:

- 12 oz. Anhydrous Lanoline (British Pharmacopeia Standard)
- 1 fl. oz. Mobil Aero Instrument Oil (MIL-L-7870A or NATO-O-142)
- 25 fl. oz. 1, 1, 1 Inhibited Trichlorethane (Dow Chemical Company "Chlorothene NU")

A convenient package of cleaner-lubricant is now available for contacts of wiping, knifing or sliding types. This fluid is pressure packed and the container is fitted with a flexible tube to facilitate the directing of fluid to obscure points. Packaged in 12 oz. cans, it may be ordered as AWA Electrical Contact Cleaning Lubricant.

5.3 FAULT FINDING, REPAIR AND ADJUSTMENT AFTER REPAIR

In the event of a fault or an apparent fault in the instrument, check that the a.c. mains supply is present and the front panel power switch is turned on, next check the fuse in the rear of the instrument. Check the mains voltage selector switch is on the correct setting for the a.c. mains voltage being used. Check that the audio input is connected to the instrument and that a signal is present.

Next check that the power supply is functioning by probing the two T0220 integrated circuit voltage regulators on the right hand rear corner of the main P.C.B. Their outputs should be + and -12 V ± 0.5 V.

Level Meter Section:-

No output for any attenuator setting. If the weighting filter is selected when the option has not been plugged into the machine then no output appears.

Check that the plug and socket assy. connecting the attenuator selector switch to the P.C.B. is mating properly.

Check that a signal appears on the F242A OUTPUT terminals. If so, then the fault lies in the true RMS to DC convertor, if not, then the fault lies in the attenuator, preamplifier filters or meter amplifier.

Nulling Loop & Frequency Ranging:-

The nulling loop can be divided up into seven sections.

- a) Bridge and Associated Amplifiers
- b) Bridge resistive arm control
- c) Isolation amplifier
- d) Frequency locked loop
- e) Bridge reactive arm control
- f) Coarse Ranging circuitry
- g) Fine Ranging circuitry

Failure of one part of the system will often produce an apparent fault in a completely different area.

a) and b) Failures in either the bridge amplifiers or bridge resistive arm control will usually only cause a poor null without affecting the ranging circuitry. The fault cause may then be separated by examining T.P.16. If the fault lies in the resistive arm loop the signal will appear as shown in Fig. 5.1a.



FIG. 5.1

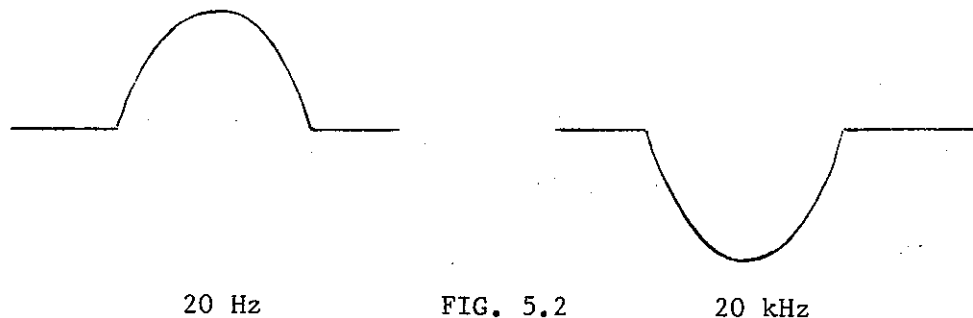
Failure in any of the amplifiers will usually produce gross distortion which is being nulled as far as possible by the control loop and will appear as shown in Fig. 5.1b.

c) Failures in any of the isolation amplifiers will not allow the frequency locked loop to lock up. To check these amplifiers, examine pin 1 of IC25. If the ranging circuitry is hunting, the output should be a sine wave whose amplitude momentarily changes. If the ranging circuitry is not hunting, the output should be a constant amplitude sine wave.

d) Frequency Locked Loop and In Phase and Quadrature Generators. Failure of this section can cause the ranging circuit to hunt but usually will not. The f.l.l. can be checked by examining pins 13 and 12 of IC27. The outputs should be antiphase square waves at twice the incoming signal frequency. To check the In Phase and Quadrature generator, verify that pins 13 and 12 IC30 are antiphase square waves at the incoming signal frequency and that IC30 pin 1 is in phase with IC26 pin 4. Also pin 1 IC30 should be 90° phase shifted with respect to pin 13 IC30, while pin 2 IC30 is antiphase with pin 1 IC30.

e), f) & g) Failure in the bridge reactive arm control, coarse ranging or fine ranging circuitry will cause the relay control counter to hunt, jumping between ranges.

In order to locate the fault the system must first be stabilised. Applying either a 20 Hz or 20 kHz signal should stop the oscillation. If under one of these conditions the "FREQ OUT OF RANGE" light comes on and the loop stops hunting, then the fault probably lies in the reactive arm control loop. This can be verified by examining TP16 again. The signal should appear as shown in Fig. 5.2



If the F242 nulls correctly at either 20 Hz or 20 kHz or the ranging circuitry continues to hunt then the fault lies in the range control circuitry. To separate out faults in the fine and coarse ranging circuitry set up an oscilloscope as for Test Specification No. 6.2.2.2. With a 20 Hz input signal 15 clock positive going edges should appear in each clock burst and at 20 kHz none should appear. For intermediate frequencies the bridge range can be counted off by the number of clock edges appearing as shown in Table 1. It is normal for the clock burst to be momentarily disturbed by any relay operation.

Table 1.

Number of Clock Edges	Lower End of Range
0	14,000
1	9,000
2	5,800
3	3,730
4	2,400
5	1,550
6	1,000
7	640
8	414
9	266
10	172
11	111
12	71.1
13	45.8
14	29.5
15	19.00

If the coarse ranging circuitry is functioning correctly and the ranging circuit is still hunting, examine IC14 pin 10 and 6. If pin 10 has positive going $\frac{1}{2}$ second wide pulses then the fault probably lies in the comparator circuitry (IC's 19, 21 and 23). The pulses may be so close together that they appear a continuous +12 V. If the positive pulses appear on pin 6, then the fault probably is in the fine ranging circuit.

After several years of operation the offset voltage in the resistive and reactive arm integrator operational amplifier inputs may become excessive. The machine can be readjusted according to Test Specification section 6.2.2.1. Any frequency between 20 Hz and 20 kHz can be used; the major requirement is better than -84 dB noise and distortion.

PART 6CALIBRATION AND TEST PROCEDURE

6.1 TEST EQUIPMENT REQUIRED

1. AWA G251 Level Oscillator or equivalent.
2. Input cable with 5 turns wound on toroid core TDK 1 X 27 H5C2, with three contact plug.
3. 75 Ω precision attenuator 0 - 100 dB.
4. Precision resistors (0.5%)
2 x 300 Ω
1 x 600 Ω
1 x 75 Ω
5. Siemens Selective Level Meter (Rel 3W29 3D 332) or equivalent.
- 6.* AWA ULTRA LOW DISTORTION Oscillator G233.
7. 15 MHz Cathode Ray Oscilloscope.
- 8.* AWA G231 Oscillator.
9. Counter of accuracy ± 0.1 Hz on low range.
10. Wandel u. Goltermann EPM-1 Milliwatt Test Set with 600 Ω balanced probe.
11. High voltage amplifier as supplied.
 - (a) 25 V r.m.s. output into high impedance.
 - (b) Linearity ± 0.05 dB for a 10 dB change in level.
 - (c) Gain 30 dB.
 - (d) Input impedance 10 k Ω .

* AWA Low Distortion Oscillator G232, may be used as an alternative to both these instruments.

6.2 ADJUSTMENT AND TESTING

6.2.1 Level Meter Testing

6.2.1.1 Provisional Level Alignment

1. With the power turned off, mechanically zero the F242A meter.
2. SETTINGS:
G251 1 kHz, 600 Ω , 0 dBm
F242A 600 Ω , LEVEL dBm, UNBAL. 0 dBm
3. Adjust G251 level to exactly 0 dBm with its fine level control.
4. Adjust F242A Cal-control RV1 for 0 dB on F242A meter scale.

6.2.1.2 Frequency Response and A.C. Monitor

1. Set-up:

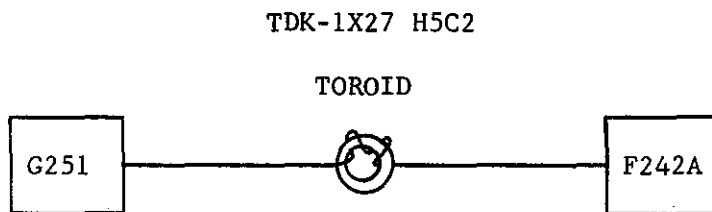


FIG. 1

2. SETTINGS: F242A 600 Ω , 0 dBm, LEVEL dBm,
All filters out

G251 600 Ω , 0 dBm

3. Set G251 frequency to 1 kHz. Set level of G251 so that F242A meter reads 0 dB.
4. Check the F242A meter indications at the following frequencies. Make allowance for the G251 response calibration. CHECK both "BAL" and "UNBAL".
- 4a. Use G231 to check 10 Hz response.

FREQUENCY Hz	10	100	1 k	10 k	30 k	100 k
TOLERANCE \pm dB	0.2	0.2	Ref.	0.2	0.2	0.2 UNBAL. 0.3 BAL.

5. Check that the "OUTPUT" terminal gives about 2 V r.m.s. unloaded.

6.2.1.3 Attenuator Test at 1 kHz

1. Set-up: 0 dBm to -80 dBm

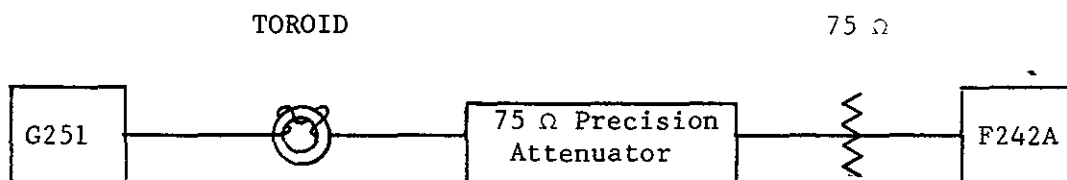


FIG. 2

2. SETTINGS: F242A BRIDGING, LEVEL dBm,
ALL FILTERS OUT, UNBAL.

G251 1 kHz, 9 dBm, 75 Ω

ATTENUATOR 0 dB
3. Set F242A to 0 dBm range and adjust level of G251 to read 0 dB on F242A meter.
4. Switch in 10 dB attenuation and ensure that the F242A meter indicates -10 dB ± 0.5 dB. Switch out the 10 dB attenuator again.
5. Switch in successively 10 dB more attenuation whilst increasing the sensitivity of the F242 in 10 dB steps. Check that the F242A meter stays always within 0 dB ± 0.2 dB.
6. Set-up: 0 dBm to +30 dBm

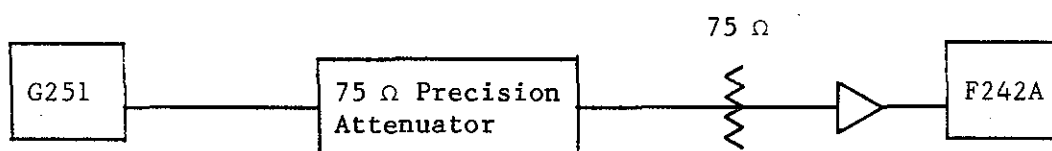


FIG. 3

7. SETTINGS: F242A BRIDGING, LEVEL dBm
ALL FILTERS OUT, UNBAL

G251 1 kHz, 9 dBm, 75 Ω

ATTENUATOR 30 dB
8. Set F242A to 0 dBm range and adjust level of G251 to read 0 dB on F242A meter.
9. Switch out successively 10 dB attenuation whilst decreasing the sensitivity of the F242A in 10 dB steps. Check that the F242A meter stays always within 0 dB ± 0.2 dB.

6.2.1.4 High Level Attenuator Test for REL. LEVEL, UNBALANCED

Repeat tests 6, 7 & 9 of 6.2.1.3 with the F242A set to REL. LEVEL, UNBAL, BRIDGING, COARSE SET REF switch in 4th position from full anticlockwise, FINE SET REF control adjusted for 0 dB on F242A meter with G251 level as in test 4.1.3.8.

6.2.1.5 High Level Attenuator Test for REL. LEVEL, BALANCED

Repeat tests 6, 7 & 9 of 6.2.1.3 for +20 dBm only, with F242A set to BAL, other settings as for 6.2.1.4.

6.2.1.6 COARSE SET REF Attenuator Test

1. Test set-up as in test 6.2.1.3.6
2. Settings: F242A BRIDGING, UNBAL, REL. LEVEL, 0 dBm, ALL FILTERS OUT, FINE SET REF control as for 6.2.1.4, COARSE SET REF. switch fully clockwise.

G251 1 kHz, 75 Ω , Level as in 6.2.1.3.8.

ATTENUATOR 50 dB.

3. Successively rotate the COARSE SET REF Switch anti-clockwise whilst switching out 10 dB steps on the attenuator and check that the F242A Meter reading remains within ± 0.5 dB. Tick result only.
4. Switch F242A to BAL and check reading does not vary by more than 0.5 dB (RLG Test). Tick result only.

6.2.1.7 FINE SET REF Attenuator Test

1. Test set-up as in test 6.2.1.3.6.
2. Settings: F242A BRIDGING, UNBAL, 0 dB range, REL. LEVEL, ALL FILTERS OUT, COARSE SET REF control 4th position from fully anti-clockwise.

G251 1 kHz, 75 Ω , Level as in 6.2.1.3.8.

ATTENUATOR 32 dB.

3. Rotate FINE SET REF control fully clockwise and check F242A meter reading is 1 ± 0.5 dB. Tick only.
4. Rotate FINE SET REF control fully anti-clockwise and check F242A meter reading is 12 ± 1 dB. Tick only.

6.2.1.8 Attenuator Test at 100 kHz

Repeat all tests of 6.2.1.3 with a frequency of 100 kHz instead of 1 kHz.

6.2.1.9 Noise

1. Set F242A to 600 Ω , range switch to -80 dBm, no filter button depressed.
2. Check that reading is below 0.4 V on the 10 V scale of the meter, both for "Bal" and "Unbal".
3. Set F242A to "BRIDGING", check that reading is below -13 dB.

6.2.1.10 Longitudinal Suppression Test

1. Set-up:

Note * Resistors should be 0.5% to ensure matching.

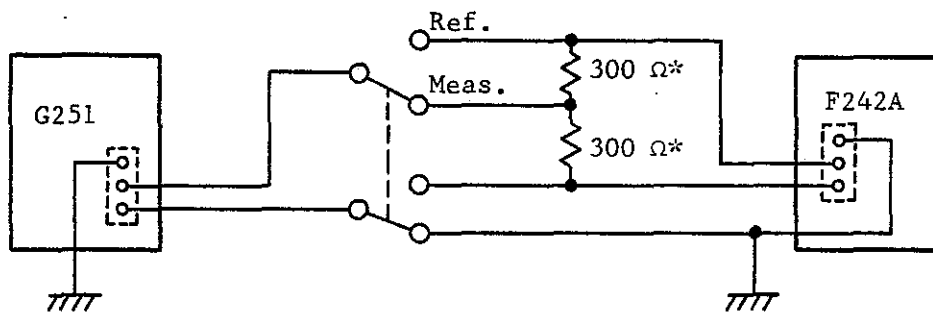


FIG. 4

2. SETTINGS: F242A "Bal" "Bridging"

G251 600 Ω, 30 kHz

3. In the reference position adjust G251 level for 0 dBm reading on F242A.

4. Switch to "Meas" position and check that F242A reading is below -40 dBm

6.2.1.11 Return Loss

1. Set up: For 30 kHz and 100 kHz

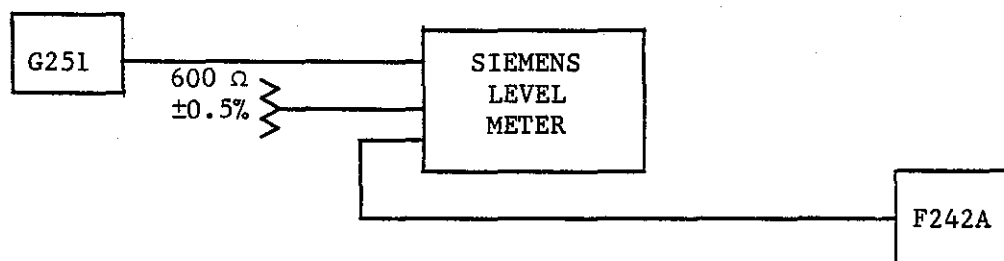


FIG. 5

2. SETTINGS: Siemens Meter Z-switch to 600 Ω high, function switch to wide band return loss, range switch -10 dBm

G251) 600 Ω, "Low Z-out", adjust level for 0 dB
G231) on Siemens level meter

F242A 0 dBm range, 600 Ω

3. Work through the following table, set G251 to respective frequency and F242A to respective mode. For 100 kHz reading it is necessary to use equal lengths of cable to F242 and 600 Ω termination.

	10 Hz	30 kHz	100 kHz
Balanced	30 dB	30 dB	-
Unbalanced	40 dB	40 dB	34 dB

4. 10 Hz Return Loss Set-up

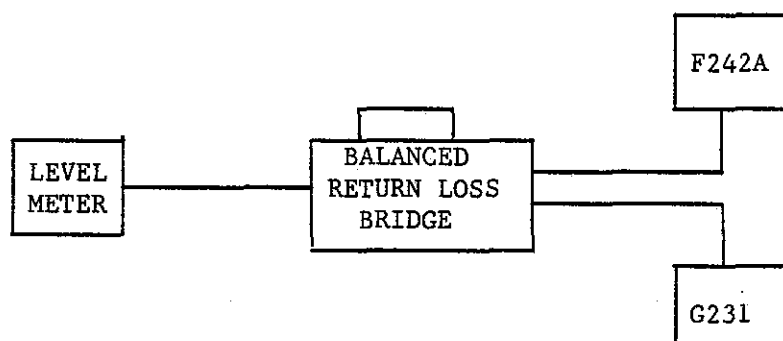


FIG. 6

5. Level Meter Balanced 600 Ω - 10 dB
 F242A 600 Ω ; Bal or Unbal
 G231 10 Hz; level so that level meter reads -10 dB
 with bridge on calibrate
6. Calibrate bridge at 10 Hz with bridge internal termination switch in OUT position.
- Switch bridge to READ and read balanced return loss on level meter. Repeat for Unbalanced F242A.

6.2.1.12 Lo-Cut Filter

- Set up: See Fig. 7
- Settings: G251 0 dBm, 600 Ω , 1 kHz
 F242A 0 dBm, 600 Ω , LEVEL, UNBAL
- Set G251 so that F242A reads exactly 0 dB on meter.
- Switch F242A to LO-CUT and check that the meter indication is 0 dB \pm 0.15 dB.
- Set G251 to 400 Hz and check that F242A meter indication is 0 dB \pm 0.2 dB.

6. Set G251 to 50 Hz and check that F242A indicates a level of less than -45 dBm.

6.2.1.13 Hi-Cut Filter

1. Same as for Lo-cut Filter steps 1, 2 and 3 (6.2.1.12).
2. Switch F242A to Hi-Cut and check that the meter indication is 0 dB ± 0.1 dB
3. Switch G251 to 10 kHz and check that F242A meter indication is above -0.5 dB.
4. Set G251 to 32 kHz and check that F242A meter indication is below -18 dB.

6.2.1.14 Test of Program Weighting Network (Option 001)

1. Set up:

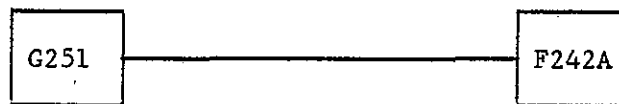


FIG. 7

2. SETTINGS: G251 0 dBm, 600 Ω , 6300 Hz
F242A 0 dBm, 600 Ω , LEVEL dBm, UNBAL, ALL FILTERS OUT.
3. Set G251 so that F242A reads exactly -0.2 dB on meter.
4. Switch F242A to WTG and +10 dB. Adjust RV401 so that the meter reads +2.0 dB. Increase G251 level by 0.2 dB.
5. LEAVE THE OSCILLATOR LEVEL CONSTANT and check the F242A WTG response against the following table.

Hz Frequency	31.5	63	100	200	400	800	1k	2k	3.15k	k4	5k
Response	- 29.9	- 23.9	- 19.8	- 13.8	- 7.8	- 1.9	0	+ 5.6	+ 9.0	+ 10.5	+ 11.7
Tolerance	2.0	1.4	1.0	0.85	0.7	0.55	0.5	0.5	0.5	0.5	0.5

Frequency Hz	6.3k	7.1k	8k	9k	10k	12.5k	14k	16k	20k	31.5k
Response dB	+ 12.2	+ 12.0	+ 11.4	+ 10.1	+ 8.1	0	- 5.3	- 11.7	- 22.2	- 42.7
Tolerance \pm dB	0	0.2	0.4	0.6	0.8	1.2	1.4	1.65	2.0	+2.8 -0.5

6.2.1.15 Test of Telephone Weighting Network (Option 002)

1. Set-up: As in 6.2.1.14.1.
2. Settings: G251 0 dBm, 600 Ω , 800 Hz
F242A 0 dBm, 600 Ω , UNBAL, ALL FILTERS OUT

3. Set G251 so that F242A reads exactly 0 dB on meter.
4. Switch F242A to Tel. Wtg. and adjust RV1 on the Telephone Weighting Network so that meter reads exactly 0 dB.
5. Leave G251 level constant and check Tel. Wtg. response against following table.

Frequency (Hz)	50	100	200	400	600	800	1K
Response (db)	-63	-41	-21	-6.3	-2.0	0.0	+1.0
Tolerance (dB)	<u>+2</u>	<u>+2</u>	<u>+2</u>	<u>+1</u>	<u>+1</u>	0	<u>+1</u>

Frequency (Hz)	1.2K	1.5K	2K	3K	4K	5K	>5K
Response (dB)	0	-1.3	-3	-5.6	-15	-36	<-36
Tolerance (dB)	<u>+1</u>	<u>+1</u>	<u>+1</u>	<u>+1</u>	<u>+3</u>	<u>+3</u>	

6.2.1.16 Level Calibration

Calibrate the G251 at a setting of 1 kHz 600 Ω 0 dBm, using the W & G EPM-1 Milliwatt Test Set.

The G251 may then be used for level calibration as below:-

1. Settings: G251 1 kHz 600 Ω 0 dBm
F242 600 Ω LEVEL dBm UNBAL 0 dBm
2. Adjust G251 to exactly 0 dBm.
3. Adjust F242A CAL control RV1 for 0 dB on F242A scale.

6.2.1.17 Testing of "C" Message Weighting Network

1. Set-up: As in 6.2.1.14.1.
2. Settings: G251 0 dBm 600 Ω 1 kHz
F242A 0 dBm 600 Ω UNBAL. ALL FILTERS OUT.
3. Check that the F242A reads exactly 0 dB on the meter
4. Switch to WTG on the F242A and adjust RV1 on the weighting network so that the meter again reads exactly 0 dB.

5. Leave the G251 level constant and check the "C" Message frequency response against the following table.

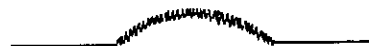
Freq.	Level (dB)	Tol. (dB)
60 Hz	-55.7	± 1
200 Hz	-25.0	± 1
500 Hz	- 7.5	± 0.5
800 Hz	- 1.5	± 0.5
1 kHz	0	± 0 (reference)
2 kHz	- 1.3	± 0.5
3 kHz	- 2.5	± 0.5
5 kHz	-28.5	± 1.5
25.3 kHz	<-60.0	$\pm 0 - \infty$

6.2.2 Nulling Loop Testing

6.2.2.1. Bridge Balance Adjustment

Bottom cover must be fitted.

- Settings: F242A Bridging Unbal. All filters out.
AWA G233 Ultra Low Distortion Oscillator
2000 Hz, Level 0.3 Volts
15 MHz c.r.o. Trigger mode EXT from G233 Oscillator
sync output.
Input from F242A Internal Test Point 16
Vert gain as desired.
- Set COARSE FREQ. CLOCK ADJ RV4 and EXPONENT COMPARATOR OFFSET ADJ RV6 to approx. mid. point.
- Calibrate F242A for distortion measurement with switched calibrate attenuator in the 4th position from full anti-clockwise. If necessary, adjust the signal level.
- Ensure that F242A is nulling at least approximately.
- Adjust X ARM [OR NUL RV3 and R ARM [OR NULL RV2 to completely null signal. Use oscilloscope to aid adjustment as shown below. The low cut filter may be used if hum is present.



R ARM out of adjustment

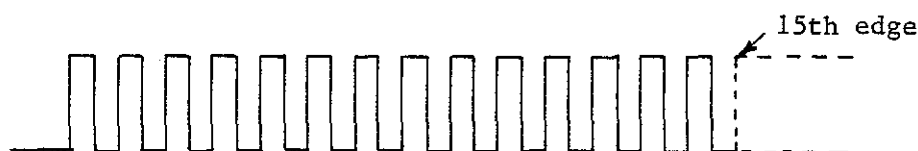


X ARM out of adjustment

Allow at least 30 seconds for loop to settle completely before verifying that adjustment is complete. For final adjustment refer to F242A meter not c.r.o. A display of the F242A output is also useful. The null should be -88 dB to -90 dB distortion.

6.2.2.2 Auto Ranging Circuit Adjustment

1. Settings: F242A Bridging Unbal.
All filters out
G233 0.3 volts approx.
29.5 Hz ± 0.1 Hz (33.9 ± 0.1 ms)
15 MHz C.R.O. triggered externally from TP19
Monitoring TP13
Vert 5 V/div Hor 20 μ sec/div
2. Go through normal procedure for distortion measurement on F242A.
3. Short TP15 to TP14.
4. Adjust EXPONENT COMPARATOR OFFSET ADJ RV6 to centre of band where oscillation is observed. Remove short circuit.
5. Move oscilloscope probe to TP12. Adjust COARSE FREQ CLOCK ADJ RV4 so that waveform on c.r.o. appears as shown below with 15th rising edge just appearing.



6.2.2.3 Bridge Range Test

1. Settings: F242A Bridging Unbal. All filters out
G233 0.8 volt approx.
Counter monitoring G233 frequency accurate to ± 1 Hz.
2. Set G233 frequency to 90 Hz and operate F242A for normal distortion readings. Distortion should be of the order of -86 dB.
3. Slowly increase the frequency, so the nulling loop is able to keep track of the change in frequency with the attenuation set at -40dB until the F242A changes range. This will show as an audible click from the range control relays combined with the F242A meter momentarily going off scale. Note the frequency at which the range occurs referring to the table below.
4. Slowly decrease the frequency as above until the range changes back again. Note the frequency at which the range change occurs.

5. Repeat steps 3 and 4 as per the following table of frequencies.

Starting Frequency	Range Change UP Greater than	Range Change DOWN Less than
90	119	115
600	700	667
900	1092	1037
1400	1708	1610
2100	2652	2500
3500	4093	3882

6. Set the frequency to 19.25 \pm 0.1 Hz (51.9 \pm 0.25 msec period) and 21000 Hz \pm 100 Hz and verify that bridge nulls without FREQ OUT OF RANGE lights front panel coming on.

6.2.2.4 Frequency Out of Range Test

- Settings: F242A Bridging Unbal. All Filters out
G233 0.8 volts approx.
15 MHz C.R.O. monitoring either side of C99
Vert. 1 V/div Hor. 10 μ sec/div
- Set the G233 frequency to 30 kHz \pm 1 kHz, and operate the F242A for normal distortion readings. Verify that the FREQ OUT OF RANGE light on the front panel comes on.
- Switch the front panel attenuator to -20 dB and check that the waveform on C99 is a sine wave of approx. 2.4 volts p-p. Check that this waveform is present for all attenuator settings above -20 dB.
- Set the G233 to 100 kHz \pm 10 kHz and verify that the FREQ OUT OF RANGE light stays on.

6.2.2.5 Residual Distortion Test

- Settings: F242A Bridging Unbal. All filters out.
G233 Ultra Low Distortion Oscillator
Level set to 0.3 volts.
- Calibrate F242A with the COARSE SET REF attenuator in the 4th position from fully anti-clockwise.
- Set oscillator to the frequencies in the table below and ensure that the observed residual distortion is less than the figure given. Allow at least 10 seconds for the F242A and oscillator to settle after each frequency change.

FREQ.	RESIDUAL
20 Hz	-84 dB
200 Hz	-84 dB
2 kHz	-86 dB
20 kHz	-84 dB

PART 7COMPONENT SCHEDULE

7.1 EXPLANATORY NOTES

The component schedule is laid out as follows:

Column 1 Circuit Reference Number
 Column 2 Description
 Column 3 AWA Stock Code Number

Because of unavailability at the date of manufacture, some components in the equipment may differ slightly from the components listed in the schedule. These substitute components do not degrade the performance of the equipment.

When ordering replacement components from AWA, the type number of the unit (or sub-unit) and the circuit reference number of the component should be quoted in addition to the details appearing in the component schedule. This information will ensure the supply of a suitable substitute component should the listed component be obsolete or unavailable.

7.2 DISTORTION & NOISE METER F242A, 2A70542

7.2.1 Components Mounted on Chassis

SWF	Switch, power	C&K Toggle DPDT 7201-P3PYZQ
SWG	Voltage switch	Arco T225/SD
D100	LED Indicator	Rodan type BD701R
SKC	International Mains Socket	1019556
ME1	Meter	AWA 70542W6
T1	Input transformer	AWA 3TW69964
T2	Power transformer	AWA 1TU69967
FS1	20mm fuse link, 100mA, delayed action	Australux DA205 (for 240 V)
	20mm fuse link, 200mA, delayed action	Australux DA205 (for 120 V)

7.2.2 Components on Printed Circuit Board 2R70543

7.2.2.1 Capacitors

C1	Capacitor, electrolytic, aluminium, 220 μ F, +50-10%, 63V	1007837
C2	Capacitor, electrolytic, aluminium, 220 μ F, +50-10%, 63V	1007837
C3	Capacitor, met. polyester, 100nF, \pm 10%, 250V	227096
C4	Capacitor, ceramic disc, 22pF, \pm 5%, 500V NPO	220883
C5	Capacitor, electrolytic, tantalum, 10 μ F, \pm 10%, 20V	228772
C6	Capacitor, ceramic disc, 22pF, \pm 5%, 500V NPO	220883
C7	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C8	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C9	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C10	Capacitor, electrolytic, tantalum, 2 μ 2F, \pm 10%, 20V	1004176
C11	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C12	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C13	Not used	

C14	Capacitor, electrolytic, tantalum, 2 μ 2F, \pm 10%, 20V	1004176
C15	Capacitor, electrolytic, tantalum, 2 μ 2F, \pm 10%, 20V	1004176
C16	Capacitor, electrolytic, tantalum, 330 μ F, \pm 10%, 6V	229778
C17	Capacitor, electrolytic, tantalum, 68 μ F, \pm 10%, 15V	229628
C18	Capacitor, electrolytic, tantalum, 47 μ F, \pm 20%, 35V	1008308
C19	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C20	Capacitor, ceramic disc, 33pF, \pm 5%, 500V, NPO	221162
C21	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C22	Capacitor, electrolytic, tantalum, 180 μ F, \pm 10%, 6V	229747
C23	Capacitor, ceramic disc, 4p7F, \pm 0p5F, 500V, NPO	220217
C24	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C25	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C26	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C27	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C28	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C29	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C30	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C31	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C32	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C33	Capacitor, polystyrene, 729pF, \pm 2%	AEE Type PFE216-LB3729G
C34	Capacitor, polystyrene, 31n4F, \pm 1%	AEE Type PFE216-DC5314F
C35	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C36	Capacitor, polystyrene, 11n6F, \pm 2%	AEE Type PFE216-DC5116G
C37	Capacitor, polystyrene, 20n5F, \pm 2%	AEE Type AFE216-DC5205G
C38	Capacitor, polystyrene, 1n75F, \pm 2%	AEE Type PFE216-GC4175G
C39	Capacitor, ceramic disc, 22pF, \pm 5%, 500V, NPO	220883
C40	Capacitor, met. polyester, 100nF, \pm 10%, 250V	227096
C41	Capacitor, ceramic disc, 22pF, \pm 5%, 500V, NPO	220883
C42	Capacitor, electrolytic, tantalum, 47 μ F, \pm 10%, 6V	229556
C43	Capacitor, polystyrene, 100nF, \pm 1%	RIFA Type PFE216-DD61
C44	Capacitor, polystyrene, 100nF, \pm 1%	RIFA Type PFE216-DD61
C45	Capacitor, ceramic, disc, 47 nF, +80%-20%, 25 V, Hi-K	226822
C46	Capacitor, polystyrene, 100nF, \pm 1%	RIFA Type PFE216-DD61
C47	Not used	
C48	Not used	
C49	Capacitor, polystyrene, 578pF, \pm 2%	AEE Type PFE216-LB3578G
C50	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C51	Capacitor, polystyrene, 562pF, \pm 2%	AEE Type PFE216-LB3562G
C52	Capacitor, polystyrene, 578pF, \pm 2%	AEE Type PFE216-LB3578G
C53	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C54	Capacitor, ceramic disc, 47nF, +48-20%, 25V, HiK	226822
C55	Capacitor, ceramic disc, 4p7F, \pm 0p5F, 500V	220217
C56	Capacitor, electrolytic, tantalum, 180 μ F, \pm 10%, 6V	229747
C57	Capacitor, ceramic disc, 150pF, \pm 5%, 500V, N750	222716
C58	Capacitor, met. polyester, 100nF, \pm 10%, 250V	227096
C59	Capacitor, electrolytic, tantalum, 180 μ F, \pm 10%, 6V	229747
C60	Capacitor, electrolytic, tantalum, 150 μ F, \pm 10%, 15V	229736
C61	Capacitor, electrolytic, tantalum, 47 μ F, \pm 20%, 35V	1008308
C62	Capacitor, polystyrene, 560pF, \pm 2%	AEE Type PFE216-LB356G
C63	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C64	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C65	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C66	Capacitor, ceramic disc, 10pF, \pm 1pF, 500V, NPO	220456
C67	Capacitor, ceramic disc, 33pF, \pm 5%, 500V, NPO	221162
C68	Capacitor, ceramic disc, 1nF, \pm 20%, 500V, HiK	1005387
C69	Capacitor, electrolytic, tantalum, 22 μ F, \pm 10%, 15V	229320
C70	Capacitor, electrolytic, tantalum, 1 μ F, \pm 10%, 35V	227739

C71	Capacitor, electrolytic, aluminium, 2200 μ F, +100-10%, 25V	
	AEE Type PEG123-HL422	
C72	Capacitor, electrolytic, aluminium, 2200 μ F, +100-10%, 25V	
	AEE Type PEG123-HL422	
C73	Capacitor, met. polyester, 330nF, \pm 10%, 250V	1014720
C74	Capacitor, met. polyester, 330nF, \pm 10%, 250V	1014720
C75	Capacitor, electrolytic, tantalum, 1 μ F, \pm 10%, 35V	227739
C76	Capacitor, met. polycarbonate, 1 μ F, \pm 2%, 63V	Anelco, MFD 1 μ FG63V
C77	Capacitor, polystyrene, 172nF, \pm 1%	AEE Type PFE216-DF6172F
C78	Capacitor, polystyrene, 29n5F, \pm 1%	AEE Type PFE216-DC5295F
C79	Capacitor, polystyrene, 5n09F, \pm 1%	AEE Type PFE216-GC4509F
C80	Capacitor, ceramic, disc, 22 pF, \pm 5%, NPO	220883
C81	Capacitor, met. polycarbonate, 1 μ F, \pm 2%, 63V	Anelco, MFD 1 μ FG63V
C82	Capacitor, polystyrene, 172nF, \pm 1%	AEE Type PFE216-DF6172F
C83	Capacitor, polystyrene, 29n5F, \pm 1%	AEE Type PFE216-DC5295F
C84	Capacitor, polystyrene, 5n09F, \pm 1%	AEE Type PFE216-GC4509F
C85	Not used	
C86	Capacitor, electrolytic, tantalum, 22 μ F, \pm 10%, 15V	229320
C87	Capacitor, ceramic disc, 22pF, \pm 5%, 500V, NPO	220883
C88	Capacitor, electrolytic, tantalum, 100 μ F, \pm 10%, 10V	229699
C89	Capacitor, ceramic disc, 15pF, \pm 1pF, 500V, NPO	220704
C90	Capacitor, electrolytic, tantalum, 22 μ F, \pm 10%, 15V	229320
C91	Capacitor, electrolytic, tantalum, 330 μ F, \pm 10%, 6V	229778
C92	Capacitor, electrolytic, tantalum, 22 μ F, \pm 10%, 15V	229320
C93	Capacitor, electrolytic, tantalum, 100 μ F, \pm 10%, 10V	229699
C94	Capacitor, ceramic disc, 100pF, \pm 5%, 500V, N750	222214
C95	Capacitor, electrolytic, tantalum, 22 μ F, \pm 10%, 15V	229320
C96	Capacitor, electrolytic, tantalum, 22 μ F, \pm 10%, 15V	229320
C97	Capacitor, ceramic plate, 22pF, \pm 2%, 100V, NPO	Philips 2222-632-10229
C98	Capacitor, ceramic plate, 220pF, \pm 2%, 100V, N750	Philips 2222-632-58221
C99	Capacitor, electrolytic, tantalum, 220 μ F, \pm 10%, 10V	229765
C100	Capacitor, ceramic disc, 100pF, \pm 5%, 500V, N750	222214
C101	Not used	
C102	Capacitor, electrolytic, tantalum, 100 μ F, \pm 10%, 10V	229699
C103	Capacitor, met. polyester, 220nF, \pm 10%, 250V	1006225
C104	Capacitor, ceramic plate, 220pF, \pm 10%, 100V	Philips 2222-630-03221
C105	Not used	
C106	Capacitor, met. polycarbonate, 2 μ 2F, \pm 10%, 250V	1005249
C107	Capacitor, ceramic disc, 100pF, \pm 5%, 500V, N750	222214
C108	Capacitor, met. polyester, 1 μ F, \pm 10%, 250V	227851
C109	Capacitor, met. polycarbonate, 4 μ 7F, \pm 10%, 100V	1018620
C110	Not used	
C111	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C112	Capacitor, ceramic disc, 1nF, +80-20%, 500V, HiK	225026
C113	Capacitor, ceramic disc, 4n7F, \pm 20%, 500V, HiK	225987
C114	Capacitor, electrolytic, tantalum, 150 μ F, \pm 10%, 15V	229736
C115	Capacitor, electrolytic, tantalum, 22 μ F, \pm 10%, 15V	229320
C116	Capacitor, ceramic disc, 10pF, \pm 1pF, 500V, NPO	220456
C117	Capacitor, met. polyester, 470nF, \pm 10%, 250V	227472
C118	Capacitor, met. polyester, 100nF, \pm 10%, 250V	227096
C119	Capacitor, met. polyester, 100nF, \pm 10%, 250V	227096
C120	Capacitor, polystyrene, 120pF, \pm 2%	AEE Type PFE210-GB312G
C121	Capacitor, ceramic disc, 1nF, +80-20%, 500V, HiK	225026
C122	Capacitor, ceramic disc, 6p8F, \pm 0p5F, 500V, NPO	220380
C123	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C124	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C125	Capacitor, electrolytic, tantalum, 10 μ F, \pm 10%, 20V	228772

C126	Not used	
C127	Capacitor, electrolytic, tantalum, 39 μ F, $\pm 10\%$, 10V	229530
C128	Capacitor, ceramic disc, 100pF, $\pm 5\%$, 500V, N750	222214
C129	Capacitor, ceramic disc, 10pF, ± 1 pF, 500V, NPO	220456
C130	Capacitor, ceramic disc, 100pF, $\pm 5\%$, 500V, N750	222214
C131	Capacitor, ceramic plate, 47pF, $\pm 2\%$, NPO	Philips 2222-632-10479
C132	Capacitor, ceramic plate, 68pF, $\pm 2\%$, NPO	Philips 2222-632-10689
C133	Capacitor, ceramic plate, 1n5, $\pm 10\%$	Philips 2222-630-03152
C134	Capacitor, ceramic disc, 10nF, +80-20%, 30V, HiK	1021119
C135	Capacitor, ceramic plate, 6p8F, $\pm 2\%$, NPO	Philips 2222-632-09688
C136	Capacitor, ceramic plate, 47pF, $\pm 2\%$, NPO	Philips 2222-632-10479
C137	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	225822
C138	Capacitor, met. polyester, 2 μ 2F, $\pm 10\%$, 63V DC	ERO MKT 1822
C139	Capacitor, met. polyester, 22nf, $\pm 10\%$, 400V DC	ERO MKT 1822
C140	Capacitor, electrolytic, tantalum, 1 μ F, $\pm 10\%$, 35V	227739
C141	Capacitor, electrolytic, tantalum, 2 μ 2F, $\pm 10\%$, 20V	1004176
C142	Capacitor, ceramic disc, 47pF, $\pm 5\%$, 500V, NPO	221431
C143	Capacitor, polystyrene, 27nF, $\pm 2\%$	AEE Type PFE216-DC527G
C144	Capacitor, ceramic disc, 470pF, $\pm 20\%$, 500V, HiK	224204
C145	Not used	
C146	Capacitor, ceramic disc, 10pF, ± 1 pF, 500V, NPO	220456
C147	Capacitor, electrolytic, aluminium, 680 μ F, +50-10%, 16V	1024575
C148	Capacitor, electrolytic, aluminium, 680 μ F, +50-10%, 16V	1024575
C149	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C150	Not used	
C151	Capacitor, electrolytic, tantalum, 1 μ F, $\pm 10\%$, 35V	227739
C152	Capacitor, ceramic disc, 330pF, $\pm 20\%$, 500V, HiK	223707
C153	Capacitor, ceramic disc, 100pF, $\pm 5\%$, 500V, N750	222214
C154	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	225822

7.2.2.2 Resistors

R1	Resistor, metal film, 604 Ω , $\pm 2\%$, 2W	Corning FP42
R2	Resistor, metal film, 38k3 Ω , $\pm 1\%$, 100ppm, 1/4W	1021403
R3	Resistor, metal film, 38k3 Ω , $\pm 1\%$, 100ppm, 1/4W	1021403
R4	Resistor, metal film, 1k3 Ω , $\pm 1\%$, 100ppm, 1/4W	1008749
R5	Resistor, metal film, 10 Ω , $\pm 2\%$, 1/4W	1008698
R6	Resistor, metal film, 1k3 Ω , $\pm 1\%$, 100ppm, 1/4W	1008749
R7	Resistor, metal film, 470k Ω , $\pm 2\%$, 1/4W	1008810
R8	Resistor, metal film, 87k6 Ω , $\pm 0.5\%$, 50ppm, 1/4W	RN60C
R9	Resistor, metal film, 820k Ω , $\pm 2\%$, 1/4W	1008816
R10	Resistor, metal film, 330 Ω , $\pm 2\%$, 1/4W	1008734
R11	Resistor, metal film, 6k65 Ω , $\pm 1\%$, 100ppm, 1/4W	1021348
R12	Resistor, metal film, 5k90 Ω , $\pm 0.5\%$, 50ppm, 1/4W	RN60C
R13	Resistor, metal film, 820k Ω , $\pm 2\%$, 1/4W	1008816
R14	Resistor, metal film, 1k27 Ω , $\pm 1\%$, 100ppm, 1/4W	1021296
R15	Resistor, metal film, 96k5 Ω , $\pm 0.5\%$, 50ppm, 1/4W	RN60C
R16	Resistor, metal film, 866 Ω , $\pm 0.5\%$, 50ppm, 1/4W	RN60C
R17	Resistor, metal film, 787 Ω , $\pm 1\%$, 100ppm, 1/4W	1021281
R18	Resistor, metal film, 240 Ω , $\pm 2\%$, 1/4W	1008731
R19	Resistor, metal film, 732 Ω , $\pm 0.5\%$, 50ppm, 1/4W	RN60C
R20	Resistor, metal film, 3k28, $\pm 0.5\%$, 50ppm, 1/4W	RN60C
R21	Not used	
R22	Resistor, metal film, 80R6 Ω , $\pm 0.5\%$, 50ppm, 1/4W	RN60C
R23	Resistor, metal film, 12k Ω , $\pm 2\%$, 1/4W	1008772
R24	Resistor, metal film, 220k Ω , $\pm 2\%$, 1/4W	1008801
R25	Resistor, metal film, 82 Ω , $\pm 2\%$, 1/4W	1008720

R26	Not used	
R27	Resistor, metal film, 100k Ω , $\pm 2\%$, 1/4W	1008794
R28	Not used	
R29	Not used	
R30	Not used	
R31	Not used	
R32	Not used	
R33	Resistor, metal film, 1k Ω , $\pm 2\%$, 1/4W	1008746
R34	Not used	
R35	Not used	
R36	Resistor, metal film, 200k Ω , $\pm 2\%$, 1/4W	1008801
R37	Resistor, metal film, 100 Ω , $\pm 2\%$, 1/4W	1008722
R38	Resistor, metal film, 15k4 Ω , $\pm 0.5\%$, 50ppm, 1/4W	RN60C
R39	Resistor, metal film, 2k43 Ω , $\pm 0.5\%$, 50ppm, 1/4W	RN60C
R40	Not used	
R41	Resistor, metal film, 665 Ω , $\pm 0.5\%$, 50ppm, 1/4W	RN60C
R42	Resistor, metal film, 200 Ω , $\pm 0.5\%$, 50ppm, 1/4W	RN60C
R43	Resistor, metal film, 12k4 Ω , $\pm 0.5\%$, 50ppm, 1/4W	RN60C
R44	Resistor, metal film, 4k7 Ω , $\pm 2\%$, 1/4W	1008762
R45	Not used	
R46	Resistor, metal film, 68k Ω , $\pm 2\%$, 1/4W	1008790
R47	Resistor, metal film, 390 Ω , $\pm 2\%$, 1/4W	1008736
R48	Resistor, metal film, 1k8 Ω , $\pm 2\%$, 1/4W	1008752
R49	Resistor, metal film, 1k Ω , $\pm 2\%$, 1/4W	1008746
R50	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R51	Resistor, metal film, 150 Ω , $\pm 2\%$, 1/4W	1008726
R52	Resistor, metal film, 150 Ω , $\pm 2\%$, 1/4W	1008726
R53	Resistor, metal film, 100k Ω , $\pm 2\%$, 1/4W	1008794
R54	Resistor, metal film, 2k2 Ω , $\pm 2\%$, 1/4W	1008754
R55	Not used	
R56	Resistor, metal film, 2k2 Ω , $\pm 2\%$, 1/4W	1008754
R57	Resistor, metal film, 2k2 Ω , $\pm 2\%$, 1/4W	1008754
R58	Resistor, metal film, 1k5 Ω , $\pm 1\%$, 100ppm, 400 mW	1008750
R59	Resistor, metal film, 1k5 Ω , $\pm 1\%$, 100ppm, 400 mW	1008750
R60	Not used	
R61	Resistor, metal film, 1k Ω , $\pm 2\%$, 1/4W	1008746
R62	Resistor, metal film, 3k3 Ω , $\pm 2\%$, 1/4W	1008758
R63	Resistor, metal film, 1k5 Ω , $\pm 2\%$, 1/4W	1008750
R64	Resistor, metal film, 1k5 Ω , $\pm 1\%$, 100ppm, 400 mW	1008750
R65	Not used	
R66	Resistor, metal film, 1k5 Ω , $\pm 1\%$, 100ppm, 400 mW	1008750
R67	Resistor, metal film, 1k5 Ω , $\pm 1\%$, 100ppm, 400 mW	1008750
R68	Resistor, metal film, 1k Ω , $\pm 2\%$, 1/4W	1008746
R69	Resistor, metal film, 1k5 Ω , $\pm 2\%$, 1/4W	1008750
R70	Resistor, metal film, 3k3 Ω , $\pm 2\%$, 1/4W	1008758
R71	Resistor, metal film, 22k Ω , $\pm 2\%$, 1/4W	1008778
R72	Resistor, metal film, 3k28 Ω , $\pm \frac{1}{2}\%$, 25ppm, 0.4W	Roederstein Mk2
R73	Resistor, metal film, 942 Ω , $\pm \frac{1}{2}\%$, 25ppm, 0.4W	Roederstein Mk2
R74	Resistor, metal film, 40k2 Ω , $\pm \frac{1}{2}\%$, 25ppm, 0.4W	Roederstein Mk2
R75	Not used	
R76	Not used	
R77	Not used	
R78	Not used	
R79	Not used	
R80	Not used	

R81	Resistor, metal film, 1k2 Ω , $\pm 2\%$, 1/4W	1008748
R82	Resistor, metal film, 1k2 Ω , $\pm 2\%$, 1/4W	1008748
R83	Resistor, metal film, 2k2 Ω , $\pm 2\%$, 1/4W	1008754
R84	Resistor, metal film, 5k1 Ω , $\pm 2\%$, 1/4W	1008763
R85	Not used	
R86	Resistor, metal film, 120k Ω , $\pm 2\%$, 1/4W	1008796
R87	Resistor, metal film, 2k2 Ω , $\pm 2\%$, 1/4W	1008754
R88	Resistor, metal film, 1k5 Ω , $\pm 2\%$, 1/4W	1008750
R89	Resistor, metal film, 681 Ω , $\pm 1\%$, 100ppm, 400 mW	1008742
R90	Resistor, carbon, 10M Ω , $\pm 10\%$, 1/3W	Philips Type CR25
R91	Resistor, metal film, 100 Ω , $\pm 2\%$, 1/4W	1008722
R92	Resistor, metal film, 220 Ω , $\pm 2\%$, 1/4W	1008730
R93	Resistor, metal film, 4k7 Ω , $\pm 2\%$, 1/4W	1008762
R94	Resistor, metal film, 33k Ω , $\pm 2\%$, 1/4W	1008782
R95	Not used	
R96	Resistor, metal film, 19k1 Ω , $\pm 1\%$, 100ppm, 400 mW	1021381
R97	Resistor, metal film, 1k27 Ω , $\pm 1\%$, 100ppm, 400 mW	1021296
R98	Resistor, metal film, 32k4 Ω , $\pm 1\%$, 100ppm, 400 mW	1021398
R99	Resistor, metal film, 220k Ω , $\pm 2\%$, 1/4W	1008802
R100	Resistor, metal film, 27 Ω , $\pm 2\%$, 1/4W	1008708
R101	Resistor, metal film, 47k Ω , $\pm 2\%$, 1/4W	1008786
R102	Resistor, metal film, 1k Ω , $\pm 2\%$, 1/4W	1008746
R103	Resistor, metal film, 47 Ω , $\pm 2\%$, 1/4W	1008714
R104	Resistor, metal film, 33 Ω , $\pm 2\%$, 1/4W	1008710
R105	Resistor, metal film, 6.8k Ω , $\pm 2\%$, 1/4W	1008766
R106	Resistor, metal film, 4k42 Ω , $\pm 1\%$, 100ppm, 400 mW	1021335
R107	Resistor, metal film, 4k42 Ω , $\pm 1\%$, 100ppm, 400 mW	1021335
R108	Resistor, metal film, 4k42 Ω , $\pm 1\%$, 100ppm, 400 mW	1021335
R109	Resistor, metal film, 2k2 Ω , $\pm 2\%$, 1/4W	1008754
R110	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R111	Resistor, metal film, 1k Ω , $\pm 2\%$, 1/4W	1008746
R112	Resistor, metal film, 2k21 Ω , $\pm 1\%$, 100ppm, 400 mW	1008754
R113	Resistor, metal film, 2k2 Ω , $\pm 2\%$, 1/4W	1008754
R114	Resistor, metal film, 2k2 Ω , $\pm 2\%$, 1/4W	1008754
R115	Not used	
R116	Resistor, metal film, 390 Ω , $\pm 2\%$, 1/4W	1008736
R117	Resistor, metal film, 390 Ω , $\pm 2\%$, 1/4W	1008736
R118	Resistor, metal film, 4k42 Ω , $\pm 1\%$, 100ppm, 400 mW	1021335
R119	Resistor, metal film, 3k83 Ω , $\pm 1\%$, 100ppm, 400 mW	1021331
R120	Not used	
R121	Resistor, metal film, 2k2 Ω , $\pm 2\%$, 1/4W	1008754
R122	Resistor, metal film, 470 Ω , $\pm 2\%$, 1/4W	1008738
R123	Resistor, metal film, 1k6 Ω , $\pm 2\%$, 1/4W	1008751
R124	Resistor, metal film, 4k7 Ω , $\pm 2\%$, 1/4W	1008762
R125	Not used	
R126	Resistor, metal film, 4k7 Ω , $\pm 2\%$, 1/4W	1008762
R127	Resistor, metal film, 2k2 Ω , $\pm 2\%$, 1/4W	1008754
R128	Not used	
R129	Not used	
R130	Resistor, metal film, 1k65 Ω , $\pm 1\%$, 100ppm, 400 mW	1021304
R131	Resistor, metal film, 1k58 Ω , $\pm 1\%$, 100ppm, 400 mW	1021303
R132	Resistor, metal film, 1k54 Ω , $\pm 1\%$, 100ppm, 400 mW	1021302
R133	Resistor, metal film, 2k15 Ω , $\pm 1\%$, 100ppm, 400 mW	1021313
R134	Resistor, metal film, 2k55 Ω , $\pm 1\%$, 100ppm, 400 mW	1021318
R135	Not used	
R136	Resistor, metal film, 3k01 Ω , $\pm 1\%$, 100ppm, 400 mW	1008757
R137	Resistor, metal film, 3k16 Ω , $\pm 1\%$, 100ppm, 400 mW	1021325
R138	Resistor, metal film, 4k02 Ω , $\pm 1\%$, 100ppm, 400 mW	1021332

R139	Resistor, metal film, 5k11 Ω , $\pm 1\%$, 100ppm, 400 mW	1008763
R140	Not used	
R141	Resistor, metal film, 8k45 Ω , $\pm 1\%$, 100ppm, 400 mW	1021355
R142	Resistor, metal film, 6k34 Ω , $\pm 1\%$, 100ppm, 400 mW	1021346
R143	Resistor, metal film, 4k75 Ω , $\pm 1\%$, 100ppm, 400 mW	1008762
R144	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R145	Not used	
R146	Resistor, metal film, 100 Ω , $\pm 2\%$, 1/4W	1008722
R147	Resistor, metal film, 3k3 Ω , $\pm 2\%$, 1/4W	1008758
R148	Resistor, metal film, 3k3 Ω , $\pm 2\%$, 1/4W	1008758
R149	Resistor, metal film, 680 Ω , $\pm 2\%$, 1/4W	1008742
R150	Not used	
R151	Resistor, metal film, 390 Ω , $\pm 2\%$, 1/4W	1008736
R152	Resistor, metal film, 634 Ω , $\pm 1\%$, 100ppm, 400 mW	1021274
R153	Resistor, metal film, 665 Ω , $\pm 1\%$, 100ppm, 400 mW	1021276
R154	Resistor, metal film, 68k Ω , $\pm 2\%$, 1/3W	1008790
R155	Not used	
R156	Resistor, metal film, 825 Ω , $\pm 1\%$, 100ppm, 400 mW	1008744
R157	Resistor, metal film, 270 Ω , $\pm 2\%$, 1/4W	1008732
R158	Resistor, metal film, 1k5 Ω , $\pm 2\%$, 1/4W	1008750
R159	Resistor, metal film, 681 Ω , $\pm 1\%$, 400mW	1008742
R160	Not used	
R161	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R162	Resistor, metal film, 680 Ω , $\pm 2\%$, 1/4W	1008742
R163	Resistor, metal film, 100 Ω , $\pm 2\%$, 1/4W	1008722
R164	Resistor, metal film, 470 Ω , $\pm 2\%$, 1/4W	1008738
R165	Not used	
R166	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R167	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R168	Resistor, metal film, 12k Ω , $\pm 2\%$, 1/4W	1008772
R169	Resistor, metal film, 75 Ω , $\pm 2\%$, 1/4W	1008719
R170	Resistor, metal film, 10 Ω , $\pm 2\%$, 1/4W	1008698
R171	Resistor, metal film, 75 Ω , $\pm 2\%$, 1/4W	1008719
R172	Resistor, metal film, 15k Ω , $\pm 2\%$, 1/4W	1008774
R173	Resistor, metal film, 18k Ω , $\pm 2\%$, 1/4W	1008776
R174	Resistor, metal film, 15k Ω , $\pm 2\%$, 1/4W	1008774
R175	Not used	
R176	Resistor, metal film, 806 Ω , $\pm 1\%$, 100ppm, 400 mW	1021282
R177	Resistor, metal film, 2k7 Ω , $\pm 2\%$, 1/4W	1008756
R178	Resistor, metal film, 1k00 Ω , $\pm 1\%$, 100ppm, 400 mW	1008746
R179	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R180	Not used	
R181	Resistor, metal film, 100k Ω , $\pm 2\%$, 1/4W	1008794
R182	Resistor, metal film, 100 Ω , $\pm 2\%$, 1/4W	1008722
R183	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R184	Resistor, metal film, 100k Ω , $\pm 2\%$, 1/4W	1008794
R185	Not used	
R186	Resistor, metal film, 100 Ω , $\pm 2\%$, 1/4W	1008722
R187	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R188	Resistor, metal film, 100k Ω , $\pm 2\%$, 1/4W	1008794
R189	Resistor, metal film, 100 Ω , $\pm 2\%$, 1/4W	1008722
R190	Not used	
R191	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R192	Resistor, metal film, 100k Ω , $\pm 2\%$, 1/4W	1008794
R193	Resistor, metal film, 100 Ω , $\pm 2\%$, 1/4W	1008722
R194	Not used	
R195	Not used	

R196	Not used	
R197	Not used	
R198	Not used	
R199	Not used	
R200	Not used	
R201	Resistor, metal film, 182k Ω , $\pm 1\%$, 400mW	1008800
R202	Resistor, metal film, 5k6 Ω , $\pm 2\%$, 1/4W	1008764
R203	Resistor, metal film, 3k3 Ω , $\pm 2\%$, 1/4W	1008758
R204	Resistor, metal film, 33k Ω , $\pm 2\%$, 1/4W	1008782
R205	Resistor, metal film, 560 Ω , $\pm 2\%$, 1/4W	1008740
R206	Resistor, metal film, 100k Ω , $\pm 2\%$, 1/4W	1008794
R207	Resistor, metal film, 1k5 Ω , $\pm 2\%$, 1/4W	1008750
R208	Not used	
R209	Not used	
R210	Not used	
R211	Resistor, metal film, 4k7 Ω , $\pm 2\%$, 1/4W	1008762
R212	Resistor, metal film, 3k3 Ω , $\pm 2\%$, 1/4W	1008758
R213	Resistor, metal film, 15k Ω , $\pm 2\%$, 1/4W	1008774
R214	Resistor, metal film, 11k Ω , $\pm 2\%$, 1/4W	1008771
R215	Not used	
R216	Resistor, metal film, 390 Ω , $\pm 2\%$, 1/4W	1008736
R217	Resistor, metal film, 5k6 Ω , $\pm 2\%$, 1/4W	1008764
R218	Resistor, metal film, 100 Ω , $\pm 2\%$, 1/4W	1008722
R219	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R220	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R221	Resistor, metal film, 47k Ω , $\pm 2\%$, 1/4W	1008786
R222	Not used	
R223	Resistor, metal film, 47k5 Ω , $\pm 1\%$, 400mW	1008786
R224	Resistor, metal film, 2k7 Ω , $\pm 2\%$, 1/4W	1008756
R225	Not used	
R226	Resistor, metal film, 4k3 Ω , $\pm 2\%$, 1/4W	1008761
R227	Resistor, metal film, 680 Ω , $\pm 2\%$, 1/4W	1008742
R228	Resistor, metal film, 47 Ω , $\pm 2\%$, 1/4W	1008714
R229	Resistor, metal film, 1k Ω , $\pm 2\%$, 1/4W	1008746
R230	Resistor, metal film, 1M Ω , $\pm 2\%$, 1/4W	1008818
R231	Resistor, carbon, 1M5 Ω , $\pm 10\%$, 1/3W	Philips CR25
R232	Resistor, metal film, 2M21 Ω , $\pm 1\%$, 400mW	1021545
R233	Resistor, metal film, 432k Ω , $\pm 1\%$, 400mW	1008809
R234	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R235	Resistor, metal film, 47k Ω , $\pm 2\%$, 1/4W	1008786
R236	Resistor, metal film, 2k7 Ω , $\pm 2\%$, 1/4W	1008756
R237	Resistor, metal film, 47k5 Ω , $\pm 1\%$, 400mW	1008786
R238	Not used	
R239	Resistor, metal film, 220 Ω , $\pm 2\%$, 1/4W	1008730
R240	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R241	Resistor, metal film, 3k9 Ω , $\pm 2\%$, 1/4W	1008760
R242	Resistor, metal film, 2k2 Ω , $\pm 2\%$, 1/4W	1008754
R243	Resistor, metal film, 390k Ω , $\pm 2\%$, 1/4W	1008808
R244	Resistor, metal film, 390k Ω , $\pm 2\%$, 1/4W	1008808
R245	Not used	
R246	Resistor, metal film, 4k7 Ω , $\pm 2\%$, 1/4W	1008762
R247	Resistor, metal film, 4k7 Ω , $\pm 2\%$, 1/4W	1008762
R248	Resistor, metal film, 27k Ω , $\pm 2\%$, 1/4W	1008780
R249	Resistor, metal film, 27k Ω , $\pm 2\%$, 1/4W	1008780
R250	Resistor, metal film, 470k Ω , $\pm 2\%$, 1/4W	1008810
R251	Resistor, metal film, 820 Ω , $\pm 2\%$, 1/4W	1008744
R252	Resistor, metal film, 3k0 Ω , $\pm 2\%$, 1/4W	1008760
R253	Resistor, metal film, 6k8 Ω , $\pm 2\%$, 1/4W	1008766

R254	Resistor, metal flkm, 470 Ω , $\pm 2\%$, 1/4W	1008734
R255	Resistor, metal film, 4k7 Ω , $\pm 2\%$, 1/4W	1008762
R256	Resistor, metal film, 22k Ω , $\pm 2\%$, 1/4W	1008698
R257	Resistor, metal film, 10 Ω , $\pm 2\%$, 1/4W	1008698
R258	Resistor, metal film, 10 Ω , $\pm 2\%$, 1/4W	1008698
R259	Resistor, metal film, 100k Ω , $\pm 2\%$, 1/4W	1008794
R260	Resistor, metal film, 100k Ω , $\pm 2\%$, 1/4W	1008794
R261	Resistor, metal film, 220k Ω , $\pm 2\%$, 1/4W	1008802
R262	Resistor, metal film, 75k Ω , $\pm 2\%$, 1/4W	1008719
R263	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R264	Resistor, metal film, 1k Ω , $\pm 2\%$, 1/4W	1008746
R265	Not used	
R266	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R267	Resistor, metal film, 2k Ω , $\pm 2\%$, 1/4W	1008753
R268	Not used	
R269	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R270	Not used	
R271	Resistor, metal film, 6k2 Ω , $\pm 2\%$, 1/4W	1008765
R272	Resistor, metal film, 4k7 Ω , $\pm 2\%$, 1/4W	1008762
R273	Resistor, metal film, 22k Ω , $\pm 2\%$, 1/4W	1008778
R274	Resistor, metal film, 47k Ω , $\pm 2\%$, 1/4W	1008786
R275	Resistor, carbon, 3M3 Ω , $\pm 10\%$, 1/3W	Philips 2322-211-12335
R276	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R277	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R278	Resistor, metal film, 22k1 Ω , $\pm 1\%$, 100ppm, 400 mW	1008778
R279	Resistor, metal film, 44k2 Ω , $\pm 1\%$, 100ppm, 400 mW	1021466
R280	Resistor, metal film, 220k Ω , $\pm 2\%$, 1/4W	1008802
R281	Resistor, metal film, 4k7 Ω , $\pm 2\%$, 1/4W	1008762
R282	Resistor, metal film, 220k Ω , $\pm 2\%$, 1/4W	1008802
R283	Resistor, metal film, 2k Ω , $\pm 2\%$, 1/4W	1008753
R284	Resistor, metal film, 22k Ω , $\pm 2\%$, 1/4W	1008778
R285	Resistor, metal film, 100k Ω , $\pm 2\%$, 1/4W	1008794
R286	Resistor, metal film, 51k Ω , $\pm 2\%$, 1/4W	1008787
R287	Resistor, metal film, 400k Ω , $\pm 2\%$, 1/4W	1008805
R288	Resistor, metal film, 114k Ω , $\pm 1\%$, 100ppm, 400 mW	1021436
R289	Resistor, metal film, 100 Ω , $\pm 2\%$, 1/4W	1008722
R290	Resistor, metal film, 100k Ω , $\pm 2\%$, 1/4W	1008794
R291	Resistor, metal film, 10k Ω , $\pm 2\%$, 1/4W	1008770
R292	Resistor, metal film, 2k2 Ω , $\pm 2\%$, 1/4W	1008754
R293	Resistor, metal film, 825 Ω , $\pm 1\%$, 100ppm, 400 mW	1008744
R294	Resistor, metal film, 1M Ω , $\pm 2\%$, 1/4W	1008818
R295	Resistor, metal film, 470k Ω , $\pm 2\%$, 1/4W	1008810
R296	Resistor, carbon, 10M Ω , $\pm 10\%$, 1/3W	Philips Type CR25
R297	Resistor, carbon, 10M Ω , $\pm 10\%$, 1/3W	Philips Type CR25
R298	Resistor, metal film, 27k Ω , $\pm 2\%$, 1/4W	1008780
R299	Resistor, metal film, 15k Ω , $\pm 2\%$, 1/4W	1008774
R300	Resistor, metal film, 4k3 Ω , $\pm 2\%$, 1/4W	1008761
R301	Resistor, metal film, 100k Ω , $\pm 1\%$, 100ppm, 400 mW	1008794
R302	Resistor, metal film, 100k Ω , $\pm 1\%$, 100ppm, 400 mW	1008794
R303	Resistor, metal film, 22k Ω , $\pm 2\%$, 1/4W	1008778
R304	Resistor, metal film, 220k Ω , $\pm 2\%$, 1/4W	1008802
R305	Resistor, metal film, 909k Ω , $\pm 1\%$, 100ppm, 400 mW	1021508

7.2.2.3 Variable Resistors

RV1	Resistor, variable, cermet, 5k Ω , $\pm 10\%$	Beckman 72PM
RV2	Resistor, variable, cermet, 100k Ω , $\pm 10\%$	Beckman 72PM
RV3	Resistor, variable, cermet, 100k Ω , $\pm 10\%$	Beckman 72PM
RV4	Resistor, variable, cermet, 20k Ω , $\pm 10\%$	Beckman 72PM
RV5	Not used	
RV6	Resistor, variable, cermet, 20k Ω , $\pm 10\%$	Beckman 72PM

7.2.2.4 Resistor Networks

RN1	Resistor network, 15X100k Ω , $\pm 2\%$	Bournes 4116R-002-104
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7.2.2.5 Inductors

L1	Inductor, 1mH, $\pm 5\%$	TDK0810 SK102J
L2	Inductor, 1m2H, $\pm 5\%$, kinked leads	TDK0810 SK122J

7.2.2.6 Photocells

PCC1	Photo conductive cell	Clairex Electronics Type CLM6500
PCC2	Photo conductive cell	Clairex Electronics Type CLM6500

7.2.2.7 Relays

RLA	Relay, 1C.O., 12V	National RSD-12V
RLB	Relay, 1C.O., 12V	National RSD-12V
RLC	Relay, 1C.O., 12V	National RSD-12V
RLD	Relay, 1C.O., 12V	National RSD-12V
RLE	Relay, 4C.O., 12V	Siemens V23030-A1017-A104
RLF	Relay, 1C.O., 12V	National RSD-12V
RLG	Used on 2R70545	
RLH	Relay, 1C.O., 12V	National RSD-12V
RLI	Not used	
RLJ	Relay, 2C.O., 12V	National NF2-12V
RLK	Relay, 4C.O., 12V	Siemens V23030-A1017-A104
RLL	Relay, 4C.O., 12V	Siemens V23030-A1017-A104
RLM	Relay, 6C.O., 12V	Siemens V23030-A1017-A106
RLN	Relay, 1C.O., 12V	National RSD-12V
RLO	Not used	
RLP	Relay, 1C.O., 12V	National RSD-12V

7.2.2.8 Transistors

Q1	Transistor, BC549	1024854
Q2	Transistor, PN4121	
Q3	Transistor, BC549	1024854
Q4	Transistor, PN3643	
Q5	Not used	
Q6	Transistor, BC549	1024854
Q7	Transistor, PN4250	906790
Q8	Transistor, BC549	1024854
Q9	Transistor, PN4250	906790
Q10	Not used	
Q11	Not used	
Q12	Not used	

Q13	Transistor, BC549	1024854
Q14	Transistor, BC549	1024854
Q15	Transistor, PN3643	
Q16	Transistor, PN4121	
Q17	Transistor, BC549	1024854
Q18	Transistor, PN3643	
Q19	Transistor, BC549	1024854
Q20	Transistor, BC549	1024854
Q21	Transistor, BC549	1024854
Q22	Transistor, PN4121	
Q23	Transistor, PN4121	
Q24	Transistor, PN3643	
Q25	Not used	
Q26	Transistor, BC549	1024854
Q27	Transistor, BC549	1024854
Q28	Transistor, BC549	1024854
Q29	Transistor, BC549	1024854
Q30	Transistor, BC549	1024854
Q31	Transistor, BC549	1024854
Q32	Transistor, BC549	1024854
Q33	Transistor, BC549	1024854
Q34	Transistor, BC549	1024854
Q35	Transistor, BC549	1024854
Q36	Transistor, BC549	1024854
Q37	Transistor, BC549	1024854
Q38	Not used	
Q39	Not used	
Q40	Not used	
Q41	Not used	
Q42	Transistor, PN4121	
Q43	Transistor, BC549	1024854
Q44	Transistor, PN4250	906790
Q45	Transistor, BC549	1024854
Q46	Transistor, 2N5962	
Q47	Transistor, BC549	1024854
Q48	Transistor, BC549	1024854
Q49	Transistor, 2N4250	906790
Q50	Not used	
Q51	Transistor, PN4250	906790
Q52	Transistor, BC549	1024854
Q53	Transistor, BC549	1024854

7.2.2.9 Integrated Circuits

IC1	Integrated circuit, CD4066BE <u>or</u> MC4066BCP	
IC2	Integrated circuit, CD4016BE <u>or</u> MC4016BCP	
IC3	Integrated circuit, LM318N	National Semiconductor
IC4	Integrated circuit, CA3100E	RCA
IC5	Integrated circuit, CA3046	RCA
IC6	Integrated circuit, LM301AN	National Semiconductor
IC7	Integrated circuit, LM301AN	National Semiconductor
IC8	Integrated circuit, CA3130E	RCA
IC9	Integrated circuit, CA3130E	RCA
IC10	Integrated circuit, CA3100E	
IC11	Integrated circuit, CD4016BE <u>or</u> MC14016BCP	
IC12	Integrated circuit, CD4053BE	RCA

IC13	Integrated circuit, CD4023BE <u>or</u> MC4023BCP	
IC14	Integrated circuit, CD4098BE <u>or</u> MC14528BCP	
IC15	Integrated circuit, CA3140E	RCA
IC16	Integrated circuit, CA3130E	RCA
IC17	Integrated circuit, CD4029BE <u>or</u> MC4029BCP	
IC18	Integrated circuit, CD4029BE <u>or</u> MC4029BCP	
IC19	Integrated circuit, CD4008BE <u>or</u> MC4008BCP	
IC20	Not used	
IC21	Integrated circuit, CD4023BE <u>or</u> MC4023BCP	
IC22	Integrated circuit, CD4049UBE <u>or</u> MC4049UBCP	
IC23	Integrated circuit, CD4070BE <u>or</u> MC14070BCP	
IC24	Integrated circuit, CA3240E	
IC25	Integrated circuit, CA3240E	
IC26	Integrated circuit, CD4070BE <u>or</u> MC14070BCP	
IC27	Integrated circuit, CD4013BE <u>or</u> MC14013BCP	
IC28	Integrated circuit, CA3130E	RCA
IC29	Integrated circuit, μ A734DC	Fairchild
IC30	Integrated circuit, CD4013BE <u>or</u> MC14013BCP	
IC31	Integrated circuit, CD4066BE <u>or</u> MC4066BEP	
IC32	Integrated circuit, LM339N	National Semiconductor
IC33	Integrated circuit, MC7812CT, c/w mounting Kit MK199-3	Motorola
IC34	Integrated circuit, MC7912CT, c/w mounting Kit MK199-3	Motorola
IC35	Integrated circuit, CD4081BE <u>or</u> MC14081BCP	
IC36	Integrated circuit, CD4075BE	RCA
IC37	Integrated circuit, CD4071BE	RCA
IC38	Integrated circuit, CD4081BE	RCA
IC39	Integrated circuit, CD4049BE	RCA
IC40	Not used	
IC41	Integrated circuit, CD4075BE	RCA
IC42	Integrated circuit, CD4072BE	RCA
IC43	Integrated circuit, CD4071BE	RCA
IC44	Integrated circuit, CD4081BE	RCA
IC45	Integrated circuit, CD4081BE	RCA

7.2.2.10 Diodes

D1	Diode, 1N914	597291
D2	Diode, 1N914	597291
D3	Diode, 1N914	597291
D4	Diode, 1N914	597291
D5	Not used	
D6	Not used	
D7	Diode, 1N914	597291
D8	Not used	
D9	Not used	
D10	Not used	
D11	Zener Diode, BZX79 C5V6	1006326
D12	Not used	
D13	Not used	
D14	Not used	
D15	Not used	
D16	Not used	
D17	Not used	
D18	Not used	
D19	Not used	
D20	Not used	
D21	Not used	

D22	Not used	
D23	Not used	
D24	Not used	
D25	Not used	
D26	Not used	
D27	Not used	
D28	Not used	
D29	Not used	
D30	Not used	
D31	Not used	
D32	Zener diode, BZX79 C5V1	1005272
D33	Zener diode, BZX79 C6V8	596891
D34	Diode, 1N914	597291
D35	Not used	
D36	Diode, 1N914	597291
D37	Diode, 1N914	597291
D38	Diode, 1N914	597291
D39	Diode, 1N914	597291
D40	Not used	
D41	Zener diode, BZX79 C4V7	596857
D42A	Diode, 1N4003	1004811
D42B	Diode, 1N4003	1004811
D42C	Diode, 1N4003	1004811
D42D	Diode, 1N4003	1004811
D43	Diode, 1N914	597291
D44	Diode, 1N914	597291
D45	Diode, 1N914	597291
D46	Diode, 1N914	597291
D47	Diode, 1N914	597291
D48	Diode, 1N914	597291
D49	Not used	
D50	Not used	
D51	Diode, 1N914	597291
D52	Diode, 1N914	597291
D53	Diode, 1N914	597291
D54	Diode, 1N914	597291
D55	Not used	
D56	Diode, 1N914	597291
D57	Diode, 1N914	597291
D58	Not used	
D59	Not used	
D60	Not used	
D61	Diode, light emitting, 5082-4484	Hewlett Packard
D62	Diode, 1N914	597291
D63	Diode, MB7501	Motorola
D64	Diode, 1N914	597291
D65	Diode, 1N914	597291
D66	Diode, 1N914	597291
D67	Diode, 1N914	597291
D68	Diode, 1N914	597291
D69	Diode, 1N914	597291
D70	Diode, 1N914	597291
D71	Diode, 1N914	597291
D72	Diode, 1N914	597291
D73	Diode, 1N914	597291
D74	Diode, 1N914	597291

7/14

1-70542R

7.2.2.11 Switches

SWA	Switch	AWA 70543-4-29
SWB	Switch	AWA 70543-4-02
SWC	Switch	AWA 70543-4-29

7.2.2.12 Connectors

SKA	Printed circuit board socket, 7 way	AWA 70543-4-10
PLB	Printed circuit board plug, 15 pin	Utilux M4030-15A
SKC	Printed circuit board connector, 18 way	AWA 70543-4-06
SKD	Socket, coaxial, P.C.B. mounting	Belling-Lee Type L1465/PCS

7.2.3 Components on Set Reference Amplifier Assembly 2R70545

C301	Capacitor, electrolytic, tantalum, 180 μ F, \pm 10%, 6V	229747
C302	Capacitor, electrolytic, tantalum, 1 μ F, \pm 10%, 35V	227739
C303	Capacitor, ceramic disc, 22pF, \pm 5%, 500V, NPO	220883
C304	Capacitor, electrolytic, tantalum, 22 μ F, \pm 10%, 15V	229320
C305	Capacitor, electrolytic, tantalum, 22 μ F, \pm 10%, 15V	229320
C306	Capacitor, electrolytic, tantalum, 22 μ F, \pm 10%, 15V	229320
C307	Capacitor, ceramic disc, 47nF, +80-20%, 25V, HiK	226822
C308	Capacitor, ceramic disc, 100pF, \pm 5%, 500V, N750	222214

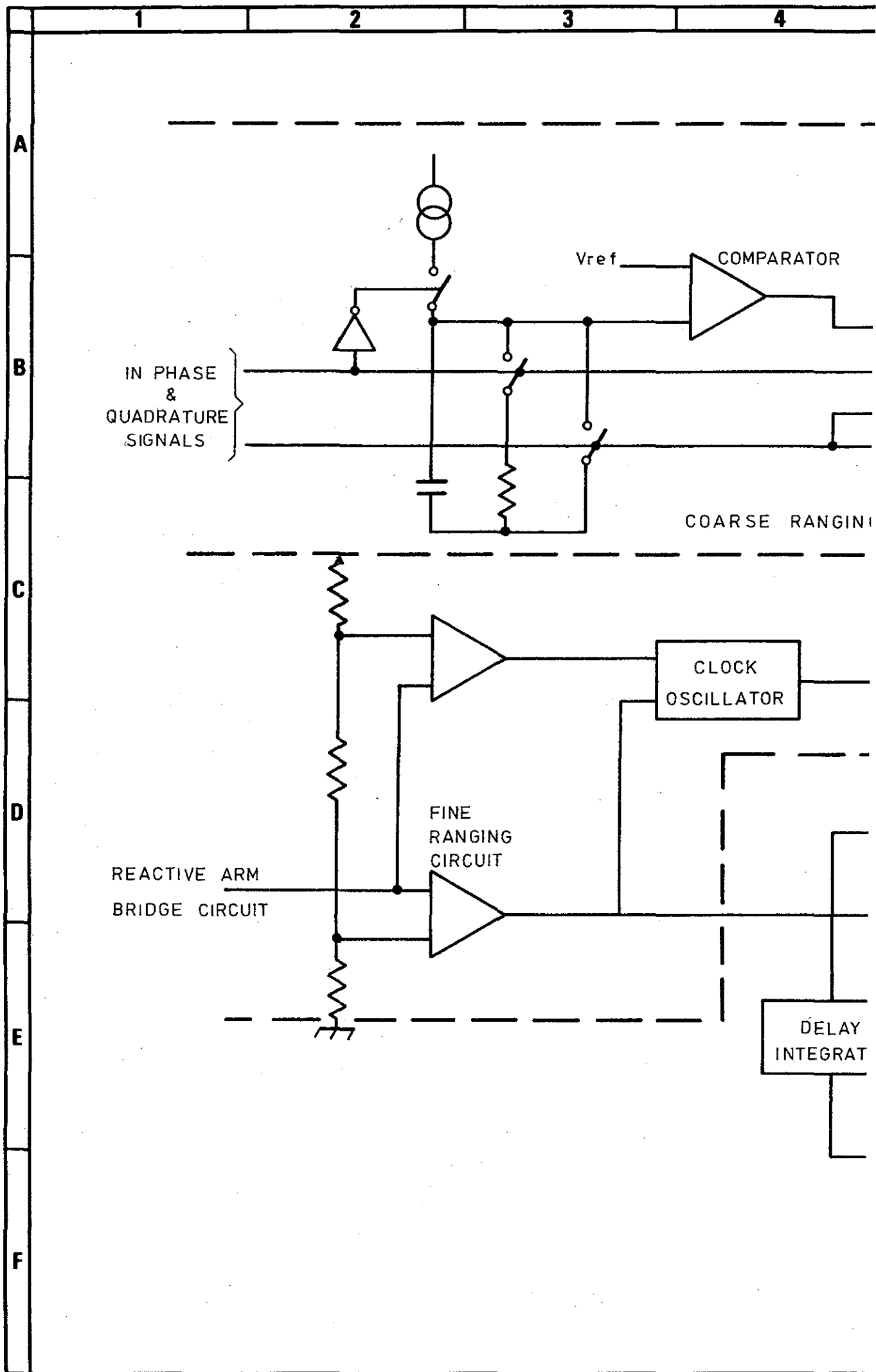
R301	Resistor, metal glaze, 68k Ω , \pm 2%, 1/4W	1008790
R302	Resistor, metal glaze, 22k Ω , \pm 2%, 1/4W	1008778
R303	Resistor, metal glaze, 6k8 Ω , \pm 2%, 1/4W	1008766
R304	Resistor, metal glaze, 3k3 Ω , \pm 2%, 1/4W	1008758
R305	Resistor, metal glaze, 100 Ω , \pm 2%, 1/4W	1008722
R306	Resistor, metal glaze, 3k3 Ω , \pm 2%, 1/4W	1008758
R307	Resistor, metal glaze, 62k Ω , \pm 2%, 1/4W	1008789
R308	Resistor, metal glaze, 100 Ω , \pm 2%, 1/4W	1008722
R309	Resistor, metal glaze, 100k Ω , \pm 2%, 1/4W	1008794
R310	Resistor, metal glaze, 100k Ω , \pm 2%, 1/4W	1008794
R311	Resistor, metal glaze, 560 Ω , \pm 2%, 1/4W	1008740
R312	Resistor, metal glaze, 100 Ω , \pm 2%, 1/4W	1008722
R313	Resistor, metal glaze, 7k5 Ω , \pm 2%, 1/4W	1008767
R314	Resistor, metal glaze, 2k7 Ω , \pm 2%, 1/4W	1008756
R315	Resistor, metal glaze, 240 Ω , \pm 2%, 1/4W	1008731
R316	Resistor, metal glaze, 1k2 Ω , \pm 2%, 1/4W	1008748
R317	Resistor, metal glaze, 560 Ω , \pm 2%, 1/4W	1008740
R318	Resistor, metal glaze, 100 Ω , \pm 2%, 1/4W	1008722
R319	Resistor, metal glaze, 1k5 Ω , \pm 2%, 1/4W	1008750
R320	Resistor, metal glaze, 10k Ω , \pm 2%, 1/4W	1008770
R321	Resistor, metal glaze, 10k Ω , \pm 2%, 1/4W	1008770

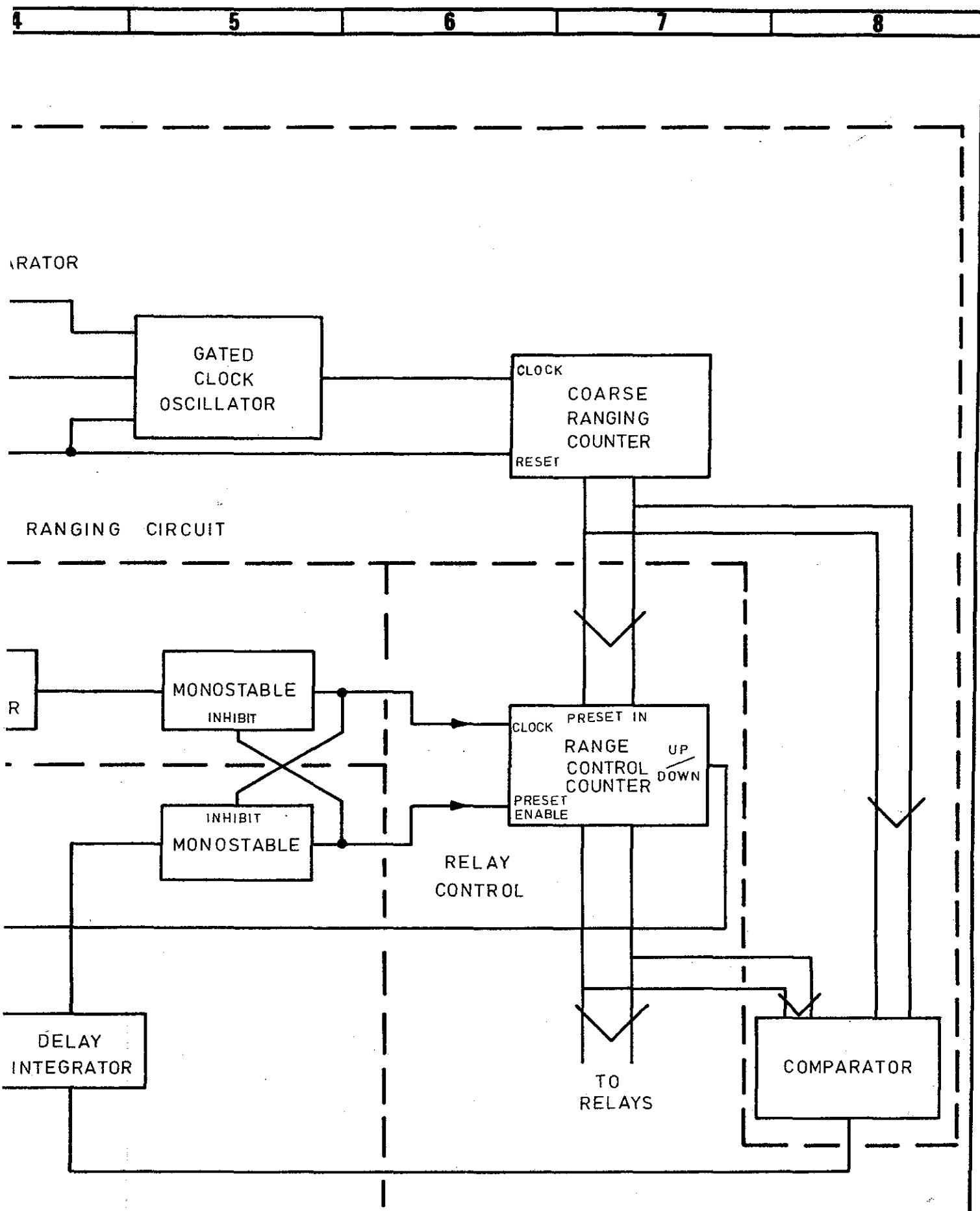
RV301	Resistor, variable, plastic film, 5k Ω , \pm 10%	Clarostat 380C3
-------	---	-----------------

RLG	Relay, IC.O., 12V	National RSD12V
-----	-------------------	-----------------

Q301	Transistor, 2N2857	
Q302	Transistor, BC550	
Q303	Transistor, PN4121	
Q304	Transistor, PN5962	
Q305	Transistor, BC549	1024854
Q306	Transistor, BC549	1024854
Q307	Transistor, PN4250	906790

D301	Diode 1N914	597291
SWD	Switch Assembly (includes RV315)	AWA 70545-4-02
7.2.4	Meter Range Switch Assembly 2A70546	
SWE	Switch	AWA 70546-4-01
SKB	Connector, female, 15 way	Utilux M2695-15 c/w Contacts M2759





**AMALGAMATED WIRELESS
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ENGINEERING PRODUCTS DIVISION

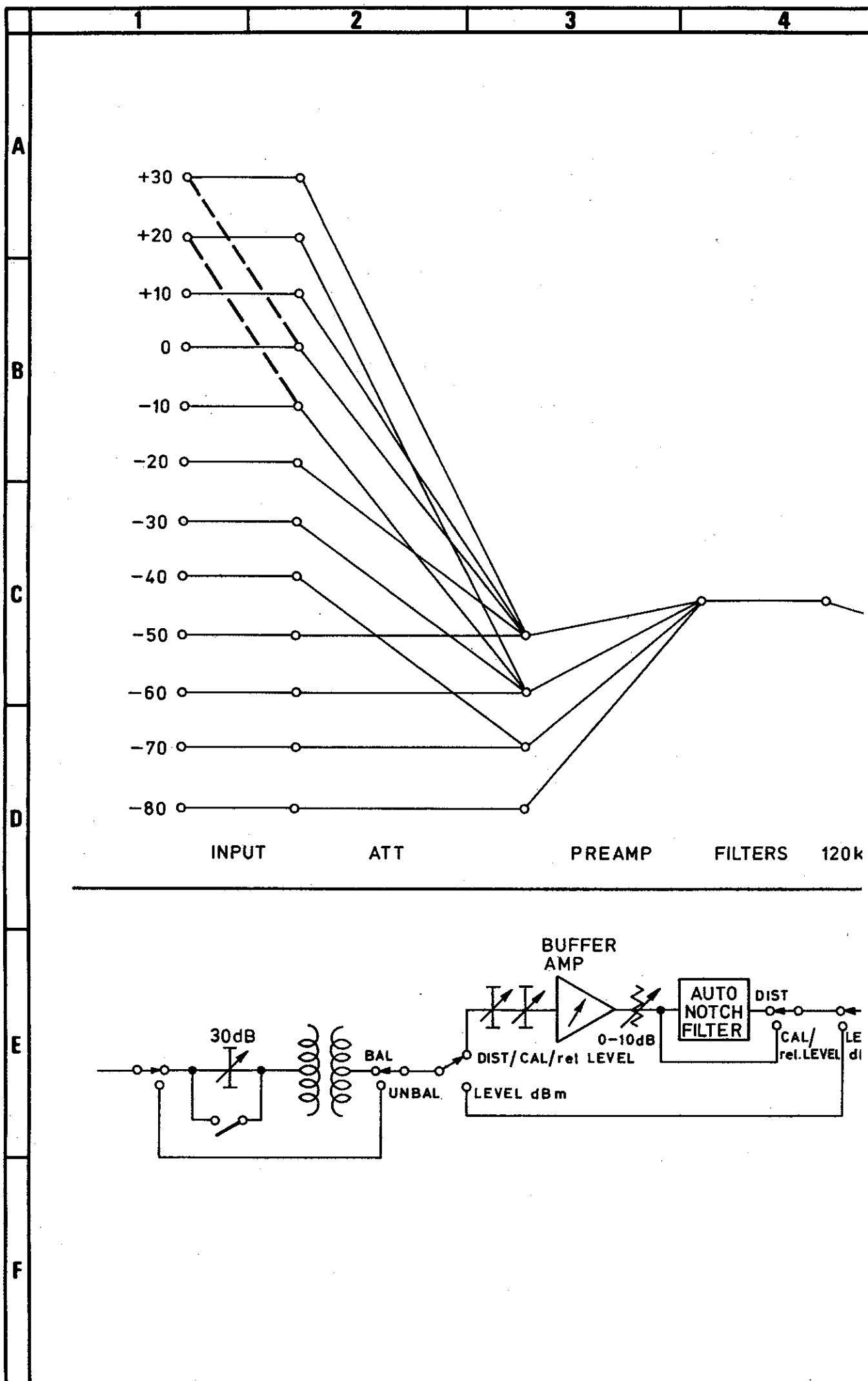
TYPE No.

TITLE BLOCK DIAGRAM
NULLING LOOP RANGE CONTROL
DISTORTION AND NOISE METER

DRAWING No.

70542-3-57

ISSUE



INPUT	LEVEL, dBm		LEVEL, rel.	
	UNBAL	BAL	UNBAL	BAL
+30	C, 6, 5, 6'	C, E, 13, 5, 6'	C, N, P, 13, 5, 6'	C, E, 13, 5, 6'
+20	6, 5, 6'	E, 13, 5, 6'	N, P, 13, 5, 6'	E, 13, 5, 6'
+10	C, 12, 5, 6'		N, P, C, 5, 6'	C, E, 5, 6'
0	C, 13, 5, 6'			N, P, 5, 6'
-10	13, 5, 6'			
-20	C, 5, 6'			
-30	5, 6'			
-40	B, 5, 6'			
-50	C, D, 12'			
-60	D, 12'			
-70	B, D, 12'			
-80	A, B, D, 12'			

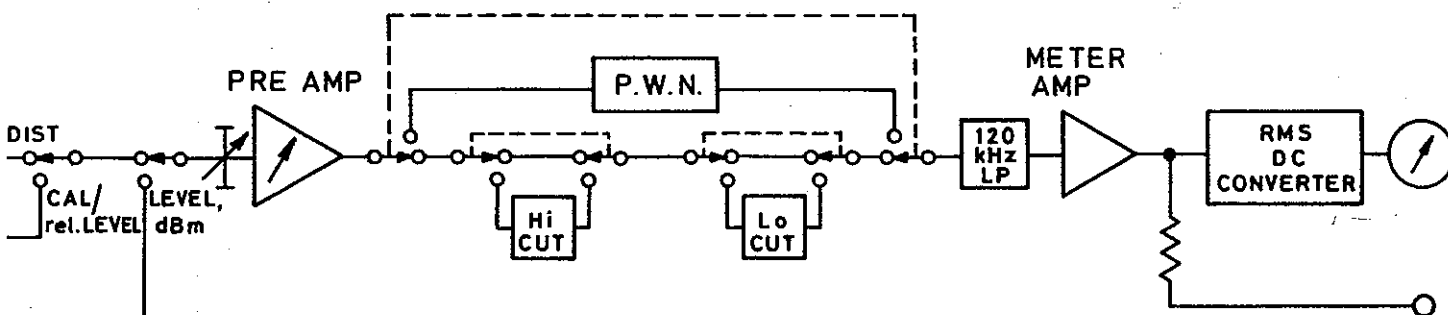
~2V rms

--- BALANCED

LEVEL DIAGRAM

MODE CONTROL SET TO LEVEL dBm

ERS 120kHz LP METER
AMP



**AMALGAMATED WIRELESS
(AUSTRALASIA) LTD**

ENGINEERING PRODUCTS DIVISION

TYPE No.

TITLE

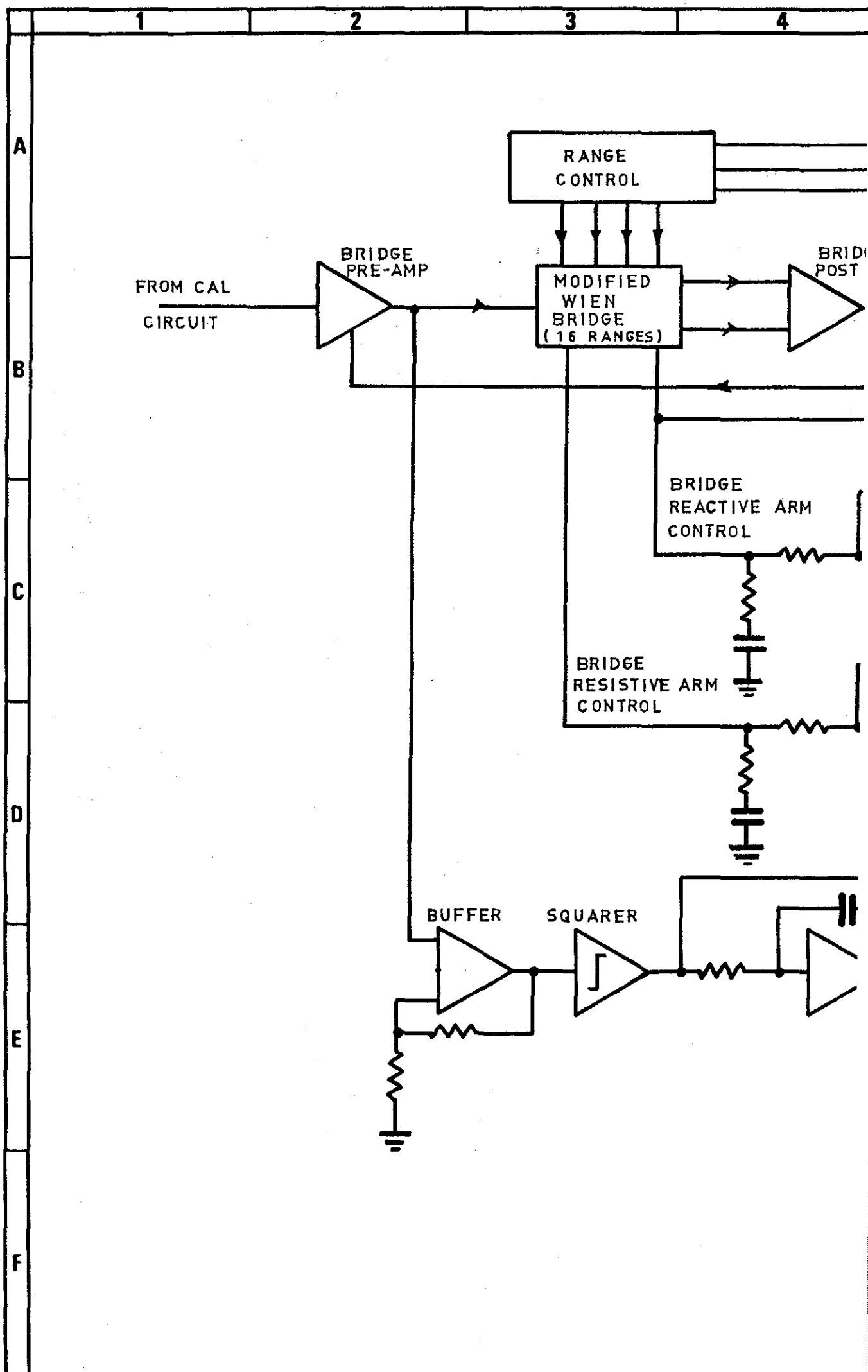
**F242A SIMPLIFIED
BLOCK SCHEMATIC
AND LEVEL DIAGRAM**

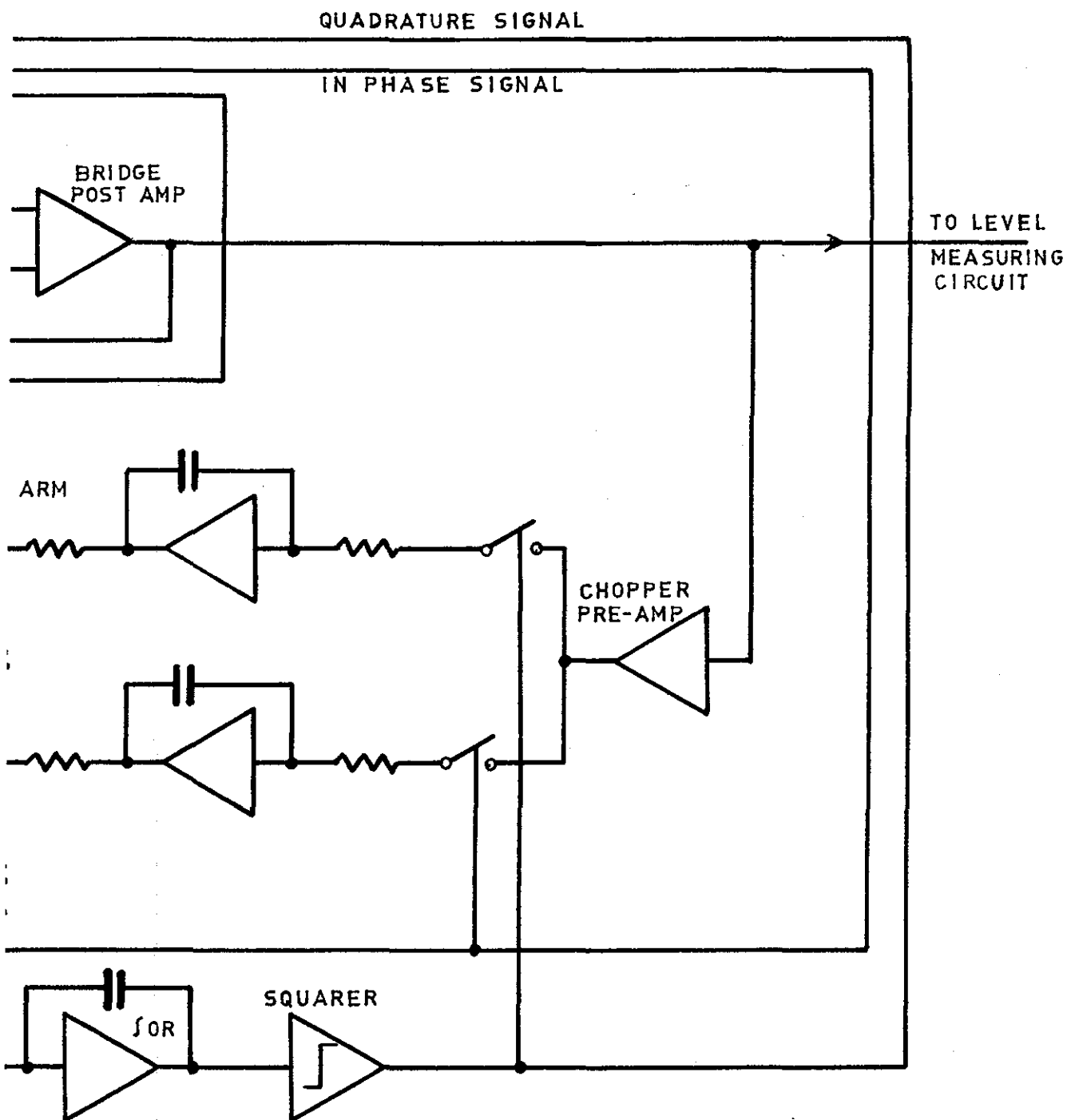
DRAWING No.


70542-3-56

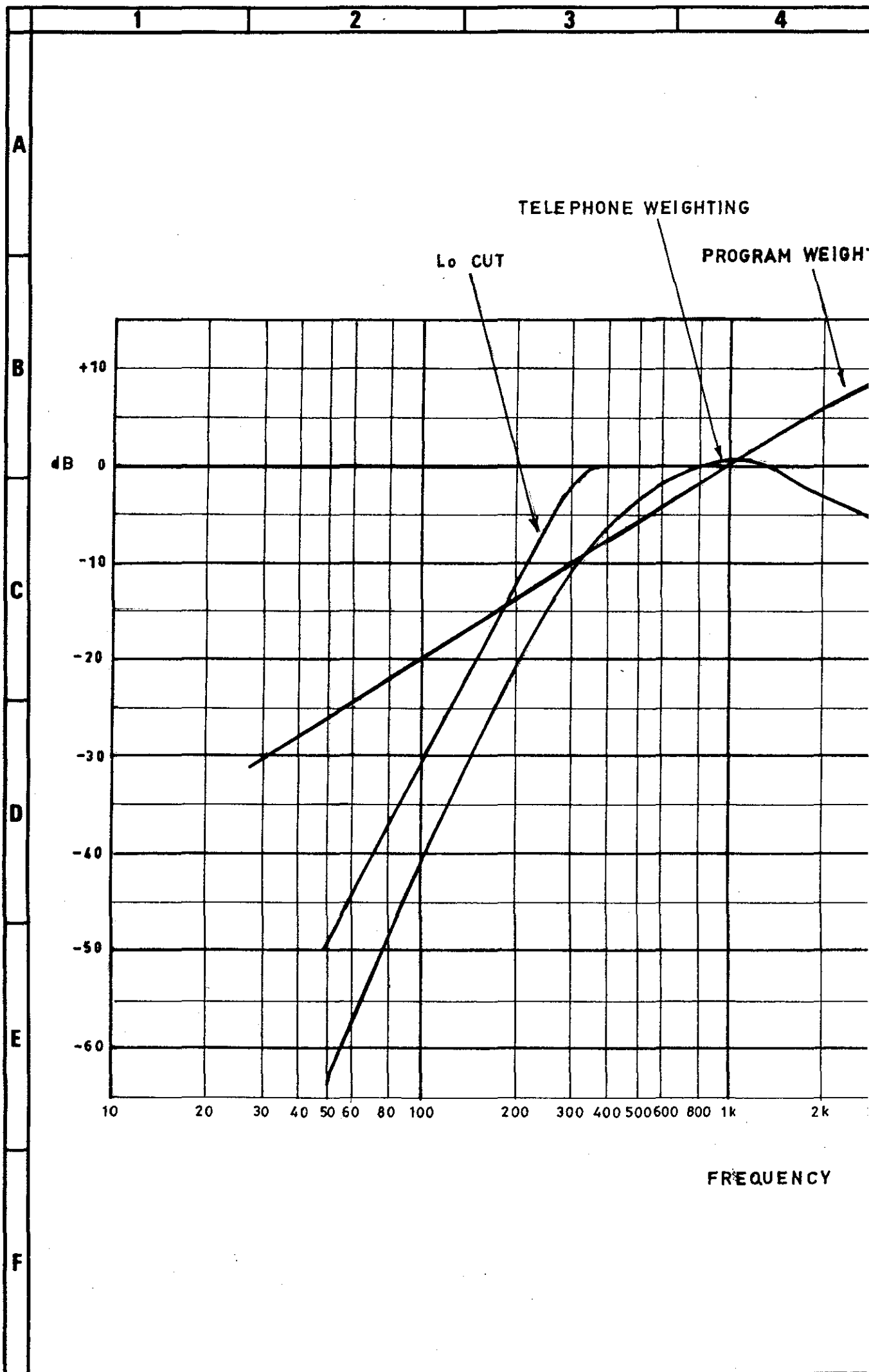
ISSUE

0





	AMALGAMATED WIRELESS (AUSTRALASIA) LTD	TITLE BLOCK DIAGRAM NULLING LOOP F242 DISTORTION AND NOISE METER	
	ENGINEERING PRODUCTS DIVISION		
TYPE No.	DRAWING No. 70542 - 3 - 26	ISSUE	



4

5

6

7

8

RAM WEIGHTING

HI CUT

FLAT RESPONSE
UNBALANCED

QUENCY

**AMALGAMATED WIRELESS
(AUSTRALASIA) LTD****ENGINEERING PRODUCTS DIVISION**

TYPE No.

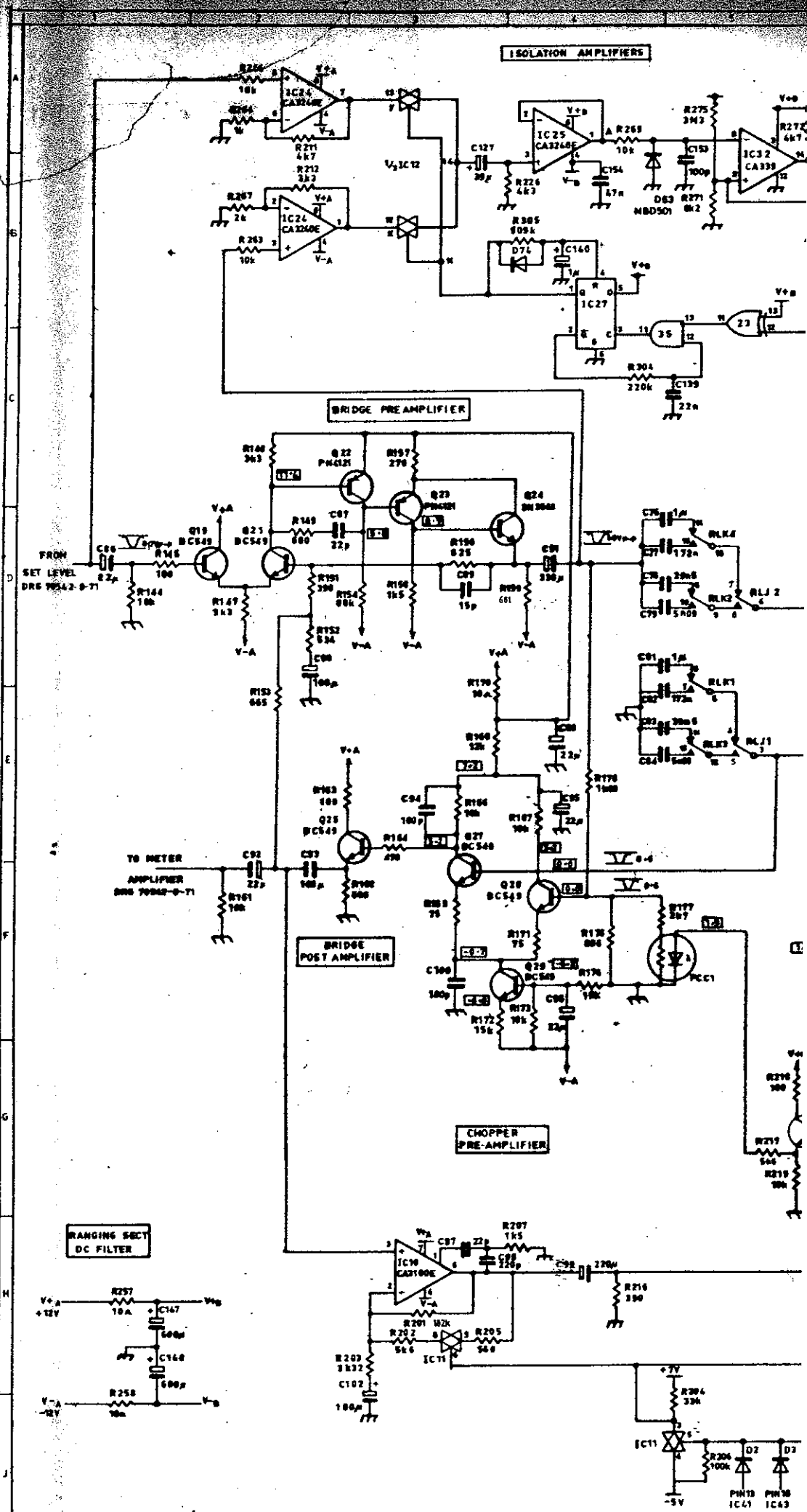
TITLE

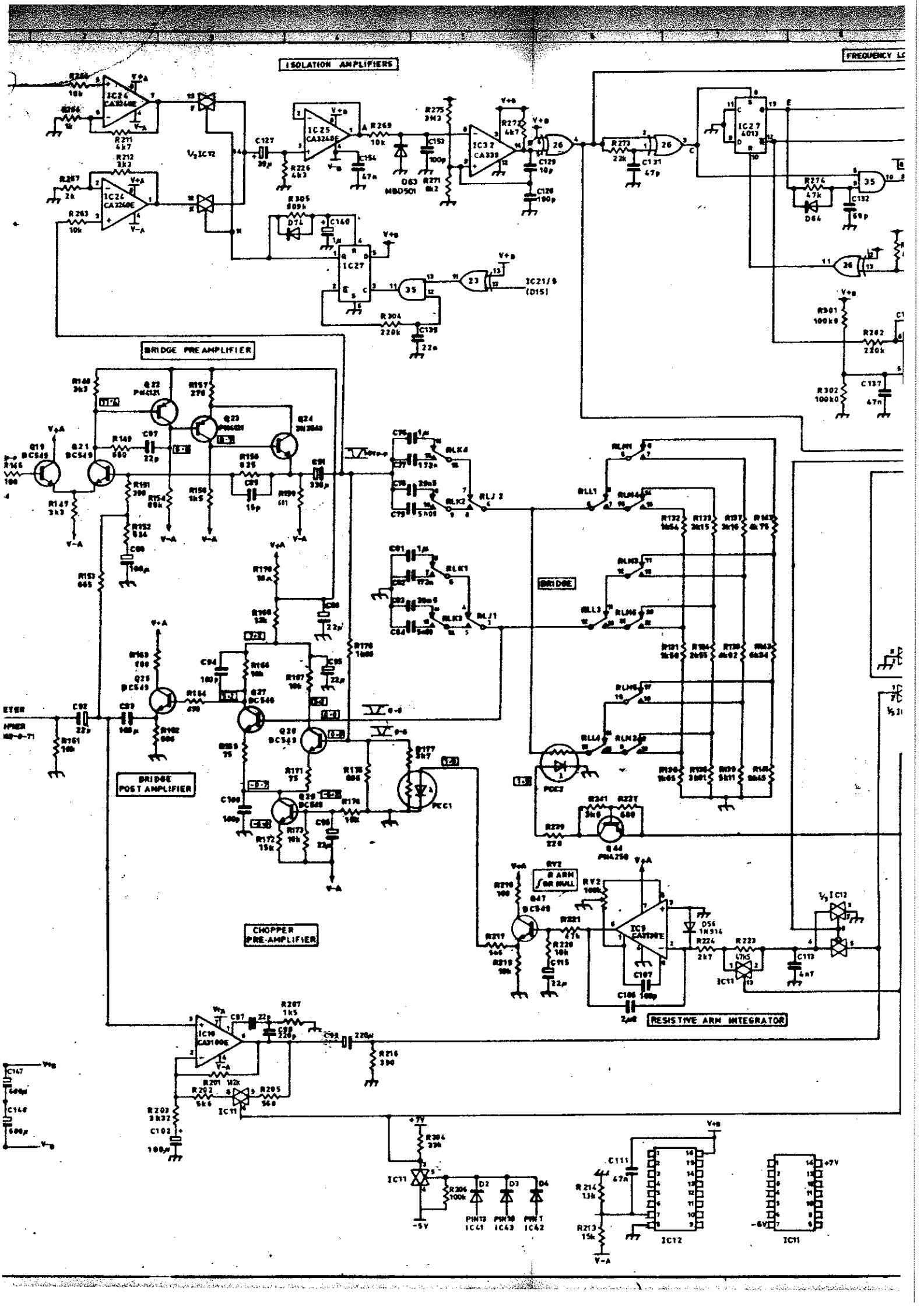
FILTER RESPONSE CURVES

DRAWING No.

70550-3-26

ISSUE





FREQUENCY LOCKED LOOP

IN PHASE AND QUADRATURE GENERATORS

EXPONENTIAL PERIOD GENERATOR

EXPONENT COMPARATOR OFFSET ADJ.

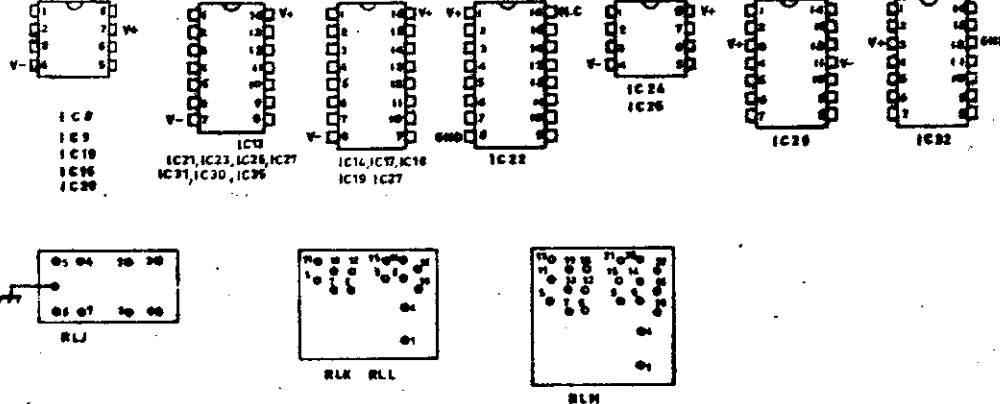
X ARM CONTROL LIMIT DETECTOR

REACTIVE ARM INTEGRATOR

IC	TYPE	IC	TYPE	IC	TYPE	IC	TYPE
1		11	4016	21	4022	31	4044
2		12	4053	22	4049	32	LM339
3		13	4023	23	4030	33	
4		14	4020	24	CA3240E	34	
5		15		25	CA3240E	35	4001
6		16	CA3130E	26	4070	36	
7		17	4029	27	4013	37	
8	CA3130E	18	4023	28	CA3130E	38	
9	CA3130E	19	4000	29	CA734	39	
10	CA3130E	20		30	4013	40	

4016 COMPARAE OR MC1420CP

TOP VIEWS




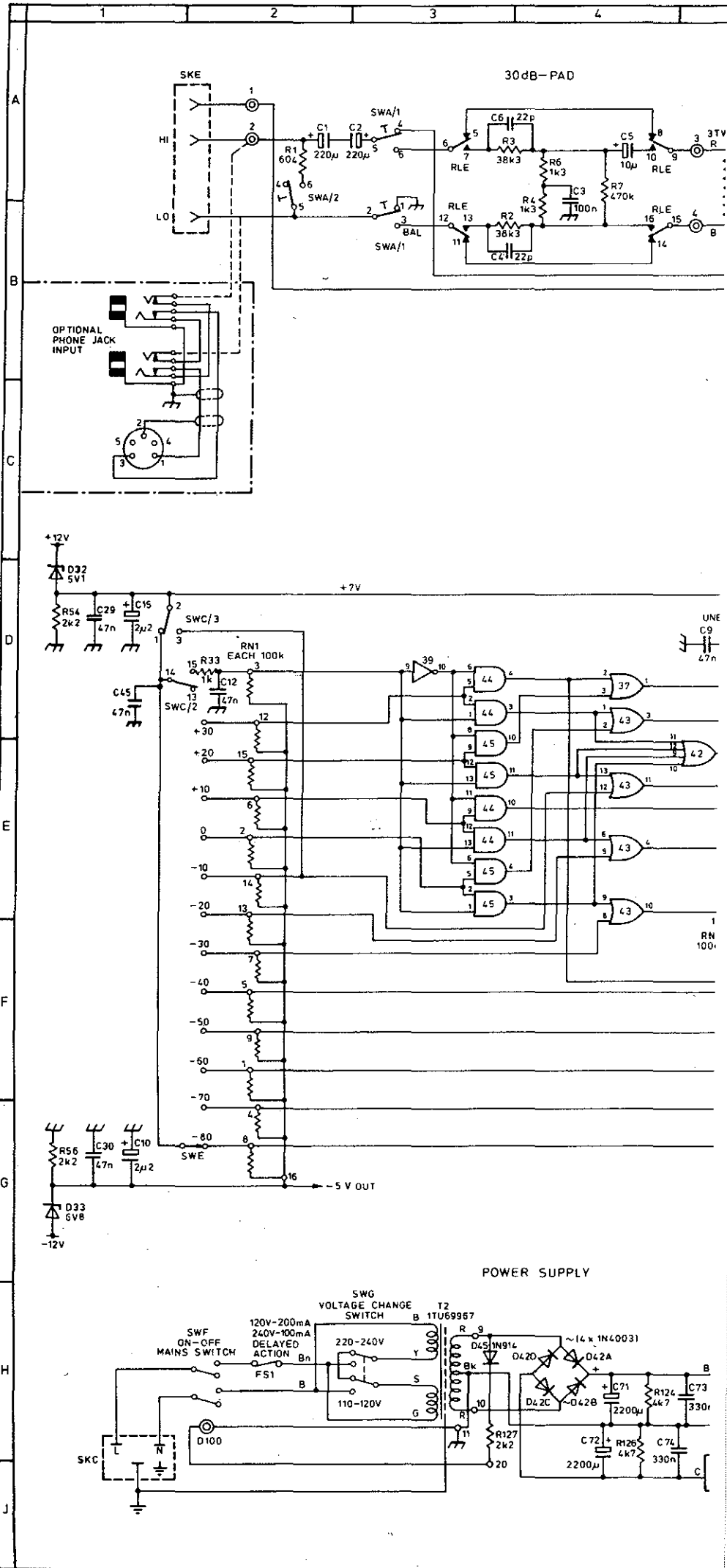
D.C. VOLTAGES ENCLOSED IN □ STEADY STATE NULLED COND

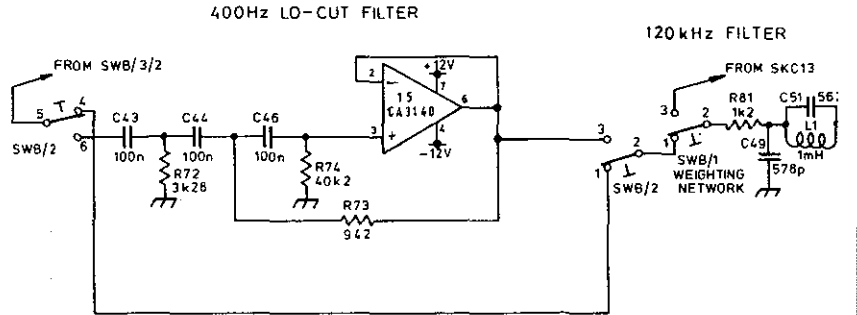
CIRCUIT POINT	HANDBOOK TITLE	WAVEF
A	INPUT SIGNAL	
B	COMPARATOR OUTPUT	
C	IC 26 PIN 2	
D	F.L.T. COMPARTOR INPUT	
E	F.L.T. OUTPUT	
F	IN PHASE	
G	QUADRATURE	
H	QUADRATURE	
I	EXPONENTIAL ZERO	
J	EXPONENTIAL	
K	EXPONENTIAL PERIOD OUTPUT	
L	COARSE RANGING CLOCK	
M		
N		

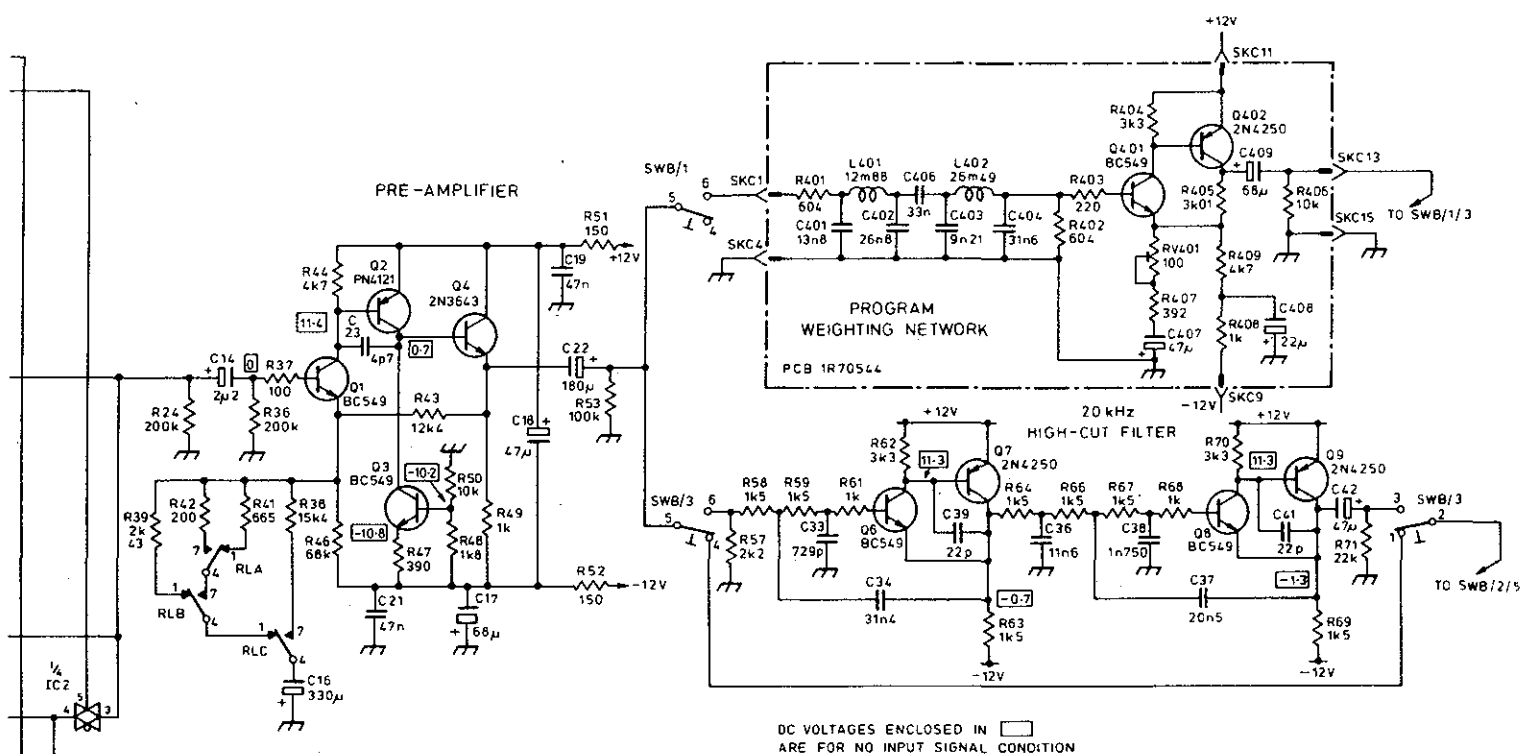
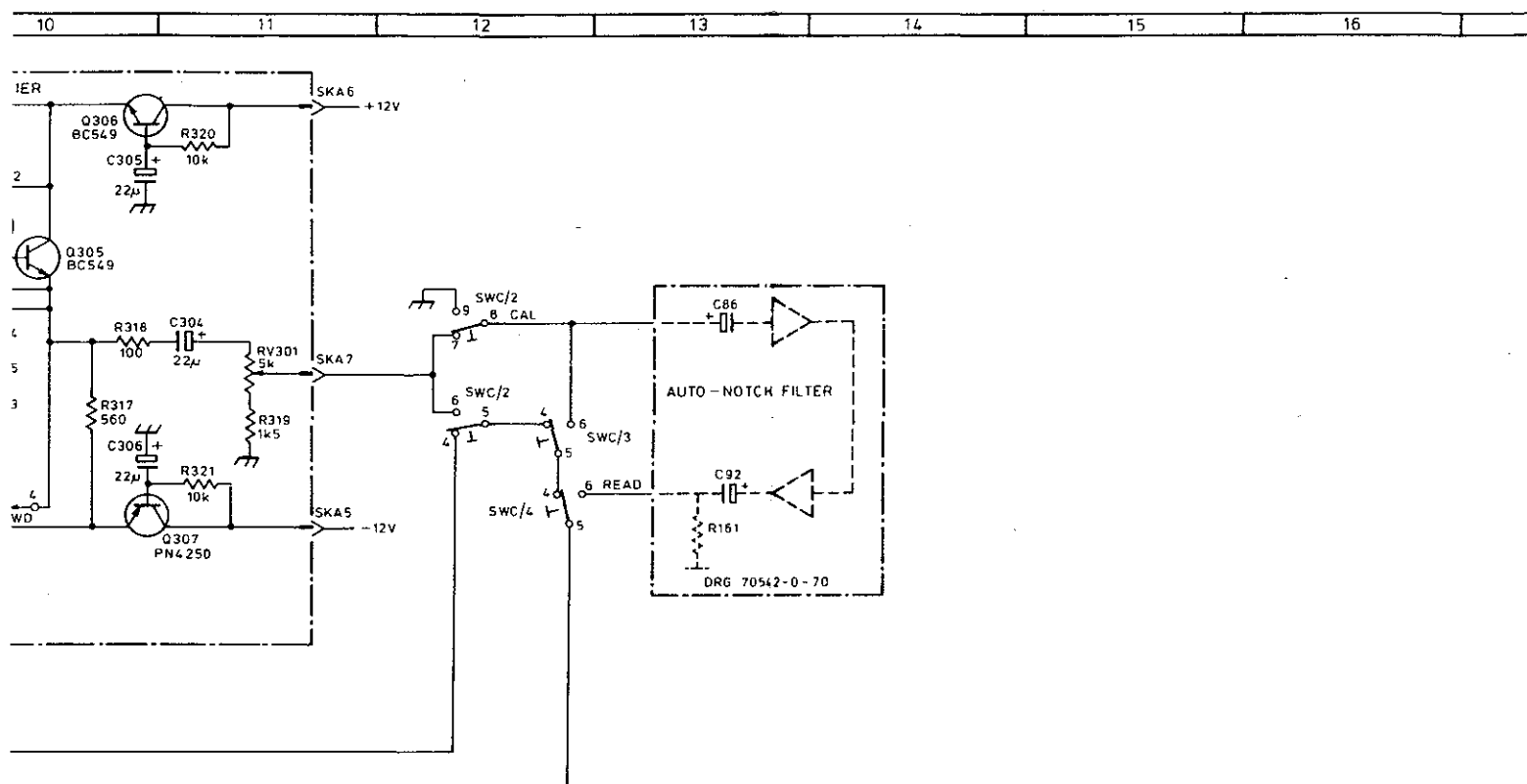


RELAY	J	K	L	M	FREQUENCY COVERED
1 C10 PMS	0	14	11	6	
	2	0	0	8	19 — 29.5
	0	8	0	1	24.5 — 45.8
	0	8	1	0	45.8 — 71.1
	0	8	1	1	71.1 — 110.5
	0	1	0	0	110.5 — 171.5
	0	1	8	1	171.5 — 266.3
	0	1	1	0	266.3 — 413.5
	0	1	1	1	413.5 — 642
	1	0	0	0	642 — 997
	1	0	0	1	997 — 1548
	1	0	1	0	1548 — 2404
	1	0	1	1	2404 — 3733
	1	1	0	0	3733 — 5796
	1	1	0	1	5796 — 9000
	1	1	1	0	9000 — 14000
	1	1	1	1	14000 — 21000

	AMALGAMATED WIRELESS (AUSTRALASIA) LTD	TITLE F742A DISTORTION AND NOISE METER MULLING LOOP SECTION
	ENGINEERING PRODUCTS DIVISION	
TYPE No 2A70542 PCB JRT8543	DRAWING No 70542-8-70 SERIAL No 386 ONWARD	ISSUE 1

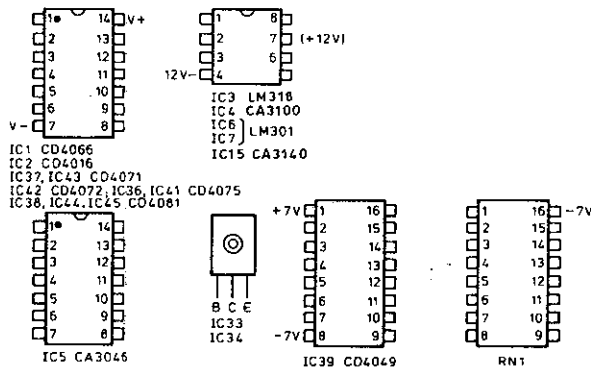




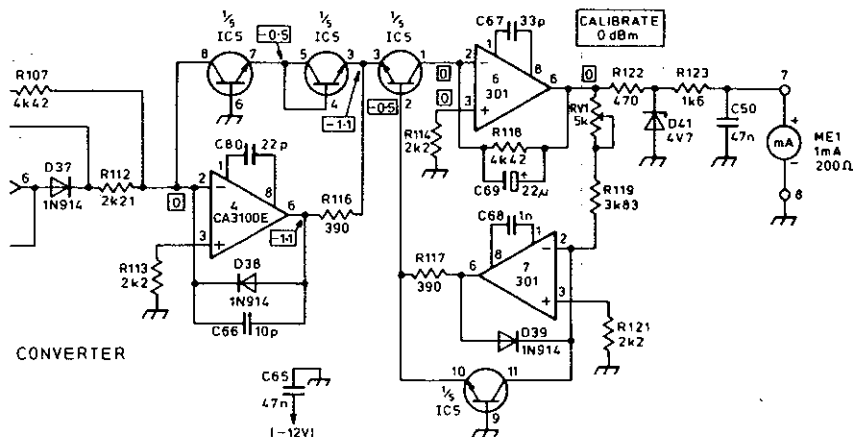
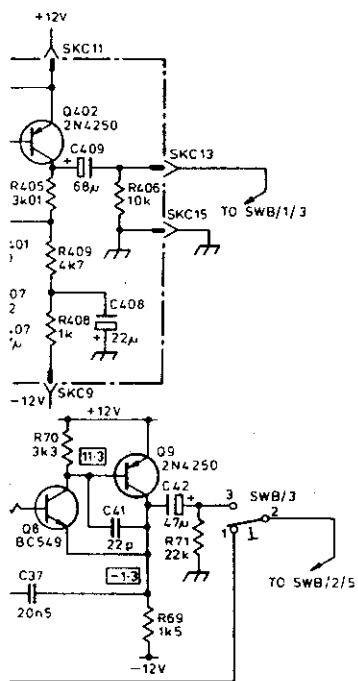
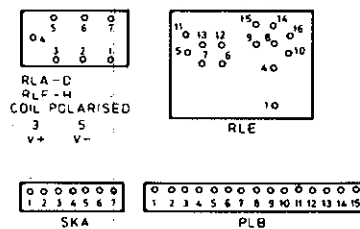


SWA/1	BAL/UNBAL
SWA/2	BRIDGING/600Ω
SWB/1	WEIGHTING NETWORK
SWB/2	L ₀ CUT
SWB/3	H ₀ CUT
SWC/1	LEVEL/dBm
SWC/2	LEVEL/REL
SWC/3	DISTORTION/CAL
SWC/4	DISTORTION/READ

IC TOP VIEWS



WIRING VIEWS OF RELAYS



	AMALGAMATED WIRELESS (AUSTRALASIA) LTD ENGINEERING PRODUCTS DIVISION		TITLE F742A DISTORTION AND NOISE METER LEVEL METER SECTION
	TYPE NO. 2A70542	DRAWING NO. 70542-0-71 SERIAL No 586 ONWARD	