Instruction / Service Manual
for

6425B
Precision Component Analyser

Part Nº 9H6425B

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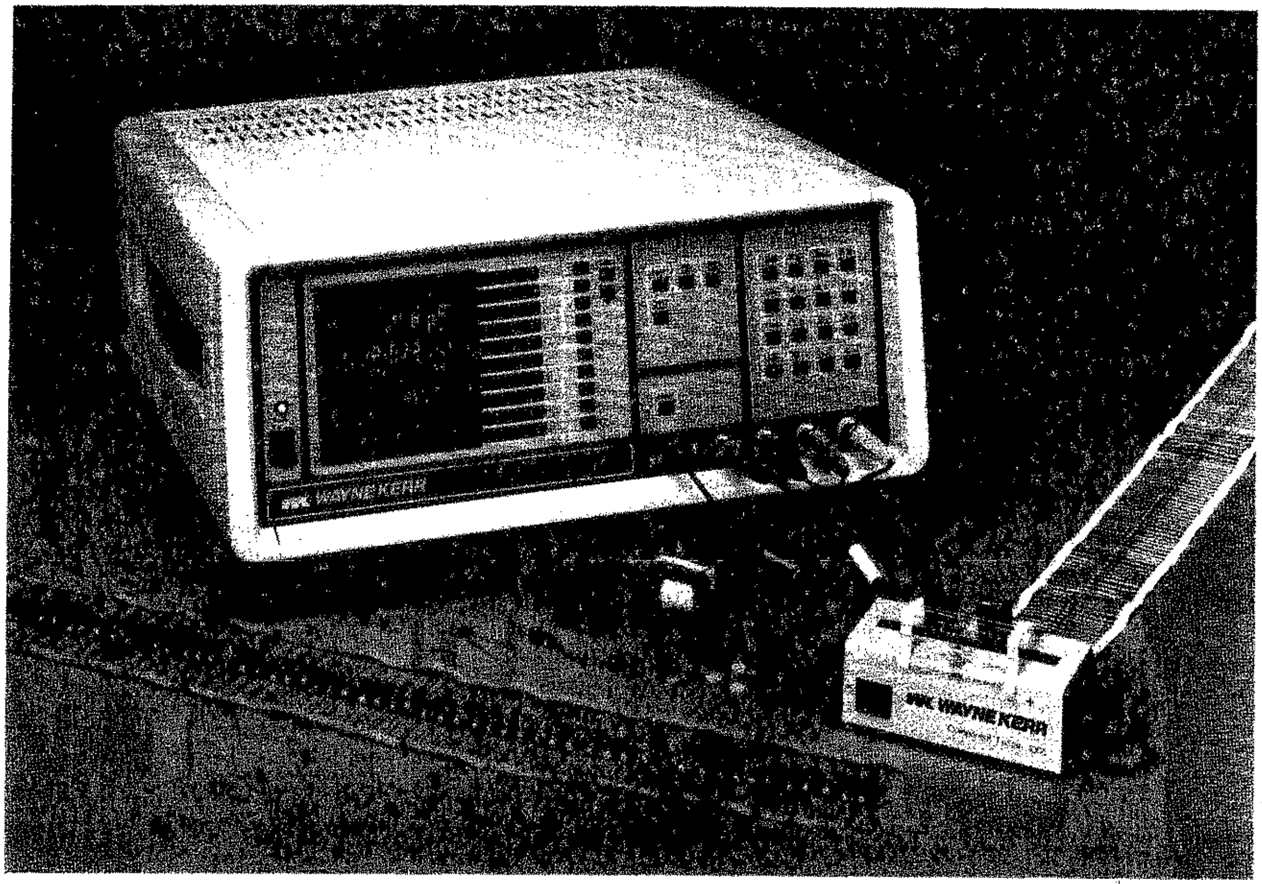
THIS MANUAL COMPRISES TWO PARTS
WHICH ARE INDEPENDENTLY INDEXED

Part No. 9H6425. Issue 3 01.95

PART 1   OPERATING INSTRUCTIONS

PART 2   SERVICE / MAINTENANCE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1. INTRODUCTION

1.1 DESCRIPTION

The 6425B is designed to give fast and accurate readout of component values, easy sorting of resistors, capacitors and inductors, detailed analysis of networks, and rapid monitoring of changing values. An extended measurement range, wide choice of operating frequency and adjustable drive level make the Analyzer a powerful tool in design laboratories, goods inwards sections, test departments and in connection with chemical and physical research work.

A cathode-ray tube is used to present clear and unambiguous results in numeric and graphic form, to display warning and other messages and, under software control, it automatically labels a set of ten 'soft' keys to show the parameter selection available for each mode of operation. All key settings are retained in non-volatile memory. Because there are no variable controls requiring user adjustment, and values can be read directly in the terms required, confidence in the validity of results is maximized for all levels of operator skill.

Four-terminal connections provide continuous correction for losses occurring in measurement leads or fixtures, ensuring the maintenance of dependable five-figure resolution and the specified accuracy over the full C, L and R ranges. The number of digits displayed - up to a maximum of six - is automatically adjusted to be commensurate with the accuracy. Trimming (O/C and S/C) is, in each case, a simple push-button operation, with corrections applied automatically to suit the particular measurement conditions at any time.

Range selection is automatic, with manual over-ride provided, together with a visual reminder when an alternative range would offer better resolution. Should a measurement lie beyond the range selected manually, the display is blanked, obviating false results.

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Sorting, pass/fail and deviation operations are all provided for. A numeric keypad allows limits to be set precisely, in % or Absolute terms, with the software guiding the user through the procedure and warning of any missing or invalid keying operations. A keyboard lockout function protects against unauthorized or inadvertent changes to established measurement conditions.

Other features include direct readout of D,Q or loss resistance at the same time as C or L, choice of equivalent series or parallel circuit values, display of actual signal level at the test point and provision for introducing dc polarizing voltages.

Options for the Precision Component Analyzer include an RS232-C Printer Interface; a GPIB Interface (to IEEE Std 488.1-1987); a Standard Handler Interface and Analog Outputs of 2 measured parameters. Basic information on these options is included in this Manual : for further details please contact your Supplier.

1.2 GUARANTEE

The equipment supplied by Farnell Instruments Limited is guaranteed against defective material and faulty manufacture for a period of twelve months from the date of despatch. In the case of material or components employed in the equipment but not manufactured by us we allow the customer the period of any guarantee extended to us.

The equipment has been carefully inspected and submitted to comprehensive test at the factory prior to despatch. If, within the guarantee period, any defect is discovered in the equipment in respect of material or workmanship and reasonably within our control, we undertake to make good the defect at our own expense subject to our standard conditions of sale. In exceptional circumstances and at the discretion of the Service Manager, a charge for labour and carriage costs incurred may be made.

Our responsibility is in all cases limited to the cost of making good the defect in the equipment itself. The guarantee does not extend to third parties, nor does it apply to defects caused by abnormal conditions of working, accident, misuse, neglect or wear and tear.

1.3 STORAGE AND SHIPMENT

The instrument should be stored in a clean dry environment. The following environmental limitations apply to both storage and shipment:

Temperature	-40°C to +70°C (-40°F to +158°F)
Relative humidity	95% to +40°C non-condensing.

When returning the instrument please ensure adequate care is taken with packing, and arrange insurance cover against transit damage or loss. If possible re-use the original packing box, following the instructions below:

Wrap the instrument, together with accessories and instruction/service manual, in anti-static polystyrene and seal with adhesive tape. Fit the original polystyrene packing pieces to the sides of the unit and place in original packing box. Seal the box with heavy duty adhesive tape.

2 SPECIFICATION

MEASUREMENT SYSTEM	Microprocessor-controlled. 'Soft' keys for measurement functions & conditions. Selected functions held in non-volatile memory. Electronic 'lock-out' of key functions. Measurement trigger by remote contacts. Plug-in options for interface with controllers/ printers/plotters/sorters.
DISPLAY	7-inch (18cm) CRT for values, conditions, soft-key functions, instructions and warning messages. Number of digits displayed (max: 6) depends on measurement accuracy.
MEASUREMENT FUNCTIONS	C & D, C & Q, C & R } Series or parallel L & D, L & Q, L & R } equivalent circuit C & G, L & G Parallel equivalent circuit Z & $\angle\theta$, Z & Signal level at Unknown Y & $\angle\theta$, Y & Signal level at Unknown Deviation: % change from measured Nominal (L C Z or Y). Limits: % or Absolute for Go/Nogo testing, with Analog Bar Display. Binning: Sorts by major/minor term limits into 9 bins (tenth for rejects). Auto-Trim: Compensates for residual series impedance and parallel capacitance of measurement leads up to 1Ω /50pF maximum. Trimmed value held in non-volatile store.
MEASUREMENT CONDITIONS	Frequency (Hz): 20, 25, 30, 40, 50, 60, 80, 100, 120, 150, 200 etc, repeats each decade up to 60k, then 75k, 100k, 120k, 150k, 200k, 300k (42 frequencies). Frequency accuracy: ±0.01%.

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MEASUREMENT CONDITIONS (continued)

AC Drive level:

10mV - 500mV (10mV steps)	Available if Unknown
520mV - 1.0V (20mV steps)	impedance ≥10Ω
1.05V - 2.5V (0.05V steps)	Available if Unknown
2.6V - 5.0V (0.1V steps)	impedance ≥80Ω
1mA - 50mA (1mA steps)	Available if Unknown
52mA - 100mA (2mA steps)	impedance ≤10Ω

Drive mode (current/voltage) selected automatically as a function of impedance range.

When in current drive, with Z or Y selected, the voltage across the Unknown can be displayed, and vice versa.

At 300kHz, voltage drive restricted to 3V maximum.

AC Level accuracy (at source):

30Hz - 120kHz:	voltage	±4%	±2mV
" "	current	±5%	±200μA
20Hz & 25Hz	voltage	±7.5%	±2mV
120kHz - 200kHz	current	±8.5%	±200μA
300kHz:	voltage	±11.5%	±2mV
"	current	±12.5%	±200μA

Source loading. Max level reduction at Zu = 10Ω :

Capacitive or Inductive Unknown:

4% (voltage drive)

3% (current drive)

Resistive Unknown:

18% (voltage or current drive).

DC Bias voltage.

Internal: adjustable supply with separate on/off switch and safety link.

0.1V - 5V (0.1V steps)

5.2V - 10V (0.2V steps)

10.5V - 20V (0.5V steps)

Open-circuit accuracy ±2% ±60mV

Max. continuous leakage current in Unknown: 3mA +0.25mA/V.

DC Bias voltage, Internal (continued)

Charge/discharge limited to <1A or <500V/sec.

External: additional supply can be connected in series with internal supply to increase available voltage. Controlled by internal on/off switch. Supply current limited to 1A.

Max. total voltage (internal + external): 50V.

Open-circuit accuracy at measurement terminals: ±2% ±60mV.

Max. continuous leakage current in Unknown: 3mA.

MEASUREMENT RANGES

Automatic range selection can be inhibited by Hold function (Range Error shows when a change of range could give improved accuracy). When in Hold, a desired range can be selected by keying the corresponding code. (See section 6).

Range Number	Impedance coverage	Maximum ac Drive Level
1	≦1.25Ω	100mA
2	≦10Ω	100mA
3	≧10Ω	1V
4	≧80Ω	5V
5	≧640Ω	5V
6	≧5.12kΩ	5V
7	≧41kΩ	5V
8	≧328kΩ	5V

Range 8 available up to 10kHz.

Range 7 available up to 60kHz.

For drive levels below 25mA, Range 1 not available.

For drive levels below 250mV, highest range at each frequency not available.

At 300kHz, max level = 3V.

MEASUREMENT ACCURACY

At 1V or 100mA. Slow Speed. (See also page 2-7). Resolution figures apply from 250mV or 25mA upwards. From 30mV to 240mV, and 3mA to 24mA, multiply by 10.

Resistance (R) or Impedance (Z)

Basic accuracy (1kHz): ±.05% 0.2Ω - 12MΩ

Full details on pages 2-8 and 2-9.

Resolution:		
	0.005mΩ	up to 10kHz
	0.05mΩ	at 100kHz
	0.2mΩ	at 300kHz

Conductance (G)

Basic accuracy (1kHz): ±.05% 80nS - 5S

Full details on pages 2-8 and 2-9.

Resolution:		
	0.01nS	up to 10kHz
	0.2nS	at 20kHz
	1nS	at 50kHz
	5nS	at 100kHz
	0.02μS	at 300kHz

Capacitance (C)

Basic accuracy (1kHz): ±.05% 20pF - 1800μF

Full details on pages 2-10 and 2-11.

Resolution:		
	0.002pF	at 1kHz
	0.0002pF	at 10kHz
	0.002pF	at 50kHz
	0.01pF	at 100kHz

Dissipation Factor (D)

Basic accuracy (1kHz): ±.0002 60pF - 320μF

Full details on pages 2-12 and 2-13.

Resolution:		
	0.00005	up to 10kHz
	0.0005	at 100kHz
	0.002	at 300kHz

Inductance (L)

Basic accuracy (1kHz): ±.1% 3μH - 200H

Full details on pages 2-14 and 2-15.

Resolution: 0.1nH from 5kHz upwards

Quality Factor (Q)

Basic accuracy (1kHz): ±(.05Q)% 40μH - 160H

Full details on pages 2-16 and 2-17.

Resolution:

better than 2% for Q $\ngtr$1400 up to 10kHz

Q $\ngtr$140 at 100kHz

Q $\ngtr$32 at 300kHz

MEASUREMENT SELECTION	Repetitive (free-running) or Single shot triggered by dedicated front-panel key or remote contact via 3.5mm jack on front panel. This key remains active during keyboard lockout.
Measurement Speeds	Normal: Approx 300ms/measurement above 300Hz. Slows progressively below 300Hz to approx 600ms at 20Hz. Fast (reduced accuracy): Above 500Hz approx 85ms; 300Hz approx 90ms; 100Hz approx 160ms; 50Hz approx 250ms; 20Hz approx 600ms Slow (improved resolution): Approx 1.3s/measurement up to 75kHz. 750ms/measurement for 100kHz and above.
MEASUREMENT CONNECTIONS	Four BNC connectors permit 2, 3 and 4-terminal connections with screens at ground potential. Connection diagrams available on CRT display. Terminals withstand connection of charged capacitors, up to 50V (100mF max) or up to 500V (2μF max), either polarity. Rear panel safety link can be removed to inhibit internal dc bias. External bias supply connects in place of safety link. Circuits are NOT protected against reverse-connected external supply.
TEMPERATURE RANGE	Storage: −40°C to +70°C (−40°F to +158°F). Operating: 0°C to +40°C (+32°F to +104°F). Full Accuracy: 10°C to +30°C (+50°F to +86°F).
POWER SUPPLY	115V ±10% or 230V ±10% ac only. Consumption nominally 70VA. Instruments may be converted for 50Hz or 60Hz operation by fitting an internal wire link. Operation is possible with this link incorrectly set, but full accuracy may not be maintained.

DIMENSIONS	Width:	443mm (17.5in.)
	Height (inc. feet):	195mm (7.7in.)
	Depth (overall):	470mm (18.5in.)
	Weight:	16kg (35lb)

ORDER CODES/OPTIONS/ACCESSORIES

Basic order code: 6425B

Factory fitted options:

RS232-C (printer output)	add /A
GPIB interface (printer output or full control)	add /B
Analog Output (major/minor terms)	add /C
Handler interface	add /D
US Army option (contract DAAH01-94-D-0014) (comprising special rack mounting components, power lead and 115V 60Hz operation)	add /R

Accessories:

1005	4 terminal component fixture
1505	4 terminal lead set (individual crocodile clips)
A40190	Grounded component adaptor
A40100	Kelvin clips (fine jaw)
A40180	Kelvin clips (large jaw)
1905A	SMD chip probe lead set (needle probes for mounted components)
A40120	SMD chip tweezers
32005	Rack mounting kit

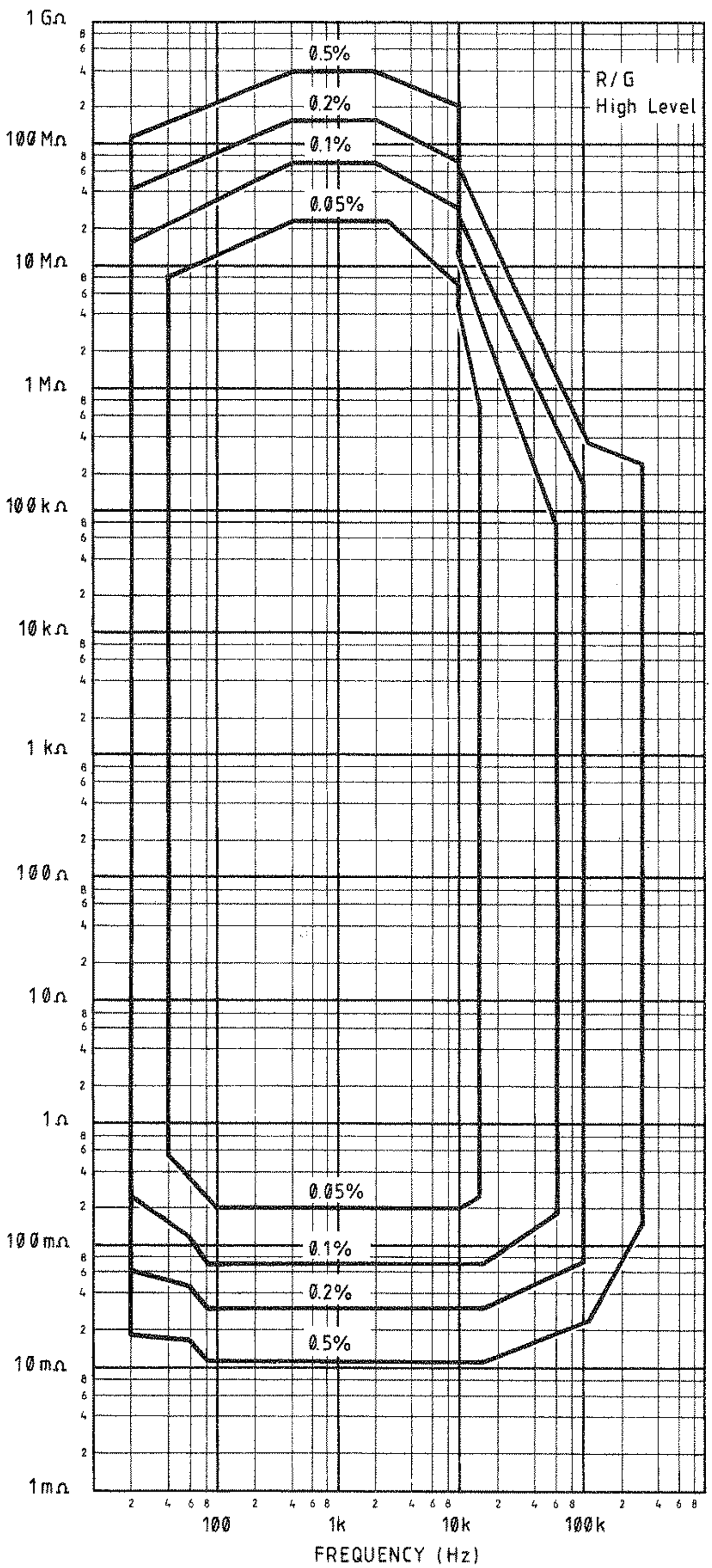
As standard, 6425B is supplied with accessories 1505 and A40100.

In step with rapidly developing technology the Company is continually improving its products and therefore reserves the right at any time to alter specifications or designs without prior notice.

MEASUREMENT ACCURACY

Iso-Accuracy charts define the measurement ranges available, at specified accuracies, over the available frequency band. For each of the five parameters - R/G, C, D, L and Q - two sets of curves are given: one for measurements at an ac level of 1V/100mA, the second for a level of 200mV/20mA. All curves assume that the Slow measurement speed is used, that the Analyzer has been trimmed at the frequency used for measurements and that the component under test is pure. Beside each chart is a summary of these conditions and information on the accuracy applicable when some or all of the conditions change.

Fig. 2.1 R/Z/G High Level Accuracy



CONDITIONS
AC Drive Level: 1V/100mA
Slow Speed
Analyzer trimmed at measurement frequency
Q ≯ 0.1

Except on highest and lowest measurement ranges, the adjacent Iso-Accuracy chart applies also as follows:

250mV - 5V and 25mA - 100mA
Normal Speed
Interpolated trim

For Fast Speed, on all ranges, the Normal Speed accuracy figures must be doubled. Supply frequency rejection is also reduced, causing additional unquantifiable errors dependent on measurement lead layout, particularly at frequencies below 600Hz and low a.c. drive levels.

O/C and S/C Trim corrections under various conditions of interpolation, speed and level are given in the table following these Iso-Accuracy charts.

For impure components, and for measurements on the highest or lowest available ranges, the full accuracy expressions, shown below, apply. During the first hour of operation, parallel capacitance trim may drift by up to 0.05pF, series impedance by up to 0.2mΩ. Subsequent drifts, including ambient temperature change not exceeding 5°C, are included in the interpolated trim correction figures in the table (page 2-18).

For 1 > Q > 0.1 multiply accuracy by (1+Q)

For Q > 1 (loss resistance of inductor)
see Q accuracy chart (page 2-16)
D < 1 (loss resistance of capacitor)
see D accuracy chart (page 2-12)

High R values: Accuracy = $\pm(A + 100\ Y_T.Rx)\%$

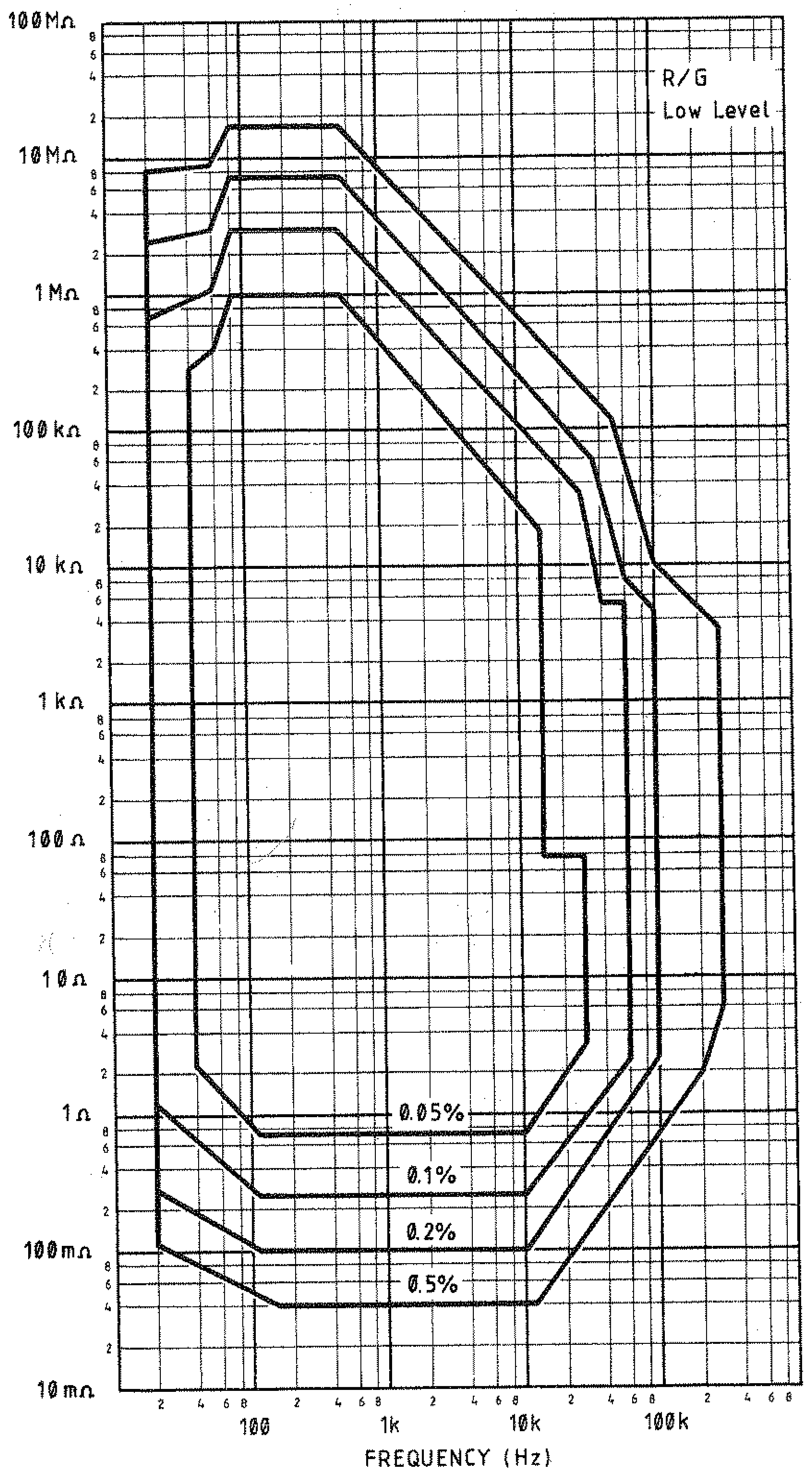
Low R values: Accuracy = $\pm(A + 100R_T/Rx)\%$

where
A = Accuracy from adjacent chart
Rx = measured value of unknown component
Y_T = sum of Y_I, Y_N, Y_L (as appropriate, from Table - page 2-18).

R_T = sum of Z_I, R_N, R_L (as appropriate, from Table - page 2-18).

Conductance (G): Find accuracy for equivalent R value from R = 1/G

Fig. 2.2 R/Z/G Low Level Accuracy



CONDITIONS
AC Drive Level: 200mV/20mA
Slow Speed
Analyzer trimmed at measurement frequency
$Q \nless 0.1$

Except on highest and lowest measurement ranges, the adjacent Iso-Accuracy chart applies also as follows:

50mV - 240mV and 5mA - 24mA
Normal Speed
Interpolated trim

For Fast Speed, on all ranges, the Normal Speed accuracy figures must be doubled. Supply frequency rejection is also reduced, causing additional unquantifiable errors dependent on measurement lead layout, particularly at frequencies below 600Hz and low a.c. drive levels.

O/C and S/C Trim corrections under various conditions of interpolation, speed and level are given in the table following these Iso-Accuracy charts.

For impure components, and for measurements on the highest or lowest available ranges, the full accuracy expressions, shown below, apply. During the first hour of operation, parallel capacitance trim may drift by up to 0.05pF, series impedance by up to 0.2mΩ. Subsequent drifts, including ambient temperature change not exceeding 5°C, are included in the interpolated trim correction figures in the table (page 2-18).

For 1 > Q > 0.1 multiply accuracy by (1+Q)

For Q > 1 (loss resistance of inductor) see Q accuracy chart (page 2-17)
D < 1 (loss resistance of capacitor) see D accuracy chart (page 2-13)

High R values: Accuracy = $\pm(A + 100\, Y_T . Rx)\%$

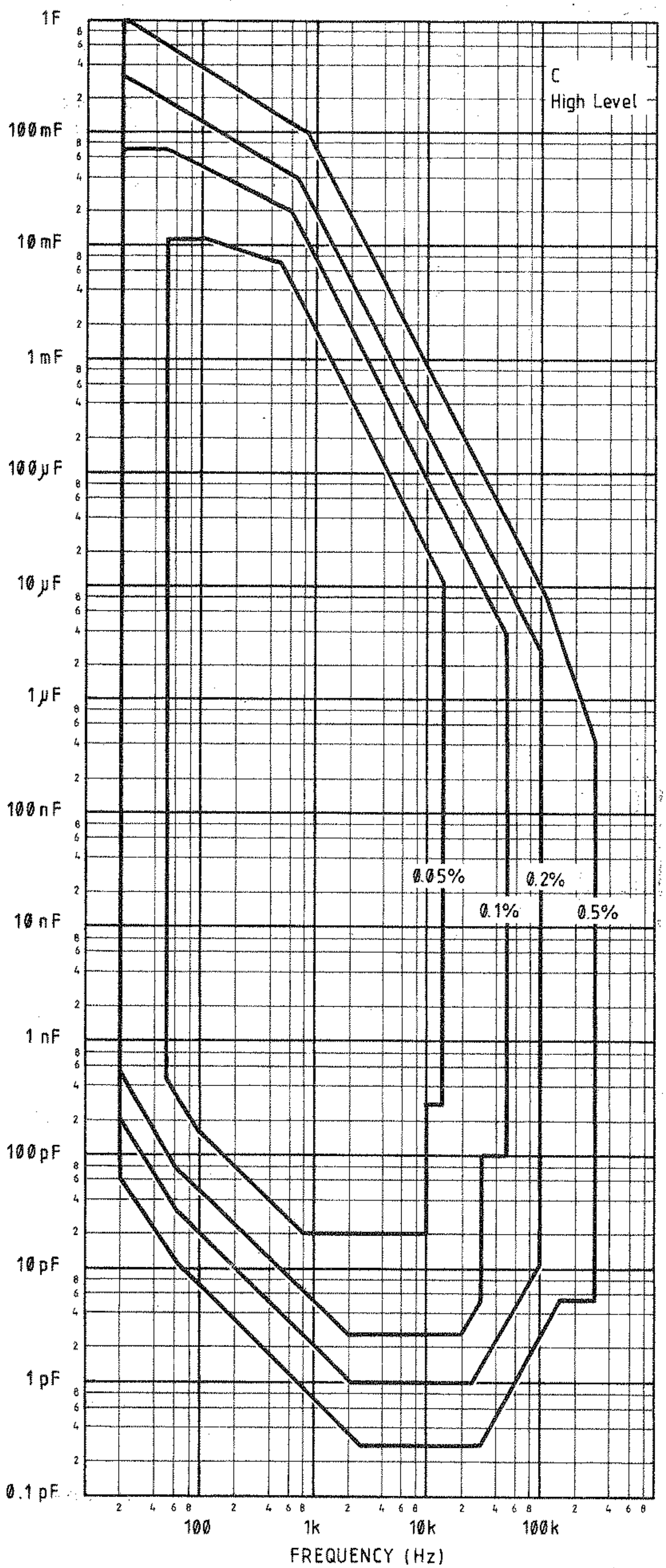
Low R values: Accuracy = $\pm(A + 100 R_T / Rx)\%$

where
A = Accuracy from adjacent chart
Rx = measured value of unknown component
Y_T = sum of Y_I, Y_N, Y_L (as appropriate, from Table - page 2-18).

R_T = sum of Z_I, R_N, R_L (as appropriate, from Table - page 2-18).

Conductance (G): Find accuracy for equivalent R value from R = 1/G

Fig. 2.3 C High Level Accuracy



CONDITIONS
AC Drive Level: 1V/100mA
Slow Speed
Analyzer trimmed at measurement frequency
D ≯ 0.1
Except on highest and lowest measurement ranges, the adjacent Iso-Accuracy chart applies also as follows:

250mV - 5V and 25mA - 100mA
Normal Speed
Interpolated trim

For Fast Speed, on all ranges, the Normal Speed accuracy figures must be doubled. Supply frequency rejection is also reduced, causing additional unquantifiable errors dependent on measurement lead layout, particularly at frequencies below 600Hz and low a.c. drive levels.

O/C and S/C Trim corrections under various conditions of interpolation, speed and level are given in the table following these Iso-Accuracy charts.

For impure components, and for measurements on the highest or lowest available ranges, the full accuracy expressions, shown below, apply. During the first hour of operation, parallel capacitance trim may drift by up to 0.05pF, series impedance by up to 0.2m Ω. Subsequent drifts, including ambient temperature change not exceeding 5°C, are included in the interpolated trim correction figures in the table (page 2-18).
If D > 0.1, multiply C accuracy by (1 + D)
High C values:Accuracy = $\pm(A + 100X_T \cdot \omega\, Cx)\%$

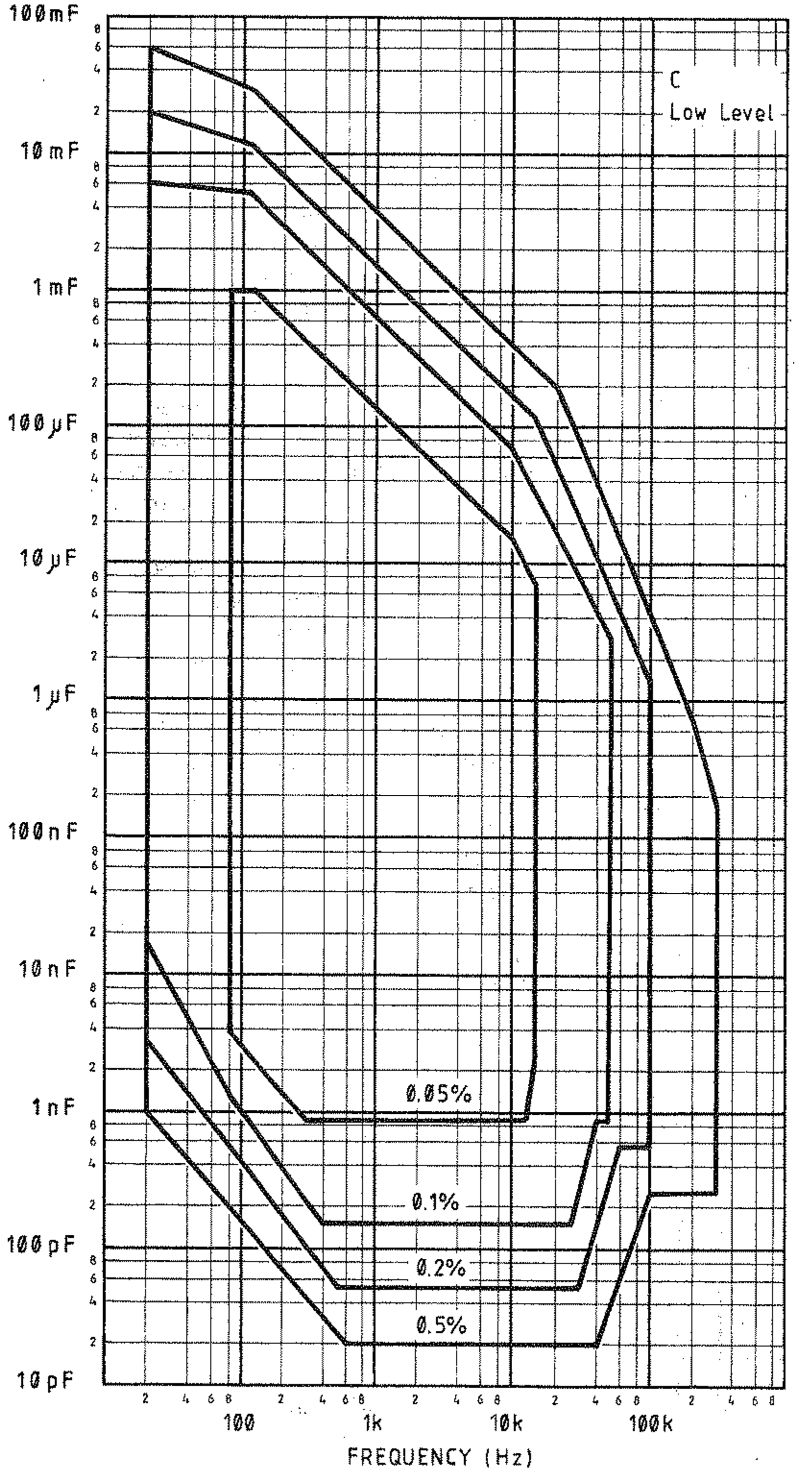
Low C values:Accuracy = $\pm(A + 100C_T/Cx)\%$

where
A = Accuracy from adjacent chart
Cx = measured value of unknown component
X_T = sum of Z_I, X_N, X_L (as appropriate, from Table - page 2-18).

C_T = sum of C_I, C_N, C_L (as appropriate, from Table - page 2-18).

ω = 2π x frequency

Fig. 2.4 C Low Level Accuracy



CONDITIONS
AC Drive Level: 200mV/20mA
Slow Speed
Analyzer trimmed at measurement frequency
$D \nmid 0.1$

Except on highest and lowest measurement ranges, the adjacent Iso-Accuracy chart applies also as follows:

- 50mV - 240mV and 5mA - 24mA
- Normal Speed
- Interpolated trim

For Fast Speed, on all ranges, the Normal Speed accuracy figures must be doubled. Supply frequency rejection is also reduced, causing additional unquantifiable errors dependent on measurement lead layout, particularly at frequencies below 600Hz and low a.c. drive levels.

O/C and S/C Trim corrections under various conditions of interpolation, speed and level are given in the table following these Iso-Accuracy charts.

For impure components, and for measurements on the highest or lowest available ranges, the full accuracy expressions, shown below, apply. During the first hour of operation, parallel capacitance trim may drift by up to 0.05pF, series impedance by up to 0.2m Ω. Subsequent drifts, including ambient temperature change not exceeding 5°C, are included in the interpolated trim correction figures in the table (page 2-18).

If D > 0.1, multiply C accuracy by (1 + D)

High C values: Accuracy = $\pm(A + 100X_T.\omega\, Cx)\%$

Low C values: Accuracy = $\pm(A + 100C_T/Cx)\%$

where

A = Accuracy from adjacent chart

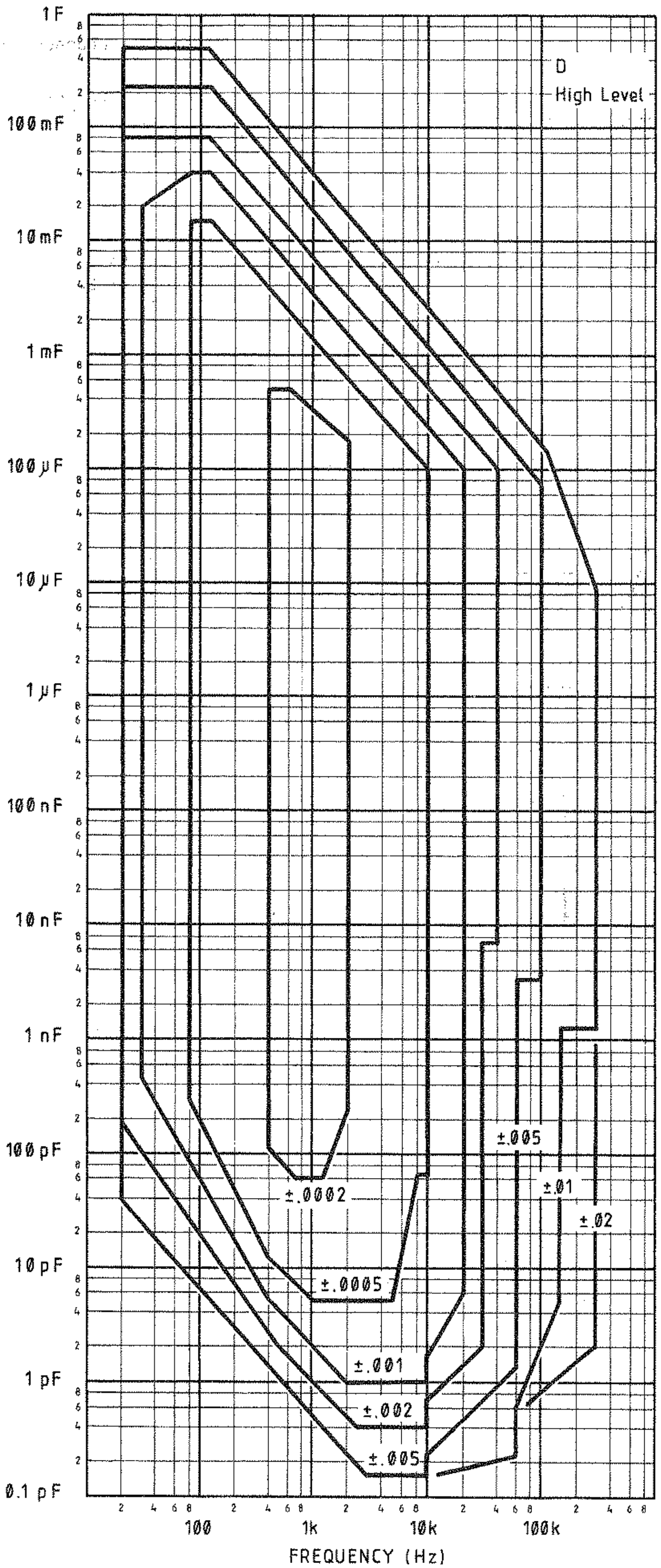
Cx = measured value of unknown component

X_T = sum of Z_I, X_N, X_L (as appropriate, from Table - page 2-18).

C_T = sum of C_I, C_N, C_L (as appropriate, from Table - page 2-18).

ω = 2π x frequency

Fig. 2.5 D High Level Accuracy



CONDITIONS

AC Drive Level: 1V/100mA

Slow Speed

Analyzer trimmed at measurement frequency

D ≯ 0.1

Except on highest and lowest measurement ranges, the adjacent Iso-Accuracy chart applies also as follows:

- 250mV - 5V and 25mA - 100mA
- Normal Speed (not ± .0002 curve)
- Interpolated trim

For Fast Speed, on all ranges, the Normal Speed accuracy figures must be doubled. Supply frequency rejection is also reduced, causing additional unquantifiable errors dependent on measurement lead layout, particularly at frequencies below 600Hz and low a.c. drive levels.

O/C and S/C Trim corrections under various conditions of interpolation, speed and level are given in the table following these Iso-Accuracy charts.

For impure components, and for measurements on the highest or lowest available ranges, the full accuracy expressions, shown below, apply. During the first hour of operation, parallel capacitance trim may drift by up to 0.05pF, series impedance by up to 0.2mΩ. Subsequent drifts, including ambient temperature change not exceeding 5°C, are included in the interpolated trim correction figures in the table (page 2-18).

If D > 0.1, multiply D accuracy by $(1 + D^2)$.

High capacitance values :

D accuracy = $\pm(A + R_T . \omega Cx)$

Low capacitance values :

D accuracy = $\pm (A + Y_T / \omega Cx)$

Capacitor series loss resistance (esr) - accuracy = $\pm (A/\omega\ Cx)\ \Omega$

Capacitor parallel loss resistance (epr) - accuracy = $\pm (100A.Rx/\omega\ Cx)\%$

where

A = Accuracy from adjacent chart

Cx = measured value of unknown component

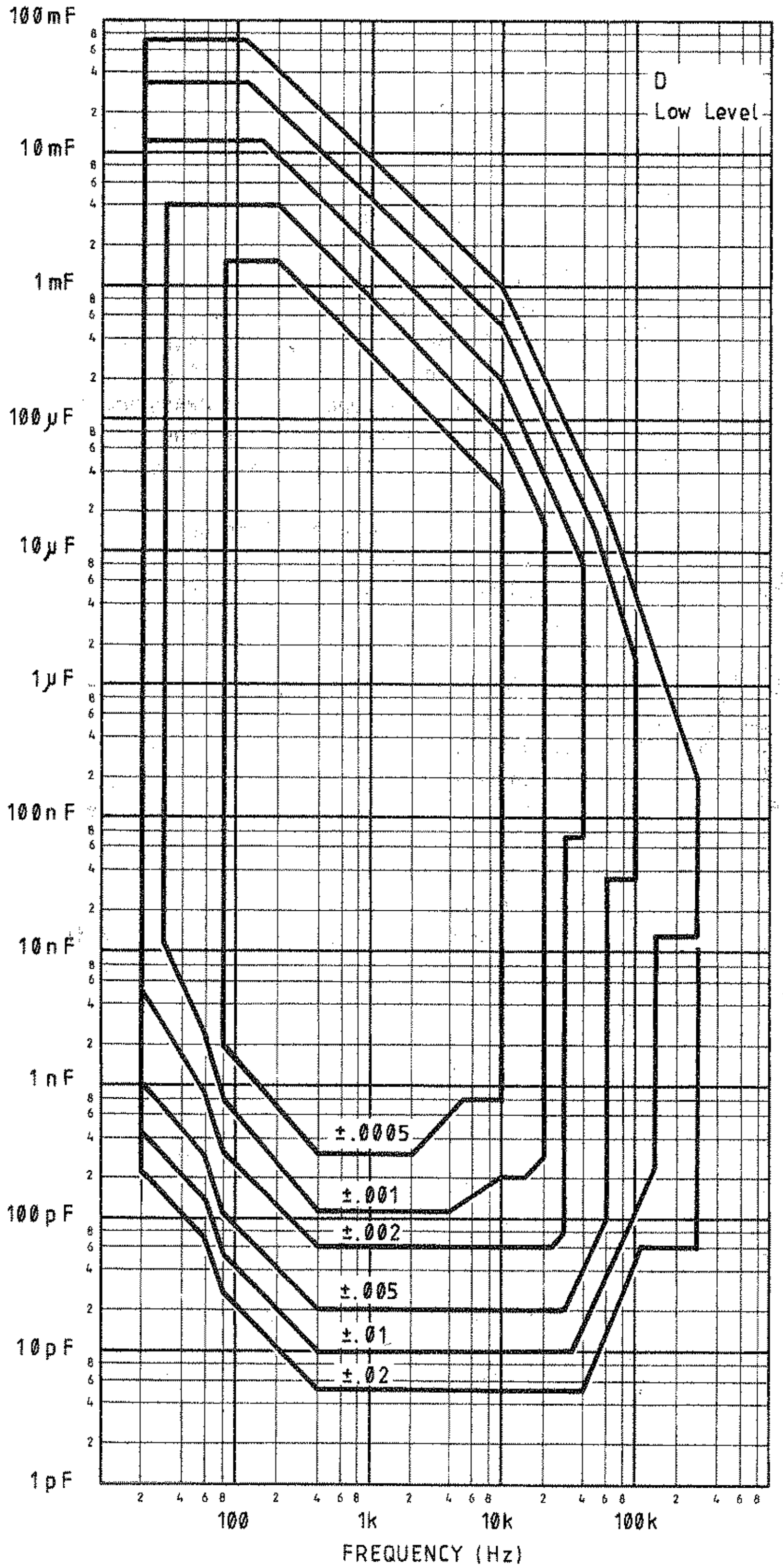
Rx = measured value of unknown component

R_T = sum of Z_I, R_N, R_L (as appropriate, from Table - page 2-18).

Y_T = sum of Y_I, Y_N, Y_L (as appropriate, from Table - page 2-18).

ω = 2π x frequency

Fig. 2.6 D Low Level Accuracy



CONDITIONS
AC Drive Level: 200mV/20mA
Slow Speed
Analyzer trimmed at measurement frequency
D ≯ 0.1
Except on highest and lowest measurement ranges, the adjacent Iso-Accuracy chart applies also as follows:

- 50mV - 240mV and 5mA - 24mA
- Normal Speed
- Interpolated trim

For Fast Speed, on all ranges, the Normal Speed accuracy figures must be doubled. Supply frequency rejection is also reduced, causing additional unquantifiable errors dependent on measurement lead layout, particularly at frequencies below 600Hz and low a.c. drive levels.

O/C and S/C Trim corrections under various conditions of interpolation, speed and level are given in the table following these Iso-Accuracy charts.

For impure components, and for measurements on the highest or lowest available ranges, the full accuracy expressions, shown below, apply. During the first hour of operation, parallel capacitance trim may drift by up to 0.05pF, series impedance by up to 0.2mΩ. Subsequent drifts, including ambient temperature change not exceeding 5°C, are included in the interpolated trim correction figures in the table (page 2-18).

If D > 0.1, multiply D accuracy by $(1 + D^2)$.
High capacitance values :
D accuracy = $\pm(A + R_T\ .\omega\, Cx)$

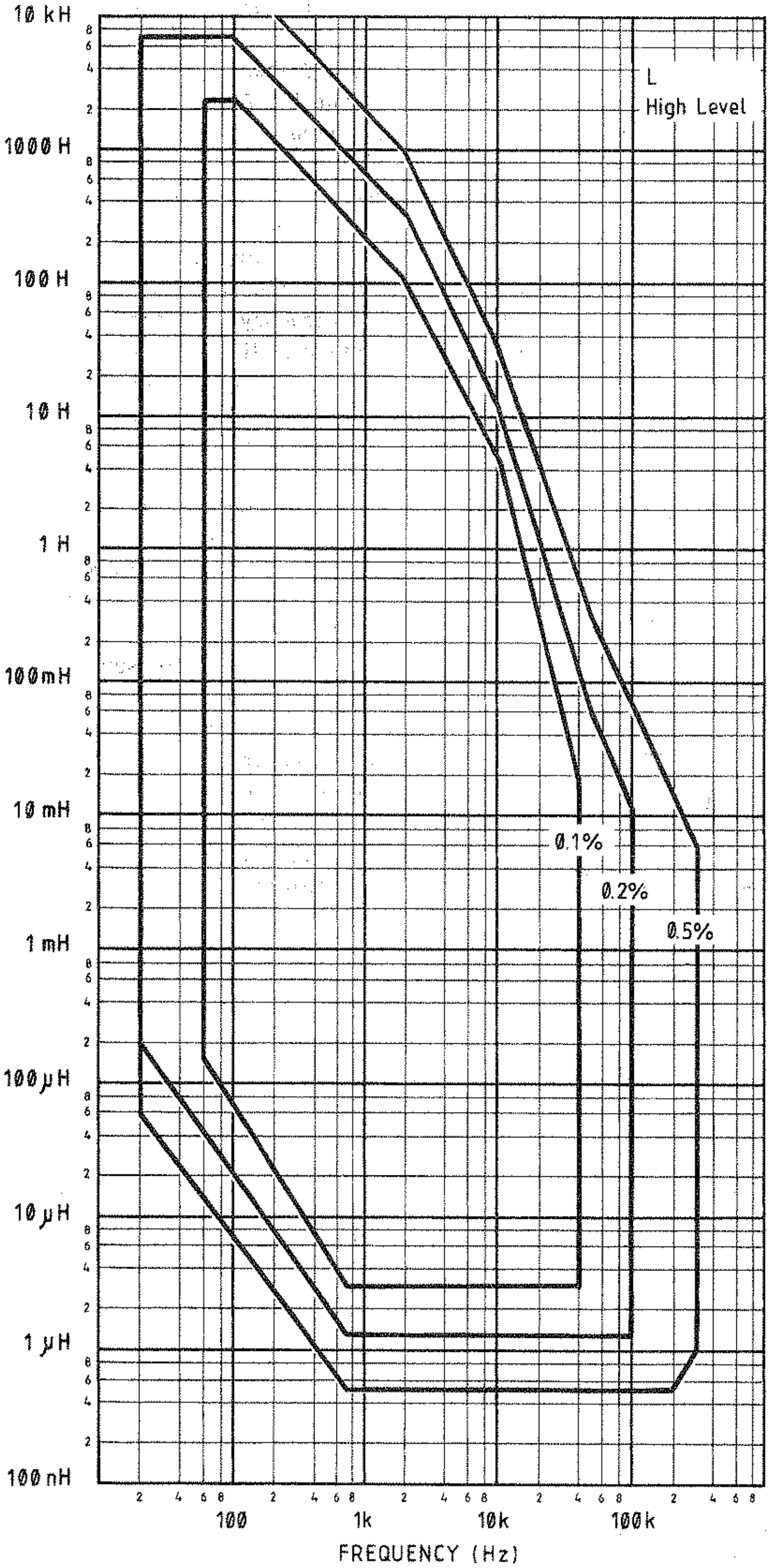
Low capacitance values :
D accuracy = $\pm\ (A + Y_T/\omega\, Cx)$

Capacitor series loss resistance (esr)
- accuracy = $\pm\ (A/\omega\, Cx)\Omega$
Capacitor parallel loss resistance (epr)
- accuracy = $\pm\ (100A.Rx/\omega\, Cx)\%$

where
A = Accuracy from adjacent chart
Cx = measured value of unknown component
Rx = measured value of unknown component
R_T = sum of Z_I, R_N, R_L (as appropriate, from Table - page 2-18).

Y_T = sum of Y_I, Y_N, Y_L (as appropriate, from Table - page 2-18).
ω = 2π x frequency

Fig. 2.7 L High Level Accuracy



CONDITIONS
AC Drive Level: 1V/100mA
Slow Speed
Analyzer trimmed at measurement frequency
Q ≮ 10
Except on highest and lowest measurement ranges, the adjacent Iso-Accuracy chart applies also as follows:

250mV - 5V and 25mA - 100mA
Normal Speed
Interpolated trim

For Fast Speed, on all ranges, the Normal Speed accuracy figures must be doubled. Supply frequency rejection is also reduced, causing additonal unquantifiable errors dependent on measurement lead layout, particularly at frequencies below 600Hz and low a.c. drive levels.

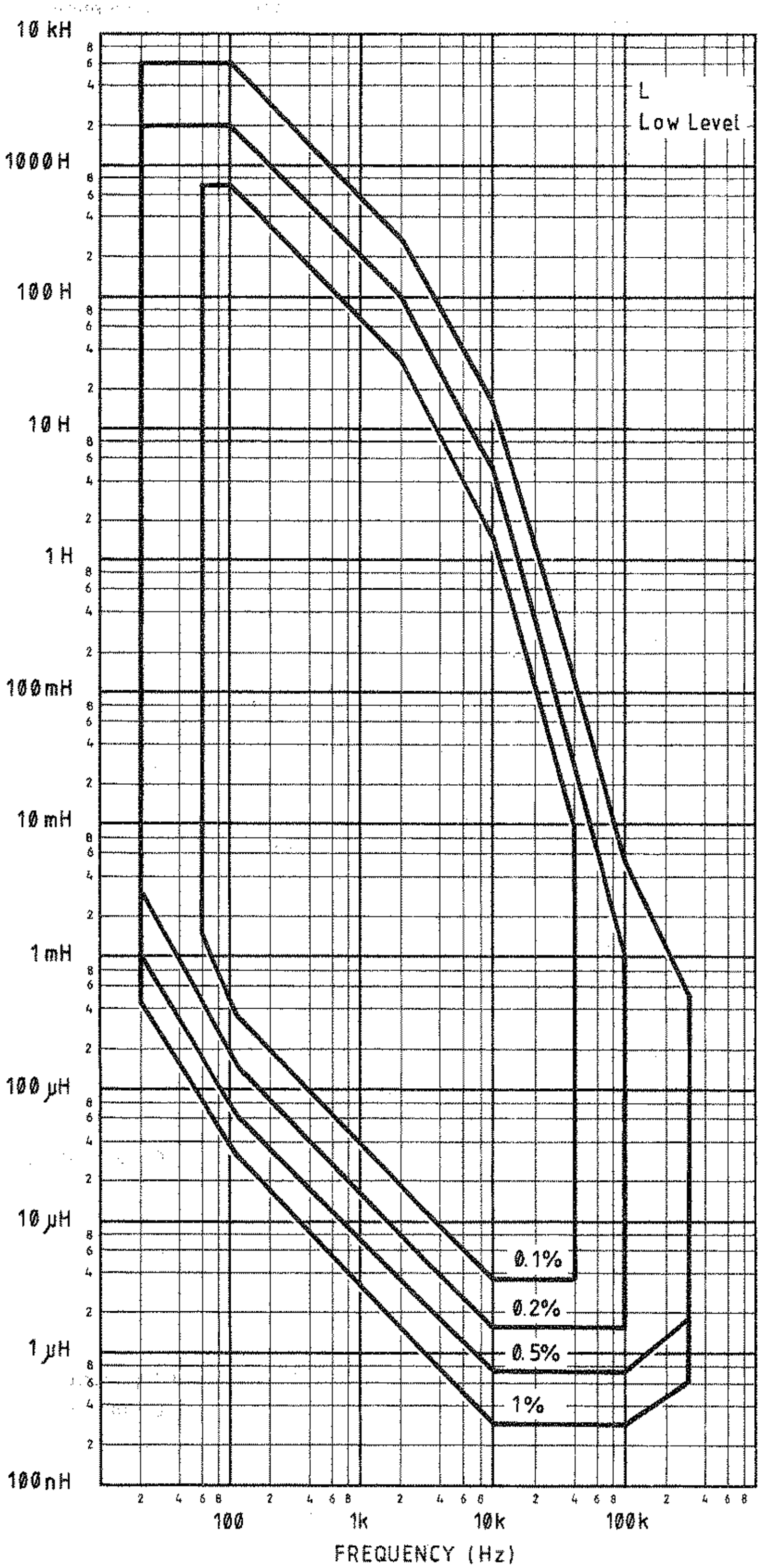
O/C and S/C Trim corrections under various conditions of interpolation, speed and level are given in the table following these Iso-Accuracy charts.

For impure components, and for measurements on the highest or lowest available ranges, the full accuracy expressions, shown below, apply. During the first hour of operation, parallel capacitance trim may drift by up to 0.05pF, series impedance by up to 0.2mΩ. Subsequent drifts, including ambient temperature change not exceeding 5°C, are included in the interpolated trim correction figures in the table (page 2-18).

If Q < 10, multiply L accuracy by (1 + 1/Q).
High L values:
Read accuracy direct from chart
Low L values:
Accuracy = ± $(A + 100L_T / Lx)\%$

where
A = Accuracy from adjacent chart
Lx = measured value of unknown component
L_T = sum of L_I, L_N, L_L (as appropriate, from Table - page 2-18).

Fig. 2.8 L Low Level Accuracy



CONDITIONS
AC Drive Level: 200mV/20mA
Slow Speed
Analyzer trimmed at measurement frequency
Q ≮ 10
Except on highest and lowest measurement ranges, the adjacent Iso-Accuracy chart applies also as follows:

50mV - 240mV and 5mA - 24mA
Normal Speed
Interpolated trim

For Fast Speed, on all ranges, the Normal Speed accuracy figures must be doubled. Supply frequency rejection is also reduced, causing additional unquantifiable errors dependent on measurement lead layout, particularly at frequencies below 600Hz and low a.c. drive levels.

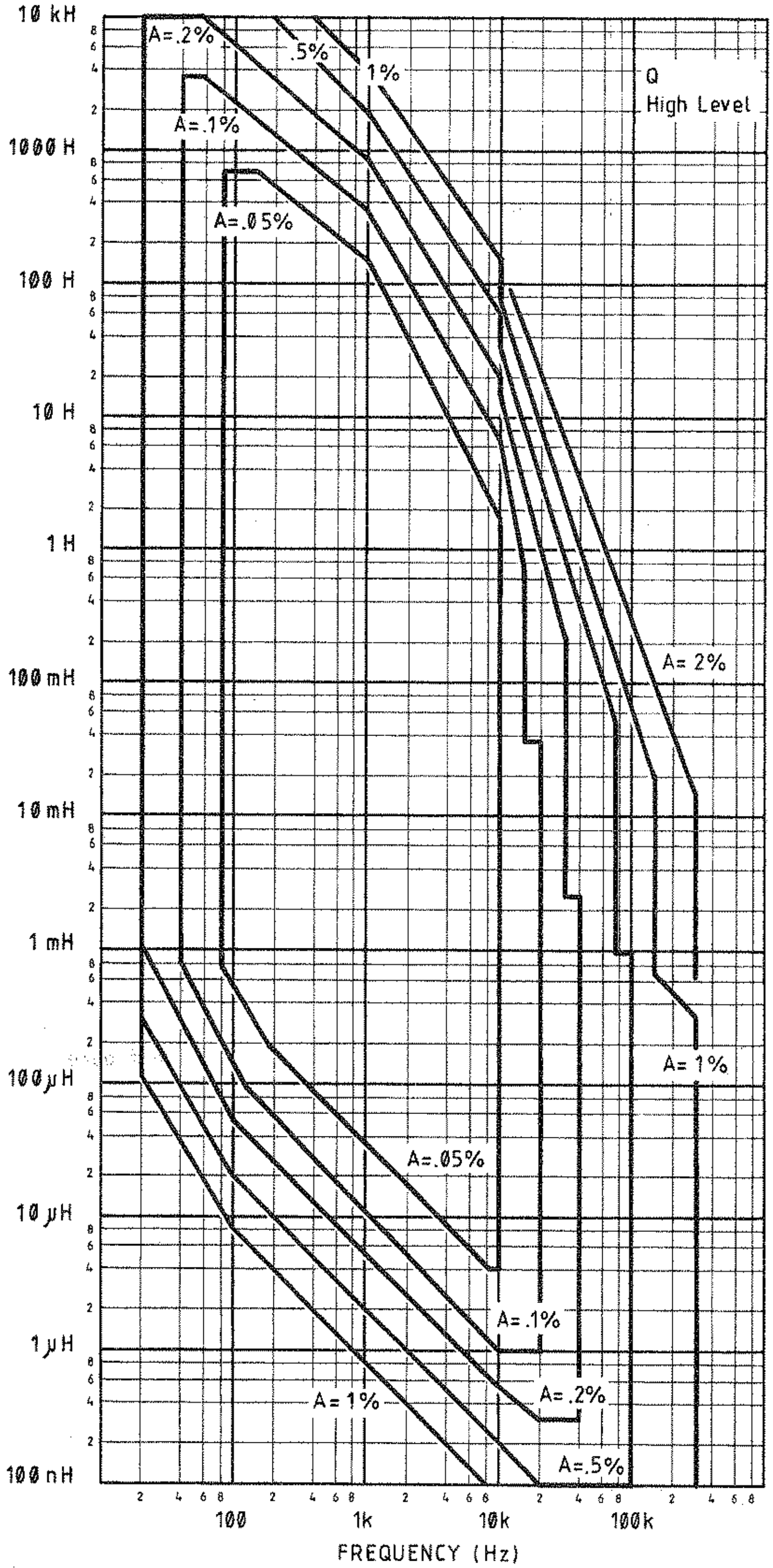
O/C and S/C Trim corrections under various conditions of interpolation, speed and level are given in the table following these Iso-Accuracy charts.

For impure components, and for measurements on the highest or lowest available ranges, the full accuracy expressions, shown below, apply. During the first hour of operation, parallel capacitance trim may drift by up to 0.05pF, series impedance by up to 0.2mΩ. Subsequent drifts, including ambient temperature change not exceeding 5°C, are included in the interpolated trim correction figures in the table (page 2-18).

If Q < 10, multiply L accuracy by $(1 + 1/Q)$.
High L values :
Read accuracy direct from chart
Low L values :
Accuracy = ± $(A + 100L_T / Lx)$%

where
A = Accuracy from adjacent chart
Lx = measured value of unknown component
L_T = sum of L_I, L_N, L_L (as appropriate, from Table - page 2-18).

Fig. 2.9 Q High Level Accuracy



CONDITIONS

AC Drive Level: 1V/100mA

Slow Speed

Analyzer trimmed at measurement frequency

Except on highest and lowest measurement ranges, the adjacent Iso-Accuracy chart applies also as follows:

- 250mV - 5V and 25mA - 100mA
- Normal Speed
- Interpolated trim

For Fast Speed, on all ranges, the Normal Speed accuracy figures must be doubled. Supply frequency rejection is also reduced, causing additional unquantifiable errors dependent on measurement lead layout, particularly at frequencies below 600Hz and low a.c. drive levels.

O/C and S/C Trim corrections under various conditions of interpolation, speed and level are given in the table following these Iso-Accuracy charts.

For impure components, and for measurements on the highest or lowest available ranges, the full accuracy expressions, shown below, apply. During the first hour of operation, parallel capacitance trim may drift by up to 0.05pF, series impedance by up to 0.2mΩ. Subsequent drifts, including ambient temperature change not exceeding 5°C, are included in the interpolated trim correction figures in the table (page 2-18).

For all Q values:

Q accuracy = $A(Q + 1/Q)$

High inductance values:

Read Q accuracy direct from chart

Low inductance values:

Q accuracy = $\pm(A + 100R_T/\omega Lx)(Q + 1/Q)\%$

Inductor series loss resistance

- accuracy = $\pm(A.\omega Lx/Rx)\%$

Inductor parallel loss resistance

- accuracy = $\pm(A.\omega LxRx)\%$

where

A = Accuracy from adjacent chart

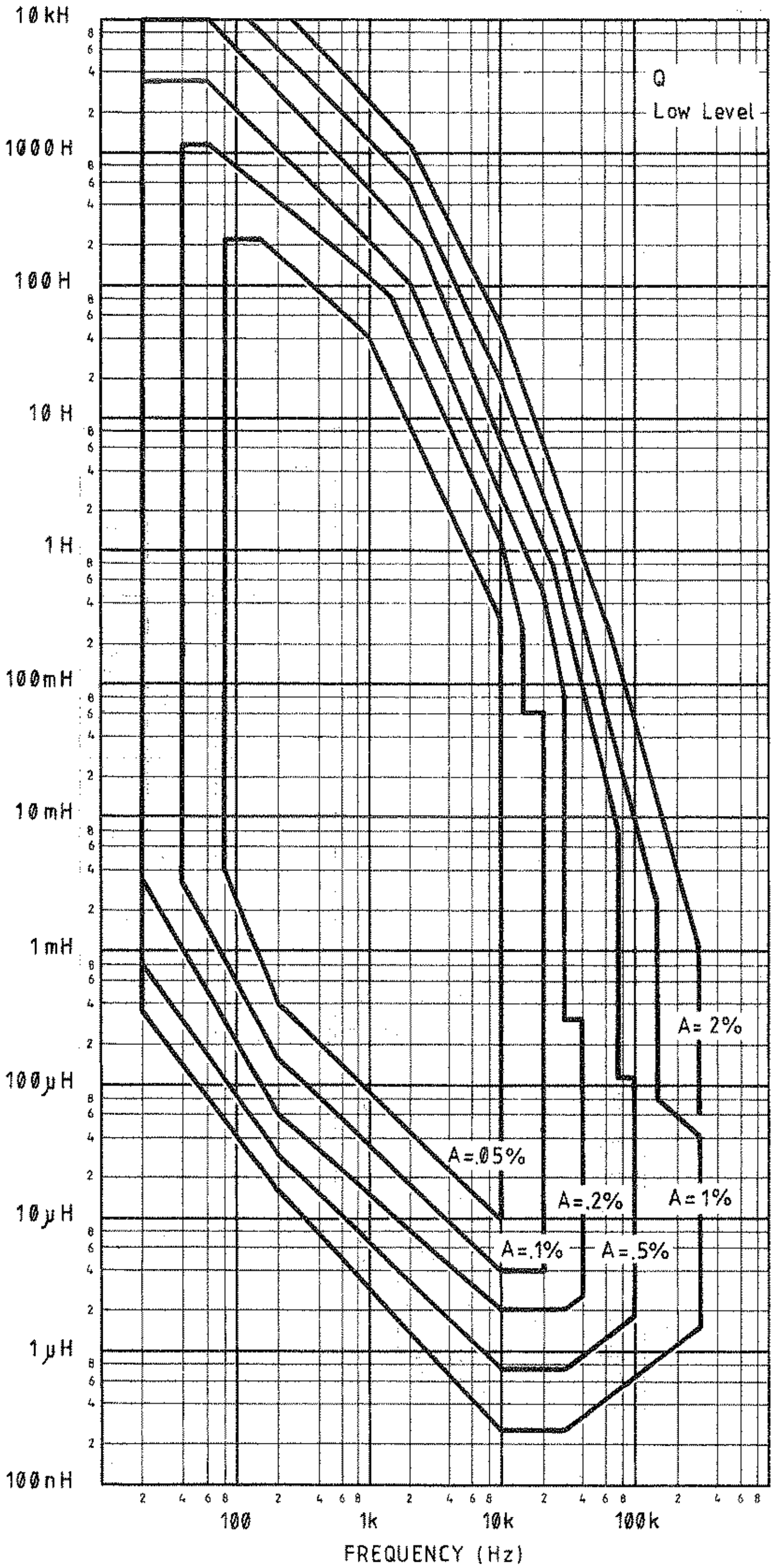
Lx = measured value of unknown component

Rx = measured value of unknown component

R_T = sum of Z_I, R_N, R_L (as appropriate, from Table - page 2-18).

ω = 2π x frequency

Fig. 2.10 Q Low Level Accuracy



CONDITIONS
AC Drive Level:200mV/20mA
Slow Speed
Analyzer trimmed at measurement frequency
Except on highest and lowest measurement ranges, the adjacent Iso-Accuracy chart applies also as follows:

50mV - 240mV and 5mA - 24mA
Normal Speed
Interpolated trim

For Fast Speed, on all ranges, the Normal Speed accuracy figures must be doubled. Supply frequency rejection is also reduced, causing additional unquantifiable errors dependent on measurement lead layout, particularly at frequencies below 600Hz and low a.c. drive levels.

O/C and S/C Trim corrections under various conditions of interpolation, speed and level are given in the table following these Iso-Accuracy charts.

For impure components, and for measurements on the highest or lowest available ranges, the full accuracy expressions, shown below, apply. During the first hour of operation, parallel capacitance trim may drift by up to 0.05pF, series impedance by up to 0.2mΩ. Subsequent drifts, including ambient temperature change not exceeding 5°C, are included in the interpolated trim correction figures in the table (page 2-18).

For all Q values:
Q accuracy = $A(Q + 1/Q)$
High inductance values:
Read Q accuracy direct from chart
Low inductance values:
Q accuracy = $\pm (A + 100R_T/\omega Lx)(Q + 1/Q)\%$
Inductor series loss resistance
- accuracy = $\pm(A.\omega Lx/Rx)\%$
Inductor parallel loss resistance
- accuracy = $\pm(A.\omega LxRx)\%$
where
A = Accuracy from adjacent chart
Lx = measured value of unknown component
Rx = measured value of unknown component
R_T = sum of Z_I, R_N, R_L (as appropriate, from Table - page 2-18).

ω = 2π x frequency

Table 2.1 O/C TRIM CORRECTIONS f = frequency in kHz

	INTERPOLATION		NORMAL SPEED		LEVEL .5 - 5V		LEVEL .25V		LEVEL .1V		
FREQUENCY RANGE (Hz)	Y_I (nS)	C_I (pF)	Y_N (nS)	C_N (pF)	Y_L (nS)	C_L (pF)	Y_L (nS)	C_L (pF)	Y_L (nS)	C_L (pF)	
20-60	.13	.02/f	.04	.007/f	.2	.032/f	.2	.032/f	.5	.08/f	For drive levels below .1V multiply level corrections by .1V/level.
80-1k	.13	.02/f	.03	.005/f	.1	.016/f	.2	.032/f	.5	.08/f	
1k2-10k	.13xf	.02	.02	.003/f	.1xf	.016	.2xf	.032	.5xf	.08	
12k-60k	.2xf	.032	.01xf	.002	.16xf	.025	.32xf	.05	1.3xf	.2	
75k-300k	1.6xf	.25	.03xf	.005	.32xf	.05	.64xf	.1	4xf	.6	

Table 2.2 S/C TRIM CORRECTIONS f = frequency in kHz

	INTERPOLATION		NORMAL SPEED			LEVEL = 50mA			
FREQUENCY RANGE (Hz)	Z_I (μΩ)	L_I (nH)	R_N (μΩ)	X_N (μΩ)	L_N (nH)	R_L (μΩ)	X_L (μΩ)	L_L (nH)	
20 - 60	300	50/f	50	25	4/f	125	125	20/f	For drive levels below 50mA multiply level corrections by 50mA/level.
80 - 250	120	20/f	25	25	4/f	125	125	20/f	
300 - 10k	50	8/f	25	25	4/f	40	20	3.2/f	
12k - 30k	4xf	1.0	25	25	4/f	4xf	2xf	.4	
40k - 100k	30xf	5	.5xf	0	0	$.13xf^2$	$.065xf^2$	.01xf	
120k- 300k	30xf	5	.5xf	0	0	13xf	6.5xf	1.0	

3.1 SAFETY

General

This equipment has been designed to meet the requirements of IEC publication 348, "Safety Requirements for Electronic Measuring Apparatus", and has left the factory in safe condition.

The remainder of this section on safety provides general information and general warnings which must be followed by the user to ensure safe operation and to maintain the equipment in a safe condition. Specific warnings if necessary will be found elsewhere in the manual and are not repeated here.

AC Power Supply

Power cable and connector requirements vary between countries. Always use a cable that conforms to local regulations, terminated in an IEC320 connector at the instrument end.

If it is necessary to fit a rewireable plug to the power cable, the user must observe the following colour code:

Wire Function	North American standard	Harmonised European standard
Line/Live	BLACK	BROWN
Neutral	WHITE	BLUE
Earth/Ground	GREEN	GREEN/YELLOW

The user must also ensure that the protective ground lead would be the last to break should the cable be subject to excessive strain.

If the plug is fused, a 3-amp fuse should be fitted.

continued......

If the power cable electrical connection to the a.c. power plug is through screw terminals then, to ensure reliable connections, any solder tinning of the cable wires must be removed before fitting the plug.

WARNING! Any interruption of the protective ground conductor inside or outside the equipment or disconnection of the protective ground terminal is likely to make the equipment dangerous. Intentional interruption is prohibited.

Before switching on the equipment, ensure that it is set to the voltage of the local a.c. power supply.

Adjustment, Replacement of Parts, Maintenance and Repair

When the equipment is connected to the local a.c. power supply, internal terminals may be live and the opening of covers or removal of parts (except those to which access can be gained by hand) is likely to expose live parts.

The equipment must be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance or repair.

Capacitors inside the equipment may still be charged even if the equipment has been disconnected from all voltage sources.

Any adjustment, maintenance and repair of the opened equipment under voltage must be carried out only by a skilled person who is aware of the hazards involved.

Ensure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders is prohibited.

Handling Hazards

Cathode ray tubes can implode if subject to excessive mechanical shock. Wear safety goggles if removing or replacing a CRT.

Any battery which is no longer serviceable should be disposed of intact and never incinerated. Replacement of lithium based batteries requires particular caution. Do not allow a new or used lithium battery to be short circuited, subject to any charging current or temperatures in excess of +70°C. Insulate terminals before disposal.

Beryllium oxide washers must be treated as toxic waste and be disposed of intact and never incinerated.

EPROMs could lose data if exposed to direct sunlight for 1 week or room level fluorescent lighting for 3 years.

Many components contain polymers which will give rise to toxic fumes if incinerated.

Static Electricity

Assume all integrated circuits and field effect transistors are 'static sensitive'. Before handling these components or printed circuit board assemblies containing these components, personnel should observe the following precautions:

1) The work surface should be a conductive grounded mat.

2) Soldering irons must be grounded and tools must be in contact with a conductive surface to ground when not in use.

3) Any person handling static-sensitive parts must wear a wrist strap which provides a leaky path to ground, impedance not less than 1 megohm, and not greater than 100 megohms.

continued.....

4) Components and printed circuit board assemblies must be stored in or on conductive foam or mat while work is in progress.

5) New components should be kept in the supplier's packaging until required for use.

3.2 RACK MOUNTING

A rack mounting kit (part number 32005) consisting of brackets (ears) and screws is available from your supplier, but runners must also be used to support the weight of the instrument. Top and bottom covers must remain in position, when the Analyzer is rack-mounted, but free ventilation must be allowed to the slots in the covers and to the heat sink at the rear of the instrument.

3.3 POWER CONNECTION

Check that the instrument is correct for the supply frequency (50 or 60Hz) and for the supply voltage (230V or 115V). The voltage setting is shown on a reversible plate on the rear of the instrument. To obtain the alternative setting, disconnect the instrument from the ac supply, remove the plate, re-set the switch and replace the plate with the new setting showing. Ensure that the fuse rating is correct:

230V instruments	1A-T
115V instruments	2A-T

The frequency (50 or 60Hz) for which the instrument was factory-set is marked on the rear panel. Operation from supplies of the wrong frequency will not cause damage, but noise levels may be higher on some readings. To reset instruments for the alternative frequency, contact your supplier.

Before connecting ac power, read the precautions listed under 3.1 SAFETY - AC Power Supply.

The instrument is not suitable for battery operation.

The power switch is located on the left of the front panel.

Allow up to 10 seconds for the crt display to warm up.

A rear panel control adjusts the display brightness to suit local ambient lighting levels.

3.4 MEASUREMENT CONNECTIONS

Accessory type A40100, 4-terminal leads terminated in Kelvin clips, is supplied as standard equipment with the instrument. Ensure that the colour coded plugs are mated correctly with the corresponding panel sockets.

The following alternative accessories are available to order , and may be more suitable for making connections to certain component types. In each case ensure that the colour coded plugs are correctly mated.

1005 4-terminal component fixture (see Fig. 3.2):

Remote fixture with sliding jaws that accommodate axial and radial leaded devices. Incorporates a push button switch and jack lead for triggering the measurements when 6425B is in 'single' mode (see Single/Rep modes section 5.16).

1505 4-terminal lead set (see Fig. 3.1):

600mm screened cable terminated in four crocodile clips at the component end.

A40180 Kelvin clips:

Similar to type A40100 but with larger jaws, suitable for connection to terminal posts or larger diameter component leads.

1905A SMD chip probe lead set:

2-terminal leads terminated with needle probes, suitable for connection to SMDs on circuit boards/hybrids and chip components on tape.

A40120 SMD tweezers:

Chip component tweezers for contacting leadless devices. Fully screened design eliminates effects of hand capacitance on reading. Incorporates a cam to set jaw spacing when trimming out residual capacitance.

A40190 Grounded component adaptor:

Allows 2-terminal measurements on components which have one end connected to ground. Connect the 4 colour coded BNC connectors to the 6425B using the lead provided. The non-grounded end of the device under test must be connected to the inner of the 5th non-coded BNC connector, using a suitable lead. Preferably use a screened lead, connecting the screen to the BNC outer at the adaptor end. Make no connection to this driven screen at the component end. If possible, make a short direct connection between the grounded end of the device under test and the 4mm ground terminal on the adaptor. Note that accuracy and ac drive conditions are restricted when using this adaptor:

At 100Hz 1Vmax, accuracy = 0.1% 100pF-100μF
At 100kHz 3Vmax, accuracy = 0.3% 50pF-100nF

Further information on 2, 3 and 4-terminal connections is given in section 5.21.

Further information on trimming is given in section 5.1

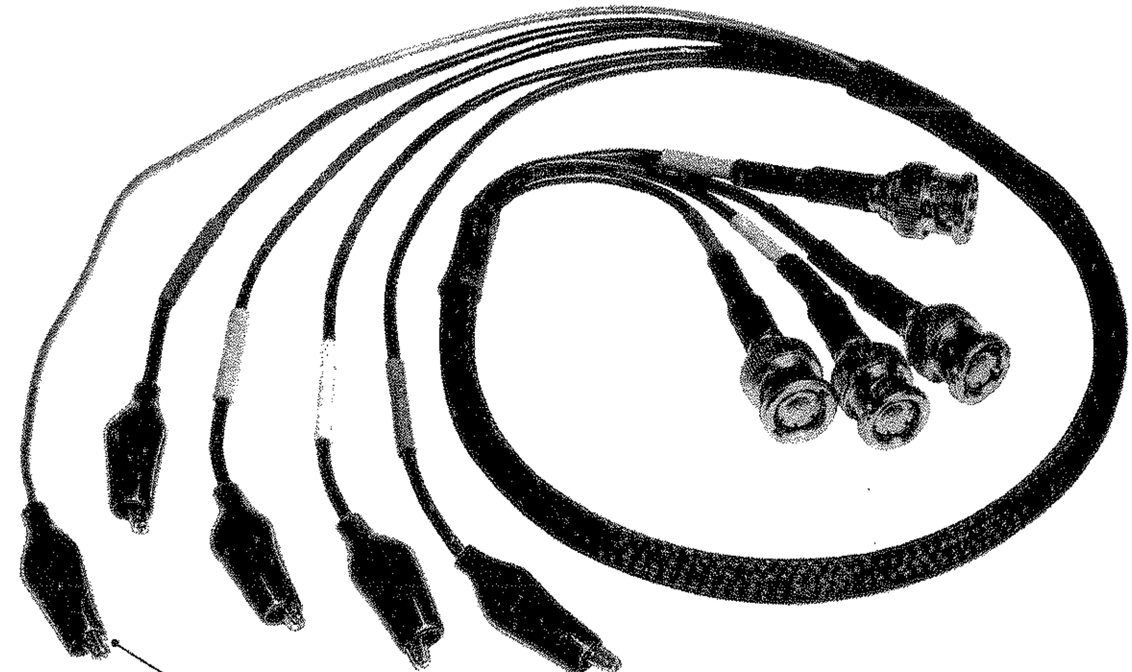


Fig. 3.1 Crocodile clip leads type 1505

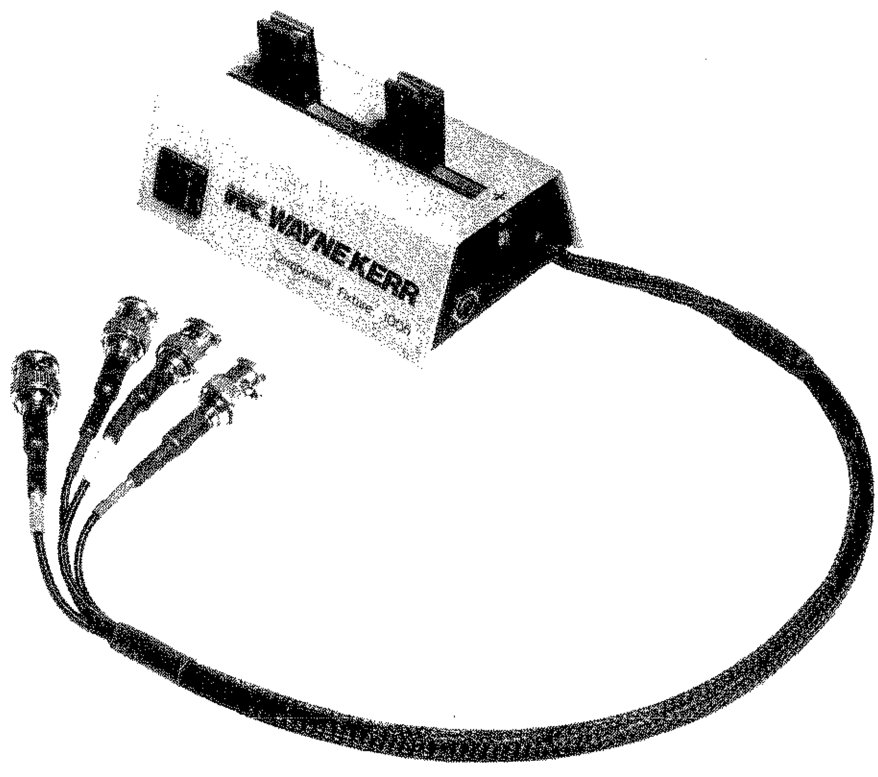


Fig. 3.2 Component Fixture type 1005

4 BASIC INFORMATION

4.1 PANEL ARRANGEMENT

An introduction to the Analyzer operation falls into the same three parts as the instrument front panel, that is : Display, Master Controls and Keypad (see Fig. 4.1).

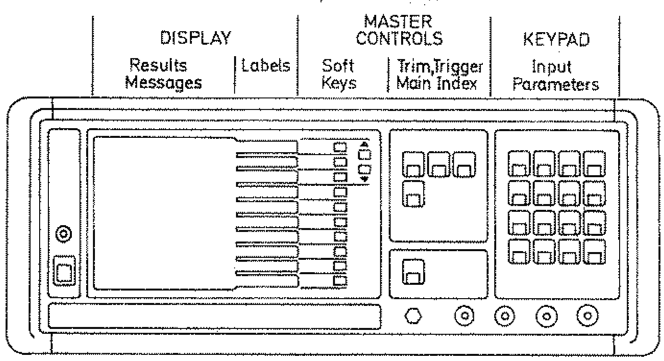


Fig. 4.1 Panel Controls

The Display is a cathode-ray tube, the main area showing results in numeric and graphic form, together with instructions, warnings, messages, and information on parameters selected or needed. The right-hand side of the crt display labels the row of ten 'soft' keys whose functions depend on the type of operation in progress.

The Master Controls consist of the ten 'soft' keys and five with dedicated functions. Two select either Trim O/C or Trim S/C. The Trigger key initiates the selected Trim operation, or a measurement in the 'single shot' mode. Pressing 'Local' restores control to the front panel when the (optional) GPIB mode is in use. The fifth key in this group is Main Index, which calls up a list of the various operating modes available. A summary of these modes is given in the next few pages, in the sequence they appear as labels for the soft keys (when Main Index has been selected). The required mode is obtained by pressing the appropriate soft key. Detailed information appears later in the Manual.

The Keypad provides the means for input of numerical values, multiples and units, or % figures for establishing and/or updating limits for sorting and pass/fail operations. Full details of its use appear in various later sections of this Manual.

4.2 MODE SUMMARIES

Normal is the usual operating mode for obtaining measurements of component values in absolute terms, together with such secondary characteristics as Q, D and loss resistance. A typical display in the Normal mode is shown in Fig. 4.2.

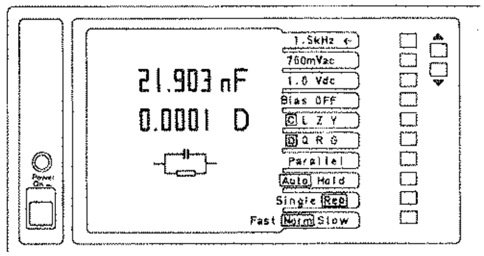


Fig. 4.2 A typical Normal mode display

From the illustration, it can be seen that - in this mode - the functions of the ten soft keys fall logically into three groups:

1 The top four establish the conditions of measurement: test frequency (see 5.2), test voltage (or current) (5.3), bias level and bias on/off (5.4).

2 The next three keys select the type of readout wanted for display: major term, minor term and alternatives of values for equivalent series or parallel circuits. The major* term can be capacitance, inductance, impedance or admittance.
The choice available for minor* term depends on the major term selected. With C or L selected, the choice is D, Q, R (series or parallel) or G (parallel only). With Z or Y selected, the choice is phase angle or ac current (on ranges giving ac voltage drive). For impedance below 10 ohms, where constant current drive is provided, the choice becomes phase angle or ac voltage.

3 The lowest three keys determine the operating mode: Automatic range selection or Hold (section 5.15), single-shot or repetitive measurements (5.16), and the rate required for repetitive measurements (5.17).

To the right of the uppermost keys are two keys for increasing or decreasing the selected parameter (indicated by an arrow).

* For simplicity of reference, "major" and "minor" are used for the terms as listed above. Strictly speaking, of course, R and G can be major terms when measuring a resistive Unknown.

Deviation mode is used for logging changes with time, temperature, frequency, level or dc bias, or for comparing components in a batch against a known good reference. It provides direct readout in % of the change in a major term from a previously measured (non-volatile) reference value. Further information on Deviation is in section 5.18.

Limits mode, intended for Goods Inwards checking, is similar to Deviation but the Nominal value, and/or upper and lower pass limits - all held in non-volatile memory - are keyed in by the operator. Checks can be made in % or absolute terms, on major or minor terms. The Limits mode also incorporates an Analog Bar display, useful for rapid adjustment of preset components. Further information on Limits is in section 5.19.

Bin Set/Bin Sort/Bin Count. These modes cater for the binning operation, which classifies components into Bin 0 to 8, according to their measured value and/or minor term, with Bin 9 provided for rejects. The Bin Set mode is used to select % or Abs and the appropriate non-volatile limits for each bin. Pressing the Bin Sort key initiates the binning operation. Bin Count is a non-volatile data logging mode which stores the total number of measurements falling into each bin, together with the batch total. Further information on binning is in section 5.20.

Connections mode provides a display of 2, 3 and 4-terminal connections, together with explanatory comments, as shown in Fig. 4.3. It is provided for reference only and is not an operating mode. Information on connections was summarized in section 3.4. For further details see sections 5.1 and 5.21.

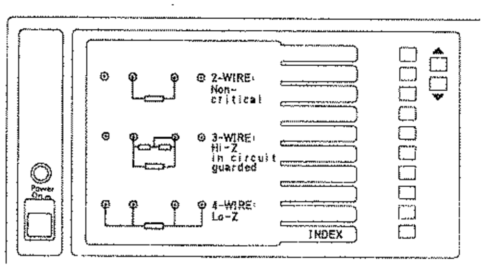


Fig. 4.3 Connections display

For chip tweezers type A40120 hold the jaws together while rotating the cam to obtain a tip spacing equivalent to the components to be tested. Hold the jaws in this position during the trimming operation, taking care to keep hands away from the actual tips.

2 Press Trigger. The series of operations can take several seconds. When trimming is complete, the Analyzer reverts to its previous settings.

Trim S/C

1 Press Trim S/C. Clip the leads to a piece of wire or a component lead, as close together as possible (see Fig. 5.1). Do not connect the clips directly to each other (this does not provide the necessary 4-terminal short circuit).

For clip leads type 1505, the yellow and brown clips should be as close together as possible on the wire.

For component adaptor type 1005, connect heavy gauge tinned copper wire between the measurement jaws.

For chip tweezers type A40120 release the cam and hold the jaws tightly together during the trimming operation.

2 Press Trigger. After several seconds, the Analyzer will revert to its previous settings.

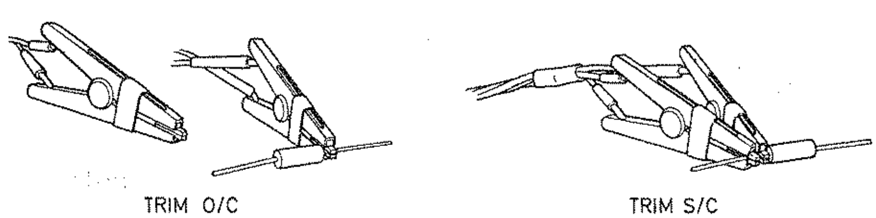


Fig. 5.1 Trim connections

5.2 FREQUENCY SELECTION

Pressing the NORMAL key (the uppermost one when Main Index is displayed) will produce a display similar to that shown in Fig. 4.2. The actual frequency shown will be the last value selected, held in a non-volatile store. The frequencies available (in Hz) are : 20, 25, 30, 40, 50, 60, 80, 100, 120, 150, 200, etc, repeating each decade up to 60k, then 75k, 100k, 120k, 150k, 200k, 300k. Two methods are available for changing the frequency. For either method, the set-up arrow should be pointing to the frequency. If necessary, press the topmost soft key to bring the arrow to this position.

The first method is to use the two keys (▲ and ▼, respectively) to increase or decrease the frequency to any of the discrete values listed above. Holding down either of these keys will produce a continuous increase (or decrease) which, after a short while, becomes faster. The change ceases when the upper (or lower) limit is reached.

The second method is to select the required frequency directly by the keyboard. As the value is keyed, the figures are shown at the bottom of the main display. If the frequency is in kilohertz, follow the number(s) by pressing Units and k. Check the display and press Enter to select the keyed value, or Clear to correct keying errors. If the frequency keyed in is not one of the discrete values listed above, the Analyzer will select the nearest frequency available.

Note: The measurement process is interrupted while keying-in data, and recommences when either Enter or Clear is pressed.

5.3 TEST SIGNAL DRIVE LEVEL

As shown in Fig. 4.2, the second from top soft key, in the NORMAL mode, shows the drive level of the ac test signal. There are 8 measurement ranges and the maximum drive level available depends on the range in use (whether selected in the Auto mode or one chosen by the operator in the Hold mode). These levels are as follows:

Range	Impedance range	Max.drive level (rms)
1	<1.25Ω	100mA
2	<10Ω	100mA
3	>10Ω	1V
4	>80Ω	5V
5	>640Ω	5V
6	>5.12kΩ	5V
7	>41kΩ	5V
8	>328kΩ	5V

Above 10kHz, highest range: 7

" 60kHz, " " : 6

Drive levels below 25mA, lowest range: 2

" " " 25mV, highest " : 7 (to 10kHz)

" " " " , " " : 6 (above 10kHz)

" " " " , " " : 5 (above 60kHz)

At 300kHz, the maximum drive available is 3V.

The range number can be displayed or extinguished (top left) by keying 'Code 9,Enter' (the selection is volatile).

The procedure for changing the drive level is similar to that for frequency selection (section 5.2). With the set-up arrow against the drive level, the value can be re-set using the up/down arrow keys or the numeric keypad.

If a drive level exceeding 1V has been selected, and the Analyzer is subsequently switched to Range 3, (whether selected manually, or automatically as a result of a change in frequency or in the Unknown itself), the level will automatically be reduced to 1V. When the Analyzer changes from voltage drive to current drive, or vice versa, the new level is the equivalent value with a 10-ohm Unknown (e.g. 1 volt becomes 100mA; 20mA would become 200mV). In all these situations, a warning message always appears.

5.4 DC VOLTAGE BIAS

A programmable internal supply can provide up to 20V dc bias across the test component during ac measurements. In the NORMAL mode, the fourth from top soft key operates as a toggle for Bias ON/OFF*. The third from top soft key is used to place the set-up arrow prior to use of the up/down arrow keys or the numeric keypad to select the required bias level. The procedure is similar to that for frequency selection (section 5.2).

WARNING	Never connect solid tantalum capacitors while Bias is ON. The surge current could damage the capacitor.

A safety link on the rear panel must be fitted before the bias function is available. Connect the unknown component (+ve to the Kelvin clip with red sleeves on its handles) before selecting Bias ON. Up to 1A current is available for rapid charging of large-value electrolytic capacitors, although the rate of charge is limited to below 0.5V/ms to avoid damage to solid tantalum capacitors and other sensitive components. Measurement will not commence until the required dc voltage is established. Select Bias OFF and allow the capacitor to discharge before disconnection.

The voltage range can be extended to a total of 50V maximum by connecting an external ground-free power supply between the bias link terminals. Because the Analyzer protection is limited in this mode, it is essential to observe the correct polarity and to keep the voltage to a maximum of 30V when the internal supply is at 20V. Bias at the measurement terminals is the sum of the internal and external voltages. With an external supply fitted, always select Bias OFF before reducing the internal voltage setting.

<u>IMPORTANT</u> The mains Power switch must be off before connecting or removing the safety link on the rear panel. The trim and set-up conditions will be retained in non-volatile memory. Remove the safety link as soon as use of the bias supply is no longer required. This will prevent a dc voltage being applied to resistors or inductors if Bias ON is inadvertently selected during measurements other than capacitance.

* At power-up, the condition is always Bias OFF and a message to this effect is displayed until keying operations commence.

5.5 CAPACITANCE MEASUREMENT (refer to Fig. 4.2, page 4-2)

If bias will be required, check that the rear-panel safety link is fitted.

1 In the NORMAL mode, use the C/L/Z/Y key to select C.

2 Connect the capacitor.

3 Set up the required frequency (see section 5.2) and (if applicable) bias voltage (see 5.4).

4 Select D, Parallel, Auto, Rep and Norm (the alternatives to these are described later).

5 When the Analyzer has Auto-ranged (or when Range has been selected manually, see Auto/Hold modes, section 5.15), set up the required drive level (see section 5.3) and (if required) select Bias ON.

6 The display will show the numerical value and units (in Fig. 4.2, 21.903nF), the dissipation factor (0.0001D) and a diagram of C and R in parallel.

7 Select Bias OFF (if applicable) and disconnect the capacitor.

Loss Resistance. As an alternative to D, R can be selected to produce a readout of the loss resistance of the capacitor.

For electrolytics and other decoupling capacitors, the preferred readout is usually ESR (equivalent series resistance).

For other classes of capacitor, EPR (equivalent parallel resistance) is more commonly used.

Formulae relating series/parallel loss resistance with C and D are given in section 7.

Effect of series inductance. Series inductance will resonate with capacitance at a frequency f_0. At frequencies below resonance, the apparent capacitance will increase. Above resonance, the impedance becomes inductive, giving a negative capacitance reading.

To establish the value of the series inductance, L_0, measurements must be made at two frequencies, f_1 and f_2. If C_1 and C_2 are the two corresponding capacitance readings obtained, the series inductance is given by:

$$L_0 = \frac{C_1 - C_2}{C_2 C_1 (\omega_2^2 - \omega_1^2)}$$

where $\omega = 2\pi \times$ frequency.

The resonance frequency is given by:

$$f_0 = \sqrt{[(f_1^2 C_1 - f_2^2 C_2)/(C_1 - C_2)]}$$

C_1 and C_2 may be +ve or -ve : the sign must be included with the value in the above expressions.

Measuring small-value capacitors. For the best accuracy when measuring small-value capacitors it is necessary to trim the bridge (O/C) at the frequency to be used for the measurement, and to ensure that the leads are not moved between the trimming and the measurement. See section 5.1 for further details. A level of 1V is an optimum value for minimizing lead errors, as this is the level used during the trimming operation.

Measuring electrolytic capacitors. The procedure for applying bias to capacitors during measurement is described in section 5.4. The polarity is marked on one of the front-panel lead connectors. The corresponding positive Kelvin clip is identified by red sleeves on the handles. Electrolytic capacitors are normally measured at 100 or 120Hz, in series configuration.

<u>Charged capacitor protection.</u> The Analyzer has internal protection against the accidental connection of charged capacitors (either polarity) to the measurement leads. Assuming that no dc bias is in use, the protection is:

500V up to 2μF
150V up to 100μF
100V up to 1000μF
50V up to 100mF

These figures apply to capacitors connected between inners of the 'orange' and 'red' leads, or between 'orange' and Ground (where the colours are those of the associated panel connectors). If bias is in use, the extent of the protection may be reduced.

WARNING

> Connection of a charged capacitor between 'red' and Ground may blow an internal 1.6-amp fuse.

5.6 INDUCTANCE MEASUREMENT

To avoid accidental application of bias, ensure that the rear-panel safety link is not fitted.

1 In the NORMAL mode, use the C/L/Z/Y key to select L.

2 Connect the inductor.

3 Set up the required frequency (see section 5.2).

4 Select Q, Series, Auto, Rep and Norm (the alternatives to these are described later).

5 When the Analyzer has Auto-ranged (or when Range has been selected manually), set up the required drive level (see section 5.3).

6 The display will show the numerical value and units (for example 7.24mH), the quality factor of the inductor (e.g. 2.9Q) and a diagram of L and R in series.

Loss Resistance. As an alternative to Q, R can be selected to produce readout of the loss resistance of the inductor. Also, values for the equivalent parallel circuit can be selected instead of the more usual series configuration.

Formulae relating series/parallel loss resistance with L and Q are given in section 7.

Effect of self-capacitance. Self-capacitance will resonate with inductance at a frequency f_0. At frequencies below resonance, the apparent inductance will increase. Above resonance, the impedance becomes capacitive, giving a negative inductance reading.

To establish the value of the self-capacitance, C_0, measurements must be made at two frequencies, f_1 and f_2. If L_1 and L_2 are the two corresponding inductance readings obtained (in parallel representation), the self-capacitance is given by:

$$C_o = \frac{L_2 - L_1}{L_2 L_1(\omega_2^2 - \omega_1^2)}$$

where $\omega = 2\pi \times$ frequency.

The resonance frequency is given by:

$$f_o = \sqrt{[(f_2^2 L_2 - f_1^2 L_1) / (L_2 - L_1)]}$$

L_1 and L_2 may be +ve or -ve: the sign must be included with the value in the above expressions.

Measuring small-value inductors. The Analyzer measures the difference between the inductance of S/C trimming and the test item fitted into the same location. Therefore, stable lead arrangements are essential for low inductance measurements; use of the component fixture, accessory 1005, is recommended. When using the fixture, S/C trim is achieved by placing a wire across the jaws.

A 5cm length of 1mm wire has an inductance of 0.05μH.
A 5cm length of 2mm wire has an inductance of 0.04μH.

The Q is always low, but self-capacitance is not a problem at the 6425 measurement frequencies. For best inductance measurement results, work at 10kHz in series configuration. Where possible, measure at 100mA as this is the signal level used during trimming.

It must be appreciated that when an inductor is measured at a frequency much lower than that for which it is designed (e.g. an h.f. choke tested at a.f.) it will tend to behave as an inductive resistor. In these circumstances, the inductance measurement accuracy is widened by the factor (1 + 1/Q). The value of this factor can be determined by using the Q feature.

Air-cored coils are particularly susceptible to supply frequency pick-up. For this reason, keep them well clear of power transformers, away from the scan coils of the Analyzer and, whenever possible, measure at 10kHz. If low-frequency measurements are required. and trouble persists, use Slow setting. For best measurement accuracy keep air cored coils away from any metal object.

Measuring iron-cored inductors. The effective value of all iron-cored inductors can vary widely with the magnetization and, therefore, with the level of the test signal. Ideally, they should be measured at the frequency of use, with the same ac and dc levels as apply in use. When core materials can be damaged by excessive magnetization (for example, some tape heads and microphone transformers), check before connection that the test signal level is acceptable. If the ac test signal does not generate sufficient core flux, arrangements should be made for the inductor to pass dc during measurement. The essential requirements are to prevent this current entering the instrument measurement circuits, and to minimize the effect of the dc supply components on the measured value. Wayne Kerr Precision Inductance Analyzer, model 3245, is designed specifically for such measurements and, with one or more model 3220 Bias Units, up to 100 amps DC can be passed. However, the 6425 can perform very valuable measurements with DC passing, as described in the next section.

Inductors passing DC. The arrangement is a special case of the Analyzer's ability to measure a component in the presence of shunt elements (details are in 5.21: In-circuit measurements).

AC measurements can be performed on inductors or other components passing direct current by using the circuit arrangement shown in Fig. 5.2. The DC passes through Zs, Zd and Lu in series, and is prevented from entering the Analyzer current detector by the blocking capacitors as shown in the figure.

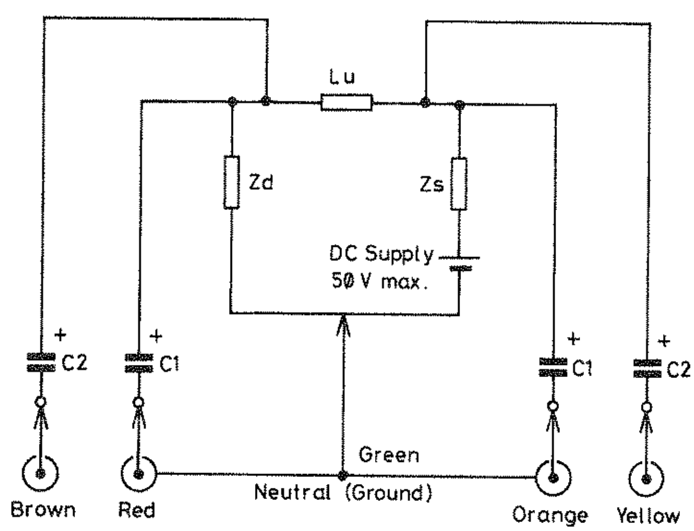


Fig. 5.2 Inductors passing DC

The components Zs and Zd may be resistors, although the use of chokes will reduce power dissipation and supply voltage, particularly at higher currents. The required ac impedance varies with measurement range and frequency and may be found by reference to section 5.21. If chokes are used they should be adequately gapped to prevent the core becoming saturated by the direct current. For operation at a single frequency, the impedance of each choke can be raised by connecting a parallel resonating capacitor. The value of this is given by $\frac{1}{(2\pi f)^2 L}$, from which should be subtracted the self-capacitance of the choke.

The value of C1 in Fig. 5.2 should be 100µF for frequencies of 10kHz or above, rising to 1mF at 1kHz and 10mF at 100Hz. Note that the charging current of this capacitor flows directly into the current sense terminal of the Analyzer, which is internally fused at 1.6A. If the dc bias is to exceed 1A, take care to increase the supply gradually from zero to avoid blowing this fuse, and similarly to decrease it gradually to zero before removing the inductor under test. C2 may be of lower value, perhaps 10% of C1.

WARNING

> To avoid the danger of electric shock, always set the direct current to zero before disconnecting the inductor under test. Back-emf voltages can be dangerous even at bias currents below 100mA.

5.7 IMPEDANCE MEASUREMENT (see also section 5.14)

If the component could be damaged by dc bias, ensure that the rear-panel safety link is not fitted.

1 In the NORMAL mode, use the C/L/Z/Y key to select Z.

2 Connect the component(s) or network.

3 Set up the required frequency (see section 5.2).

4 Select Angle, Auto, Rep and Norm (the alternatives to these are described later).

5 When the Analyzer has Auto-ranged (or when Range has been selected manually), set up the required drive level (see section 5.3).

6 The display will show the value of the impedance in Ohms and the angle (in degrees) between the voltage and current. By convention, a positive phase angle implies an inductive impedance.

5.8 ADMITTANCE MEASUREMENT (see also section 5.14)

If the component could be damaged by dc bias, ensure that the rear-panel safety link is not fitted.

1 In the NORMAL mode, use the C/L/Z/Y key to select Y.

2 Connect the component(s), network or conductivity cell.

3 Set up the required frequency (see section 5.2).

4 Select Angle, Auto, Rep and Norm (the alternatives to these are described later).

5 When the Analyzer has Auto-ranged (or when Range has been selected manually), set up the required drive level (see section 5.3).

6 The display will show the value of the admittance in Siemens (S) and the angle (in degrees) between the voltage and current. By convention, a positive phase angle implies capacitive admittance.

5.9 RESISTANCE MEASUREMENT

If the component could be damaged by dc bias, ensure that the rear-panel safety link is not fitted.

1 In the NORMAL mode, set up the required frequency (see section 5.2).

2 Connect the resistor.

3 Selection of the 'major' term must be C or L for R to become available at the 'minor' term key. The choice depends on the resistance value, which also determines the preferred selection of Parallel or Series.

For resistors above 1000 ohms, select C, R and Parallel
" " below " " " L, R " Series

4 Select Auto, Rep and Norm (the alternatives are described later).

5 When the Analyzer has Auto-ranged (or when Range has been selected manually), set up the required drive level (see section 5.3).

6 Beneath the small C or L value, the display will show the resistance value in Ohms and a diagram of parallel C/R or series L-R.

Note: It is not unusual for small changes to occur in the measured value of a resistor when the test frequency is changed. The effect can be caused by small reactive terms (which are present with all resistors) or by skin effect. Their effect is minimal when tests are made at 100/120Hz. The high resolution of the instrument may also show up variations in resistance due to temperature changes.

5.10 CONDUCTANCE MEASUREMENT

If the component could be damaged by dc bias, ensure the the rear-panel safety link is not fitted.

1 In the NORMAL mode, set up the required frequency (see section 5.2).

2 Connect the component or conductivity cell.

3 Selection of the 'major' term must be C or L for G to become available at the 'minor' term key. It is normal to select C.

4 Select Parallel, Auto, Rep and Norm (the alternatives to these are described later: Series is not available with G).

5 When the Analyzer has Auto-ranged (or when Range has been selected manually), set up the required drive level (see section 5.3).

6 Beneath the L or C value, the display will show the conductance in Siemens (S) and a diagram of parallel L/G or C/G.

5.11 D & Q MEASUREMENTS

Normally, D will be selected when making capacitance measurements (section 5.5) and Q with inductance (5.6). However, the Analyzer can equally well be set to read D with L, or Q with C. The expressions for D and Q, for series and parallel capacitive or inductive circuits, are in the Theory Reference section (7).

<u>Note.</u> Q is computed by the Analyzer from 1/D. Therefore, with low-loss coils, as D becomes very small, the high Q reading is likely to fluctuate. It follows that in these circumstances the accuracy and resolution are limited (see Specification).

5.12 UNKNOWN CURRENT/VOLTAGE

As described in section 5.3, the test signal level is a function of the range in use, and is a current drive for impedances below 10 ohms and a voltage drive on all other ranges. When the major term selection is Z or Y, the 'minor term' key offers either Vac or Iac as an alternative to Angle (described in section 5.14). On ranges 1 and 2 (current drive), the 'minor term' key makes Vac available - a measure of the voltage developed across the unknown (see Fig. 5.3). Above 10 ohms, the alternative to Angle is Iac - a measure of the current passed by the test component. This feature is invaluable when examining the properties of non-linear devices, and for checking that signal levels are within permitted limits for sensitive devices.

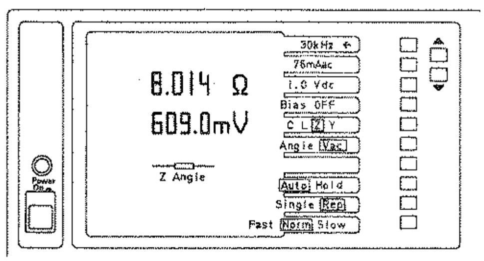


Fig. 5.3 Unknown Current/Voltage display

5.13 SERIES/PARALLEL EQUIVALENTS

At a given frequency, a two-terminal R,C,L network can be represented in polar form (sections 5.7, 5.8 and 5.14) or in fully equivalent series or parallel circuits. The Analyzer can be set to display values in series or parallel format (not series for G) although, as a general guide, parallel will be preferred for components whose impedance exceeds 1000 ohms, and series for components below this value.

It is worth noting that, for a relatively pure component, the major term will remain substantially the same in series or parallel representation. A small L, C or R term in a series circuit is equivalent to a large term in the parallel equivalent, and vice versa. D and Q values are independent of series/parallel selection.

It must be remembered that series/parallel equivalents obtained at one frequency are NOT applicable at any other frequency. No computations have to be made by the operator but, for reference, the appropriate formulae are given in the Theory Reference section (7).

5.14 POLAR MEASUREMENTS (Z/Angle & Y/Angle)

Sections 5.7 (Impedance measurement) and 5.8 (Admittance measurement) describe the procedure for obtaining measurements in polar form :

$$|Z| \quad \angle\theta$$

or

$$|Y| \quad \angle\theta$$

where $|Z|$ is the modulus of the impedance

$|Y|$ " " " " " admittance

and $\angle\theta$ is the phase angle, assumed
positive for inductive impedance
negative for capacitive impedance
positive for capacitive admittance
negative for inductive admittance

Note that δ (used in the expression $D = \tan\delta$) is $(90 - \theta)°$.

Formulae relating resistive and reactive terms to Polar measurements are given in the Theory Reference section (7).

5.15 AUTO/HOLD MODES

The Analyzer has eight measurement ranges, listed in section 5.3. For most measurements, it is convenient to use the Auto mode and leave the Analyzer to select that range giving the best accuracy. In some situations, however, users will prefer to pre-select a particular range, or to hold the instrument on the range it has selected in the Auto mode. The latter can be used to speed measurements on a batch of similar components. In this condition (unless single-shot mode is used) the display will show Range Error while no component is fitted.

To display (or extinguish) the range number in use, key in 'Code 9, Enter'*. In the Hold mode, the range can be changed manually by keying Codes 1 to 8. For example, to select range 4, key in 'Code 4, Enter'. In the Hold mode, Range Error will be indicated when a change of range would give better measurement accuracy. If the value is completely beyond the capability of the range selected, the display is blanked.

* At power-up, the range will be the one last selected, but the number will not be displayed until 'Code 9, Enter' is keyed.

5.16 SINGLE/REP MODES

With Single selected, the readout of the last measurement remains displayed until Trigger is pressed. Remote triggering is possible by connecting a single-pole switch (push-button or footswitch) across the 3.5mm jack below the Trigger key. (Note that there is a small voltage present on both contacts of the jack, therefore neither side must be Grounded). Component fixture type 1005 has a trigger push-button. At each triggering, the instrument makes a new measurement.

In the repetitive mode, the Analyzer automatically performs a continuous series of measurements, updating the display as each one is completed. The rate of this repetition is detailed in the next section.

5.17 FAST/NORM/SLOW MODES

The Normal rate for repetitive measurements is approximately 3.3 measurements per second, for test frequencies of 300Hz or higher. Below 300Hz the measurement period increases progressively to about 600ms per measurement at 20Hz. Full specified accuracy is obtained in the Normal mode, except when measuring very low or very high impedances. See Specification (section 2).

The Slow rate is approximately 1.3s per measurement, becoming 750ms per measurement at 100kHz and above. The Slow setting improves the display resolution by 2:1 with a corresponding improvement in signal/noise. Rejection of supply frequency pick-up improves in this mode, particularly when the test frequency is not a multiple of the supply frequency.

The Fast setting increases the measurement rate to about 11 per second, and is useful when setting adjustable components or for speeding operation under remote control. Basic accuracy on Fast is 0.1% but rejection of supply frequency pick-up is poor. Measurement noise is minimized by screening (connect braid to Ground or green measurement lead). Below 300Hz, the measurement period increases progressively to about 600ms at 20Hz.

On the Fast setting, speed is affected by internal computations. For the fastest results, avoid the polar format, use Series for ranges 1 - 4, and Parallel for ranges 5-8. Also, use range Hold (see 5.15).

5.18 DEVIATION

As stated in 4.2, this mode provides direct readout in % of changes to C, L, Z or Y from a previously measured reference value. (For resistance, Z is used, and for conductance, Y). A typical Deviation display is shown in Fig. 5.4.

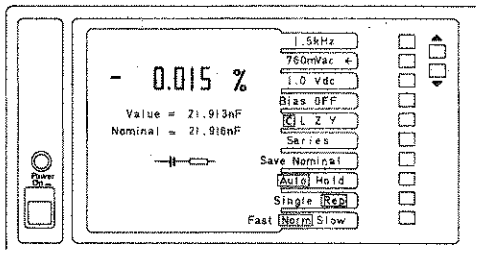


Fig. 5.4 A typical Deviation display

1 In the Deviation mode, use the C/L/Z/Y key to select the required parameter.

2 Connect the reference component (if this is a capacitor, and bias voltage is required, refer to section 5.5).

3 Set up the required frequency (see section 5.2).

4 Select, as required, Series or Parallel (see 5.13) if C or L selected in Step 1; Auto or Hold (5.15); Single or Rep (5.16); and Fast, Norm or Slow (5.17).

5 Set up the required drive level (5.3); if using Single, press Trigger; then press Save Nominal.

6 Changes in the value, as % deviation from the reference component, can now be displayed as similar components are substituted, or as the original component is subjected to changes of temperature, drive level, bias, etc.

7 If the Nominal Saved has different units from the selected measurement parameter, the display will show the error message MEAS/NOM UNITS MISMATCH.

5.19 LIMITS

As stated in 4.2, this mode allows the operator to key in upper and lower pass limits on major or minor terms, as % tolerances on a nominal value or as absolute values. A typical Limits mode display is shown in Fig. 5.5.

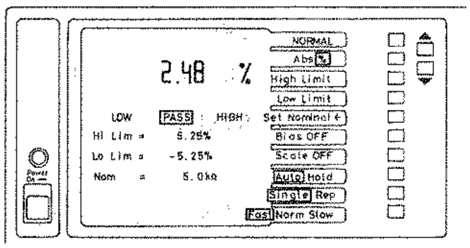


Fig. 5.5 A typical Limits mode display

Before proceeding, select NORMAL to check that the functions selected (C/L/Z/Y and D/Q/R/G) match those intended for Limits operation. (If they do not, the Analyzer will display MEAS/NOM UNITS MISMATCH). Then select Limits. The sequence is described firstly for % limits and secondly for Absolute values. The Analyzer will store limits in only one style at any time (see %/Abs Change-over).

To supplement the numerical display, an Analog Bar Display can be selected (except on a few early models). This is particularly useful when pre-set components are to be adjusted. Use of this feature is described at the end of this section.

When checking a number of similar components, the process will be quicker if Hold is used (see section 5.15).

% Limits

1 In the Limits mode, select % and High Limit.

2 Use the keypad to establish the high % figure (sign, digits and if required decimal). For example: [2] [.] [5]. (The +/- key has a toggle action and the sign can be entered before or after the digits).

3 Check the figures showing on the display. If correct, press Enter. If incorrect, press Clear and repeat step 2.

4 Select Low Limit and set up the figure in a similar manner as for the High Limit. For example: [-] [1] [.] [5].

5 Select Set Nominal and key in the required value and units. For example: [2] [1] [.] [9] [Units] [n] [F]. Check the figures showing on the display. If correct, press Enter. If incorrect, press Clear and repeat this step.

6 Check that the settings of frequency (5.2), drive level (5.3), bias (5.4), Auto/Hold (5.15), Single/Rep (5.16) and Fast/Norm/Slow (5.17) are as required.

7 Connect each component, in sequence. The display will show LOW, PASS or HIGH, together with the % departure from the nominal value (see Fig. 5.5).

<u>Absolute Limits</u>

1 In the Limits mode, select Abs and High Limit.

2 Use the keypad to establish the value of the high limit, pressing the digits, decimal (if required) and the Units key followed by the appropriate multiplier and units. For example: [8] [5] [.] [2] [Units] [n] [F].

3 Check the figures showing on the display. If correct, press Enter. If incorrect, press Clear and repeat step 2.

4 Select Low Limit and set up the value in the same manner as for the High Limit.

5 Check that the settings of frequency (5.2), drive level (5.3), bias (5.4), Auto/Hold (5.15), Single/Rep (5.16) and Fast/Norm/Slow (5.17) are as required.

6 Connect each component, in sequence. Readout is of the measured value, with a LOW/PASS/HIGH indication.

%/Abs Change-over

As already stated, the Analyzer stores limits in % terms or in absolute terms, but not in both at one time. However, limits entered in one set of terms can be converted by the Analyzer, automatically, to the corresponding alternative terms. When changing from % to Abs, the Analyzer establishes equivalent limits, suppressing the nominal value.

When changing from Abs to %, the Analyzer establishes a nominal midway between the two Abs limits, converting these values into symmetrical % limits.

Analog Bar Display

This function, which supplements the LOW/PASS/HIGH display of the Limits mode, in % or Abs terms, is enabled/disabled by the Scale ON/OFF soft-key. Length of the horizontal bar varies with the value of the component under test. A typical % display is shown in Fig. 5.6.

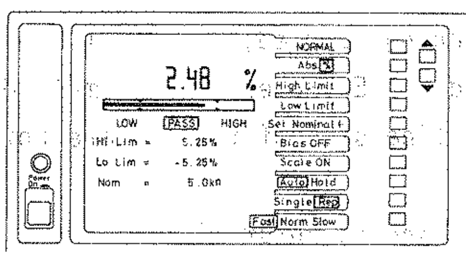


Fig. 5.6 Limits mode with Analog Bar Display

The Analog Bar Display has two fixed marks, corresponding to the High and Low limits selected for Limits mode. Whenever these limits are entered, the horizontal scaling factor is adjusted accordingly.

Scale compression is applied for values above or below the pass limits, allowing a range of values of up to 8.5 times the pass band to be displayed.

5.20 BINNING

When Main Index is selected, there are three Bin keys available, as outlined in section 4.2. Binning can be set up and operated in terms of % tolerances either side of a nominal value, or as absolute values. These alternatives are supported by two completely unrelated sets of stored limits (for binning only, not applicable to Deviation or Limits modes). For each of the bins 0 to 8, when the major term is capacitance or inductance, (i.e. units of F or H), provision is made for setting also a minor term limit. This can be in terms of maximum D, minimum Q, maximum series R, minimum parallel R or maximum parallel G. In all instances, it must be set in Abs terms, whether the major term is % or Abs. The appropriate limit of maximum or minimum is applied automatically by the Analyzer.

Bin settings - major and minor terms - and the settings for normal mode measurement, can be changed at any time, but must be of the same type when Bin Sort or Bin Count is selected. Failure to observe this will result in the error message 'MEAS/BIN UNITS MISMATCH' being displayed.

Whether % or Abs binning is used, limits for each set of bins can be 'nested' or 'stacked'. Examples of each method, for % and Abs, are shown in the table. (The sets of figures are not related).

Whatever method is used to enter limits, results will be sorted by testing each bin in numerical sequence. Any bin with limits set to zero will be ignored, and rejects will be classified as bin 9.

Table 5.1 Bin Setting Examples

Bin No.	%				Abs			
	NESTED		STACKED		NESTED		STACKED	
	High	Low	High	Low	High	Low	High	Low
0	+1%	-1%	-1%	-3%	27.5pF	26.5pF	900Ω	898Ω
1	+2%	-2%	+1%	-1%	28.0pF	26.0pF	902Ω	900Ω
2	+5%	-5%	+3%	+1%	28.5pF	25.5pF	904Ω	902Ω
3	0	0	+6%	+3%	29.0pF	25.0pF	906Ω	904Ω
4	0	0	+10%	+6%	30pF	24.0pF	0	0
5	0	0	+15%	+10%	0	0	0	0
6,7,8	0	0	0	0	0	0	0	0
9	REJECTS				REJECTS			

Note that limits for unwanted bins should be at zero.

'Nested' and 'Stacked' limits are alternatives: only one set can be stored for %, together with one set for Abs.

The 'Reset' key returns all three limits (High, Low and Minor) to zero for the selected bin. The 'Next' key is used when entering limits in order, starting with Bin 0 High Limit and stepping to the next limit or bin number in sequence.

Binning in % terms

1 From Main Index, select Bin Set.

2 Select % and Set Nominal.

3 Use the keypad to set the required digits, decimal, multiplier and units. For example: [3] [5] [0] [.] [0] [Units] [p] [F]. Check for correctness on the main display. If satisfactory, press Enter. If not correct, press Clear and re-set the required value.

4 Press High Limit. To select a particular Bin number, use the ▲ and ▼ keys. The Bin number in use is shown boxed on the main display. A typical display for setting limits in % Binning is shown in Fig. 5.7.

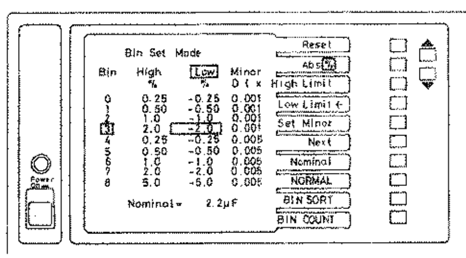


Fig. 5.7 A typical Bin Set display

5 Select Bin 0, and use the keypad to set the required high limit value, including sign if necessary. (The Analyzer will accept the sign before or after the number is keyed). No units are required when keying limits in the % mode. Check for correctness on the main display. If satisfactory, press Enter. If not correct, press Clear and re-set the required number.

6 Press 'Next'. This automatically steps the Analyzer to the next limit (i.e. Bin 0 Low) and, unless the operator makes an overriding key entry, assumes the Low Limit to be numerically the

same as the High Limit for the bin being set, but with a negative sign. If this is acceptable, again press 'Next'. If unacceptable, use the keypad as in step 5 to enter the required Low Limit and then press 'Next'. If the Nominal value set was in terms of C or L, the selection will be 'Minor' for Bin 0: perform step 7. Otherwise, go to step 8.

7 The minor term will usually be in terms of maximum D when binning capacitors, and in terms of minimum Q for inductors. However, provided that the selection corresponds with that made in the Normal mode, it can be D or Q for both C and L, or loss resistance (maximum series R or minimum parallel R) or maximum parallel G. Use the keypad to select the required number (Abs terms only, not %), then 'Units' followed by D, Q, Ω or S preceded by any necessary multiplier. Check for correctness on the main display. If satisfactory, press Enter. If not correct, press Clear and re-set the required value. If the minor term selection is not required, it can be disabled by entering a limit value of 0. The units must, however, match those selected in the Normal mode. Press 'Next'.

8 For Bin 1 High, set the limit required and continue until all relevant bins have High, Low and, when appropriate, Minor limits. Use the Reset key to clear all limits to 0 on any unused bins.

9 The setting(s) for any particular bin can be amended at any time by selecting the appropriate Bin No. and entering the new limit(s).

10 Check that the Normal settings are the same as those selected for Binning. If they are not, the message MEAS/BIN UNITS MISMATCH will appear when Bin Sort (or Bin Count) is pressed.

11 Press Bin Sort. Measurement of a component will now produce a display showing the Bin No. in which the value lies, together with measured values for the major and minor terms.

Binning in Absolute terms

1 From Main Index, select Bin Set.

2 Select Abs.

3 To select a particular Bin number, use the ▲ and ▼ keys. The Bin number in use is shown boxed on the main display.

4 Select Bin 0, High Limit, and use the keypad to set the required digits, decimal, multiplier and units. For example: [4] [7] [.] [3] [Units] [n] [F]. Check for correctness on the main display. If satisfactory, press Enter. If not correct, press Clear and re-set the required value.

5 Press 'Next'. This automatically steps the Analyzer to the next limit (i.e. Bin 0 Low). Enter the appropriate value using the keypad in the same manner as described in step 4. Press 'Next'. If the limits set for Bin 0 were C or L, the selection will be 'Minor' for Bin 0: perform step 6. Otherwise, go to step 7.

6 The minor term will usually be in terms of maximum D when binning capacitors, and in terms of minimum Q for inductors. However, provided that the selection corresponds with that made in the Normal mode, it can be D or Q for both C and L, or loss resistance (maximum series R or minimum parallel R) or maximum parallel G. Use the keypad to select the required number (Abs terms only, not %), then 'Units', followed by D, Q, Ω or S preceded by any necessary multiplier. Check for correctness on the main display. If satisfactory, press Enter. If not correct, press Clear and re-set the required value. If the minor term selection is not required it can be disabled by entering a limit value of 0. The units must, however, match those selected in the Normal mode. Press 'Next'.

7 For Bin 1 High, set the value required and continue until all relevant bins have High, Low and, when appropriate, Minor limits. Use Reset key to clear all limits to 0 on any unused bins.

8 The setting(s) for any particular bin can be amended at any time by selecting the Bin No. and entering the new limit(s).

9 Check that the Normal settings are the same as those selected for Binning. If they are not, the message MEAS/BIN UNITS MISMATCH will appear when Bin Sort (or Bin Count) is pressed.

10 Press Bin Sort. Measurement of a component will now produce a display showing the Bin No. in which the value lies, together with measured values for the major and minor terms.

Bin Count

This is a non-volatile data logging mode which stores the total number of measurements falling into each bin, together with the batch total. The store is up-dated only when measurements are triggered in Single mode, with either Bin Count or Bin Sort selected. With Bin Count selected, measurement errors (misconnected components, etc) can be corrected by pressing 'Delete last'. The Analyzer requests confirmation of this by use of the Enter key. With Bin Sort selected, an error can be deleted by first changing to Bin Count, and then proceeding as above.

To clear all stores, select Bin Count, press 'Delete all', and confirm this by use of the Enter key. WARNING. This procedure resets to zero the count for all bins and the batch total.

[Text continues on page 5-31]

5.21 2, 3 & 4-TERMINAL CONNECTIONS

The Analyzer has four front-panel sockets for screened cable connections to the Unknown component, test fixture or conductivity cell. In each case, the outer connection provides the screening and the inner is the 'active' connection. The innermost pair of panel connectors carry the signal source (orange) and current return (red) signals, while the outer pair serve to monitor the actual voltage at the Unknown, excluding any IR drops arising in the source and return leads. With the Kelvin Clip leads supplied, or with the alternative Component Fixture 1005, screened four-terminal connections are made automatically to the component under test.

In some cases it may prove more convenient to use leads with crocodile clips or other special terminations. See section 3.4 for details of available accessories. Alternatively special leads may be manufactured locally. Any connecting leads longer than about 15 cm should be screened, and the screens of the leads connected to the Orange and Red sockets should be connected together at the component or fixture end. This connection may also be used to ground any screens or guard terminals associated with the component or fixture. The screens of the Brown and Yellow sense leads should be unconnected at the component end.

To minimize variations in lead inductance (low impedance high frequency measurements) the 4 wires should be tightly laced together, ensuring that the Red and Brown leads are diagonally opposite within the harness. If the impedance being measured is greater than about 100 ohms, 4-terminal connections are not necessary, the S/C Trim facility being used to remove the effect of series lead impedance. The Analyzer will continue to operate with the Brown and Yellow sense leads disconnected; to maintain accuracy do not plug anything into the Brown or Yellow sockets. The characteristics of cables used for special leads may affect measurement accuracy when the Unknown impedance is very low or very high, particularly with extended length cables.

For low impedances, the main advantage of 4-terminal connections is to reduce the effect of contact resistance variations at the Unknown component. Resistance of the central conductor reduces the 4-terminal performance, degradation increasing linearly with lead resistance.

After trimming with connections of 0.45 ohms/lead, resistance variations will be reduced by approximately 100 times compared with 2-terminal connections.

For measurements made on the highest impedance ranges, cable capacitance may increase measurement errors, particularly at high frequencies. A total capacitance of 500pF per cable will produce no degradation, and increasing this to 1.5nF per cable will give a maximum error of 0.1% for frequencies up to 30kHz, increasing to 1% at 300kHz. If 2-terminal connections are used, these capacitance figures may be doubled. For frequencies of 1kHz and below, or on lower measurement ranges, these errors become negligible.

If the Unknown component has a large area of metal not connected to either of its measured terminals (e.g. a screen or core), this should be separately connected to ground using the green clip lead. If on the other hand there is a relatively large unscreened conducting surface which is connected to one of its measured terminals (e.g. an air spaced tuning capacitor), this should be connected to the Orange signal source (bias +ve) lead to minimize noise pick-up.

In-circuit measurements

A component connected into a circuit can usually be measured even when the impedances of other components connected to it are comparable to or less than that of the one under test. This is possible by connecting one side of all such elements to the grounded neutral terminal of the Analyzer, as shown in Fig. 5.9. Zu is the unknown component, Zd and Zs are shunting elements, connected to ground via the green clip lead when using standard leads type 1505/1905A/A40100/A40180.

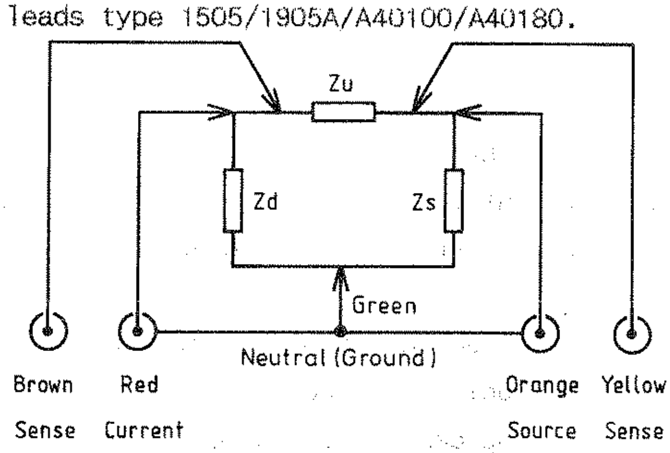
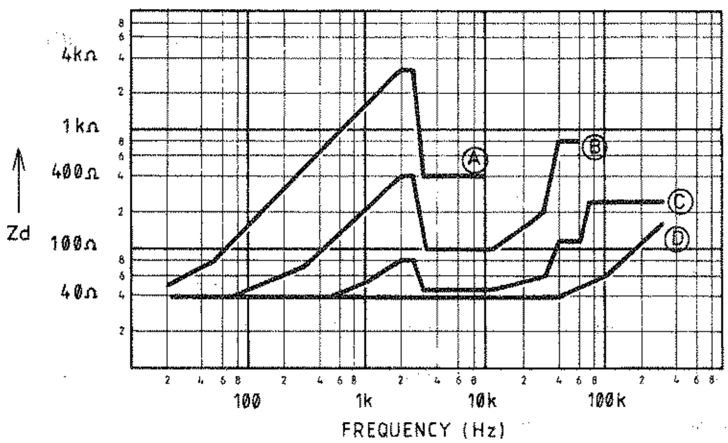


Fig. 5.9 In-circuit measurements

The presence of Zd introduces a small measurement error, dependent on the frequency and impedance range in use. Fig. 5.10 shows the minimum shunt impedance (i.e. R, ωL or $1/\omega C$) for an additional error (magnitude or phase) not exceeding 1%. Note that when measuring high impedances it may be beneficial to use range Hold and select a lower measurement range. (See section 5.15).



Curve	Range(s)	Level
A	8 7	≧ 250mV < 250mV
B	7 6	≧ 250mV < 250mV
C	5 & 6 4 & 5	≧ 250mV < 250mV
D	1 - 4 1 - 3	≧ 250mV < 250mV

Fig. 5.10 Effect of shunt loading on current terminal

The effect of Zs alone is negligible compared to the equivalent Zd effect, although signal level reductions could occur on ranges 1 and 2 (drive current divides between Zu and Zs). On ranges 3, 4 and 5 the signal drive voltage has a low output impedance and it is important that the total current in Zs and Zu does not exceed 125mA rms. On ranges 6, 7 and 8 the drive voltage has a source impedance of nominally 50 ohms. If the level reduction is significant, noise performance will be impaired. When Zd and Zu are connected simultaneously, an additional error term occurs due to the impedance of the guard lead. This error may become significant when Zu is larger than Zd and Zs and is given by

$$\text{Error (\%)} = 100 \times \frac{Zu \times Zg}{Zs \times Zd}$$

At low frequencies, Zg is approximately 25mΩ for lead types A40100, A40180 or 1505. At frequencies above 10kHz the series inductance, which depends to some extent on lead and component positioning, may become significant. For lowest inductance, arrange the leads in order to minimize the areas of the two loops formed by a) the Orange (Source) lead, via Zs and the Green lead to neutral and b) the Red (Current Detector) lead, via Zd and the Green lead to neutral. In this case inductance should not exceed 0.25µH.

Note that the low frequency resistance value can be significantly improved by returning Zs and Zd directly to the outer of the Red BNC connector, although this may conflict with the h.f. inductance requirement.

5.22 KEYBOARD LOCKOUT

The Analyzer has provision for protecting all key settings against unauthorized or inadvertent changes. By entering 'Code 6425' the functioning of all keys except Trigger is disabled. In this situation, the selected parameters and all measurement conditions are maintained and cannot be varied. Note that the keyboard lockout is non-volatile, i.e. it will remain locked if power is removed and restored. When any changes are required, re-entering 'Code 6425' will restore normal operation.

6 CODES

Use of the Code key, followed by one of the numbers listed below and Enter, gives access to functions which are not available via the labelled keys. (Codes 0.1 to 0.7 are test software and will not normally be required by operators. To exit from these, press Main Index.)

0.1	Character Set - Press Enter to step through.
0.2	Grid Test Pattern
0.3	Non-destructive RAM test
0.4	Keyboard test
0.5	Eprom test*
0.6	Generates 10Hz Square Wave from Analog O/P.
0.65	Tests Linearity and I/O ports on Analog O/P.
0.7	Reports if Bin Handler (SHI) is fitted.
1 to 8	Manually Set Range.
9	Display/Extinguish range number.
9.1	Clears data in non-volatile memory
10	Printer ON
11	Printer OFF
6425	Set/Reset lock on keys.

* Eprom test is slow and exit is not possible until the test is complete.

7 THEORY REFERENCE

Abbreviations

B	Susceptance (=1/X)	R	Resistance
C	Capacitance	X	Reactance
D	Dissipation factor ($\tan \delta$)	Y	Admittance (= 1/Z)
E	Voltage	Z	Impedance
G	Conductance (= 1/R)	ω	2π x frequency
I	Current		
L	Inductance	Subscript s	Series
Q	Quality (magnification) factor	Subscript p	Parallel

Formulae

$$Z = E/I \quad \text{(all terms complex)}$$

$$Y = I/E = 1/Z$$

$$Z_s = R + jX = R + j\omega L = R - j/\omega C$$

$$|Z_s| = \sqrt{(R^2 + X^2)}$$

$$|Z_p| = RX/\sqrt{(R^2 + X^2)}$$

$$Y_p = G + jB = G + j\omega C = G - j/\omega L$$

$$|Y_p| = \sqrt{(G^2 + B^2)}$$

$$|Y_s| = GB/\sqrt{(G^2 + B^2)}$$

where $X_L = \omega L$, $X_C = 1/\omega C$, $B_C = \omega C$, $B_L = 1/\omega L$.

$$Q = \omega L_s/R_s = 1/\omega C_s R_s \quad \text{(Series R,L,C values)}$$

$$Q = R_p/\omega L_p = \omega C_p R_p \quad \text{(Parallel R,L,C values)}$$

$$D = G_p/\omega C_p = \omega L_p G_p \quad \text{(Parallel G,L,C values)}$$

$$D = R_s/\omega L_s = \omega C_s R_s \quad \text{(Series R,L,C values)}$$

Note: The value Q = 1/D is constant regardless of series/parallel convention.

Series/Parallel conversions

$$R_s = R_p/(1 + Q^2) \qquad R_p = R_s(1 + Q^2)$$

$$C_s = C_p(1 + D^2) \qquad C_p = C_s/(1 + D^2)$$

$$L_s = L_p/(1 + 1/Q^2) \qquad L_p = L_s(1 + 1/Q^2)$$

The Analyzer display gives true series or parallel values (whichever format is selected) at the test frequency. It must be remembered that conversions (series/parallel), using the above formulae, will produce values applicable ONLY at the test frequency.

Polar derivations

$$R_s = |Z| \cos\theta \qquad G_p = |Y| \cos\theta$$

$$X_s = |Z| \sin\theta \qquad B_p = |Y| \sin\theta$$

Note that, by convention, +ve angle indicates an inductive impedance or capacitive admittance.

Also, if capacitance is measured as inductance, the L value will be -ve.
" inductance " " " capacitance, " C " " " "

$D = \tan\delta$ where $\delta = (90 - \theta)°$ admittance measurement.

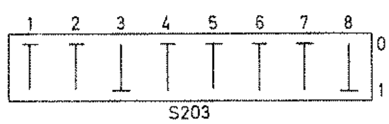
$Q = 1/\tan\delta$ where $\delta = (90 - \theta)°$ impedance measurement.

8 RS232-C INTERFACE (OPTION CODE /A)

When fitted with this option, the Analyzer can be used to drive a printer or other recording device conforming to EIA Standard RS232-C. The Option card, which is common to other Wayne Kerr instruments, has links and switches which have been set during installation to suit the Analyzer. Further switches must be set by the user to provide characteristics of the RS232-C link to correspond with those of the receiving equipment before data can be transmitted.

8.1 SETTING DATA CHARACTERISTICS

To gain access to the option card, first remove instrument cover. Switch S203 (located rear left) sets the characteristics of the transmitted data to match those of the printer. If the characteristics of the printer are not known, set all the switches to '1' initially. The most important characteristic, which MUST correspond at each end of the link, is the Baud rate (switches 6, 7, 8). Note that power to the instrument must be off whenever these settings are changed.



Switch 1
Sets data word length: 1 = 7 bits, 0 = 8 bits.

Switch 2
Not used.

Switch 3
Sets number of stop bits: 1 = 2 bits, 0 = 1 bit.
Setting 0 may give slight speed advantages with slow data rates.

Switch 4
Most equipments use a single parity bit to check for possible data errors. Switch 4 selects this function: 1 = ON, 0 = OFF.

Switch 5

Parity check may be odd or even: 1 = EVEN, 0 = ODD.

Note that equipments vary in their response to a detected parity error. They may print a standard character (?) or there may be a separate warning lamp. During setting up it is usually possible to run both ends of the link with parity 'off', but it should be used wherever possible to detect errors.

Switches 6, 7, 8

These set the Baud rate (data rate). Always use the fastest rate that the peripheral equipment can handle.

Baud rate	6	7	8
110	0	0	0
150	1	0	0
300	0	1	0
600	1	1	0
1200	0	0	1
2400	1	0	1
4800	0	1	1
9600	1	1	1

8.2 CABLE CONNECTORS & DATA FLOW DIRECTION

The RS232-C link is specified for linking peripheral equipment to computers, and some of the pin connections are different at the two ends of the cable. When driving a printer, convention dictates that the printer is peripheral, (DTE), so the instrument option card should be wired as a computer, (DCE). Ensure that S204 (located rear right) is set as follows:

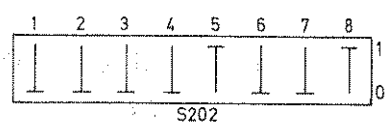
Connections to the 25-way output socket are as follows:

Pin	
1	Ground
2	Receive Data
3	Transmit Data
4	Clear to Send
5	Request to Send
6	Data Term Ready
7	Ground
8	Received Line Signal Det.
20	Data Set Ready

Other pins are not used for RS232-C interface.

8.3 CARD ADDRESS

Behind and to the right of SK202 are two DIL switches, S201 and S202. These set the card address and other characteristics to allow it to operate with the instrument. The correct settings for this option are shown below.



8.4 ENABLING THE PRINTER OUTPUT

When the RS232-C option is fitted, output can be enabled by entering 'Code 10' or disabled by entering 'Code 11'. When entered, the timed message 'PRINTER ON' or 'PRINTER OFF' appears, indicating the current status of the output function. Outputting data to the printer slows the measurement rate, particularly at the lower baud rates. No such slowing occurs with 'PRINTER OFF' selected.

8.5 PRINTER FORMAT

When operating in the Single mode, the instrument will generate a single printed line of up to 40 characters, terminated by CR-LF.

1.0kHz	10.98µH	0.3622 Q
800 Hz	16.00µH	0.2946 Q
600 Hz	28.06µH	0.2177 Q

The above example demonstrates the response to the measurement parameter that is being updated in Normal mode measurements. The response is similar if the parameter being changed is Level or Bias.

Status

The status of the present measurement mode (except Bin Set) is output whenever the measurement mode, measurement function or any of the measurement parameters is changed.

Freq.	Level	Bias	Fast	Auto
1.0kHz	100mA	OFF	L Q	Par

The measurement mode is Normal.

The measurement functions are L and Q.

The measurement parameters are frequency 1.0kHz, level 100mA, Bias OFF, the speed is Fast, and Parallel equivalent circuit selected.

Also the instrument is in the Auto range state.

Output of Range Error

When operating in the range Hold mode, the measurement results may or may not be suppressed when a Range Error is indicated. When there is a range error, the message 'Range Error' is output terminated with CR-LF. Any displayed results are then output on the new line, terminated with CR-LF. If no results are displayed then the output is a blank line.

```
600 Hz      -0.6nF    150.0 ohm
600 Hz      -0.4nF    150.0 ohm
Range Error
600Hz       -0.4nF    851.5 ohm
Range Error
600 Hz       0.4nF    850.0 ohm
Range Error

Range Error
```

Units Prefixes

As some printers have only upper case letters for units prefixes, the following convention is used.

F	=	femto	10^{-15}
P	=	pico	10^{-12}
N	=	nano	10^{-9}
U	=	micro	10^{-6}
M	=	milli	10^{-3}
K	=	kilo	10^{3}
MG	=	mega	10^{6}
G	=	giga	10^{9}

Printing Bin Data

When Bin Set mode is selected there are no facilities provided for making a measurement; also Bin Count has no result to output. Therefore, when the RS232-C option is fitted, a new soft key - Print - is labelled in Bin Count. The example below indicates the data that is output when the key is pressed. Indicated for each bin are the limits set and the number of items that had fallen into the bin. The example shows % limits with a Nominal of 500pF.

Bin	High %	Low %	Minor D < x	Count
0	0.50	-0.50	0.001	44
1	1.0	-1.0	0.001	50
2	1.5	-1.5	0.001	54
3	2.0	-2.0	0.001	50
4	2.5	-2.5	0.001	38
5	3.0	-3.0	0.001	24
6	5.0	-5.0	0.001	25
7	10.0	-10.0	0.001	17
8	20.0	-20.0	0.001	10
9			Reject	8

Nominal 500.0pF

Total 320

8.6 EXAMPLES

Example 1. Single measurements.

Freq	Level	Bias	Slow	Auto
600 Hz	1.00V	OFF	C R	Par

600 Hz	-0.00nF	99.950 Ohm
600 Hz	0.02nF	99.955 Ohm
600 Hz	-0.00nF	99.955 Ohm

Example 2 Updating the Level parameter in Normal mode.

Freq	Level	Bias	Slow	Auto
600 Hz	1.00V	OFF	C R	Par

1.00Vac	0.10nF	99.955 Ohm
1.05Vac	0.02nF	99.950 Ohm
1.10Vac	0.04nF	99.955 Ohm

Example 3 Deviation mode with Bias On, measuring response to changing voltage:

Freq	Level	Bias	Norm	Auto
100 Hz	100mA	0 V	C	Ser
Nominal	926.8μF			

0 Vdc	0.00%	926.8μF
5.0 Vdc	0.50%	931.4μF
10.0 Vdc	2.05%	945.8μF

Example 4 Limits mode, Absolute limits

Hi Lim = 385.0 Ohm
Lo Lim = 315.0 Ohm
Slow Auto Abs Mode

330.12 Ohm PASS
312.10 Ohm LOW

Example 5 Limits mode, % limits

Hi Lim = 10.0 %
Lo Lim = -10.0 %
Nom = 350.0 Ohm
Slow Auto % Mode

0.0305 % PASS
11.460 % HIGH

Example 6 Bin Sort

Norm	Auto	Abs Mode	
Bin No. 4		0.05nF	130.92 Ohm
Bin No. 2		0.00nF	110.92 Ohm
Bin No. 3		0.05nF	120.94 Ohm

Example 7 Bin Sort with Meas/Nom units mismatch

Norm Auto Abs Mode

MEAS/NOM UNITS MISMATCH
MEAS/NOM UNITS MISMATCH
MEAS/NOM UNITS MISMATCH
MEAS/NOM UNITS MISMATCH

9 GENERAL PURPOSE INTERFACE BUS (GPIB) (OPTION CODE /B)

When fitted with this option, the Analyzer has a GPIB interface to the IEEE Std 488.1-1987 providing either:

i) automatic output of measurement data (e.g. to a printer), or
ii) full remote control of all functions via IEEE 488.

To permit simultaneous parallel operation of several devices on the bus, fairly complex device addressing and hand-shaking routines are necessary. These are fully defined by the IEEE Standard and a thorough understanding of them is necessary if the Analyzer is to be successfully incorporated into a system.

9.1 SETTING GPIB ADDRESS

The GPIB address and selection of talk only mode are set by SW1 on the GPIB option card.

To set the switch, the option card must be removed from the Analyzer. To do this, first disconnect the ac supply and remove the cover.

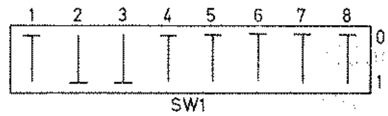
If it is desired to use the Analyzer as a talk only device, i.e. without a controller on the bus, set SW1 pole 8 to 1. The other switch poles are 'don't care'.

If it is desired to use the Analyzer with a controller:

1 Set SW1 pole 8 to 0, i.e. NOT talk only.

2 Set the required device address in binary on poles 1 to 5 of SW1 where pole 1 is the least significant bit and pole 5 is the most significant bit.

For example, with controller, device address 6:



9.2 COMMAND AND DATA FORMATS

The GPIB option conforms to IEEE Std 488.1-1987 in the following categories of allowable sub-functions:

SH1	Source Handshake - complete capability
AH1	Acceptor Handshake - complete capability
T5	Basic Talker, Serial Poll, Talk Only, Unaddressed if MLA
TE0	No Extended Talker
L4	Basic Listener, no Listen Only, Unaddressed if MTA
LE0	No Extended Listener
SR1	Service Request
RL1	Remote/Local Function - complete capability
PP0	No Parallel Poll
DC1	Device Clear
DT1	Device Trigger - complete capability
C0	Not Controller

Also available, but not included in the IEEE 488 specification, is a sub-function which allows both Remote and Local triggering of measurements by enabling the Trigger key. This mode is selected by the LOCAL TRIGGER ON command (see section 9.3). LOCAL TRIGGER OFF inhibits this mode.

Command Format

1 The command set (see section 9.3) contains both full commands and recommended abbreviations. No other forms should be used. The full commands are designed to generate self-documenting command strings.

2 Some commands require a numeric value to follow (e.g. CODE 4; FREQUENCY 1E3). If this is omitted a command error will be reported.

3 Commands must be separated by a delimiter (;) with EOI or LF sent at the end of each command string.

4 Commands will not be implemented until EOI or LF is received. Commands will be executed strictly in the order in which they appear in the string.

5 Whilst a command string in being executed, no further commands can be accepted.

6 If a measurement is in progress when a command is received, the measurement will be aborted. The MESS? command (see Data Output, item 3) is the only exception to this rule.

7 If a command error is encountered, subsequent commands in the string will be ignored.

8 The maximum acceptable string length is 256 characters. If this is exceeded a command error will be reported.

9 A command string should contain not more than one TRIGGER command. This must be the last command in the string, otherwise a command error will be reported.

10 Upper and lower case letters will be interpreted as being the same.

11 Only commands which are normally available in the selected mode will be accepted. Otherwise a command error will be reported. For example, 'NOMINAL' cannot be selected in NORMAL mode. (Except that modes can always be directly accessed without first calling INDEX).

12 Numeric data may be integers, real numbers or exponential format. Use of non-numeric multipliers (k, p etc) is not permitted. If used, a command error will be reported.

13 Units following numeric data will be recognised by the first letter only, although the full name may be used for self documenting purposes.

14 Functions which require confirmation when selected locally do not require confirmation before execution when called via GPIB.

15 Code numbers less than 1 are reserved for self test routines. These are not available under Remote control.

16 Code 9.1 should only be sent as an individual command as it has the effect of erasing all stored data.

17 The response of the instrument to Device Clear is equivalent to the Power Up condition.

18 Typical command strings for setting the instrument might be:

a) FREQ300E3;LEVEL700E-3V;L;R;SERIES;AUTO;NORMALSPEED;TRG
b) BIN 1;HILIM 10;LOWLIM-10;NOMINAL 3E-6 FARADS;BINSORT;TRIGGER

19 If a Group Execute Trigger is sent while a command string is being processed, a measurement will not be made until the command string has been finished. A command error will prevent the trigger instruction being executed.

Command Errors

1 If a command error occurs, SRQ will be generated. Types of command error will be encoded in the Status Byte (in response to a Serial Poll). See section 9.4.

2 'Nearest Available' values will be implemented but reported as a command error.

3 When sending ac signal levels, the units (V,A) must be included. If they do not match the current machine status, a command error will be reported.

Data Output

1 Output consists of measurement results and displayed messages. The messages will be encoded as a single numeric value (see section 9.5).

2 Output comprises 4 numeric values. The first value will be the encoded messages. The remaining 3 values will be the results from measurements. These results will be sent in the order in which they appear on the screen, top to bottom.

3 The encoded messages can be output at any time, independent of the measurement status, by sending the MESS? command. In this case the three data values will be set to 0.00E00.

4 Each value will be output separately. Each will terminate with CR followed by LF with EOI.

5 All values output that are surplus to the displayed measurement mode will have the value 0.00E00.

For example, a Normal Mode measurement will give four numeric values: the encoded messages, two measured results, and a fourth value of 0.00E00.

6 Numeric results will be in Engineering Format (i.e. exponential format where exponent is a multiple of 3) with no units, of variable length corresponding to screen display.

7 If an OVERRANGE results, the value 999.9E15 will be sent.

8 At the end of any Trim sequence, the encoded message value will be output with the three data values set to 0.00E00.

9 If data is available for output when not addressed to talk, SRQ will be generated. Only one SRQ will be generated for the four data values. 'Output Data Available' is indicated in the Status Byte (in response to a Serial Poll). See section 9.4.

10 Sometimes measurement is not possible because drive levels have not been established. In this case the instrument responds by outputting the current encoded message set with the three data values set to 999.9E15.

11 If the instrument enters the listen state with any output data outstanding, then this data will be discarded.

12 If a serial poll is received when the instrument is busy, the Busy condition is indicated by the Status Byte (see section 9.4). Busy conditions include processing commands, waiting to start a measurement, measurement in progress, outputting data.

13 The result LOW PASS HIGH as displayed in LIMITS mode will be output as a decimal integer, with the following representations:

0 = Units mismatch condition
1 = LOW
2 = PASS
3 = HIGH

14 To read BIN COUNT data use the command INTERROGATE. The instrument responds by outputting the encoded messages, followed by the contents of each bin in sequence from 0 to 9, followed by the total.

Talk Only state

1 This state is selected by setting switches on the GPIB option. When in this state, output is to a 'listen always' device.

2 Data output to the printer will be formatted as detailed for the RS232-C printer option (see section 8).

Operating Speed

Set up time following receipt of a GPIB command varies with the particular instruction. Typical values are between 50 and 150 ms per command, allowing mixed command strings to be processed at approximately 10 instructions per second.

To trigger a measurement and output full data (4 strings) adds approximately 150 ms to the measurement times detailed on page 2-5.

9.3 COMMAND ABBREVIATIONS

The table below shows the instrument functions which are also the IEEE Commands and are fully self-documenting. The abbreviation is an acceptable short form. Either command is accepted by the instrument.

FUNCTION	ABBREVIATION	FUNCTION	ABBREVIATION
ABS	ABS	LIMITS	LMS
ANALOG SET	ANS	LOCAL	LCL
ANGLE	ANG	LOW LIMIT 'VALUE'	LOWL
AUTO	AUT	LOCAL TRIGGER ON	LTON
BIAS ON	BSON	LOCAL TRIGGER OFF	LTOF
BIAS OFF	BSOF	MESS?	M?
BIN SET	BNSE	NEXT	NEX
BIN SORT	BNSR	NORMAL	NOR
BIN COUNT	BNCO	NORMAL SPEED	NORS
BIN NO 'VALUE'	BN	PARALLEL	PAR
BIAS 'VALUE'	BA	PRINT	PRI
C	C	Q	Q
CODE 'VALUE'	COD	R	R
CONNECTIONS	CON	REPEAT	REP
D	D	RESET	RES
DELETE ALL	DALL	SAVE NOMINAL	SAV
DELETE LAST	DLAS	SCALE OFF	SCF
DEVIATION	DEV	SCALE ON	SCN
DOWN	DOW	SET MINOR	SMR
FAST SPEED	FAS	SET NOMINAL 'VALUE'	SNO
FREQUENCY 'VALUE'	FRE	SINGLE	SIN
G	G	SERIES	SER
HIGH LIMIT 'VALUE'	HIL	SLOW SPEED	SLO
HOLD	HOL	TRIGGER	TRG
IAC	IAC	TRIM OPEN CIRCUIT	TOC
INTERROGATE	INT	TRIM SHORT CIRCUIT	TSC
INDEX	IND	UP	UP
KEYLOCK	KL	VAC	VAC
KEY UNLOCK	KU	Y	Y
L	L	Z	Z
LEVEL 'VALUE'	LEV	%	%

9.4 STATUS BYTE FORMAT

The status byte is formatted to indicate:

a) when the instrument is busy
b) when a message is displayed
c) when a result is available
d) when there is a command error

The defined bits are set according to the relevant condition or conditions.

The bit map is as follows:

X S B R M X C C

'CC' = Command error bits
'X' = not used
'M' = Message bit
'R' = Output data available
'B' = Busy bit
'S' = Service request

The command error bits indicate the following command error conditions:

00 = No error
01 = Syntax error
10 = not available
11 = buffer overflow (or DC Voltage Bias Unit not fitted)
where 0 = false, 1 = true

Examples:

01000001 = service request and command syntax error
00101000 = busy and there is a message displayed.

9.5 ENCODED MESSAGE SET

The encoded message is a decimal value, where each digit or digit pair represents messages that appear on the instrument display.

The encoded message format is as follows:

I J K K L M N

where N indicates Range or Trim errors:

0 = No message
1 = Range Error
2 = S/C Trim Error or Trim Failed:Out of Range
3 = Range Error plus S/C Trim Error
4 = O/C Trim Error or Trim Failed:Out of Range
5 = Range Error plus O/C Trim Error.

M indicates the message displayed on the warning line:

0 = No message
1 = External Bias Unit fitted
2 = Bias link not fitted

L indicates additional messages relating to the DC voltage Bias:

0 = No message
1 = Safety: bias turned off

The digit pair KK indicates the message on the message line:

00 = No message
01 = Nearest Available
02 = Voltage Drive Selected
03 = Current Drive Selected
04 = Drive Level Reduced
05 = DC Voltage Not Set
06 = (Reserved for future expansion)
07 = " " " "
08 = Meas/Bin Units Mismatch
09 = Meas/Nom Units Mismatch
10 = Level Too High
11 = (Code) Not Defined

J is reserved for future expansion

I indicates data valid or invalid or check measurement status:

0 = data valid
1 = data invalid
2 = measurement in progress

Examples:

0004002 = Drive Level Reduced and S/C Trim Error

1009005 = Data invalid plus Meas/Nom Units Mismatch plus Range Error and O/C Trim Error.

10 STANDARD HANDLER INTERFACE (SHI) (OPTION CODE /D)

10.1 INTRODUCTION

The SHI option card may be fitted into the option slot at the rear of a 6425B. It will enable the instrument to measure a component, sort it into one of the eight bins according to the measurement results and then provide the signals for external bin handling hardware to physically "bin" the component. The interface supports up to eight external bins and provision is made for external bin handler hardware to trigger a measurement directly.

Note that in this section "low" refers to a TTL logic level between 0 and 0.8V and "high" is a TTL level between 2.4 and 5V.

10.2 OPERATION

When the SHI card is fitted into an instrument, there will be no noticeable difference in its operation. If Code 0.7 is entered, the instrument will report whether or not it has detected the Interface with the messages 'BIN HANDLER FITTED' or 'BIN HANDLER NOT FITTED'. If the message 'NOT DEFINED' appears, then the software in the instrument does not support the Standard Handler Interface.

Results will be sent to the Interface only if all the following conditions are met:

i) The instrument is in Bin Count or Bin Sort mode.

ii) There is no MEAS/BIN UNITS MISMATCH error.

iii) Under Local operation, the instrument is set to Single.

10.3 INTERFACE DETAILS

The functions of the Interface lines are defined in Table 10.1 and timing waveforms are shown in Fig. 10.1. The two output signal lines $\overline{\text{BUSY}}$ and $\overline{\text{Bin Data Available (BDA)}}$ will at any time assume one of four different states:

(1) Null State

The null state is defined as

$\overline{BUSY}$ low (i.e. instrument is busy)

$\overline{BDA}$ high (i.e. no data available)

All $\overline{BIN}$ lines high (i.e. no bins selected)

This state is adopted when the instrument is unable to perform binning due to one of five reasons.

TABLE 10.1 Standard Handler Interface Signal Definitions

Pin No.	Name	Function
8	$\overline{TRIGGER}$	External trigger input. Pulling this line low while $\overline{BDA}$ is low and $\overline{BUSY}$ is high will cause the instrument to start a measurement.
10	$\overline{BUSY}$	Output signal. When low, the component at the measurement terminals of the instrument is being measured and should not be removed.
5	$\overline{BDA}$	Bin Data Available. Going low indicates the completion of a measurement cycle and that the data on the $\overline{BIN}$ lines is valid.
1	$\overline{BIN\ 0}$	Going low indicates a result in bin 0
2	$\overline{BIN\ 1}$	" " " " " " " 1
3	$\overline{BIN\ 2}$	" " " " " " " 2
4	$\overline{BIN\ 3}$	" " " " " " " 3
13	$\overline{BIN\ 4}$	" " " " " " " 4
14	$\overline{BIN\ 5}$	" " " " " " " 5
15	$\overline{BIN\ 6}$	" " " " " " " 6
16	$\overline{BIN\ 7}$	Going low indicates a result in either bin 7, 8 or 9.
24	GND	Electrical Ground.

i) The instrument is not in either Bin Sort or Bin Count mode.

ii) There is a MEAS/BIN UNITS MISMATCH error.

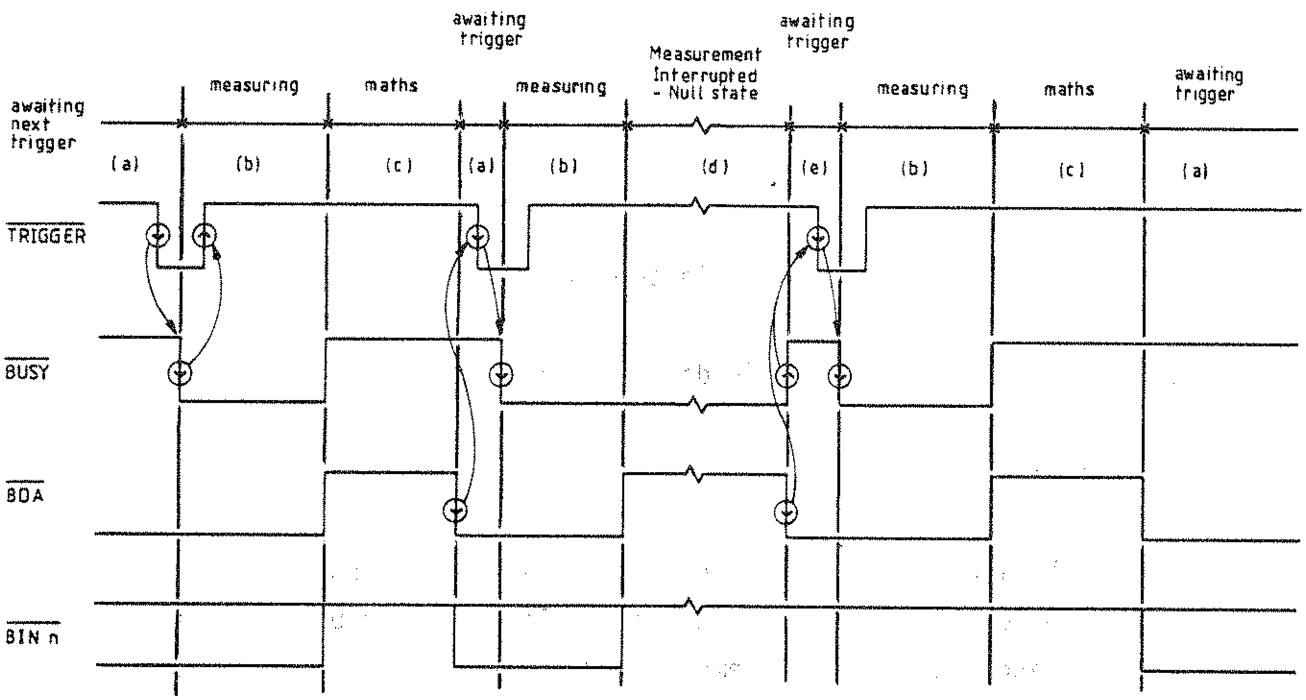
iii) The instrument is in Local operation and not in Single shot mode.

iv) The instrument has not performed a measurement since the present mode was entered.

v) A DEVICE CLEAR has been sent by a GPIB controller.

When this state is detected by external hardware, it must be assumed that the current signals on the $\overline{\text{BIN}}$ lines are invalid and should be ignored and also that the instrument is not ready for an external $\overline{\text{TRIGGER}}$ signal.

When the above conditions have cleared, the next state will be entered.



(a) - Awaiting trigger. Previous results available.

(b) - Trigger received - enter busy state. Reset trigger.

(c) - Measurement done - Remove component.

(d) - Measurement interrupted - enter 'null' state.

(e) - Null conditions have been removed - re-enter (a).

Fig. 10.1 Standard Bin Handler timing

(2) Ready for Trigger

In this state:

$\overline{\text{BUSY}}$ is high (i.e. not busy)

$\overline{\text{BDA}}$ is low (i.e. bin data is valid)

All $\overline{\text{BIN}}$ lines will be unchanged. If the previous state was a null then all bin lines will be high, meaning no bin selected, although $\overline{\text{BDA}}$ suggests that valid bin data is present.

This state indicates that the instrument is awaiting a trigger, whether from the front panel push-button, a GPIB controller or from the $\overline{\text{TRIGGER}}$ line (see section 10.4).

When the instrument receives a trigger it will respond by entering the next state.

(3) Busy

In this state:

$\overline{\text{BUSY}}$ is low (i.e. the instrument is busy)

$\overline{\text{BDA}}$ is low (i.e. bin data is valid)

All $\overline{\text{BIN}}$ lines are unchanged.

The $\overline{\text{BUSY}}$ line goes low to acknowledge the trigger and also to indicate that the component between its terminals is in the process of being measured and should not be removed until the $\overline{\text{BUSY}}$ line goes high again, when the instrument enters the next state.

(4) Not Busy

In this state:

$\overline{\text{BUSY}}$ is high (i.e. the instrument is not busy)

$\overline{\text{BDA}}$ is high (i.e. bin data is not valid)

All $\overline{\text{BIN}}$ lines high (i.e. no bins selected).

In this state the instrument has finished measuring the component under test, which may be removed and replaced by the next component. However, the instrument has still to sort the component into the relevant bin and, as the current bin is being updated, all the $\overline{\text{BIN}}$ lines are made invalid.

If this process has been completed without interruption, the instrument will re-enter the "Ready for trigger" state, waiting to measure the next component. This sequence will only be interrupted if a key on the front panel of the instrument is pressed or a command is received from a GPIB controller. In this case the current state will be "frozen" until the command has been completed. If the command results in the operating conditions of the Interface being disturbed, the instrument will enter the null state.

When the instrument is ready to continue with the next measurement, it will re-enter the "waiting for trigger" state and the measurement that was aborted may be repeated from the start.

Similarly, after the conditions leading to the null state have been rectified, another measurement may be attempted. For this to be transparent to the bin handler hardware it is recommended that it responds to the negative-going edges of the $\overline{\text{BDA}}$ line and the relevant $\overline{\text{BIN}}$ line, which will occur only when a component has been successfully measured and sorted. Note that if the component is removed, after the $\overline{\text{BUSY}}$ line goes true, and is replaced by another, then the second component will be re-measured and the first will be lost. For reliable results it is recommended that components are removed only when the instrument has completely finished sorting and has re-entered the "awaiting trigger" state. Removing the component upon BUSY going high should only be used for maximum speed, when the bin handling mechanism should be disabled before the operation of the instrument is disturbed.

Note that only 8 $\overline{\text{BIN}}$ lines are available, although 10 are provided in the software. Results indicated in bins 7, 8, and 9, will all make the $\overline{\text{BIN 7}}$ line go low.

10.4 EXTERNAL TRIGGER

Measurements may be triggered by pulling the $\overline{\text{TRIGGER}}$ line low but ONLY while the instrument is in the "awaiting trigger" state. If the $\overline{\text{TRIGGER}}$ line is pulled permanently low the $\overline{\text{BDA}}$ line will also be pulled low, impeding its operation.

If continuous measurements are required, a circuit such as that shown in Fig. 10.2 may be used to trigger a measurement from the completion of the last binning operation.

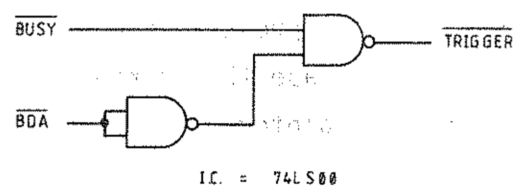


Fig. 10.2 Continuous Trigger circuit

Note that the TRIGGER line is scanned by the instrument only while in the "awaiting trigger" state and, unlike the front panel key, pulling it low at any other time will not abort a mesurement and re-start another.

<u>Note</u> that under certain conditions, such as when the instrument is in Hold and the components under test generate overloads, the turn-around of components being measured and sorted can reach 51 per second. If the external hardware cannot cope with this, then the next trigger should be held off until the hardware is ready.

If the external trigger is to be used under GPIB control, then local trigger must be enabled by sending the command "LTON".

10.5 HARDWARE DETAILS

Output drive levels:

Low state : $<$ 0.5V at 48mA

High state : $\overline{\text{BIN 0}}$ to $\overline{\text{BIN 7}}$ 2.4V at -5.2mA

Other outputs, open collector.

Outputs may be used to drive external relays for isolation purposes. In this case an external relay supply not exceeding 5.0V is required, and the relay coils must be fitted with suitable shunt diodes to absorb back emf energy.

11 ANALOG OUTPUT (OPTION CODE /C)

11.1 INTRODUCTION

The Analog Output option provides two analog output voltages which vary from 0 to 1 volt dc in proportion to the major and minor terms, respectively (upper and lower displayed results). These outputs can be used with a chart recorder to provide a printed copy of the variation in measured parameters with time.

The analog output voltage is calculated according to the measured result and two limits: a maximum limit corresponding to an output of 1V dc and a minimum limit equivalent to an output of 0V. These limits can be specified by the user according to the scale required. They are specified without dimensions because the analog voltage will be based upon the numerical displayed result, irrespective of its units. Therefore a maximum limit of 10 may be interpreted as 10 Henrys, 10 ohms or 10 Farads in Normal mode, or 10% in Deviation and Limits mode.

11.2 OPERATION

To enable the maximum and minimum limits to be entered, a mode called "Analog Set" is provided. If an Analog Output option card is fitted in the instrument, then "Analog Set" will be displayed in the main index and may be selected by pressing the corresponding soft-key. If the card is missing, then this key will not be labelled. Sample displays from Analog Set are given in Fig. 11.1.

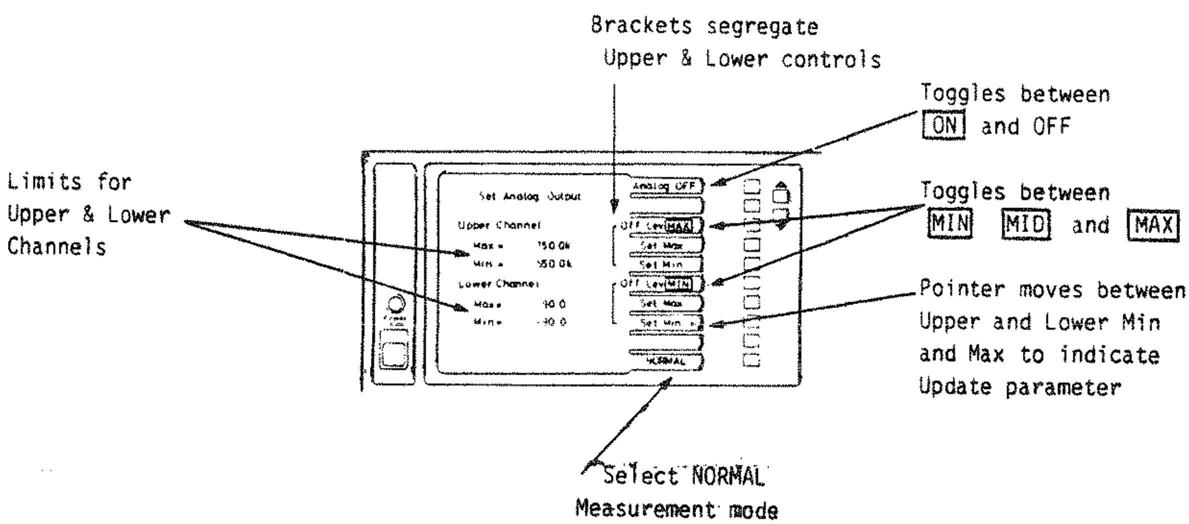


Fig. 11.1 Analog Set Mode Display

When the maximum and minimum limits have been entered, the user may switch the Analog Output to 'ON'. A measurement mode, for example "Limits", can then be entered via the Main Index. After each successive measurement, the analog voltage will be up-dated. If the result is greater than the maximum or less than the minimum, then the limiting value will be output instead.

The Analog Output will remain on until:

i) It is switched off from Analog Set mode.

ii) The Local button is pressed while in Local mode, giving this button the additional function of an "Analog Off" control.

While the Analog Output is turned off, the output voltage for each channel can be set by the user to "Min" (0V), "Mid" (0.5V) or "Max" (1.0V) to enable the deflection of the recorder to be set up.

Calculating the appropriate analog voltage slows the overall measurement rate; no such calculation will be made if the Analog Output is turned OFF.

TABLE 11.1 ANALOG SET MODE COMMANDS

SOFT KEY LABEL	FULL GPIB COMMAND	GPIB ABBREVIATION	FUNCTION
ANALOG ON/OFF	ANALOG ON *	ANN *	Enable the Analog Option.
	ANALOG OFF *	ANF *	Disable the Analog Option.
OFF LEVEL MIN/MID/MAX	UPPER OFF MIN	UFN	Specify output level when Analog is disabled for the Upper or Lower channel. MIN = 0V, MID = 0.5V, MAX = 1.0V
	LOWER OFF MIN	LFN	
	UPPER OFF MID	UFD	
	LOWER OFF MID	LFD	
	UPPER OFF MAX	UFX	
	LOWER OFF MAX	LFX	
SET MIN	UPPER MIN "Value"	UMN "Value"	Specify Minimum Limit for Upper or Lower channel.
	LOWER MIN "Value"	LMN "Value"	
SET MAX	UPPER MAX "Value"	UMX "Value"	Specify Maximum Limit for Upper or Lower channel.
	LOWER MAX "Value"	LMX "Value"	

* NOTE:
These are the only GPIB Commands that may be used in modes other than Analog Set.

11.3 SOCKET DETAILS

15 pin D-type Female.

Pin 1	Analog	0V	
Pin 2	Analog	Upper Output ('Major' term)	
Pin 3	Analog	Lower Output ('Minor' term)	
Pin 4	Digital	0V	Reserved for future use (Pins 4–15)
Pin 5	Digital	O/P bit 0	
Pin 6	Digital	O/P bit 1	
Pin 7	Digital	O/P bit 2	
Pin 8	Digital	O/P bit 3	
Pin 9	Digital	0V	
Pin 10	Digital	0V	
Pin 11	Digital	0V	
Pin 12	Digital	I/P bit 0	
Pin 13	Digital	I/P bit 1	
Pin 14	Digital	I/P bit 2	
Pin 15	Digital	I/P bit 3	

11.4 ANALOG OUTPUT

i) Output Voltage : 0 to 1V d.c. into 1 kohm minimum load. Offset adjustable by internal preset.

Output Resolution : 0.2%

Step Response : 35 ms from end of measurement to 1% final value.

Protection : Continuous short circuit.

ii) The Analog Output voltage will be calculated according to the following expression:

$$\text{Analog Voltage} = \frac{\text{Measured Value} - \text{Minimum Limit}}{\text{Maximum Limit} - \text{Minimum Limit}}$$

iii) Maximum and Minimum limits may be entered, with a sign, to enable negative percentage deviation, angles etc to be output.

The maximum and minimum limits will be interchanged automatically if the minimum limit is greater than the maximum limit. If the limits are equal, the output voltage will be 0V if the measurement is lower than the limits, and 1V if greater.

iv) The upper channel output always corresponds to the upper (major term) displayed result, and similarly for the lower channel. In measurement modes with one displayed result, the upper channel only will operate.

1 INTRODUCTION

This Section provides maintenance information on Precision Component Analyzer 6425B and circuit descriptions of the four plug-in options available: RS232-C, GPIB Interface, Handler Interface and Analog Output.

The 6425B is a sophisticated instrument and its internal circuits should not be adjusted except by suitably qualified personnel with access to the test equipment and Standard components specified.

2 SYSTEM DESCRIPTION

2.1 MICROPROCESSOR CONTROL

All functions of the system are under the direct control of a microprocessor (CPU). Each automatic cycle of operations includes an interrogation of the keypad selections - the keys do not operate directly on the measurement circuits. The CPU then controls these circuits to obtain comparative voltages for the Unknown and Standard impedances under the selected test conditions. By resolving these voltages into orthogonal components, and subsequent computation, the selected type of readout information is used to update the CRT display.

The CPU polls the keyboard and GPIB port (if fitted) as a background task. When any change is detected, the measurement is aborted and the input instruction serviced. If an ac measurement is required, it runs through a sequence of 6 or 8 operations, according to the type of measurement and the Speed selected. The operations involve the selection of the Standard and Unknown voltages and the appropriate reference signal for a phase-sensitive detector (psd). The CPU also selects the integration time used for A-D conversion. On completion of the sequence, the selected parameters are computed, trim corrections applied, and the display updated. Write to the display occurs only when changes are needed, and then only to those areas needing update. Further details are in section 2.3 and in the section 'Screen Display Character Generation' (2.6).

2.2 BASIC MEASUREMENT

Refer to Fig 2.1. The guard amplifier produces a feedback current through the Standard resistor, Rs, exactly matching the current through the component under test, Zu. A single measurement channel is switched electronically to measure the corresponding two voltages produced, Es and Eu. Resolution of these into in-phase and quadrature components, and subsequent computations, provides the required information for the display.

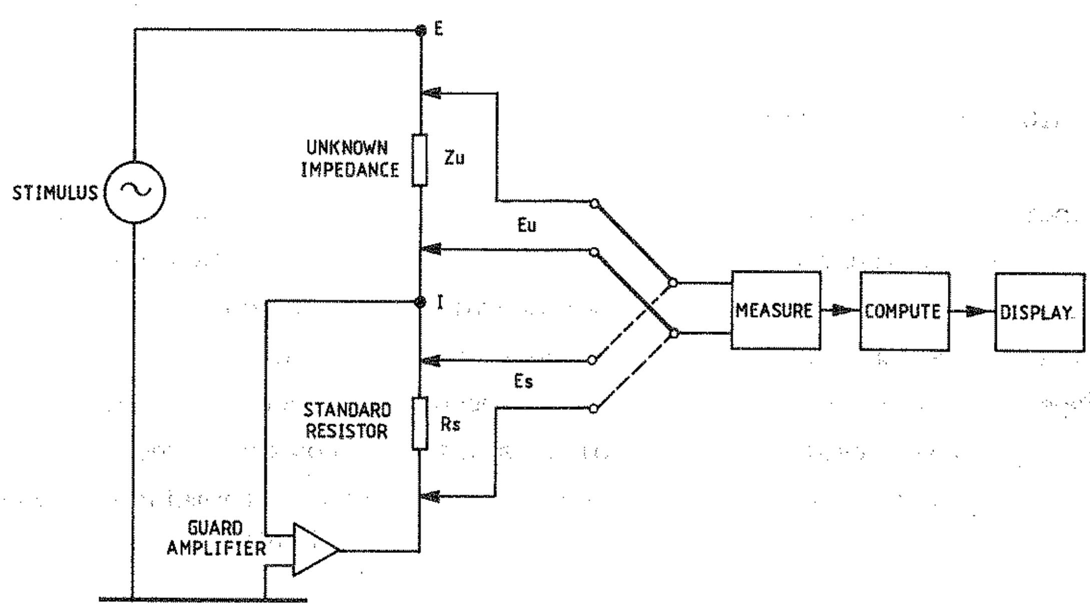


Fig 2.1 Basic Measurement

2.3 MEASUREMENT SEQUENCE

On voltage-drive ranges (3-8), the current-derived signal Es is measured first, followed by the Unknown voltage Eu. This order is reversed on current-drive ranges (1 & 2).

In the measurement channel, the psd resolves the signal to be measured, with respect to a reference signal of the same frequency as the drive signal.

The psd reference signal has four phase settings (0 - 3) separated by precise 90° shifts. Their phase relationship to the drive signal is, however, arbitrary. The orthogonal outputs of the psd are fed to the A-D converter.

The sequence for ac measurements on ranges 3-8, at NORMAL or FAST speeds, is:

Select Es
Settling delay (frequency-dependent)
Measure with psd phase 2
" " " " 0
" " " " 1
" " " " 3
Select Eu
Settling delay
Measure with psd phase 3
" " " " 0
Compute results
Output to display/output option

On repetitive measurements, Es is selected after the sixth measurement and the results computed and output during the subsequent Es settling delay.
The key polling sequence also checks whether each A/D conversion is complete.

If an overload occurs at any point, the sequence is aborted and auto-ranging started. With Hold selected, the sequence continuously restarts and RANGE ERROR is reported.

On SLOW speed, both Es and Eu are measured at all four psd phases (ie 8 measurements).

2.4 OVERALL SYSTEM

Refer to the Block Diagram, Fig. 2.4, which shows seven circuit boards:

Memory
CPU & TV
Synthesiser
Signal Source
20V Bias
Bridge
Detector

Not shown on Fig. 2.4 are the Mother board (into which the above are fitted), the power supply sub-chassis nor any of the optional plug-in boards. Because circuit functions are interdependent (one board serving more than one purpose) the descriptions are given under the following headings:

	Section
DIGITAL SYSTEM	2.5
SCREEN DISPLAY CHARACTER GENERATION	2.6
ADDRESS MAPS	2.7
Memory Map	2.7.1
I/O Map	2.7.2
FREQUENCY GENERATION	2.8
Fixed Dividers	2.8.1
Programmable Dividers	2.8.2
Staircase Generator	2.8.3
SOURCE SIGNAL DERIVATION	2.9
AC Level Selector	2.9.1
Programmable Filter (Source)	2.9.2
Output Amplifier	2.9.3
Source Resistance Selection	2.9.4
BRIDGE CIRCUITS	2.10
Neutralizer	2.10.1
Range Selection	2.10.2
UNKNOWN SIGNAL PROCESSING	2.11
Gain Selection	2.11.1
Programmable Filter (Detector)	2.11.2
Overload Detector	2.11.3
PSD, & PSD Reference Generator	2.11.4

Locations of the circuit elements referred to in these texts are stated, frequently, by board names. Component reference numbers themselves, however, are a general guide to their location:

Prefix	0	Chassis
	1	Synthesiser
	2	Memory (Mk I and Mk II) (Also RS232C Option)
	3	CPU & TV
	4	Keyboard
	5	Signal Source
	7	Power Supplies
	8	Bridge
	9	Detector
	10	Mother board
	16	20V Bias
	17	GPIB & Handler Interface Option
	18	Analog Output Option

2.5 DIGITAL SYSTEM

Block Diagram - Fig. 2.4.
CPU & TV Circuit Diagram - Fig. 7.2.
Memory Board Circuit Diagram - Fig. 7.4.
Keyboard Circuit Diagram - Fig. 7.6.

The digital system is based on a Z80 CPU, (IC305, CPU & TV board), operating with a 6.4MHz clock, which is connected via buffers to a 16-bit address bus and an 8-bit bi-directional data bus. These connect to the memory circuits, the screen display generator, synthesiser and A-D control circuits, and to the external interface Option slots.

The Z80 (CPU) has two modes of addressing external devices. These are (a) memory mapping and (b) I/O mapping.

(a) Memory mapping uses the whole of the address bus and hence can address 64k bytes. The address is qualified by the $\overline{MREQ}$ strobe. A Read ($\overline{RD}$) or Write ($\overline{WR}$) function is defined by the appropriate strobe to qualify the data.

(b) I/O mapping uses only half the address bus (AB0-AB7) and hence can only address 256 bytes. The address is qualified by the $\overline{IORQ}$ strobe. The $\overline{RD}$ and $\overline{WR}$ strobes qualify the data as above.

In the 6425B, the hardware is addressed in both modes, according to its function. Detailed address maps are in section 2.7.

The Eprom address decoder, (IC212, MkIII Memory board), provides 4 x 16k blocks for 27128 memories.

A separate 1k block decoder, IC216, is provided for RAM and memory-mapped hardware. The top 1k block is used for hardware and also feeds the page enable line $\overline{ENF}$ on the option connector. The next 1k block down ($\overline{SEN}$) is used for the screen circuits (see separate description) with the working RAM below this. The top 1k block is further decoded (IC215) to provide 6 memory-mapped enable lines to the hardware ($\overline{MEN}$ 0-5).

The RAM is non-volatile, using CMOS devices with a 3V Lithium primary cell back-up. At power-up, these devices change over to the internal 5V supply via D202 and D203. TR200, 201, 202 hold off the enable lines to the RAM until internal power supplies have been established, and normal microprocessor operation is ensured.

To permit operation of slow hardware blocks, a wait state is generated whenever the hardware or screen is addressed (IC 303, 328 and 338, CPU and TV board).

To minimize digital noise pickup, the data and address buses are not routed to the analog measurement areas (signal source, detector, bridge, 20V bias). CPU inputs from this area (ANI 4-7) feed to a common input port (IC210) located on the Memory board. CPU outputs to the analog area are I/O mapped and are routed via IC301 to a special 'quiet' data bus (ANO 0-7) which is inactive except during an I/O write. Decoded enable lines ($\overline{OEN}$ 0-7) provide for up to 8 latches to be connected to this bus.

All the above inputs and outputs are at TTL logic levels, level shifting for CMOS gates or heavy-duty relays being provided locally as required.

The keyboard drive has 4 latched addresses and 4 data lines which are decoded into 10 rows x 4 columns. The keys are polled periodically during the measurement sequence at times when any resulting digital noise pickup would be unimportant to measurement accuracy.

Power-on Reset (approx 200ms pulse) is provided by IC332. This can also be triggered during fault-finding by an internal master reset button located on the CPU & TV board. Additionally, IC337 generates a master reset (without delay) whenever the +5V digital supply falls below 4.75V, which helps to maintain the data integrity of the non-volatile RAM under supply drop-out conditions.

2.6 SCREEN DISPLAY CHARACTER GENERATION

Screen Display Generator Block Diagram - Fig. 2.5.
CPU & TV Circuit Diagram - Fig. 7.2.

The screen display circuits, located on the CPU & TV board, generate separate horizontal sync, vertical sync and video signals, all at TTL levels, which are routed to the CRT drive circuits. A non-interlaced horizontal raster is used, with a line frequency of 16.0kHz and frame frequency of 54.98Hz.

The microprocessor addresses the screen as 21 rows of 38 adjacent character cells, although the display area is only 19 rows of 37 characters. Each character cell is 8 dots wide x 12 lines high. A single byte describing the content of each character cell is stored in each of 798 (21 x 38) screen RAM locations (IC317). From these, any one of 256 standard characters can be selected for display in each character cell.

The character PROM (IC324) contains the patterns of light and dark dots making up each character, and each location in either PROM stores one horizontal line of information. Address lines A0 to A3 select the 12 lines forming each character, while address lines A4 to A11 select from the 256 different characters. The PROM contains two different character sets, one or the other being selected by IC321.

The display is generated by sequentially scanning the address lines of the screen RAM and the character PROM. The resulting patterns of 8 horizontal dots at a time are loaded into a shift register (IC323) and clocked out to the display by a 6.4MHz dot clock.

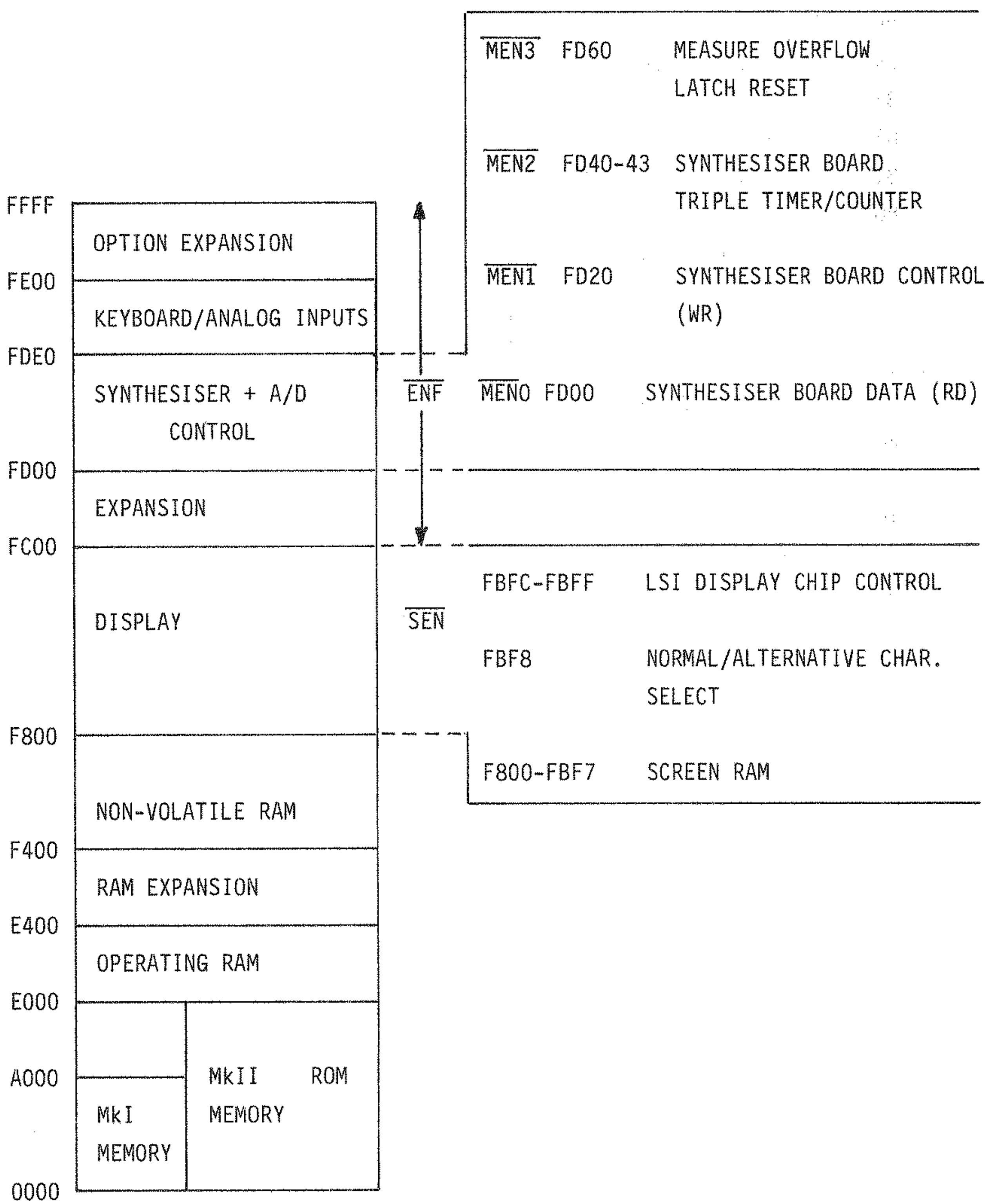
Scanning of the address lines, generation of sync pulses and cursor control are all handled by an LSI chip (IC312) which is initialized at power-up by the microprocessor. To avoid interfering with the display, the processor can write to the screen RAM only during line or frame flyback. If it attempts to write at any other times, a wait state is generated by the control logic.

During screen RAM updating, the RAM address lines are switched from IC312 to the processor address bus, by means of data multiplexers IC314-316.

2.7 ADDRESS MAPS

2.7.1 Memory Map

HEX ADDRESS 6425 MNEMONIC



2.7.2 I/O Map

(see circuit description for detailed hardware truth tables)

HEX ADDRESS		
FF	EXPANSION	
86	20V BIAS	$\overline{OEN}$ 6
85	CONTROL	$\overline{OEN}$ 5
84	DETECTOR CONTROL	$\overline{OEN}$ 4
83	NEUTRALIZER CONTROL	$\overline{OEN}$ 3
82	BRIDGE CONTROL	$\overline{OEN}$ 2
81	SIGNAL SOURCE CONTROL	$\overline{OEN}$ 1
80	AC LEVEL CONTROL	$\overline{OEN}$ 0
	OPTION EXPANSION	
40	HANDLER INTERFACE OPTION	
30		
	ANALOG OPTION	
20		
	GPIB OPTION	
10		
	RS232C OPTION	
00		

2.8 FREQUENCY GENERATION

2.8.1 Fixed Dividers (located on Synthesiser board)

Circuit Diagram - Fig. 7.8.

The fixed dividers provide the CPU and video clock frequencies by division from the 38.4MHz crystal oscillator IC132. IC104b and IC106 form ÷2 and ÷3 stages respectively to produce the 6.4MHz screen clock SCK. A further division by 3 (IC105b and IC107c) provides the 2.133MHz processor clock PCK.

2.8.2 Programmable Dividers (located on Synthesiser board)

The 42 drive frequencies (20Hz to 300kHz) are initially generated at 16fo (ie 320Hz to 4.8MHz). Frequencies from 1.6MHz (= 16 x 100kHz) upwards are generated directly by the dividers IC108 and IC109a, the required output frequency being selected by data multiplexer IC110.

Frequencies below 1.6MHz are provided by counter 2 of the programmable triple timer counter IC103, using as its clock the selected output frequency from IC110. IC111 forms a 2-way switch, selecting either the direct or divided 16fo signal for further processing by the Staircase Generator.

2.8.3 Staircase Generator (located on Synthesiser board)

The 16fo clock is used to generate an eight level, 16 time sample approximate sinewave by analog summing of the output of the bidirectional shift register IC114. The register is arranged to generate a cyclic bit pattern of increasing logic ones followed by decreasing logic ones. The summing amplifier IC130 has weighted inputs to give the required approximate sine amplitude at S1 for each time sample generated by the register.

Control counter IC113 provides a binary code for each time sample. At count 0 the register is loaded with 1000 0000 with S0, S1 held at logic one. At the 9th time sample the register direction is reversed, and on reaching the 15th sample the register is re-loaded. IC115 with IC116 decodes the 0, 9th and 15th time samples for shift left/right control of the register via latch IC123a.

2.9 SOURCE SIGNAL DERIVATION

2.9.1 AC Level Selector (Signal Source board)

Circuit Diagram - Fig. 7.10.

The stepped ac drive signal (at TP03) is received by the multiplying DAC IC503 which, with the range amplifier IC505a, sets the ac level between 10mV and 5V. The preset R506 adjusts the maximum drive level (set at 1.2kHz).

The processor control signals are received via the quiet analog bus at the octal latch IC501. Bits 0 to 5 set the signal over a 50-step range. Bits 6 and 7 set the range amplifier accordingly to give:

AC Level Range	IC501 pin number		Range Amp Gain
	12	9	
0 to 500mV	1	1	x1
520mV to 1V	0	1	x2
1.05 to 2.5V	1	0	x5
2.6 to 5.0V	0	0	x10

Pin 2 of latch IC502 provides a signal inhibit function, via level shifter TR516 and range selector IC504. This function operates only during dc bias charge or discharge periods (see section 2.10). At all other times pin 2 is at logic high, giving 0V at IC504 pin 6.

2.9.2 Programmable Filter (Signal Source board)

IC506 & IC507 form a state variable low-pass filter which provides initial filtering of the drive signal at the output IC507b (TP04). Additional filtering is provided by a similar filter in the detector circuit.

The corner frequencies are adjusted from the processor by selecting the required integrator C & R values via the analog multiplexers IC509a & b and the reed relays RL501 & RL502. The settings for the Signal Source filter (which are interleaved with the Detector Filter settings) are as follows:

Frequency Range	IC 502 pin number 6	9	15	12
20Hz	0	1	1	1
25 - 50Hz	0	1	1	0
60 - 120Hz	0	1	0	1
150 - 300Hz	0	1	0	0
400 - 800Hz	1	0	1	1
1kHz - 2kHz	1	0	1	0
2.5 - 5kHz	1	0	0	1
6 - 12kHz	1	0	0	0
15 - 30kHz	1	1	1	1
40 - 75kHz	1	1	1	0
100 - 300kHz	1	1	0	1

2.9.3 Output Amplifier (Signal Source board)

TR501 through to TR512 form a conventional audio power amplifier with a nominal gain of 2.5 times. TR510, 512 provide safe area protection for the output transistors, allowing at least 200mA peak current at normal operating voltages. Excessive transient voltages accidentally fed into the E terminal of the Analyzer are clamped to a safe level by D512, D513, with D505, D506, D508, D509 providing reverse blocking whenever the clamped transients exceed the amplifier supply rails. The ac output is coupled to the Bridge circuits via the capacitor bank C24 to C33 to permit application of dc bias at the E terminal. The power amplifier output is biased to -0.5V nominal to polarize these capacitors in the absence of bias.

2.9.4 Source Resistance Selection

Relay RL503 and associated driver circuit TR513 TR514 selects 2Ω/50Ω source resistance depending on the range requirements selected by the processor auto-range routine. The 2Ω resistor is located on the Bridge board and is increased to 50Ω by switching R558/559 in series on the Signal Source.

The truth table for these functions is as follows:

Range No	Source R	IC502 pin 19
1 - 2	50Ω	0
3 - 5	2Ω	1
6 - 8	50Ω	0

2.10 BRIDGE CIRCUITS

Circuit Diagram - Fig. 7.12.

Components to be measured are connected between the E (signal source) and I (current sense) terminals. The action of the virtual-ground guard amplifier IC801 forces the current at the I terminal to flow through one of four standard resistors (R821 to R824), selected according to measurement range by IC802, RL801, RL802. TR801 to TR806 form an output current booster used with the 10-ohm and 640-ohm Standards. This circuit incorporates simple constant-current overload protection (D809 to D812 with R847, R848). D801 to D804 protect the guard amplifier against normal input overloads. Additional protection is provided by FS801 mounted on the Bridge board; this will not normally blow except under exceptional fault conditions.

IC805 and IC806 form a differential amplifier feeding the ac detector circuits. To perform ac impedance measurements, the amplifier input is alternately connected (via IC804) to measure the voltages across the Unknown component (Eu) or the Standard resistor (Es). For each connection, a series of two or four complex measurements is made (see section 2.3), the microprocessor computing the required measurement parameter from the results. The amplifier output appears at TP01 on the Detector board.

TR809 to TR811 form a wideband buffer to isolate the switching action of IC804 from the measurement leads. TR811 is a bootstrap follower driving both the collector of TR809 and its bias divider, maintaining a high input impedance at all frequencies. The output of this buffer feeds two hf phase trim networks. The main phase trim network comprises R810, R811 and the input capacitance of the signal selector/amplifier combination. IC804 selects this network whenever the 10Ω, 640Ω or 5k12 Standard resistors are in use, the phase lag introduced being adjusted on test to balance that due to the stability capacitor (C816, 817, 818, 844) connected across each Standard resistor. When the 40k96 Standard is in use, the alternative network R808, R809, C808 is selected by IC804, being adjusted to compensate for the self-capacitance of the Standard resistor.

DC blocking is provided for each ac signal input, the input time-constants being kept equal. As a result, low-frequency phase errors cancel out when the impedance calculations are performed. During bias charge or discharge periods, the output of blocking capacitor C810 is clamped by TR812 to voltage divider R895, R896. This is adjusted on test to equal the normal dc input voltage of the wideband follower. The operation of this clamp minimizes circuit settling time after application or removal of dc bias.

The truth table for the signal select control lines is as follows (all settings apply with 1V or 100mA signal levels selected):

Range/ Function	Signal Select	Standard Resistor	IC810 Pin Numbers 19	5	16	6	IC811 Pin 12
1-4	Es	10Ω	1	1	0	1	1
5-6	Es	640Ω	0	1	0	1	1
7	Es	5k12	1	0	0	1	1
8	Es	40k96	0	0	1	0	1
	Eu	x	x	x	1	1	1
Bias charge/ discharge	x	x	x	x	x	x	0

2.10.1 Neutralizer (part of Bridge board)

For operation at high frequencies (3kHz to 300kHz) the loop gain of the guard amplifier is increased by the action of the neutralizer circuit (IC812 to IC816). Without this circuit, the loop gain is progressively reduced by the current flowing in the compensation capacitor C821. The voltage feeding this capacitor (IC801 pin 8) is scaled by the resistor chain R830-R837, inverted by the video amplifier IC813 (nominal gain -5), further scaled by resistor chain R856 to R860 and integrated by IC816, which is connected in feedforward mode to minimize hf phase errors. The resulting output voltage is applied to either R827 or R828, producing a current which cancels that flowing in C821 at the chosen operating frequency only. For each frequency-setting the scaling attenuators are altered by the MPU to maintain this cancellation. The preset control R874 compensates for the tolerances in C821, C834 and the gain of IC813. The control truth table for the neutralizer circuit is as follows:

Freq (kHz)	IC811 pin number				
	2	19	5	16	6
≦2	0	0	0	1	1
2.5/3	0	1	0	0	1
4	0	0	0	0	1
5	1	0	0	0	1
6	1	1	0	0	1
8	0	0	1	0	1
10	1	0	1	0	1
12	1	1	1	0	1
15	0	1	1	1	1
20	0	0	1	1	1
25	1	0	1	1	1
30	1	1	1	1	1
40	0	0	0	0	0
50	1	0	0	0	0
60	0	1	1	0	0
75	0	0	1	0	0
100	1	0	1	0	0
120	1	1	1	0	0
150	0	1	1	1	0
200	0	0	1	1	0
300	1	1	1	1	0

2.10.2 Range Selection (Bridge board & Detector board)

Bridge Board Circuit Diagram Fig. 7.12.
Detector Board Circuit Diagram Fig. 7.14.

Impedance measurement range is selected by choice of Standard resistor together with a precision x8 attenuator located on the Detector board. For ac levels ≥250mV or 25mA, eight ranges are available. Below these levels, the settings are altered to increase the detector input levels, and only 6 ranges are available. The various settings used are detailed in the table.

RANGE SELECTION

AC MEASUREMENTS			HIGH LEVEL ≥250mV/25mA			LOW LEVEL <250mV/25mA		
Range No.	Impedance Coverage(Ω)	Max Level	Standard Resistor	Es gain	Eu gain	Standard Resistor	Es gain	Eu gain
1	<1.25	100mA	10Ω	x1	x8	-	-	-
2	1.25-10	100mA	10Ω	x1	x1	10Ω	x8	x8
3	10-80	1V	10Ω	x1	x1	10Ω	x8	x8
4	80-640	5V	10Ω	x8	x1	640Ω	x1	x8
5	640-5k12	5V	640Ω	x1	x1	640Ω	x8	x8
6	5k12-41k	5V	640Ω	x8	x1	5k12	x8	x8
7	41k-328k	5V	5k12	x8	x1	40k96	x8	x8
8	>328k	5V	40k96	x8	x1	-	-	-

2.11 UNKNOWN SIGNAL PROCESSING

2.11.1 Gain Selection (Detector board - Fig. 7.14.)

Amplifiers IC903, IC904a with the analog multiplexers IC902a, b and c form a programmable gain stage by selection of feedback ratio at IC902c and forward attenuation at IC902b and IC902a. The x8 ratio is of high accuracy and is used as part of the range selection routines. The other two sections are used only to compensate for drive level variations. With Range Hold and Range 3 selected from the keyboard the following truth table applies:

Gain Ratio			Signal Level	IC901 pin number		
				19	16	15
x8	x4.5	x2.2	0 - 60mV	0	0	0
x8	x4.5	x1	70 - 140mV	0	0	1
x8	x1	x2.2	150 - 240mV	0	1	0
x1	x4.5	x2.2	250 - 520mV	1	0	0
x1	x4.5	x1	540mV - 1.1V	1	0	1
x1	x1	x2.2	1.12 - 2.35V	1	1	0
x1	x1	x1	2.4 - 5.0V	1	1	1

2.11.2 Programmable Filter (Detector board)

Amplifiers IC904b, IC907a and IC907b, with analog multiplexers IC908a and IC908b, form a state variable low-pass filter with corner frequencies interleaved with the Source Programmable Filter (see Source board description). The combination of the two filters maintains effective harmonic filtering at all frequencies. The detector filter settings are:

Frequency Range	IC901 pin number 9	6	5	2
20 - 30Hz	0	1	1	0
40 - 80Hz	0	1	0	1
100 - 200Hz	0	1	0	0
250 - 500Hz	1	0	1	1
600 - 1200Hz	1	0	1	0
1.5 - 3kHz	1	0	0	1
4 - 8kHz	1	0	0	0
10 - 20kHz	1	1	1	1
25 - 50kHz	1	1	1	0
60 - 120kHz	1	1	0	1
150 - 300kHz	1	1	0	0

The detector filter output appears at TP02 on the Detector board.

Any dc present at the filter output is removed by the selectable ac coupling. The shorter time-constant is selected for faster settling time, when the measurement frequency is 250Hz or above, via junction FET TR905.

2.11.3 Overload Detector (Detector board)

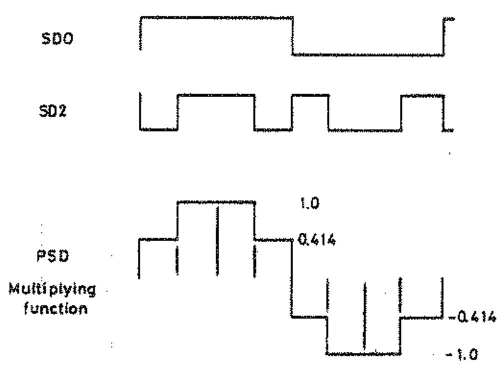
The overload detector monitors the peak signal entering the Detector circuit (5V rms max) and the level at the PSD input (1V rms max) by comparators IC914a and b respectively. If an overload occurs, the output is latched (IC914c).

The measurement cycle comprises 6 or 8 A-D conversions and, at the end of each, the processor reads the latch before setting $\overline{MSR}$ high, which resets the latch. If an overload has occurred during the previous A-D conversion, the processor will abort the measurement cycle and immediately enter the auto-range routine.

2.11.4 PSD, & PSD Reference Generator (Detector & Synthesiser boards)

Detector Circuit Diagram - Fig. 7.14.
Synthesiser Circuit Diagram - Fig. 7.8.

The phase-sensitive detector (PSD) employs a 4-level multiplying reference signal which contains no harmonics below the seventh. Hence the PSD rejects low-order odd harmonics as well as all even harmonics. The reference signal is made up from the sum of two waveforms SD0 and SD2:

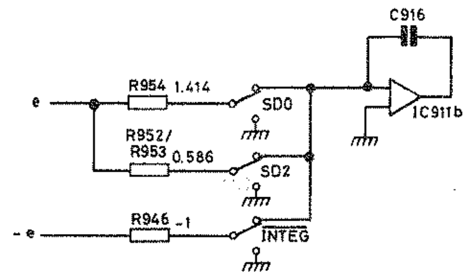


SD0 and SD2 can be generated in 4 different phase positions and are derived from clock signals of 16, 4 and 2x the measure frequency fo by the gating circuits IC118 and IC119. The gated waveforms are synchronized with the Staircase Generator at the output latches IC121 a and b to remove propagation delay variations. The PSD drive waveforms are enabled only during the integration period of each A-D conversion.

The processor selects the appropriate phase position via control lines PP0 and PP1 according to the following table:

Octal Latch IC102 Output			
PP1 P2	PP0 P19	Phase	
0	0	0°	0
0	1	90°	1
1	0	180°	2
1	1	270°	3

The PSD drive signals are received at the PSD (located on the Detector board) via buffers TR901 - TR903 and drive IC910 which serves as a two-pole change-over analog switch. (SD0 and SD2 in diagram).



The signal current to the A-D integrator IC911b is modulated by the selection of R954, R952/R953 or neither.

Dual polarity operation is obtained by biasing the circuit to 50% of fsd during the A-D integration period. This bias is derived from the 5V reference voltage, inverted by IC911a, which also provides a phase-inverted measure signal to the PSD to provide full-wave rather than half-wave detection. The effect of this is to cancel 1f noise and to improve suppression of switching transients. The multiplied signal is fed directly into the analog to digital converter integrator as a current, which avoids amplifier slew-rate distortion at the fast switching edges.

2.12 A-D CONVERSION

The A-D converter comprises a digital control section located on the Synthesiser board (component prefix 1) and an analog section on the Detector board (component prefix 9). Once triggered by the microprocessor, the A-D conversion process proceeds unsupervised, and on completion it waits to be polled by the microprocessor, as part of the keyboard polling routine. Each measurement cycle comprises 6 separate A-D conversions (8 with SLOW speed selected), with different signal and/or PSD phase selections. See section 2.3.

The A-D converter uses the charge balancing technique, where the signal is summed with the reference during the integration period. The reference signal is switched on and off as required to maintain the integrator output close to zero. During integration, the integrator output oscillates about zero, the measure counter being enabled whenever the reference signal is on.

At the end of the integration period, the PSD is switched off and the reference current is left on to take the integrator output to an arbitrary negative level outside the band of oscillation, giving a final accurate conversion count.

2.12.1 Measure Counter (Synthesiser circuit)

Synthesiser Circuit Diagram - Fig. 7.8.

The A-D counter uses a 20-bit measure counter chain. The most significant 16 bits are provided by counter 0 within the programmable triple timer counter IC103. IC105a and IC104a prescale the 16-bit counter to provide the remaining 5 (least significant) bits. The counter chain is clocked directly by the 38.4MHz master clock and enabled by the $\overline{\text{MSR}}$ control line from the processor being active with the INTEGRATION control signal (see 2.12.3). On a long measurement the counter chain may overflow. This is detected by latch IC123b to inform the processor. The overflow is noted in software and the latch is reset before the next overflow can occur via the $\overline{\text{MEN3}}$ line.

2.12.2 Measure Timer (Synthesiser circuit)

Synthesiser Circuit Diagram - Fig. 7.8.

Integration times are set by the user via the Fast, Medium and Slow measure modes. The processor loads counter 1 (in one-shot mode) of the triple timer counter IC103 with the appropriate binary number to give a time-out within a whole number of measure periods. When enabled by the RUN control line (from the A-D control circuit) the counter gate IC103 p14, becomes logic high and the counter counts down. On reaching zero count, output 1, (IC103 pin 13) becomes a logic high, resetting the $\overline{\text{INTEG}}$ latch IC120b at the next rising edge of the synchronizing signal.

2.12.3 A-D Conversion Timing (Synthesiser & Detector boards)

Synthesiser Circuit Diagram - Fig. 7.8.
Detector Circuit Diagram - Fig. 7.14.

The following description of the A-D conversion process should be read with reference to the timing diagram, Fig 2.2.

The MPU initiates a measurement by setting $\overline{MSR}$ low, which enables the RUN latch IC122b and resets the zero crossing comparator IC913. The RUN latch becomes set on the next measure signal period via the SYNC flip-flop IC122a, which generates a clock waveform at measure frequency in phase with the Staircase Generator. The RUN latch in turn enables the INTEGRATOR latch IC120b which in turn enables the PSD drive latches IC121a and b. The RUN and INTEGRATOR control lines activate the analog switch IC912, setting the A-D converter to measure mode by opening the integrator capacitor shorting switch (IC912, S4, D4). The A-D Offset reference (which is routed through the PSD full-wave inverting stage IC911a, R946) is also enabled at IC912, S1, D2.

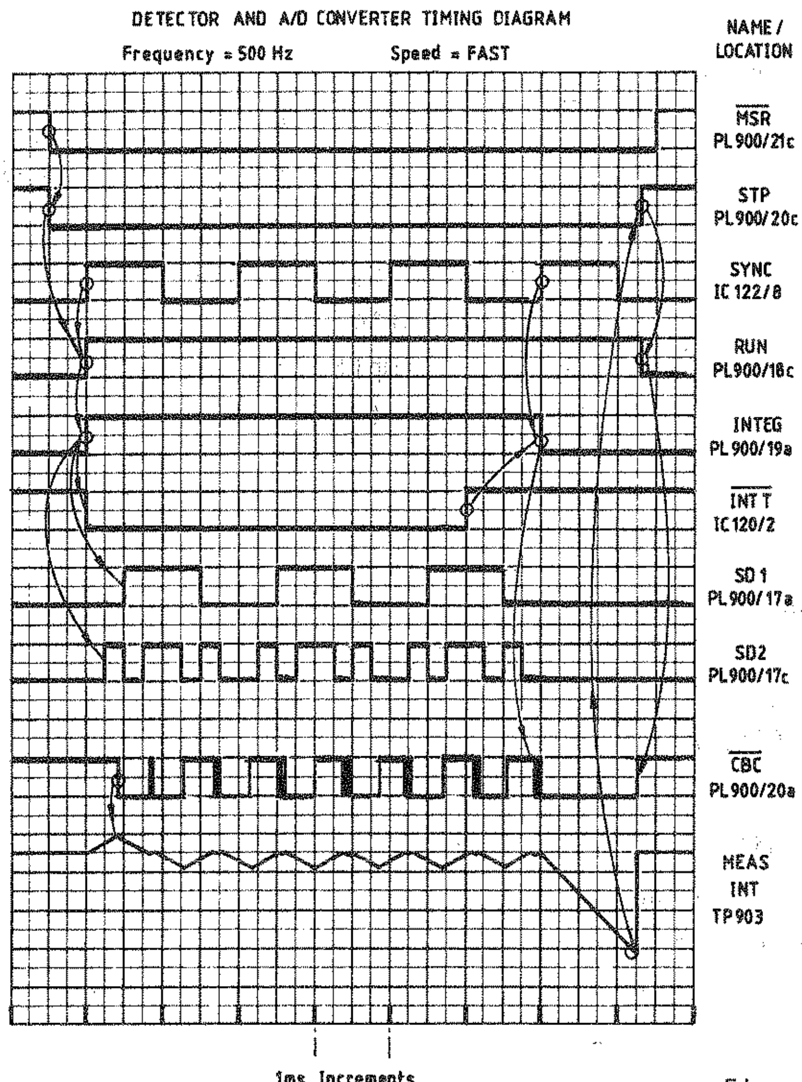


Fig. 2.2 Timing Diagram

The HIGH/LOW monitor compares the integrator output with 0V, sending an error status signal (H/L) to the CHARGE BALANCE CONTROL circuit IC109b, IC124, IC120a, IC127. The charge balance control generates two 2.34kHz clocks with duty cycles of 15/16 and 1/16 at IC124 outputs. At the start of each charge balance period, the appropriate waveform is selected by the sampling circuit IC120a, IC127 depending on the status of the H/L line for the predominantly on or off reference current at the A-D converter.

IC135 selects a higher charge balance clock frequency, for measurement frequencies between 600Hz and 1.5kHz, giving improved measurement accuracy.

The CBC and $\overline{\text{CBC}}$ control lines are generated at IC133 latch which is synchronized with the master clock to remove timing errors. The reference current is switched into the integrator summing junction by IC912, S3, D3 via R947.

At the end of the integration time-out (generated within the programmable timer counter IC103), the D input at IC120b INTEGRATOR latch becomes high.

The next measure sync period toggles the INTEGRATOR latch, inhibiting further PSD and CBC drive. The $\overline{\text{INTEG}}$ line remains high, holding the reference current switch IC912, S3, D3 on. The integrator output is forced -ve until the zero crossing comparator IC913 latches, sending a STOP signal to reset the RUN latch IC122b, this in turn resetting the INTEGRATOR latch IC120b to switch off the reference current to the integrator. The $\overline{\text{RUN}}$ line becoming low informs the MPU that conversion is complete and $\overline{\text{MSR}}$ is set high to reset the A/D converter. The $\overline{\text{MSR}}$ line may be set high at any time by the MPU if a measurement is to be aborted.

2.13 20V BIAS UNIT

Block Diagram - Fig. 2.4.
Circuit Diagram - Fig. 7.16.

The 20V Bias circuit consists of a programmable 0 - 20V dc supply which is connected, via a rear panel link, to a 1kΩ resistor (R1617) feeding the output connection of the Signal Source circuit. The user may omit the link for safety, or alternatively an external supply may be connected in place of the link, when the bias becomes the sum of the internal and external voltages. For rapid charging and discharging, the 1kΩ resistor is short-circuited by the processor (RL02/1), ac drive and measurements being inhibited during these periods (identified by the display "DC VOLTAGE NOT SET"). At other times the dc voltage across R1617 is monitored to detect voltage errors due to excess leakage current or connection of undischarged capacitors. A second relay (RL1601) connects R1617 to ground (via R1616) when Bias Off is selected, bypassing the rear panel link. This is also used as a discharge path when an external supply is in use, as most external supplies cannot sink reverse currents.

2.13.1 Programmable Voltage Source

IC1601a with its complementary output stages (TR1601 - TR1606) form a virtual ground amplifier. IC1605 is a multiplying DAC providing a programmable current which flows in the feedback resistor (R1614 - R1615) to give a defined voltage at the Bias Link connector PL1602. TR1601 and TR1604 provide 1A current limiting during charging or discharging, the circuit being protected against connection of charged capacitors by R1607, D1603, D1604, D1612, D1626. The output stage operates from a single polarity unregulated supply (designated +20V) with TR1609 providing a continuous -50mA bleed to maintain linear operation close to zero output.

The reference input to IC1605, derived from IC1603 and divider chain R1638 - R1640, is switched by the multiplexer IC1604 to provide three output voltage ranges, corresponding to steps of 0.1, 0.2 or 0.5V. IC1605 provides fine setting over a 50-step range (6 data inputs, binary weighted).

2.13.2 Status Comparators

Two sections of quad comparator IC1608 monitor the voltage across the rear panel link, using 4-terminal connections to eliminate wiring drop. Presence of an external supply is detected by a positive link voltage >100mV (ANI5 goes low). Absence of the link is detected if Bias ON is attempted; this generates a negative link voltage (ANI7 goes low).

The other two sections of IC1608 form a window comparator, monitoring the voltage across R1607 during charge or discharge periods. When charge/discharge is complete, this voltage falls within the comparator window (pins 13/14 go high). Similarly, the voltage across R1616 (used for discharge only) is monitored by one section of IC1602 (pin 2 goes high). A second section of IC1602 (pin 1 output) gates these two outputs with the RL1602 drive signal, the resulting output appearing at ANI4 during charge/discharge periods only (High = bias correct).

2.13.3 Hold Comparator

IC1601b is connected as a differential amplifier sensing the voltage across R1617. The ac component appearing when measurements are enabled is removed by the filter R1622, R1623, C1605, C1606, the resulting dc error voltage being detected by separate Low and High comparators (IC1602 pins 13 and 14). The dc threshold for these comparators increases with total dc bias (R1624, R1628), allowing for the effect of resistor tolerances in the differential amplifier. To improve settling time, the filter resistors are bypassed during charge/discharge (RL1602/2 and RL1603/1). The two comparator outputs are combined and gated by sections of IC1609, appearing at ANI4 during 'bias hold' periods only (High = bias correct).

When switching off bias after a sustained application, dielectric storage in the output blocking capacitor of the Signal Source circuit causes a gradual increase in dc output level. To compensate for this, TR1611 provides a 2.5mA current bleed, turned on as necessary by the High comparator via TR1610. This circuit may continue to cycle for a minute or two after turning bias off. The resulting narrow pulses on ANI4 are normally ignored by software timing, except when measurement of capacitors >5000μF increases the dielectric storage effect. During charge/discharge periods the High comparator is held off (via D1622) inhibiting this current bleed.

The Bias Control truth table and bit map is given on the next page.

Bias Control Truth Table and Bit Map

		IC1606 Pin No.			IC1607 Pin No.						
		10	7	2	19	15	12	9	6	5	2
Bias OFF		0	0	0	0	0	0	0	0	0	0
Bias ON Charge/Discharge		1	X	X	0	X	X	X	X	X	X
Bias ON Hold		1	X	X	1	X	X	X	X	X	X
Level Setting (Bias ON)											
x1 Range	0.0V	1	0	0	X	0	0	0	0	0	0
x1 Range	0.1V	1	0	0	X	0	0	0	0	0	1
x1 Range	0.2V	1	0	0	X	0	0	0	0	1	0
x1 Range	0.4V	1	0	0	X	0	0	0	1	0	0
x1 Range	0.8V	1	0	0	X	0	0	1	0	0	0
x1 Range	1.6V	1	0	0	X	0	1	0	0	0	0
x1 Range	3.2V	1	0	0	X	1	0	0	0	0	0
x1 Range	5.0V	1	0	0	X	1	1	0	0	1	0
x2 Range	10.0V	1	0	1	X	1	1	0	0	1	0
x5 Range	20.0V	1	1	0	X	1	1	0	0	1	0

2.14 POWER SUPPLIES/GROUNDING

Power Supplies Circuit Diagram - Fig. 7.18.

IMPORTANT See Notes on Fig. 2.3.

The power supply unit comprises analog supplies, a 5-volt supply and a floating bias supply (see Fig. 2.3). Additionally, there are 12V regulators, bias control circuits and local supply regulators. Although the designs of these individual circuits are based on conventional principles, it is essential that no ground (or return) paths are introduced additional to those in the diagram. Failure to observe this will introduce loops that could seriously affect proper operation of the Analyzer.

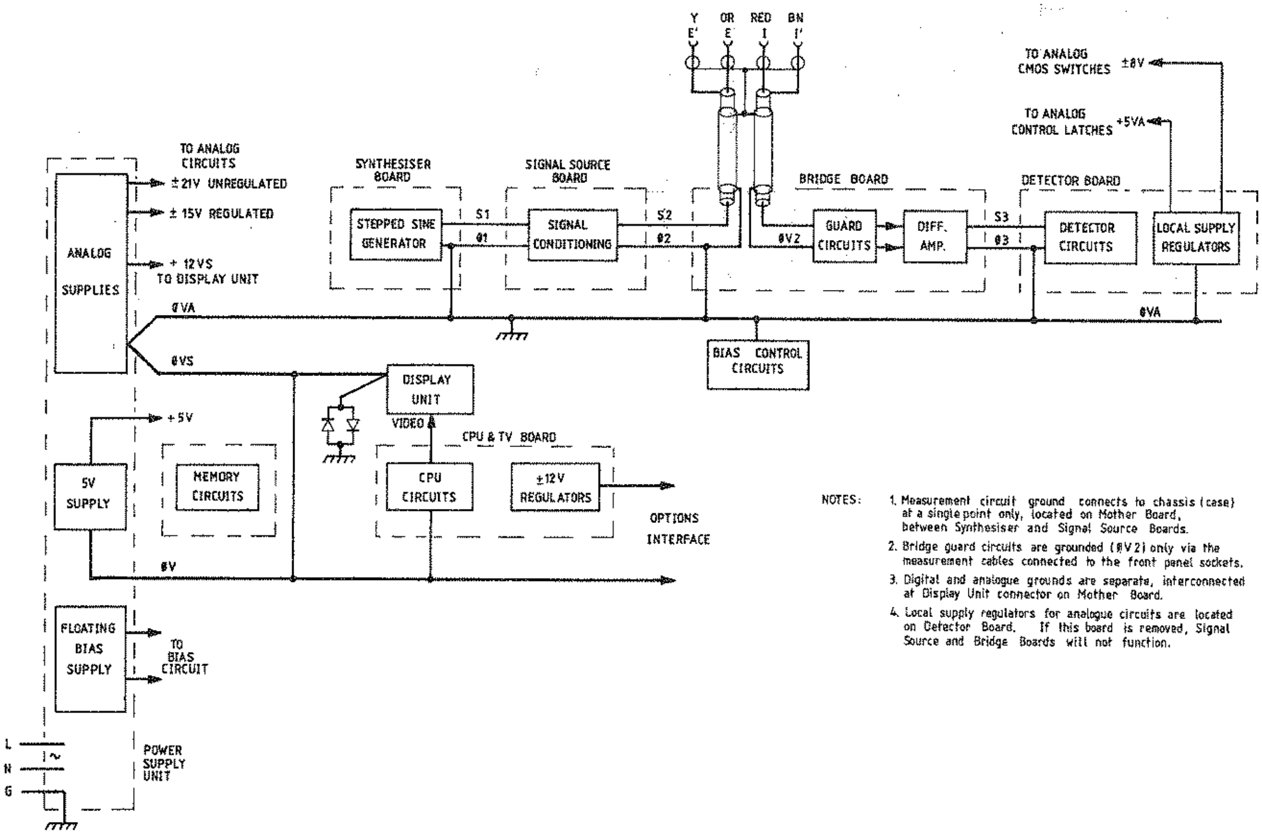


Fig. 2.3 Grounding and Power Supplies

2.15 RS232C INTERFACE OPTION (SIO OUTPUT)

Circuit Diagram - Fig. 7.25.

The card address is set up on switches S201 and S202. Gates IC200, IC201, IC203 provide an output when a matching address occurs on the address bus.

The data bus is connected to the UART IC208 via buffers IC205, IC206. The baud rate and data characteristics are set on switch S203, which is connected to the bus via IC207.

The serial data and control interface with IC208 is via buffers and the two-pole switches of S204. These switches permit the interchange of the data and handshake lines so that the Analyzer can operate as the computer or the peripheral end of the RS232C link.

2.16 GPIB/HANDLER INTERFACE OPTION

GPIB/Handler Interface Option, Circuit Diagram - Fig. 7.27.
This option has an additional circuit board (PAL board) mounted in place of IC10, 11, 12 & 13. See Circuit Diagram - Fig. 7.29.

IC1708 Decodes the I/O address to produce a high at IC1712 pin 11 when the board is accessed.

The GPIB and Handler versions of this board are identical except for the address range which is 10 to 17 Hex for GPIB and 30 to 37 Hex for Handler. Settings of SW1702 to achieve this are detailed on the circuit diagram.

IC1 on the additional PAL board produces the required timing signals to interface IC1701 to the microprocessor.

On a read from or write to IC1701, the internal registers are selected by RS0 to RS2 and data is coupled to/from the option bus by IC1707. IC1707 is made active by the same signal as $\overline{CS}$, and its direction determined by $\overline{RD}$.

When a read from register 4 of IC1701 is attempted, an enable is produced at $\overline{ASE}$ which in turn enables IC1706 and couples SW1701 to the option bus. By this means the user set Device address and talk only bit are read by the processor.

IC1702 to IC1705 are tristatable drivers which convey signals between the Output port SK1702 and the GPIA IC1701.

IC1701 may be configured under software control to generate an interrupt in response to certain IEEE bus events. The interrupt is sent to the processor by the open collector driver IC3 on the additional PAL board, its output appearing at pin 8.

At power-up, the microprocessor performs a read at bit 7 of register 3 of IC1701, to establish the presence of a GPIB and/or Handler Interface option in the instrument.

2.17 ANALOG OUTPUT OPTION

Circuit Diagram - Fig. 7.31.

The Analog Output option provides two dc output voltages, derived from two rectangular-wave signals under software control, in addition to four TTL input and four TTL output lines.

IC1801 performs the initial address decoding, the output on pin 6 going high whenever I/O addresses 020H - 027H are selected.

The first half of IC1802 decides whether the address relates to the analog circuits (addresses 020H - 023H) or the digital circuits (024H - 027H). If analog, the on-chip decoding of IC1804 is used. If digital, the second half of IC1802 is used to determine whether a Read or Write has been performed. A Write will generate a pulse to IC1806 which will store the current state of the data bus. The output of IC1806 is buffered by half of IC1803 to provide the digital output port. A Read will cause the outputs of the second half of IC1803 to be enabled, allowing the data bus to reflect the logic states of the Input port. At the same time TR1801 will be enabled, pulling data line D7 low, which is used by the microprocessor to determine the presence of an Analog Output option at power-up.

IC1804 contains three software-programmable timers. The first of these is used as a rate generator, generating a 347Hz rectangular wave (pin 10). The other two timers each take this base frequency and act as programmable monostable flip-flops, generating variable pulse-width signals. These signals will normally be 0-5V TTL and are used to switch the analog switch IC1807 between 0V and a negative reference of -6.3 to -7.2 volts.

The resulting negative-going rectangular signals feed into 3-pole low-pass filters (IC1808 and IC1809). Each filter contains an inverting stage to convert the output to a positive-going dc level, and each incorporates pre-set offset and scale adjustments to compensate for circuit tolerances. These may be adjusted and the circuit performance verified as follows, using built-in test software and test connector (see TEST EQUIPMENT REQUIRED, item 4.17).

1 With the Analog Output board and test connector (4.17) fitted, select Main Index. The option ANALOG SET should be displayed. (Failure for this to show implies that address decoding or one of the data lines has failed). Select ANALOG SET, set the ANALOG ON/OFF to OFF, and set the UPPER OFF LEVEL to MIN. Connect a DVM on 1V dc range to TP2(+ve) and TP1. Set the output voltage to between -1mV and 1mV by adjusting R1810 (upper zero).

2 Set the UPPER OFF LEVEL to MAX. Set the output voltage to between 0.999 and 1.001V by adjusting R1824 (upper scale).

3 Set the UPPER OFF LEVEL to MID. Switch the DVM to an rms ac range and check that the ripple is less than 10mV rms.

4 Select Code 0.65. Set DVM to 2V dc range. Using the ▲ and ▼ keys, step the output voltage from 0.0V to 1.0V dc, checking that the dc output voltage is within ±1mV of the value displayed on the Analyzer at each step.

5 Connect the DVM between TP3 (+ve) and TP1 and repeat steps 1 to 4, setting LOWER instead of UPPER and adjusting R1815 for zero and R1814 for scale.

6 Connect an oscilloscope between TP2 (signal) and TP1 (ground). Select 200mV/div and 20ms/div. Select Main Index, followed by Code 0.6. Overshoot on the 10Hz square-wave should be less than 100mV, and the settling time less than 35ms.

7 Transfer the oscilloscope signal input to TP3 and repeat step 6. Remove the DVM and oscilloscope.

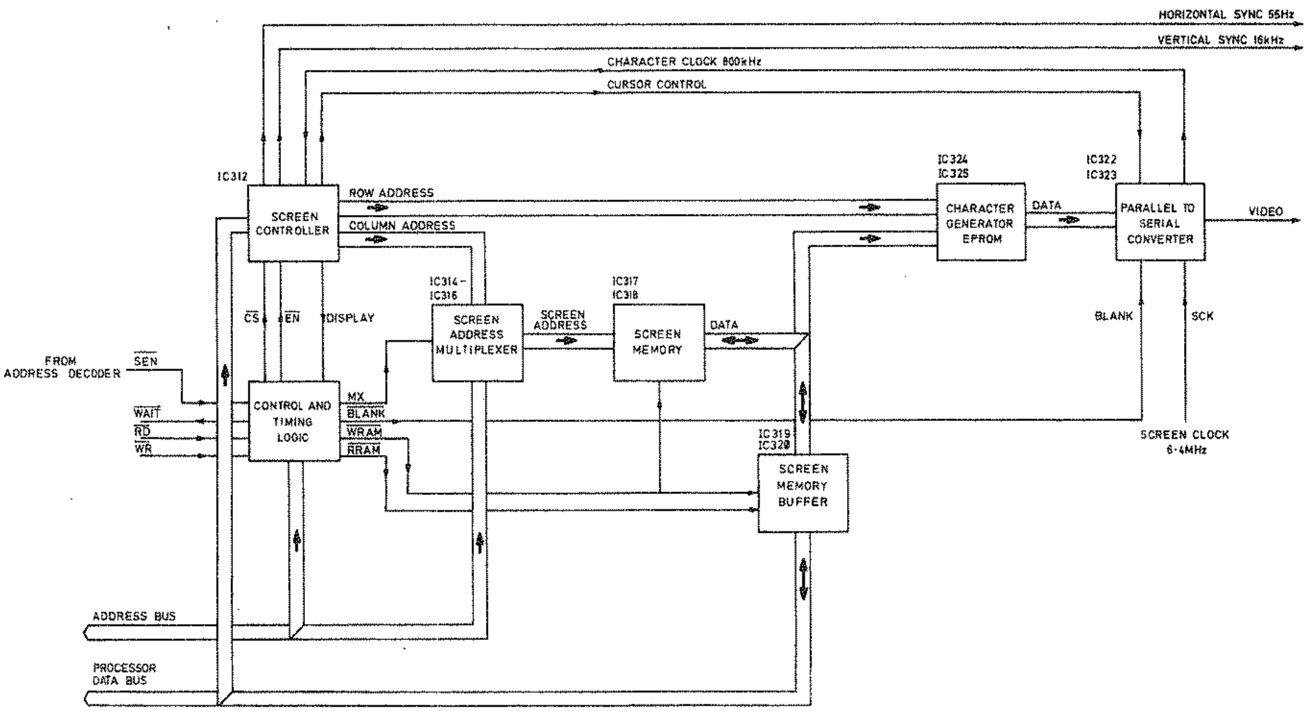


Fig. 2.5

Screen Display Generator - Block Diagram

DV/25739/A

3 CLEANING AND DISMANTLING

3.1 SAFETY

General

This equipment has been designed to meet the requirements of IEC publication 348, "Safety Requirements for Electronic measuring Apparatus", and has left the factory in safe condition.

The remainder of this section on safety provides general information and general warnings which must be followed by the user to ensure safe operation and to maintain the equipment in a safe condition. Specific warnings if necessary will be found elsewhere in the manual and are not repeated here.

AC Power Supply

Power cable and connector requirements vary between countries. Always use a cable that conforms to local regulations, terminated in an IEC320 connector at the instrument end.

If it is necessary to fit a rewireable plug to the power cable, the user must observe the following colour code:

Wire Function	North American standard	Harmonised European standard
Line/Live	BLACK	BROWN
Neutral	WHITE	BLUE
Earth/Ground	GREEN	GREEN/YELLOW

The user must also ensure that the protective ground lead would be the last to break should the cable be subject to excessive strain.

If the plug is fused, a 3-amp fuse should be fitted.

If the power cable electrical connection to the ac power plug is through screw terminals then, to ensure reliable connections, any solder tinning of the cable wires must be removed before fitting the plug.

WARNING! Any interruption of the protective ground conductor inside or outside the equipment is likely to make the equipment dangerous. Intentional interruption is prohibited.

Before switching on the equipment, ensure that it is set to the voltage of the local ac power supply.

continued.....

Adjustment, Replacement of Parts, Maintenance and Repair

When the equipment is connected to the local ac power supply, internal terminals may be live and the opening of covers or removal of parts (except those to which access can be gained by hand) is likely to expose live parts.

The equipment must be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance or repair.

Capacitors inside the equipment may still be charged even if the equipment has been disconnected from all voltage sources.

Any adjustment, maintenance and repair of the opened equipment under voltage must be carried out only by a skilled person who is aware of the hazards involved.

Ensure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders is prohibited.

Handling Hazards

Cathode ray tubes can implode if subject to excessive mechanical shock. Wear safety goggles if removing or replacing a CRT.

Any battery which is no longer serviceable should be disposed of intact and never incinerated. Replacement of lithium based batteries requires particular caution. Do not allow a new or used lithium battery to be short circuited, subject to any charging current or temperatures in excess of +70°C. Insulate terminals before disposal.

Beryllium oxide washers must be treated as toxic waste and be disposed of intact and never incinerated.

EPROMs could lose data if exposed to direct sunlight for 1 week or room level fluorescent lighting for 3 years.

Many components contain polymers which will give rise to toxic fumes if incinerated.

continued.....

Static Electricity

Assume all integrated circuits and field effect transistors are 'static sensitive'. Before handling these components or printed circuit board assemblies containing these components, personnel should observe the following precautions:

1) The work surface should be a conductive grounded mat.

2) Soldering irons must be grounded and tools must be in contact with a conductive surface to ground when not in use.

3) Any person handling static-sensitive parts must wear a wrist strap which provides a leaky path to ground, impedance not less than 1 megohm, and not greater than 100 megohms.

4) Components and printed circuit board assemblies must be stored in or on conductive foam or mat while work is in progress.

5) New components should be kept in the supplier's packaging until required for use.

3.2 CLEANING

To clean the case and front panel of the instrument, use a soft cloth moistened with methyl alcohol. Avoid the use of abrasive cleaners or petroleum based solvents. If available, a proprietary anti-static screen cleaner may be used to clean the display area.

3.3 DISMANTLING

On rear lip of the top cover, turn 2 screws (using a 4mm a/f wrench) counter clockwise until a resistance is felt (do NOT attempt to remove them). Raise rear lip slightly and push the cover forward to clear front lip. Remove cover. A similar procedure applies for removal of bottom cover, if this is necessary.

To release the board retaining plate, remove 2 screws holding the plate to 2 round pillars, and lift this edge to lower the 'outer' end of the plate, clearing it away from 2 studs. The front 6 boards are now accessible.

With top and bottom covers removed, 4 screws are visible which can be removed to release the front panel. To remove rear panel, power transformer screws must also be removed (see Power Supply Unit removal on next page). DO NOT remove front and rear panels at one time or the assembly will collapse. The position of the pcbs and other major items is shown in Fig. 3.1.

Access to individual boards is obtained as follows:

CPU & TV - straight pull.

Memory - remove the 64-way connector, raise board some 10cm and push the locking tabs open to release the 10-way header plug. The board can now be withdrawn. (To replace the header plug, push until it clicks into position).

Synthesiser - straight pull.

Bridge - raise the board until the 8-way screened measurement connector can be held across its ends for removal. The board can now be removed with its screening plate attached.

Detector - straight pull (board with its screening plate).

Signal Source - " " " " " " "

Keyboard - remove front panel. Unsolder leads to Trigger socket (or remove socket). Remove 7 nuts to separate the Keyboard.

20V Bias - first remove CPU & TV, Memory and Synthesiser boards (as described above). Remove 20-way ribbon connector from Mother board. From the 20V Bias board, remove the 2-pin Molex connector (with leads to Bias Link). Using a 2.5mm a/f wrench between the heat-sink fins, remove the two hexagon-socket screws holding the board mounting bracket to the rear panel. When free, disconnect the flying lead 3-pin Molex from the Power Supply board.

Power Supply Board - remove 3 Molex connectors from the Board (1 to reservoir capacitors, 1 to power transformer and 1 to Bias board), and the flying-lead with Molex from the Mother board. Use a wrench (as just described for 20V Bias board) to free board bracket from back panel.

Option boards - the top cover of the Analyzer, and the board retaining plate, must be removed when inserting or removing option boards. Usually, it will also be necessary to remove the Detector and/or Signal Source boards. Options are held by 2 captive screws (top and bottom of their panels) and have 64-way connectors mating to their inside edge.

Display Unit - see WARNING at beginning of section 3. Remove the 6-way Molex connector from Mother board (the connector on the Display Unit varies with supplier). From inside the Analyzer, remove four screws from the base and one (on most models) from the top corner bracket. The complete unit can now be withdrawn.

Power Supply Unit - this is bolted to the rear panel and the two items should not be separated. To obtain access to the Power Supply Unit, remove the bottom cover. This exposes 2 screws into power transformer. Remove these and the 4 screws holding the rear panel to the main framework. Before separating the rear panel, remove connectors as necessary and separate one end of the on/off switch rod (twist to break adhesive bond). Unless previously removed, the rear panel will carry with it the Power Supply and 20V Bias boards, together with any Options.

Re-assembly is the reverse of the procedures above. Always check that the connectors are correctly positioned and securely fitted; in some instances this must be done before the board is re-fitted to the Analyzer.

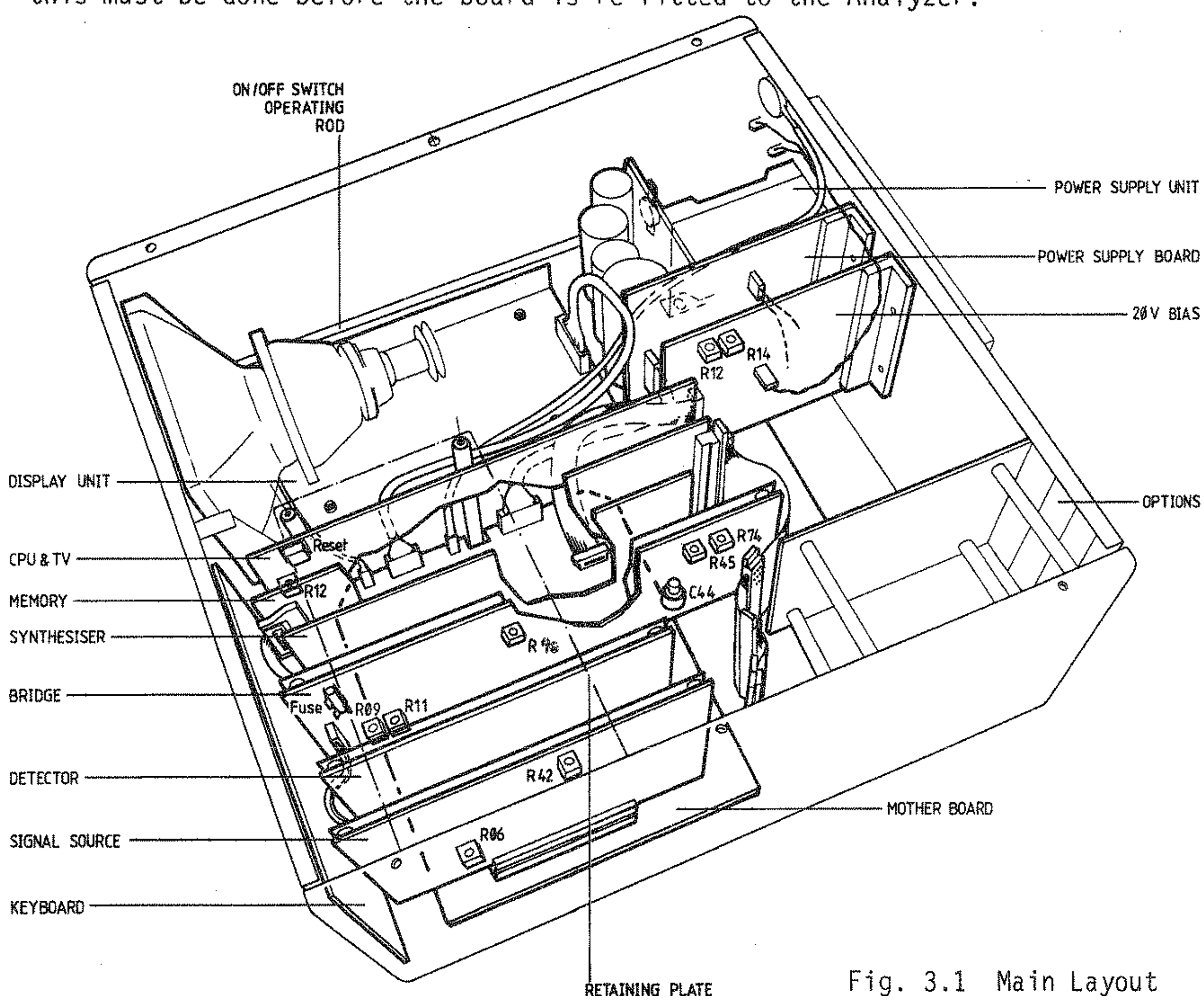


Fig. 3.1 Main Layout

4 TEST EQUIPMENT AND TOOLS REQUIRED

4.1	Current Meter	To measure dc currents of 10μA ±1μA, 250mA ±1mA. Multimeter set to dc current range
4.2	DC Voltmeter	To measure dc voltages of 0-1V, resolution ±1mV and 0-30V, resolution ±10mV. Multimeter set to measure dc volts
4.3	AC Voltmeter	To measure ac voltages in the frequency range 20Hz to 300kHz. Average or rms responding, rms sine-wave calibrated Level range 0.5mV - 10mV, accuracy ±3% 10mV - 5V, accuracy ±0.1% Bandwidth 1MHz (or use item 4.4) Screened input lead, terminated BNC plug
4.4	Low-pass Filter	To reduce bandwidth of AC Voltmeter to 1MHz nominal for levels below 10mV. See Fig. 4.0 for suitable circuit
4.5	Frequency Counter	To measure 8kHz to ±0.001%
4.6	Oscilloscope	Input sensitivity range 10mV/div to 1V/div. Bandwidth >1MHz
4.7	10Ω Resistor	Connected across BNC plug. Value measured at plug: 10Ω ±0.1%
4.8	500μF Capacitor	Connected across BNC plug. Electrolytic or tantalum type, low voltage working, +ve end to centre pin of plug. Value of series capacitance measured at 20Hz: 500μF ±10%
4.9	100Ω Resistor	Wire-ended. Rating 5W. Value 100Ω ±1%

4.10	Standards	Screened, 4-terminal Standards terminated in four BNC connectors. See Fig. 4.2 for details of wiring. Screens isolated from Ground.
	R Values	Known values are relative to S/C. 1.00Ω ±1%. Known value ±0.005% 10.00Ω ±1%. " " ±0.005% 80.00Ω ±1%. " " ±0.005% 640.0Ω ±1%. " " ±0.005% 5.12kΩ ±1%. " " ±0.005% 470Ω ±1%.
	C Values	Known values are relative to O/C. 385pF ±1%. Known value (at 10kHz) ±0.005%. * 3.08nF ±1%. " " (at 100Hz & 10kHz) ±0.005%. * 24.6nF ±1%. " " (at 100Hz & 10kHz) ±0.005%. * 43 or 47pF silver mica or gas-filled. Value and dissipation factor known to ±0.005% at 10kHz. * 20nF ±2.5%. Polystyrene. D factor at 10kHz <0.0001
4.11	Extender Board	Single Eurocard size fitted with DIN 41612 64-way a/c indirect connectors
4.12	Variac	100VA minimum rating
4.13	DC Supply	30V 1A variable supply
4.14	Voltage Source	Floating 140mVdc source (eg battery & resistive divider network), accuracy ±5mV with 1kΩ load (Fig. 4.1)
4.15	Capacitor	100μF, 35V, terminated in 2 BNC plugs

* Silver mica capacitors, dissipation factor known to ±0.005% at 100Hz & 10kHz. Alternatively, a separate polystyrene capacitor of known low dissipation factor may be used in addition, in which case only the C value of the silver mica Standard is required to be known.

4.16 Test Lead   Screened 50Ω lead with two BNC connectors for Oscilloscope/Counter/DC "Link"

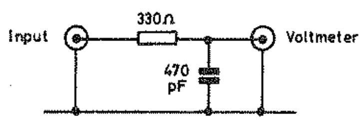


Fig. 4.0 Low-pass Filter

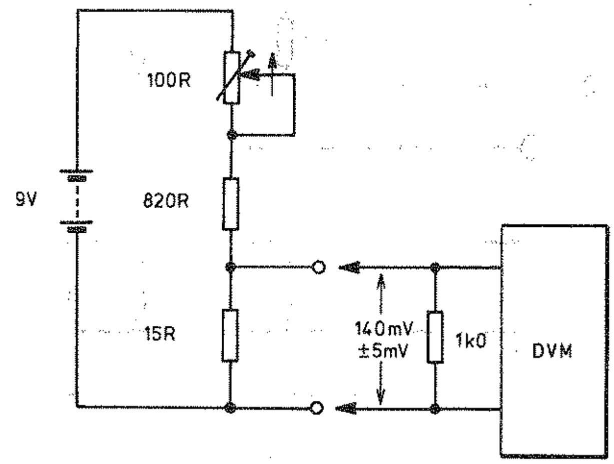


Fig. 4.1 Voltage Source

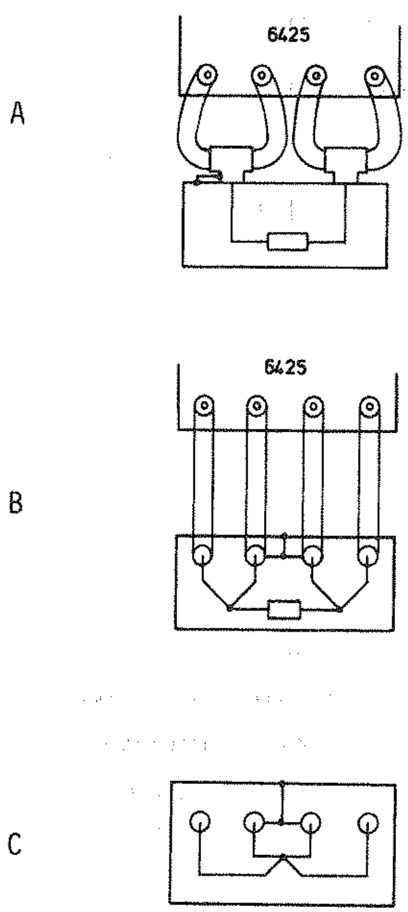


Fig. 4.2 Screened Standards

<u>Notes on Standards (see Fig. 4.2)</u>

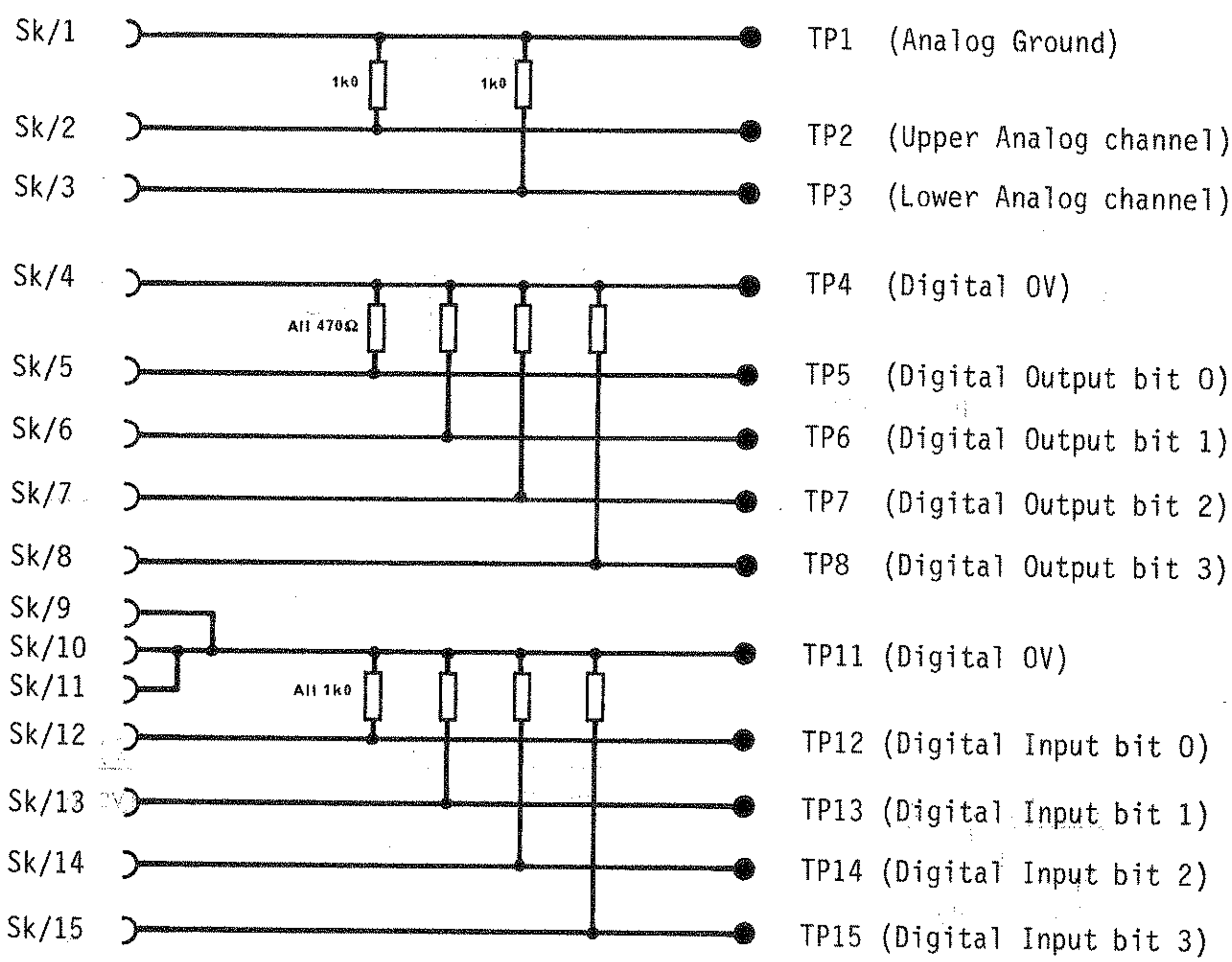
Connections to 6425 should always be 4-terminal. (A & B).

Leads to screened boxes must be 4-terminal for low impedance Standards, with Red and Orange outers linked at box end and connected to box itself. Yellow and Brown outers O/C at box end. (B).

All R Standards, also the 20nF and 24.6nF Standards, must be 4-terminal (B). Lower-value capacitance Standards may be 3-terminal (A) or 4-terminal (B). With 3-terminal Standards, use BNC T-pieces at box end to convert to 4-terminal connections to 6425. (A).

C shows a 4-terminal short circuit.

4.17 Analog Option Test Connector



Sk is a 15-way D-type male connector.
All Resistors CR25.

4.18 IEEE 488 Controller. Comprises the following:

1 Personal Computer (IBM model PC or 100% compatible equivalent unit) having 3.5" or 5.25" floppy disk drive and 512kbytes (minimum) RAM. Fitted with GPIB controller card (National Instruments model GP1B-PCII). The controller card may be purchased from Farnell Instruments, part no 097 PCII.

2 Interconnecting cable conforming to IEEE std 488.1-1987 (part 4).
Farnell Instruments part no 093EEE03

3 Wayne Kerr GPIB test software. Farnell Instruments part no 4STP3192

4.19 ESSENTIAL TOOLS

Screwdrivers:
1. Flat bladed small (approx 3.2 mm width).
2. Posidrive medium (number 1 size).
3. Posidrive large (number 2 size).

Open ended spanners: sizes 5mm, 5.5mm, 6mm, 13mm AF.

Hexagon wrenches (Allen keys): sizes 2.5mm, 4mm AF

Insulated trimming tools:
1. Flat-bladed (approx 2mm width).
2. Hexagon shaft (2.5mm AF).

5 SETTING-UP PROCEDURES

5.1 BATTERY REPLACEMENT

See Safety Warning under section 3.1 'HANDLING HAZARDS'

Life of the Lithium battery used in the non-volatile RAM circuits is normally greater than ten years. To check the state of the battery, remove the Memory Board (see section 3.3) and measure the voltage across B200. If this is less than 3.0 volts, the battery should be replaced using the following procedure.

Remove the old battery, and break the link between TP02 and TP03. Connect the Current Meter (item 4.1) across these test points (+ve to TP02). Fit the replacement battery, taking care to ensure the correct polarity. The CMOS RAM standby current should not exceed 10µA. Remove the meter, replace the link between TP02 and TP03, and refit the Memory Board, ensuring that the Keyboard connector (SK201) is inserted correctly.

5.2 POWER INPUT

See Safety Warning under section 3.1 'AC POWER SUPPLY'

Ensure that the rear panel Bias Link is fitted. Verify the supply voltage setting and ensure that the correct supply fuse is fitted. Link the inners of the red and orange measurement connectors. Connect the instrument to the ac supply via the Variac (item 4.12). Set this to the local nominal voltage, switch on and check that the yellow LED indicator is illuminated.

When the CRT display is visible, select Main Index and NORMAL. Set Bias to 10V and turn it ON. The message 'DC VOLTAGE NOT SET' should appear. This test draws maximum bias current (short-circuit condition) and confirms satisfactory operation of the power supply. Use the Variac to set the input voltage to the Analyzer to the low limit (207V for 230V instruments, 103V for 115V instruments). Use the DC Voltmeter (item 4.2) to check dc voltage levels at the regulator board output pins. Pin numbers and acceptable limits are in Table 5.0.

WARNING

The dc bias short-circuit current of 1A causes R1607 at the top of the 20V Bias board to run very hot. Take care to avoid touching it, and keep measurement leads away to prevent damage. Switch Bias OFF except when making measurements.

On completion of these checks, remove the Bias Link.

Table 5.0 Internal Supply Tolerances

Output	Nominal	+Pin	-Pin	Limits
*Logic Supply	5.2V	1	2	4.92-5.43
Bias Supply	20.0V	PL02/2	PL02/1	18 - 23
Power Amp Supply (+ve)	+21V	5	8	19.3-24.0
Screen Supply	+12V	6	8	11.4-12.6
Analog +ve Supply	+15V	7	8	14.25-15.75
Analog -ve Supply	-15V	8	10	14.25-15.75
Power Amp Supply	-21V	8	11	19.0 - 25.0

* R710 (value 12R, 33R, 47R or 56R ±1%) is selected during manufacture to achieve correct output voltage. Increasing R710 increases output voltage.

5.3 VOLTAGE TRIP SETTING

Switch off the ac power, remove the CPU & TV Board and connect the DC Voltmeter across TP1 and TP2 (+ve). Refit the Board via Extender Board (item 4.11). Remove the Variac and connect the Analyzer to the ac supply. Switch on. The Voltmeter should read between 4.75 and 4.80V. If necessary, adjust R312. Remove the Voltmeter and re-fit the CPU & TV Board directly to the Analyzer.

5.4 DISPLAY

> See Safety Warnings under section 3.1 'ADJUSTMENT, REPLACEMENT OF PARTS, MAINTENANCE AND REPAIR' and 'HANDLING HAZARDS'.

The Analyzer has an OEM CRT drive circuit. Consequently, setting details and locations of preset controls vary according to manufacturer. Horizontal and Vertical Sync. do not normally need adjustment but, if required, consult the appropriate Appendix.

5.5 BRIGHTNESS

Switch on. Set the Brightness control on the rear panel fully clockwise. Adjust the preset Contrast control on the CRT drive board for maximum brightness of the display without serious defocussing. If necessary, also adjust the preset Brightness control until the background level is just invisible. Check operation of the rear-panel Brightness control and set to a normal level.

5.6 ALIGNMENT

Using the keyboard, enter Code 0.2, then press Enter to obtain the CRT test pattern. If miskeying occurs, press Clear and repeat. The centre line on the test pattern should be horizontal. If necessary, slacken the clamp screw on the deflection coil assembly, rotate as appropriate, and retighten the clamp.

If the display height is incorrect, adjust the preset Height or V. Amp control on the CRT drive board.

If the display width is incorrect, adjust the ferrite slug in the Width or H. Amp inductor. Use the correct tool when making this adjustment, or the slug may be damaged.

If the overall display is not centralized, adjust the two shift ring magnets on the deflection coil assembly.

The combined use of these last three adjustments should result in a display pattern which is centralized and approximately fills the screen.

5.7 PIN-CUSHION ADJUSTMENT

If appreciable pin-cushion distortion occurs, the procedure for minimizing it may differ on some models. Do not make any adjustments unless substantial correction is necessary.

If the deflection unit has bar magnets for pin-cushion correction, adjust these by bending them forward and towards the CRT to obtain straight vertical edges on the display pattern. Then adjust ring magnets on the pegs around the display coils, rotating them as necessary to obtain horizontal top and bottom edges on the display. Each of the magnet positions affects one corner or one edge of the display. In the corners of the display it may not be possible to obtain straight horizontal and vertical lines simultaneously on the test pattern, in which case always adjust for best possible horizontal straightness.

After adjustment, the magnets should be re-locked with suitable cement.

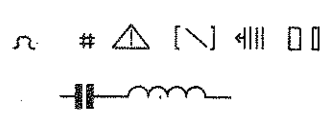
5.8 LINEARITY AND POSITION ADJUSTMENT

The vertical spacing between the key legends should correspond exactly to the printed line spacing. If necessary, carefully adjust the display height to achieve this. The display should fill the screen with all details clearly visible: if necessary, make further slight adjustments to the shift ring magnets and width inductor. When set correctly, the key legends should appear in the lower half of their display "windows", when viewed from a position approximately 60cm directly in front of the CRT. If necessary, adjust the linearity preset in conjunction with the height control to obtain this condition for all keys simultaneously.

Finally, adjust the Focus control for best possible focus at the 4 corners of the test pattern.

5.9 CHARACTER GENERATOR

5.9.1 To test the correct operation of the Character Generator circuits, press Main Index followed by Code 0.1 then Enter. Two versions will be displayed of each upper case letter, lower case letter, numeral and punctuation mark, the lower version being enclosed between two lines. Ensure that these two versions match exactly. The lower line of the display should read



NOTE 'Prom 1' displayed in top righthand corner.

5.9.2 Press the Enter key to obtain a display of all large-size characters, these being constructed mosaic-wise from special character shapes. Ensure that each character is displayed correctly.

5.9.3 Press Enter. Note 'Prom 2' displayed in top righthand corner. Display should show characters as in 5.9.1, omitting the capacitor.

5.9.4 Press Enter. Large characters should be displayed as in 5.9.2.

5.9.5 Press Enter. Two columns of Bar Graphs should be displayed, the righthand column showing a centre mark. The length of the bar shown should increase from just under 50% at the top of the screen to about 60% at the bottom.

5.9.6 Press Main Index, followed by CONNECTIONS, and ensure all circuit symbols are displayed correctly.

5.10 RAM AND KEYBOARD TESTS

Press Main Index, followed by Code 0.3, then Enter to perform a self-test on the operating RAM and the screen RAM.
If no failures occur, the instrument will return to the previous set up conditions. Otherwise a message will appear giving the location of the failure.

Press Code 0.4, then Enter to obtain a Keyboard test pattern. Press each key in turn, finishing with Main Index, to ensure correct operation without bouncing. Press Main Index again to exit from this test.

If it is required to check the Trigger socket, connect the lead or fixture normally used. Press Code 0.4 again, then Enter. Operate the switch on the lead or fixture and check that the effect is the same as pressing the Trigger button on the Analyzer.

5.11 EPROM TEST

Press Code 0.5, Enter, to perform self-test of the main software EPROMS. A cyclic redundancy signature is obtained for each EPROM in turn and its status displayed on the screen. Press Main Index to exit from test.

5.12 TEST CONDITIONS

Press Main Index and select NORMAL.
Select Hold, Rep and Norm.
Press Code 6 and Enter to set the Analyzer to range 6.
Select C, R and Parallel.

5.13 SIGNAL SOURCE BOARD

Set frequency to 8.0kHz, level to 10mV ac, bias to 0.0Vdc and select Bias OFF.

Using the screened lead (item 4.16), connect the Oscilloscope to the orange measurement terminal. With range 6 retained, check that the display on the Oscilloscope is a sinewave of approximately 30mV p-p, with a dc error not exceeding ±10mV. Some hf noise is permitted, not exceeding 30mV p-p, with an Oscilloscope bandwidth of 20MHz.

5.13.1 Bias Setting and Power-Up Check

Switch power off. While monitoring the output on the Oscilloscope, switch on the power. After the initial spike (lasting about 0.5 seconds), the output should remain within ±100mV before returning to the previous signal conditions. Previously selected display settings should be retained. Switch power off. Connect the DC Voltmeter between TP01 (+ve) and TP02 on the Signal Source board. Switch power on. The DC Voltmeter reading should be 50mV ±10mV. If necessary, adjust Set Bias (preset R542) on the Signal Source board.

Connect the Frequency Counter (item 4.5) to the yellow measurement terminal. Set level to 1.00V ac. The frequency reading should be between 7999.2 and 8000.8Hz.

Switch the Analyzer on and off a number of times and check that the non-volatile display settings are retained. A self-check is performed at power-up and any corruption causes the display to revert to the Main Index mode, with an indication of the memory area that has failed.

5.13.2 Level Setting

Ensure Hold is selected. Key Code 5, Enter, to select range 5. Set level to 1V ac. Set frequency to 1.2kHz. Using a screened lead, connect the AC Voltmeter to the yellow measurement terminal. Check that the reading is 1.00V ±0.5%. If necessary, adjust Set Level (preset R506).

Set the level to each of the following values and check that the Voltmeter reading is always within the specified limits.

10, 20, 30, 40, 70, 80mV	±2mV
150, 160mV	±3mV
310, 320, 500mV	±5mV
2.5V	2.4625 - 2.5375V
5.0V	4.925 - 5.075V

5.13.3 Source Impedance

Reset level to 1.00Vac. Temporarily replace the Oscilloscope by a 10Ω 0.1% resistor (item 4.7). The AC Voltmeter reading should be between 800 and 820mV. Press Code 1 and Enter to select range 1. The level display should change from 1.00V to 100mA and the AC Voltmeter should read between 812 and 855mV. Remove the 10Ω resistor and reconnect the Oscilloscope.

5.13.4 Frequency Response

Press Code 3, Enter, to select range 3. Select 20Hz and then step upwards through each frequency in turn. At each step, check the Oscilloscope display for a sine wave of approximately the correct frequency and ensure that the AC Voltmeter reading is between the following limits:

20 & 25Hz	0.95 - 1.05V
30Hz - 120kHz	0.975 - 1.025V
150kHz	0.965 - 1.035V
200kHz	0.94 - 1.06V
300kHz	0.90 - 1.10V

The value of C507 (33, 39, 43 or 47pF) is selected during manufacture to achieve the 150kHz to 300kHz values.

5.13.5 Output Coupling Capacitor

Select 20Hz. Replace the Oscilloscope by a 500μF capacitor (item 4.8). The level should not fall below 0.9V. Disconnect the capacitor, AC Voltmeter and Counter.

5.14 BRIDGE BOARD

5.14.1 Bias Setting

Switch off power, and connect DC Voltmeter (item 4.2) between TP01(+ve) and TP02 on the Bridge board. Switch power on and check that the Voltmeter reading is 50mV ±10mV. If necessary, adjust Set Bias (preset R845). Transfer the DC Voltmeter to TP03 and TP04 on the Bridge Board. The reading should be 0V ±10mVdc. If necessary, adjust R896. Switch off power, and disconnect DC Voltmeter.

5.14.2 Neutralizer Tuning

Connect the AC Voltmeter (item 4.3) to the brown measurement terminal, using a screened lead (item 4.16). If the Voltmeter has a bandwidth exceeding 1MHz, insert the Low-pass Filter (item 4.4) in the input lead, close to the Voltmeter. Connect the 5.12kΩ Standard (see 4.10) between the red and orange measurement terminals.

Set frequency to 60kHz, level to 3.00Vac, and select Hold and Rep. Key in Code 6, Enter, to select range 6. If Range No. is not displayed, turn it on by keying Code 9, Enter.

Key in Code 7, Enter, to select range 7. This should cause the reading to blank and RANGE ERROR message to appear. The Voltmeter reading should be less than 4.0mV. If necessary, adjust Set Neutralizer (preset R874) on the Bridge board for minimum Voltmeter reading.

Using the ▼ key, step the frequency downwards to 2kHz. At each step, check that the Voltmeter reading does not exceed the following limits:

40 - 60kHz	4.0mV	
30kHz	2.2mV	
15 - 25kHz	2.0mV	If necessary, the Low-pass Filter
3.0 - 12kHz	0.9mV	bandwidth may be reduced by a factor of
2.0 - 2.5kHz	3.0mV	10 for frequencies of 20kHz and below

Set frequency to 75kHz. The Analyzer should automatically select range 6. Using the ▲ key, check at each frequency up to 300kHz that the Voltmeter reading does not exceed 1.35mV. If necessary, re-adjust R874 to bring all readings within limits. Note that if the first part of this test is to be repeated, range 7 must be re-selected after setting the frequency to 60kHz or below.

5.14.3 Range 1 Input Impedance

With the test equipment connected as for the previous test, replace the 5.12kΩ Standard by a short-circuit between the inners of the red and orange measurement terminals. Key in Code 1, Enter, to select range 1. The drive level should change to 100mA. Set the frequency to 20kHz and check that the Voltmeter reading does not exceed 30mV. Disconnect the AC Voltmeter.

5.15 DETECTOR

5.15.1 Attenuators and DC Level

Using a suitable test probe, connect Oscilloscope to TP02 on the Detector board, making the ground connection to the Detector board screen plate mounting screw. Connect the 640Ω Standard. Enter Code 4 to select range 4.

Set frequency to 1.0kHz, level to 5.00Vac and speed to Fast. The Oscilloscope should display a sinusoidal signal, switching rapidly between two levels. The larger level should be between 1.9 and 2.5V p-p.

Repeat this test with levels of 2.35V, 1.1V, 520mV and 140mV. Some dc shift may occur as the level is reduced. Ensure that the combined peak signal + dc shift does not exceed ±4V total when the level is set to 140mV.

5.15.2 Filters

Set level to 2.35Vac. Set frequency to the following values in turn, in each case ensuring that the larger displayed level is between 1.9 and 2.5V p-p.

30Hz	1.2kHz	50kHz
80Hz	3.0kHz	120kHz
200Hz	8.0kHz	300kHz
500Hz	20kHz	

5.15.3 A-D Converter Waveform

Set speed to Norm and frequency to 40kHz. Transfer the Oscilloscope probe to TP03 on the Detector board. Set the Oscilloscope sensitivity to 1V/division, dc-coupled, and the timebase to 5ms/division.

Connect the timebase synchronizing input to TP04 and adjust the Oscilloscope to trigger on the -ve going edge of the TTL level pulse present at this point. The Oscilloscope will now display the charge balancing waveforms of the A-D converter. A complete measurement sequence comprises 6 separate measurements, each giving slightly different waveforms and these will appear in succession superimposed on one another. Each waveform should comprise an initial period of 40ms (50ms for 60Hz instruments) during which the voltage oscillates between a maximum of 3.2V and a minimum of 1.8V. The voltage should then fall in approximately 1.5ms to between 0 and -0.2V before returning to 2.5V for 1ms and then repeating (see Fig. 5.1).

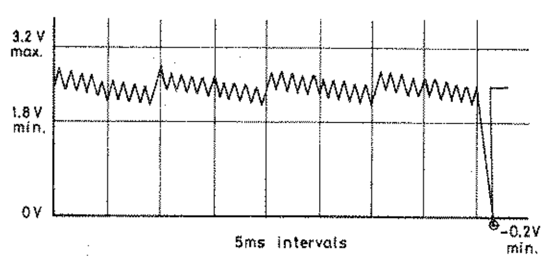


Fig. 5.1 A-D Converter Waveform

Set frequency to 15kHz and ensure these timings are maintained.

Set frequency to 1kHz. The voltage should now oscillate at twice the previous frequency and the amplitude of these oscillations should be half of their original value.

Set speed to Fast and check that the initial charge-balancing period changes to 5ms.

Set speed to Slow and change timebase setting to 20ms/division.

The Slow sequence comprises 4 measurements at 200ms and 4 measurements at 100ms. Set frequency to 100kHz and check that these timings become 100ms and 50ms respectively.

Disconnect the Oscilloscope.

5.15.4 Overload Detectors

Select Slow and set frequency to 1.5kHz. With Hold selected, enter Code 5 to select range 5.

Connect the 470Ω Standard between the red and orange measurement terminals.

Set level to 0.92Vac and check that measurement result is blanked.

Inspect the 'measure busy' asterisk (screen top left) and check that it blinks regularly at a rate of approximately 1 per second.

Set level to 1.10Vac and check that the regular blinking is replaced by either a faster irregular blink or a steady asterisk.

Set frequency to 20Hz, check that result is blanked, and that asterisk blinks at a rate of 1 per second.

Set level to 4.3Vac and check that faster blinking or a steady asterisk occurs.

5.16 ACCURACY TESTS

IMPORTANT. Do not attempt any part of these checks unless the test equipment and all the Standards are available. In particular, HF Phase adjustments are inter-dependent: do NOT perform either 5.16.3 or 5.16.10 unless both operations can be completed. It is also vitally important that all trimming operations are made with any connecting leads arranged exactly as they will be for measurement checks. If the leads are changed or moved in any way, the trimming operation must be repeated.

Trimming removes the effect of shunt impedances on high-impedance ranges and series impedance on low-impedance ranges. If Standards are only 2-terminal, the outside connectors must be removed completely (this applies to high impedances: on low-impedance ranges, 4-terminal connections are essential).

Connect the short screened leads that are to be used for connecting Standards.

5.16.1 Initial Trim - O/C

Key in Code 9.1, Enter, to clear down the non-volatile memory. Select NORMAL and set speed to Slow. Set frequency to 10kHz. Select C, G, Parallel and Rep.

Key in Code 9, Enter, to obtain a display of the currently selected measurement range. This should be 8.

Check that the residual capacitance reading does not exceed 8.8pF, with parallel conductance reading not exceeding ±10nS.

Press Trim O/C followed by Trigger to initiate the Auto-Trim process. When this is complete (allow 10-15 seconds), the display should show 0.0fF ±2fF and 0.0nS ±0.04nS.

5.16.2 Initial Trim - S/C

Connect a 4-terminal short circuit (see Fig. 4.2). The Analyzer should Auto-range to range 1, the drive level changing to 100mA.

Select L, R and Series.

Check that the residual inductance and resistance readings do not exceed 350nH and 20mΩ respectively.

Press Trim S/C followed by Trigger. When the Auto-Trim process is complete, the display should show 0.0nH ±0.4nH and 0μohm ±30μohms.

5.16.3 HF Phase (ranges 1-6)

Select Hold and key Code 4, Enter to select range 4.

Set speed to Slow and connect the 80Ω Standard, ensuring that the leads are not moved (the slightest movement will cause a greater change than the 0.1μH permitted).

The series inductance reading should be exactly 0.00μH. If necessary, adjust HF Phase (R811) on the Bridge board.

Set frequency in turn to 30kHz, 100kHz and 300kHz. In each case, the inductance reading should not exceed ±0.1μH.

5.16.4 Measurement Speed Correlation

Re-set frequency to 10kHz and note exact resistance reading. Select Fast. The inductance reading should be 0.0μH and the repeated resistance readings should not vary by more than 0.02Ω, each reading being within 0.02Ω of the value noted.

Select Norm. The inductance reading should be 0.0μH and the repeated resistance readings should not vary by more than 0.005Ω, each reading being within 0.005Ω of the value noted.

5.16.5 System Linearity & Distortion

Repeat the O/C Trim and S/C Trim procedures (see 5.16.1 and 5.16.2). Select Auto, C, D, Parallel and Slow. If range number is not displayed, key Code 9, Enter.

Connect the 20nF Polystyrene Standard.

Set frequency to 10kHz and check that range 5 has been selected. Note the exact C and D readings.

Set frequency to 12kHz and use the ▼ key to step the frequency downwards to 1.5kHz. At each step, check that:

a) range 5 remains selected

b) the change in C reading from the noted value, and the change in C reading from the previous step, do not exceed the limits shown in Table 5.1

c) the D reading, and the change in D reading from the previous step, do not exceed the limits shown in Table 5.1.

Note: The value of C818 (1nF, 1n2 or 1n5) is selected during manufacture to achieve correct D readings on range 5. If it needs to be changed, repeat 5.16.3 and the above tests (5.16.5).

Set frequency to 1kHz. Check that range 6 has been selected, and note the exact C reading. Repeat the above test, stepping frequency from 1.5kHz down to 200Hz, and applying the test limits shown in Table 5.2.

Set frequency to 150Hz. Check that range 7 has been selected, then select Hold and note the exact C reading. Repeat the above test, stepping frequency from 200Hz down to 20Hz, and applying the test limits shown in Table 5.3. Ignore RANGE ERROR which shows at 20Hz.

Set frequency to 20kHz and select Auto. Check that range 4 has been selected, and note the exact C reading. Set frequency to 12kHz and use the ▲ key to step the frequency upwards to 100kHz. At each step, check that range 4 remains selected, and that the changes in C and D readings conform to the limits shown in Table 5.4 as for previous tests.

Set frequency to 120kHz. Check that range 3 has been selected, then select 100kHz and note the exact C reading. Repeat the above test, stepping frequency from 100kHz to 300kHz and applying the test limits shown in Table 5.5.

Table 5.1 (Range 5)

FREQUENCY (kHz)	C LIMIT (±nF)	D LIMIT(±)
12	.002	.0004
10	Reference	.00035
8	.0020	.00030
6	.0020	.00030
5	.0020	.00030
4	.0020	.00025
3	.0025	.00025
2.5	.0030	.00025
2	.0040	.00015
1.5	.0040	.00015

Table 5.2 (Range 6)

FREQUENCY (Hz)	C LIMIT (±nF)	D LIMIT(±)
1.5k	.0020	.00015
1.2k	.0020	.00015
1.0k	Reference	.00015
800	.0020	.00015
600	.0020	.00015
500	.0020	.00015
400	.0020	.00015
300	.0030	.00030
250	.0040	.00030
200	.0040	.00030

Table 5.3 (Range 7)

FREQUENCY (Hz)	C LIMIT (±nF)	D LIMIT(±)
200	.0020	.00030
150	Reference	.00035
120	.0020	.00040
100	.0020	.00040
80	.0025	.00045
60	.0030	.00055
50	.0040	.00060
40	.0040	.00070
30	.0060	.00090
25	.0080	.00100
20	.0100	.00120

Table 5.4 (Range 4)

FREQUENCY (kHz)	C LIMIT (±nF)	D LIMIT(±)
12	.002	.0004
15	.002	.0004
20	Reference	.0005
25	.006	.0008
30	.006	.0010
40	.008	.0014
50	.010	.0020
60	.015	.0020
75	.015	.0025
100	.020	.0030

Table 5.5 (Range 3)

FREQUENCY (kHz)	C LIMIT (±nF)	D LIMIT(±)
100	Reference	.0030
120	.03	.004
150	.03	.004
200	.04	.005
300	.08	.008

5.16.6 S/C Trim Interpolation

Re-connect the 4-terminal short circuit as in Fig. 4.2.

If the range number is not displayed, key Code 9, Enter.

Select Auto, Z, Vac and Slow.

Check that range 1 has been selected.

Set frequency to 10kHz and level to 100mA.

During this test, and 5.16.7, ensure that the leads are not moved.

Press Trim S/C, followed by Trigger, to initiate the Auto-Trim process. When this is complete, set frequency to 20Hz and then step through to 10kHz. At each frequency, check that the Z reading does not exceed the following values:

Frequency	Impedance
20Hz - 50Hz	250µohms
60Hz - 5kHz	125µohms
6kHz	150µohms
8kHz	200µohms
10kHz	50µohms

Set level and frequency as shown below and, for each combination, check that the Z reading does not exceed the value shown:

Level (mA)	Frequency	Impedance	Range
25	20 Hz	250 µohms	1
25	10kHz	80 µohms	1
5	20 Hz	1.00mohm	2
5	10kHz	0.40mohm	2

Select L, R and series. Set level to 100mA.

Step frequency from 12kHz to 300kHz. At each frequency ensure that the L and R readings do not exceed the following values (Range 1 selected):

FREQ (kHz)	L max (±nH)	R max (±mΩ)
12	4.0	0.30
15	4.0	0.38
20	4.0	0.50
25	4.0	0.63
30	4.0	0.75
40	4.0	1.00
50	4.0	1.25
60	4.0	1.50
75	4.0	1.90
100	4.0	2.50
120	4.0	3.0
150	4.0	3.8
200	4.0	5.0
300	4.0	7.5

At 300kHz only, repeat this test with level set to 25mA (test limits ±4nH and ±7.5mΩ) and with level set to 5mA (test limits ±20nH and ±38mΩ).

5.16.7 Low Impedance Accuracy (10kHz)

After performing the previous test, select Hold.

Set frequency to 10kHz and level to 100mAac.

Select each of the following range and Standard combinations in turn, using the corresponding Code no. to select each range. In each case, ensure that the R reading corresponds to the known Standard value, within the tolerance shown, and that the L reading does not exceed the tolerance and limits shown. Ignore RANGE ERROR which appears on range 2 with 1Ω selected.

Range No	Standard	R Tolerance	L Limit*	
			Min	Max
1	1Ω	±.0004Ω (±0.4mΩ)	+25 to	+35nH
2	1Ω	±.0004Ω (±0.4mΩ)	+23.5 to	+36.5nH
2	10Ω	±.002Ω	-5 to	+45nH
3	10Ω	±.002Ω	-5 to	+45nH
3	80Ω	±.024Ω	-230 to	+270nH
4	80Ω	±.024Ω	-0.05μH to	+0.05μH
4	640Ω	±.200Ω	-3.5μH to	+2.6μH

Level Vac	Range No.	Standard (ohms)	R Tolerance (ohms)	L Limit*	
				Min	Max
5.00	4	640	0.24	-4.0μH	+3.1μH
2.35	4	640	0.24	-4.0μH	+3.1μH
520mV	4	640	0.24	-4.0μH	+3.1μH
140mV	4	640	0.24	-4.0μH	+3.1μH
50mV	4	640	0.24	-4.0μH	+3.1μH

5.16.8 Low Impedance Accuracy (100Hz)

Set level to 1.00Vac.
Select range 1 and check that level changes to 100mAac.
Set frequency to 100Hz, then repeat the whole of section 5.16.7 with the following test limits:

Range No	Standard	R Tolerance	L Limit
1	1Ω	±.0004Ω (±.4mΩ)	±0.50μH
2	1Ω	±.0004Ω (±.4mΩ)	±0.5μH
2	10Ω	±.002Ω	±5.00μH
3	10Ω	±.002Ω	±5.0μH
3	80Ω	.024Ω	±40μH
4	80Ω	.024Ω	±40μH
4	640Ω	.20Ω	±305μH

* Figures quoted assume Standard resistors have a self-inductance of 20nH relative to reference S/C except that, in the case of the 640-ohm resistor, a self-capacitance of 1pF is assumed. Other Standards may differ.

Level Vac	Range No	Standard (ohms)	R Tolerance (ohms)	L Limit (μH)
5.00	4	640	0.24	±355
2.35	4	640	0.24	±355
520mV	4	640	0.24	±355
140mV	4	640	0.24	±355
50mV	4	640	0.24	±355

5.16.9 O/C Trim Interpolation

Remove all connections from the measurement sockets.

If the range number is not visible, key Code 9, Enter.

Select Auto, Y, Iac and Slow.

Set frequency to 10kHz and level to 5.00V.

Check that range 8 has been selected.

Press Trim O/C, followed by Trigger, to initiate the Auto-Trim process. When this is complete, set frequency to 20Hz and then step through to 10kHz. At each frequency, check that the Y (admittance) reading does not exceed the following limits:

Frequency	Admittance (nS)
20-50 Hz	0.20
60-1k Hz	0.10
1.2kHz	0.12
1.5kHz	0.15
2 kHz	0.20
2.5kHz	0.25

Frequency	Admittance (nS)
3kHz	0.10
4kHz	0.40
5kHz	0.50
6kHz	0.60
8kHz	0.80
10kHz	1.00

Level (mV)	Frequency	Admittance (nS)	Range
250	20 Hz	0.2	8
250	10kHz	1.0	8
50	20 Hz	1.0	7
50	10kHz	5.0	7

Select C, G and Parallel. Set level to 5.00V.

Step frequency from 12kHz to 300kHz. At each frequency, check that correct range is selected and that the C and G readings do not exceed the following values:

FREQ (kHz)	RANGE	C Max	G Max
12	7	±10fF	±0.9nS
15	7	±25fF	±2.4nS
20	7	±25fF	±3.2nS
25	7	±25fF	±4.0nS
30	7	±25fF	±4.5nS
40	7	±25fF	±6.0nS
50	7	±25fF	±8nS
60	7	±10fF	±5nS
75	6	±0.05pF	±100nS
100	6	±0.05pF	±30nS
120	6	±0.05pF	±0.15μS
150	6	±0.05pF	±0.19μS
200	6	±0.05pF	±0.25μS
300	6	±0.05pF	±0.19μS

Level (mV)	Frequency (kHz)	Range	C Max	G Max
250	60	7	±50fF	±20nS
250	300	6	±0.1pF	±0.19μS
50	60	6	±0.40pF	±150nS
50	300	5	±0.80pF	±1.5μS

5.16.10 High Impedance Accuracy (10kHz)

NOTE: If separate Standard capacitors are available for D factor measurements, select these whenever a D measurement is required throughout test clauses 5.16.10 and 5.16.13. Use the Silver Mica Standards for all measurements of C value.

After performing the previous test, select Hold, C, D and Parallel.

Set frequency to 10kHz and level to 1.00Vac.

Select range 7 and connect the 385pF Standard capacitor.

The D reading should correspond exactly with the known D value of the capacitor at 10kHz, with a variation due to measurement noise not exceeding ±0.00005. If necessary, adjust Range 7 Phase (C844) on the Bridge board.
Check that the C reading is within ±0.15pF of the known Standard value.
Disconnect the brown and yellow measurement leads at the Analyzer end. If the Standard is 4-terminal, connect all four outers together at the Standard end of the leads. Check that the change in C reading does not exceed ±0.04pF and that the change in D reading does not exceed ±0.00015.
Re-connect the brown and yellow measurement leads to the Analyzer and, if the four outers were linked at the Standard end, remove the link.

Select each of the following range and Standard combinations in turn, using the corresponding Code No. to select each range. In each case, check that the C and D readings correspond to the known Standard values within the tolerances shown.

Range No	Standard	C Tolerance	D Tolerance
6	385pF	±0.17pF	±.00045
6	3.08nF	±0.0012nF	±.00040
5	3.08nF	±0.0014nF	±.00045
5	24.6nF	±0.010nF	±.00040

With range 5 held, connect the 640Ω Standard. Select C, R and Parallel.

Check that the R reading corresponds to known Standard value ±0.20Ω with a C reading between the limits -6.5 to +8.5pF. (See footnote on page 5-19).

5.16.11 High Impedance Accuracy (100Hz)

With settings retained from the previous test, set frequency to 100Hz. Select each of the following range and Standard combinations in turn. In each case, check that the R reading corresponds to known Standard value within tolerance shown, with a +ve or -ve C reading not exceeding the limit shown.

Range No	Standard	R Tolerance	C Max
5	640Ω	±0.20Ω	0.75nF
5	5.12kΩ	±0.0016kΩ	0.09nF
6	5.12kΩ	±0.0016kΩ	93pF

Select C, D and Parallel.

Select the following range and Standard combinations in turn.

In each case, check that the C and D readings correspond to the known Standard values within the tolerances shown. Ignore the RANGE ERROR message which appears for the first and third measurements.

Range No	Standard	C Tolerance	D Tolerance
6	24.6nF	±.011nF	±.00045
7	24.6nF	±.010nF	±.00040
7	3.08nF	±.0014nF	±.00045

5.16.12 Range 8 Accuracy (High Frequency)

Connect the 43pF (or 47pF) Standard between the Red and Orange measurement sockets.

Set the frequency to 10kHz and the level to 1.00Vac.

Select C, G, Parallel, Hold and Slow.

Select measurement range 8.

Temporarily disconnect the Red measurement lead at the Standard end and perform an O/C trim.

Check that the C reading does not exceed ±2fF and that the G reading does not exceed ±0.04nS. Re-connect the Red measurement lead and select C, D.

The D reading should correspond exactly with the known D value of the Standard, with a variation due to measurement noise not exceeding ±0.00005. If necessary, adjust Range 8 Phase (R809) on the Bridge board.

Note: The value of R808 (1k3, 2k2, 3k0) is selected during manufacture to centralise the range of R809. If it needs to be changed, repeat the O/C trim before adjusting R809.

Check that the C reading is within ±0.022pF of the known Standard value.

5.16.13 Range 8 Accuracy (Low Frequency)

Set the frequency to 100Hz and the level to 1.00Vac.

Remove all connections from the measurement sockets and perform an O/C trim.

Check that the C reading does not exceed ±0.02pF and that the G reading does not exceed ±0.01nS.

Connect the 3.08nF Standard. Check that the C and D readings are within ±0.0012nF and ±0.00040, respectively, of the known values. Disconnect the Standard.

5.17 20V BIAS BOARD

5.17.1 Voltage Setting

Ensure that the Bias link is fitted to the Analyzer. Select Code 9.1, Main Index, Normal, 10kHz, Rep and Bias ON.

Connect DVM (Item 4.2) between bias link +ve and screen of Orange socket. Set Bias to 0.0V. When the DC VOLTAGE NOT SET message has extinguished, check that the DVM reading is 0 ±5mV. If necessary, adjust R1612.

Set Bias to 20V. When the DC VOLTAGE NOT SET message has extinguished, check that the DVM reading is 20V ±0.02V. If necessary, adjust R1614.

Repeat these last two tests until both conditions are met.

Connect the DVM between centre and ground of Orange socket.

Set bias to each of the following values in turn and check that every reading lies within the limits shown.

SETTINGS	MINIMUM	MAXIMUM
5 V	4.84	5.16
10 V	9.74	10.26
20 V	19.54	20.46
0.0V	-0.060	0.060
0.1V	0.038	0.162
0.2V	0.136	0.264
0.3V	0.234	0.366
0.4V	0.332	0.468
0.7V	0.626	0.774
0.8V	0.724	0.876
1.5V	1.41	1.59
1.6V	1.51	1.69
3.1V	2.98	3.22
3.2V	3.08	3.32

Select Bias OFF.

5.17.2 Hold Filter

Select 20Hz and connect BNC link between Red and Orange sockets.
Check that the DC VOLTAGE NOT SET message does not come on during the next few seconds.

Remove the BNC link.

5.17.3 Hold Threshold

Connect Bias link +ve to inner of Orange socket.

Select Hold, and key in Code 4, Enter, to select range 4.

Select 10kHz, 2.6Vdc and Bias ON.

Check that the DC VOLTAGE NOT SET message is extinguished and that no other messages appear.

Insert the 140mV source (Item 4.14) between the Bias link and the Orange socket (negative to socket).

Check that DC VOLTAGE NOT SET appears and extinguishes cyclically.

Select 7.4Vdc on Analyzer and check that DC VOLTAGE NOT SET does not show.

Remove the 140mV source, reconnecting the Bias link to the Orange socket.

Check that DC VOLTAGE NOT SET remains extinguished.

Select Bias OFF and disconnect the link.

5.17.4 Leakage Current

Connect the 640-ohm Standard.

Select 2.3Vdc and Bias ON.
Check that DC VOLTAGE NOT SET extinguishes within a few seconds. The message will periodically re-appear and extinguish as the bias level is corrected.

Select Bias OFF.

5.17.5 Measurement Accuracy

Connect the 20nF Standard.

Select Code 9.1, Normal, 20Vdc, Slow, C, D and Trigger.

Note the C and D readings.

Select Bias ON and Trigger in quick succession.
When new readings appear, check that they are within 0.002nF and 0.0001 of those readings noted without Bias applied.

Select Rep.
Disconnect the 20nF Standard.

5.17.6 Dielectric Storage

With 20Vdc still applied, select 10mVac and connect the 100μF Capacitor between inners of Red and Orange sockets (positive to Orange).

Connect Oscilloscope to Yellow socket with screen as reference. Set Oscilloscope to 20mV/division, 2ms/division, dc coupled.

Select Bias OFF.
Check that once the Bias level has initially fallen to 0V, the dc level shown on the oscilloscope does not exceed ±80mV during the following ten seconds and, furthermore, that during the same ten seconds the DC VOLTAGE NOT SET message does not re-appear.

Remove 100μF capacitor and oscilloscope.

5.17.7 Link Status Detector

Select 0.1Vdc and remove Bias link.

Select Bias ON and check that BIAS LINK NOT FITTED and Bias OFF messages appear.

5.17.8 External Bias Supply

Connect DVM between Bias link positive (+) and inner of Orange measurement socket (-).

Select 20Vdc.

Observing polarity, replace the Bias link with the external DC Supply set to 30V ±0.1V as displayed on DVM.

Check that EXTERNAL BIAS SUPPLY message appears.

Select Bias ON.

Wait for the DC VOLTAGE NOT SET message to extinguish.

Check that the DVM reads between -1.06V and +1.06V.

Select Bias OFF.

Remove External DC Supply and replace Bias link.

6.0 COMPONENT LISTING

6.1 PARTS LIST EXPLANATION

Static sensitive parts

Before handling any parts, be sure to read the static electricity handling precautions detailed in the SAFETY section of this manual.

Spares Kit

A recommended list of spare parts is available for this instrument on request, and unless otherwise advised will assume a kit is required to cover maintenance over a minimum period of 2 years.

Parts ordering information

The parts list is grouped into separate printed circuit board assemblies and/or chassis assemblies. When ordering any of the parts listed for this instrument, ensure that the Farnell part number is quoted in full and indicate the quantity required. To order any part which is not listed, include instrument model number, serial number and a full description of the part together with the quantity required.

Where it is not practical to order parts from Farnell Instruments or a designated agent of the company, the parts list contains a manufacturer's code and part number to enable local sourcing. To extend the description of any item in the parts list, full use should be made of the implicit type descriptions contained in the part number and circuit reference prefixes. An index to these prefixes is given below. Manufacturers names are listed in section 6.19.

Circuit reference prefixes

B Battery
BR Bridge rectifier
C Capacitor
D Diode
F Fuse
FAN Fan
H Hardware
IC Integrated circuit
L Inductor
LK Link
LD Indicator
M Meter
N Network
P Potentiometer
PL Plug
Q Transistor
R Resistor
RL Relay
SK Socket
SW Switch
T Transformer
TR Transistor
TP Terminal pin/test point
U Integrated circuit
WH Wire hole
XTL Crystal
Z Zener diode

Farnell part number prefixes

B...PRINTED CIRCUIT BOARD
BC Standard
BF Flexible

C...CAPACITOR
CA Hardware
CB Polycarbonate
CC Ceramic
CD Solid electrolytic
CE Electrolytic
CF Metallised film
CG Film
CI Feedthru
CL Polypropylene
CM Mica
CP Paper
CR Polyester
CS Polystyrene

CT Tantalum
CU Surface mount
CV Variable
CX X-type
CY Y-type

D...DIODE
DB Bridge
DG General
DS SCR/Triac
DT Stud
DU Surface mount
DV Vari-cap
DZ Zener

E...ELECTRO-MECHANICAL
EA Sounder
EB Battery
EC Encoder/converter
ED Software
EM Meter
EP Printer/plotter
ER Relay
ES Speaker
ET Transducer

F...FUSE
FA Accessory
FC HRC lug
FF Fast
FH Holder
FL Label
FP Pico
FS Shroud
FT Time delay

G...CABLE ACCESSORY
GC Cable clamp
GL Lacing tape
GR Grommet
GT Tyrap

H...HARDWARE
HA Handle
HB Bracket
HC Cable assembly
HD Dial
HE Lead frame
HF Foot
HG Spring
HK Knob
HL Label
HM Moulding
HR Retainer
HS Heatsink
HW Hardware

L...OPTO-ELECTRONIC
LC LCD
LD LED
LF Filament lamp
LH Bulb holder
LN Neon

M...INSULATOR
MB Insulating bush
MC Ceramic bead
MF Insulator
MH Heatshrink sleeve
MK Insulating kit
MM Insulating washer
MP Sleeving
MR Rubber sleeve
MT Adhesive tape

P...POTENTIOMETER
PA Hardware
PC Carbon
PL Locking
PM Metal film
PW Wirewound

Farnell part number prefixes continued.

R...RESISTOR
RA Hardware
RB Precision
RC Carbon
RF Fusible
RG Glaze
RM Metal film
RN Network
RS S Shunt
RT Thermistor
RU Surface mount
RV Varistor
RW Wirewound
RX Metal oxide

S...SWITCH
SA Accessory
SB Push button
SC Micro
SF Foot
SL Thumbwheel
SM Thermal
SR Relay
SS Slide
ST Toggle
SW Wafer

T...TERMINAL/CONNECTOR
TA Accessory
TB Terminal block
TC Crimp
TG Plug
TI IDC
TK Socket
TL Terminal link
TM Terminal
TP Terminal pin
TR RF connector
TS Solder tag
TV Terminal cover

U...SURFACE MOUNT COMPONENT
UB PCB with SMT
UC Capacitor
UD Diode
UF Fuse
UI Integrated circuit
UR Resistor
UT Transistor

V...ACTIVE COMPONENT
VA Analogue integrated cct
VB Valve base
VD Digital integrated cct
VF Field effect transistor
VJ Junction FET
VN Darlington transistor
VP Transistor pad
VR Resonator
VS IC socket
VT Transistor
VV Valve/CRT
VX Crystal

Y...WIRE
YA Accessory
YB Copper braid
YC Copper strip
YD Ident
YE Enamelled
YL Link
YM Multicore cable
YP Equipment
YR Resistance
YT Tinned copper
YX Coaxial cable

Z...WINDING
ZA Accessory
ZB Bobbin
ZC Choke
ZD Tuning core
ZF Magnetic core
ZG Gapping piece
ZL Lamination
ZM Moulding
ZP Bobbin accessory
ZR Transformer
ZS Transformer
ZT Choke
ZU Transformer
ZV Choke
ZW Choke
ZX Filter choke
ZY Current transformer
ZZ Winding

Interpreting the circuit reference field

Due to limitations in the number of character spaces available, the information in the circuit reference field has been abbreviated and the following notes are provided as a guide to its interpretation:

Where a component is used more than once on an assembly the alphabetic portion of the circuit reference for its second and subsequent locations has been omitted e.g. the cicuit reference information for a component located at R1 and R6 will appear as R1 6

The cicuit reference numbers are presented in ascending decade blocks delimited by colons: second and subsequent numbers within a decade block represent only the unit value of the location (the tens and hundreds values being implied) e.g. for a component located at R54, R57, R59, R82, R87, R102, R110 and R112 the circuit reference entry will be R54 7 9:82 7:102:10 2

Where components are used in a series of neighbouring circuit reference locations the circuit reference numbers are represented as inclusive blocks using a hyphen e.g. a component located at R16, R19, R21, R24, R25, R26, R31, R37, R38, R39, R40, R44 and R46 will be represented as R16 9:21 4-6:31 37-40 4 6 (an exception to the rule occurs when a series crosses a decade block in which case the tens value is inserted).

Alternate Manufacturers Parts Cross Reference Llist

The following component references have multiple manufacture part numbers or specifications as shown on the diagrams and component parts list. The parts list item should be taken as preferential and will be of the same or better specification as that on the diagram. The Man. Part Number or specification shown on the diagram is an alternate and may be used when the preferential one is unavailable.

PAGE	COMPONENT REF.	PARTS LIST	DIAGRAM
6-7	D801,2,5,7:15,7,8: 20-26,8,9	1N4007	1N4006
6-8	R810	1K20 1%	1k2 2%
6-8	R884	1K50 1%	1k5 2%
6-8	R881	6K20 1%	6k2 2%
6-8	R850	22K0 1%	22k 2%
6-10	D508-11,5	1N4003	1N4002
6-10	R554,5	2R20 1%	2R2 2%
6-10	R535	270R 1%	270R 2%
6-10	R552,3	680R 1%	680R 2%
6.10	R543	1K00 1%	1kO 2%
6-10	R534	1K20 1%	1k2 2%
6-11	R569	1K30 1%	1k3 2%
6-11	R505	1K50 1%	1k5 2%
6-11	R502	1K80 1%	1k8 2%
6-11	R501,41	2K00 1%	2k0 2%
6-11	R539	3K30 1%	3k3 2%
6-11	R511,2	4K70 1%	4k7 5%
6-11	R538	33K0 1%	33k 2%
6-11	R550,1	68KO 1%	68k 2%
6-12	TR514	BC327	BC214
6-14	R957	1K30 1%	1k3 2%
6-14	R958	1K50 1%	1k5 2%
6-14	R928	4K70 1%	4k7 2%
6-15	IC915	REF02	9495CJ
6-21	D1603-5,7:10,1	1N4003	1N4002
6-24	D713	W02G	1KAB10
6-24	D714,21	1N4003	1N4002
6-24	D705-08	1N5401	30S1
6-24	D701-04	MR752	MR751
6-24	R709	33R0 1%	33R 2%

6.2 CASING AND MISCELLANEOUS ASSEMBLY COMPONENTS

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
JP25678	MODULAR BRIDGE PACKING	05A	DV1/25678	P2	1	
		51A	5092/3245A			
HC25730	CROC CLIP LEAD ASSY	04M	DV2/25730	P3	1	CUSTOMER ACCESSORY
HC9407	KELVIN CLIPS (FINE)	31R	R940.700.00		1	CUSTOMER ACCESSORY
HC22V2	PLUG & LEAD 22/V/2	50C	22-V-2		1	

NOTE: HC22V2 IS A EUROPEAN STANDARD POWER LEAD, SEE U.S. ARMY OPTION COMPONENT LISTING FOR AMERICAN STANDARD POWER LEAD.

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
FT1A00123	FUSE 1 AMP ANTI-SURGE 5 X 20MM	03B	S502		2	SPARE POWER FUSE (230V)
FT2A00123	FUSE 2 AMP ANTI-SURGE 5 X 20MM	03B	S502		2	SPARE POWER FUSE (115V)
7SU5303	TOP COVER	00F	2SUDJ5303	B	1	
7SU5301	BOTTOM COVER	00F	2SUDJ5301	B	1	
HW25589	COVER RETAINING BRACKET	52R	DV4/25589	P5	4	
HF99414	VERO FOOT ASSY.	90B	191-99414		1	
HW25587	ALUM TILT FOOT	52R	DV4/25587	P1	2	FIT TO VERO FOOT ASSY
HR1858	ROLL PIN 1/8" X 5/8" STD DUTY	65S	1/8"X5/8"STD+DUTY		2	
HM25517	SIDE PANEL ASSEMBLY	12H	DV1/25517	P4	2	
HA25562	HANDLE	53M	DV3/25562	P2	2	
7SU25591	BLANKING PANEL	00F	DV3/25591	P3	2	FIT OVER RACK MOUNT HOLES
7SU25555	CHASSIS	00F	DV1/25555	P4	1	
7SR25593	PCB RETAINER PILLAR	00F	DV4/25593	P2	2	
7SU25585	PCB RETAINER	00F	DV3/25585	P7	1	
MT150142	ADHESIVE BACK NEOPRENE FOAM	119A	142X150X3mm		1	
7SU25597	BRIDGE BOARD PCB SCREEN	00F	DV2/25597	P2	1	FIT TO BRIDGE BD
7SU25598	DETECTOR INDUCT PCB SCREEN	00F	DV2/25598	P4	1	FIT TO DETECTOR BD
7SU25599	SIGNAL SOURCE PCB SCREEN	00F	DV2/25599	P2	1	FIT TO SIGNAL SOURCE BD
7SU5309	VOLTAGE PLATE	00F	4SUQA5309	A	1	
7SB5299	SWITCH ROD	00F	3SUCB5299	B	1	
SA716010	SWITCH BUTTON BLACK	31I	TYPE+85+-+BLACK		1	
HM0109	LINK "P"SERIES	72H	4SV10009	A	1	
YX1159	TRIAX SCREENED CABLE 19X0.005	16R	AB1159/EPD1480		0	
HC25612	OPTION LINK CABLE ASSEMBLY	57W	DV3/25612	P5	1	
GC543	CABLE CLIP ALUMINIUM SELF ADHE	06R	543-923		1	
GCNX0	P CLIP 3.4MM I/D	04H	NX0		1	
GCNX3	P CLIP 8.0MM I/D	04H	NX3		1	
MT9X3	FOAMPAD 90X38 771/4773	49B	771/4773		2	FIT INSIDE LH SIDE PANEL

6.3 C.R.T SUB ASSEMBLY

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
4S3245CRT	C.R.T. SUB-ASSY MKII			A	1	
7SB5259	STOPPER	00F	4SUBA5259	A	1	
7SU25709	C.R.T. CHASSIS MKII	00F	DV1/25709	P2	1	
7SU25710	SUPPORT	00F	DV3/25710	P1	1	
7SU25745	SUPPORT BRACKET	00F	DV3/25745	P2	1	
DAOMIT	DIODES OMITTED	00F	DAOMIT		2	D1002 3
V115DMK8	C.R.T. ASSEMBLY	57D	115-DMK-8+115-533 (115DMK-8, DRIVE CARD + YOKE) (115-533, TUBE)		1	

6.4 BRIDGE BOARD PCB ASSEMBLY

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
5N6425BA	BRIDGE BOARD PCB ASSY			C	1	
BC25577	BARE BOARD	01K	DV1/25577	G	1	
CC14P70UD	4p70F 0.5p 500V	95B	CD08+AG04P7DS		2	C831 2
CC212P0JJ	12p0F 5% 500V	02T	GLC604+NPO		1	C821
CC3470PUM	470pF 20% 500V K1 R050	95B	CD08K1470PMS		1	C833
CEA1U00LM	1.0UF 20% 100V R020	134N	KMVB		2	C826 7
CEB47U0DM	47U0F 20% 10V R050	134N	KMVB		1	C804
CEB47U0GM	47U0F 20% 25V	18P	35-56479		4	C838:40-2
CEC100UDM	100UF 20% 10V R025	134N	SMVB		1	C803
CEC220UEM	220UF 20% 16V R050	18P	035-55221		2	C829:30
CR6100NKM	100nF 20% 63V MKT 3X08 R050	159W	MKS2MIN		16	C819:20 4 5:35-37 9:43 46-48:50-53
CR6220NLM	220nF 20% 100V MKT 4X13 R100	159W	MKS4		1	C822
CR6470NLJ	470nF 5%0 100V MKT 5X18 R150	159W	MKS4+PCM15		3	C812 4 5
CR6470NSJ	470nF 5%0 400V MKT 9X27 R225	159W	MKS4+PCM22.5		1	C810
CS268P0MH	68p0F 2%5 160V	132S	HSC		1	C834
CS282P0MF	82p0F 1%3 160V	132S	HSC		2	C808:16
CS3330PMH	330pF 2%5 160V	132S	HSC		1	C807
CS41N00MH	1n00F 2%5 160V	132S	HSC		1	C818
CS44N70MH	4n70F 2%5 160V	132S	HSC		1	C817
CV2210PH	V/CAP 2/10PF 5750 HORIZONTAL	04J	5750-HPC		1	C844
DG4007	DIODE	10I	1N4007		16	D801 2 5 7:15 7 8:20-26 8 9
		11G	1N4007			
DG4148	DIODE	23N	1N4148		7	D803 4:10 2:27:30 1
		74T	1N4148			
DZ13V60D	3.6V 5% 0W40	01P	BZX79-C3V6		2	D809:11
DZ17V50D	7.5V 5% 0W40	01P	BZX79-C7V5		2	D813 4
FF1A605X20	FUSE 1.6AMP QUICK BLOW	03B	TDC13		1	FS801
		02B	L1427B			
FH1426	FUSE HOLDER 5 X 20MM PCB MTG.	02B	L1426		1	FS801
HSTV4	H/SINK TV4	19R	HSTV4		2	
MC1	CERAMIC BEAD SMALL	57M	IPB/1		4	
PM41K00KH	1K00 10% PRESET HORZ STURN	02S	63X		3	R809:11:96
PM42K00KH1	2K00 10% PRESET HORZ STURN	02S	63X		1	R845
PM520K0KH1	20K0 10% PRESET HORZ STURN	02S	63X		1	R874
RASOT	#### SELECT ON TEST ####	00F	RASOT		2	R808:25
RB210R0FS1	10R 0.04/-0% 0.6W	18V	S102J		1	R824
		24R	MCX10R000			
RB3640RFX	640R 0.01% 0.6W	18V	S102J		1	R823
		24R	MCY640R000T			
RB45K12FX	5K12R 0.01% 0.6W	18V	S102J		1	R822
		24R	MCY5K120T			
RB540K9FX	40K96 0.01% 0.6W	18V	S102J		1	R821
		24R	MCY40K960T			
RG73M30BJ	3M30 5% 0W25 200PPM	18P	VR25		4	R813:39-41
RM18R20FF	8R20 1% 0W60 100PPM 250V	18P	MRS25+8R2		2	R893 4
		53D	SMA0207TK50			
RM210R0FF	10R0 1% 0W60 50PPM 250V	18P	MRS25		3	R883:97 8
		53D	SMA0207TK50			
RM215R0FF	15R0 1% 0W60 50PPM 250V	18P	MRS25		2	R847 8
		53D	SMA0207TK50			

COMPONENT	DESCRIPTION					MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
RM222R0FF	22R0	1%	0W60	50PPM	250V	18P	MRS25		1	R868
						53D	SMA0207TK50			
RM247R0FF	47R0	1%	0W60	50PPM	250V	18P	MRS25		2	R800:826
						53D	SMA0207TK50			
RM249R9BC	49R9	0.25%	0W25	50PPM		94M	H8		1	R858
RM3100RFF	100R	1%	0W60	50PPM	250V	18P	MRS25		8	R805 6:44 9:69:70-72
						53D	SMA0207TK50			
RM3120RFF	120R	1%	0W60	50PPM	250V	18P	MRS25		1	R860
						53D	SMA0207TK50			
RM3150RBC	150R	0.25%	0W25	50PPM		94M	H8		1	R857
RM3150RFF	150R	1%	0W60	50PPM	250V	18P	MRS25		4	R819:20:51 2
						53D	SMA0207TK50			
RM3180RFF	180R	1%	0W60	50PPM	250V	18P	MRS25		1	R859
						53D	SMA0207TK50			
RM3210RBC	210R	0.25%	0W25	50PPM		94M	H8		1	R835
RM3270RBC	270R	0.25%	0W25	50PPM		94M	H8		2	R833 7
RM3300RFF	300R	1%	0W60	50PPM	250V	18P	MRS25		1	R832
						53D	SMA0207TK50			
RM3330RBC	330R	0.25%	0W25	50PPM		94M	H8		1	R831
RM3470RBC	470R	0.25%	0W25	50PPM		94M	H8		4	R862-5
RM3560RFF	560R	1%	0W60	50PPM	250V	18P	MRS25		1	R834
						53D	SMA0207TK50			
RM3750RFF	750R	1%	0W60	50PPM	250V	18P	MRS25		1	R836
						53D	SMA0207TK50			
RM41K05BC	1K05	0.25%	0W25	50PPM		94M	H8		1	R856
RM41K20FF	1K20	1%	0W60	50PPM	250V	18P	MRS25		1	R810
						53D	SMA0207TK50			
RM41K30FF	1K30	1%	0W60	50PPM	250V	18P	MRS25		2	R808:75
						53D	SMA0207TK50			
RM41K50FF	1K50	1%	0W60	50PPM	250V	18P	MRS25		1	R884
						53D	SMA0207TK50			
RM42K00FF	2K00	1%	0W60	50PPM	250V	18P	MRS25		1	R876
						53D	SMA0207TK50			
RM42K70FF	2K70	1%	0W60	50PPM	250V	18P	MRS25		1	R882
						53D	SMA0207TK50			
RM44K30FF	4K30	1%	0W60	50PPM	250V	18P	MRS25		1	R843
						53D	SMA0207TK50			
RM44K70FF	4K70	1%	0W60	50PPM	250V	18P	MRS25		2	R838:99
						53D	SMA0207TK50			
RM45K10BD	5K10	0.5%	0W25	50PPM		94M	H8		1	R827
RM46K20FF	6K20	1%	0W60	50PPM	250V	18P	MRS25		1	R881
						53D	SMA0207TK50			
RM48K20FF	8K20	1%	0W60	50PPM	250V	18P	MRS25		1	R866
						53D	SMA0207TK50			
RM510K0FF	10K0	1%	0W60	50PPM	250V	18P	MRS25		7	R829:53-55:92:100 1
						53D	SMA0207TK50			
RM515K0FF	15K0	1%	0W60	50PPM	250V	18P	MRS25		1	R895
						53D	SMA0207TK50			
RM522K0FF	22K0	1%	0W60	50PPM	250V	18P	MRS25		1	R850
						53D	SMA0207TK50			
RM530K0FF	30K0	1%	0W60	50PPM	250V	18P	MRS25		1	R830
						53D	SMA0207TK50			
RM533K0FF	33K0	1%	0W60	50PPM	250V	18P	MRS25		1	R879
						53D	SMA0207TK50			

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
RM547K0FF	47K0 1% 0W60 50PPM 250V	18P	MRS25		1	R891
		53D	SMA0207TK50			
RM6100KFF	100K 1% 0W60 50PPM 250V	18P	MRS25		1	R846
		53D	SMA0207TK50			
RM6130KFF	130K 1% 0W60 50PPM 250V	18P	MRS25		1	R878
		53D	SMA0207TK50			
RM6330KFF	330K 1% 0W60 50PPM 250V	18P	MRS25		1	R8102(FIT IN SERIES WITH
		53D	SMA0207TK50			R813)
RM6390KFF	390K 1% 0W60 50PPM 250V	18P	MRS25		1	R877
		53D	SMA0207TK50			
RM6560KBD	560K 0.5% 0W25 50PPM	94M	H8		1	R828
RM72M20FF	2M20 1% 0W60 50PPM 250V	18P	MRS25		1	R886
RM74M70FF	4M70 1% 0W60 50PPM 250V	18P	MRS25		1	R885
RN44K70BG	4K7 2% SIL RES. NETWORK	10B	4610X-101-472		1	R861
RW12R00MF	2R0 1% 6W0	94M	C7		1	R867
		02W	W22			
RX522K0EF	22K0 1% 0W50 100PPM 350V	54E	NK5		1	R880
SRE1A5VD	DIL REED 5VDC SPNO 0.5ADC	52A	131A-4		3	RL801-3
		04C	PRMA1A05			
TBM2508PSG	8WAY STRAIGHT PIN HEADER GOLD	23M	6410+08AG+22-29-2081		1	PL802
TG10064053	DIN CONNECTOR 64 OF 96 PLUG	66C	DIN41612/C+C64M3AA+C		1	PL801
TP2137D	TEST POINT TERMINAL	90B	20-2137D		4	TP01-4
VA070CP	OP AMP SINGLE STATIC	01T	TL070CP		2	IC801:16
VA071CP	OP AMP SINGLE STATIC	01T	TL071CP		1	IC814
VA339N	COMPARATOR QUAD LO PWR	23N	LM339N		1	IC817
		70H	CA339E			
VA34082	OP AMP DUAL J-FET 8MHZ STATIC	02M	MC34082		1	IC805
VA5534AN	OP AMP SINGLE LO NOISE	01P	NE5534AN		1	IC806
VA733C	VIDEO AMP SINGLE 120MHZ	01P	UC733CN		1	IC813
		01T	UC733CN			
VD4052B	BCMOS 2X4CH MTIPLXER STATIC	23N	CD4052B		4	IC802 4:12 5
		70H	CD4052BE			
VD74LS26N	TTLS QUAD NAND HI-V 14-DIP	23N	SN74LS26N		3	IC807-9
VD74LS273N	TTLS OCTAL D-TYPE FLIP-FLOP	01T	SN74LS273N		2	IC810 1
VFJ113	J-FET N 100R .36W TO92	01P	J113		1	TR812
VP10171	TRANSISTOR PAD 10171-N	47M	10171-N		9	
VS14L	IC SKT 14WAY	28I	703-3314-01-04-10		5	
		08R	ICO-143-S8A-T			
VS16L	IC SKT 16WAY	28I	703-3316-01-04-10		4	
		08R	ICO-163-S8A-T			
VS20L	IC SKT 20 WAY	28I	703-3320-01-04-10		2	
		08R	ICO-203-S8A-T			
VS8P	IC SKT 8WAY	28I	703-3308-01-04-10		5	
		08R	ICO-083-S8A-T			
VT182PK	NPN 50V .3W TO-92	03Z	BC182PK35(4SC0174)		1	TR803
VT184C	NPN 30V .3W HI GAIN TO-92				2	TR809:10
		03Z	BC184C			
VT212PKCR	PNP 50V .3W TO-92	03Z	BC212PK35		3	TR801 4 8
VT214C	PNP 30V .3W HI GAIN TO-92	23N	BC214C		2	TR802:11
		03Z	BC214C			
VT228	NPN 60V 12.5W 1.5A TO-126	01P	BD228		1	TR806
VT229	PNP 60V 12.5W 1.5A TO-126	01P	BD229		1	TR805
YAOMIT	LINKS OMITTED	00F	YAOMIT		1	LK3,5-7
ZF1115	FERRITE BEAD L=5.6MM OD=4.15	15P	4313-020-15170		2	L801 2

6.5 SIGNAL SOURCE BOARD PCB ASSEMBLY

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
5N6425SS	SIGNAL SOURCE BOARD PCB ASSY			A	1	
BC25525	BARE BOARD	01K	DV1/25525	J	1	
CAOMIT	CAPACITORS OMITTED				1	C03
CB44N04SF	4n04F 1%0 400V	03A	M2B26A04E		2	C510 1
CB6165NMF	165nF 1%0 160V MKC	03A	MKC62/M2B		2	C512 3
CC210P0UK	10p0F 10% 500V	95B	CD08CG10P0KS		1	C521
CC215P0UK	15p0F 10% 500V	95B	CD08/CG		1	C534
CEB10U0JM2	10U0F 20% 50V R050	134N	KMVB		1	C505
CEB47U0GM	47U0F 20% 25V	18P	35-56479		2	C544 5
CEC100UDM	100UF 20% 10V R025	134N	SMVB		1	C502
CEC220UEM	220UF 20% 16V R050	18P	035-55221		2	C519:20
CED1M00KM	1.0MF 20% 63V R075	134N	KMVB+		10	C524-33
CR510N0SM	10n0F 20% 400V R100	18P	368-51103		1	C535
CR6100NKM	100nF 20% 63V MKT 3X08 R050	159W	MKS2MIN		10	C508:22 3:36 7 39-43
CS233P0MF	33p0F 3%1 160V	132S	HSC		2	C501 6
CS236P0MF	36p0F 2%8 160V	132S	HSC		1	C507 SELECT ON TEST 33-47pF
CS256P0MH	56p0F 2%5 160V	132S	HSC		1	C504
CS3100PMF	100pF 1%0 160V	132S	HSC		2	C514 5
CS42N20KH	2n20F 2%5 63V	132S	HSC		1	C516
DAOMIT	DIODES OMITTED	00F	DAOMIT		2	D17:20
DG4003	DIODE	11G	1N4003		5	D508-11 5
		47F	1N4003			
DG4148	DIODE	23N	1N4148		8	D501 3-7:18 9
		74T	1N4148			
DZ13V30E	3.3V 5% 0W50	31I	ZPD3.3		1	D516
DZ15V60E	5.6V 2% 0W50	31I	ZPD5.6		1	D521
DZ212V0E	12V 5% 0W50	31I	ZPD12		1	D514
DZT45C	TRANSIENT VOLTAGE ABSORBER	50A	ICTE-45C		1	D512
HSTV4	H/SINK TV4	19R	HSTV4		2	
MC1	CERAMIC BEAD SMALL	57M	IPB/1		4	
PM42K00KH1	2K00 10% PRESET HORZ STURN	02S	63X		2	R506:42
RAOMIT	RESISTORS OMITTED				6	R32:60 62-4:79
RM11R00FF	1R00 1% 0W60 100PPM 250V	18P	MRS25		1	R559
RM12R20FF	2R20 1% 0W60 100PPM 250V	18P	MRS25		4	R554 5:74 5
RM14R70FF	4R70 1% 0W60 100PPM 250V	18P	MRS25		1	R580
RM18R20FF	8R20 1% 0W60 100PPM 250V	18P	MRS25+8R2		2	R570 1
		53D	SMA0207TK50			
RM210R0FF	10R0 1% 0W60 50PPM 250V	18P	MRS25		1	R577
		53D	SMA0207TK50			
RM222R0FF	22R0 1% 0W60 50PPM 250V	18P	MRS25		2	R546 7
		53D	SMA0207TK50			
RM3100RFF	100R 1% 0W60 50PPM 250V	18P	MRS25		3	R540:56 7
		53D	SMA0207TK50			
RM3270RFF	270R 1% 0W60 50PPM 250V	18P	MRS25		1	R535
		53D	SMA0207TK50			
RM3680RFF	680R 1% 0W60 50PPM 250V	18P	MRS25		3	R536:52 3
		53D	SMA0207TK50			
RM3825RBC	825R 0.25% 0W25 50PPM	94M	H8		1	R508
RM41K00FF	1K00 1% 0W60 50PPM 250V	18P	MRS25		4	R503 4:43:65
		53D	SMA0207TK50			
RM41K20FF	1K20 1% 0W60 50PPM 250V	18P	MRS25		1	R534
		53D	SMA0207TK50			

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
RM41K30FF	1K30 1% 0W60 50PPM 250V	18P	MRS25		1	R569
		53D	SMA0207TK50			
RM41K50FF	1K50 1% 0W60 50PPM 250V	18P	MRS25		1	R505
		53D	SMA0207TK50			
RM41K65BB	1K65 0.1% 0W25 25PPM	94M	H8		2	R517 8
RM41K74BF	1K74 1% 0W25 100PPM	94M	H8		2	R519:20
RM41K80FF	1K80 1% 0W60 50PPM 250V	18P	MRS25		1	R502
		53D	SMA0207TK50			
RM42K00FF	2K00 1% 0W60 50PPM 250V	18P	MRS25		2	R501:41
		53D	SMA0207TK50			
RM42K21BB	2K21 0.1% 0W25 25PPM	94M	H8		2	R515 6
RM43K00FF	3K00 1% 0W60 50PPM 250V	18P	MRS25		1	R529
		53D	SMA0207TK50			
RM43K30BC	3K3 0.25% 0W25 50PPM	94M	H8		3	R507:13 4
RM43K30FF	3K30 1% 0W60 50PPM 250V	18P	MRS25		1	R539
		53D	SMA0207TK50			
RM44K70FF	4K70 1% 0W60 50PPM 250V	18P	MRS25		8	R509-12:48 9:67 8
		53D	SMA0207TK50			
RM45K11BF	5K11 1% 0W25 100PPMM	94M	H8		2	R521 2
RM47K50FF	7K50 1% 0W60 50PPM 250V	18P	MRS25		1	R533
		53D	SMA0207TK50			
RM512K0FF	12K0 1% 0W60 50PPM 250V	18P	MRS25		2	R545:66
		53D	SMA0207TK50			
RM518K7BF	18K7 1% 0W25 100PPM	94M	H8		2	R523 4
RM528K0FF	28K0 1% 0W60 50PPM 250V	18P	MRS25		2	R525 6
		53D	SMA0207TK50			
RM533K0FF	33K0 1% 0W60 50PPM 250V	18P	MRS25		2	R537 8
		53D	SMA0207TK50			
RM568K0FF	68K0 1% 0W60 50PPM 250V	18P	MRS25		2	R550 1
		53D	SMA0207TK50			
RM6100KFF	100K 1% 0W60 50PPM 250V	18P	MRS25		2	R530 1
		53D	SMA0207TK50			
RM810M0FF	10M 1% 0W60 50PPM 250V	18P	MRS25		2	R527 8
RW247R0JF	47R0 1% 2W5	02W	W21		1	R558
SR24VDC	POWER 24VDC DPCO 5AAC PC MNT	44P	11-752-232-740		1	RL503
SRE2A5VD	DIL REED 5VDC DPNO 0.5ADC	04E	E-2A-5V-D		2	RL501 2
		52A	132A-2			
TG10064053	DIN CONNECTOR 64 OF 96 PLUG	66C	DIN41612/C+C64M3AA+C		1	PL501
TP2137D	TEST POINT TERMINAL	90B	20-2137D		4	
VA351N	OP AMP SINGLE STATIC	23N	LF351N		1	IC506
VA412CN	OP AMP DUAL LO OFFSET STATIC	23N	LF412CN		2	IC505 7
VAOMIT	TRANSISTOR / IC OMITTED	00F			1	TR15
VD0808LCN	DAC 8 BIT 150NS 0.19% 16-DIP	23N	DAC0808LCN		1	IC503
VD4052B	BCMOS 2X4CH MTIPLXER STATIC	23N	CD4052B		2	IC504 9
		70H	CD4052BE			
VD74LS26N	TTLS QUAD NAND HI-V 14-DIP	23N	SN74LS26N		1	IC508
VD74LS273N	TTLS OCTAL D-TYPE FLIP-FLOP	01T	SN74LS273N		2	IC501 2
VP10171	TRANSISTOR PAD 10171-N	47M	10171-N		12	
VS14L	IC SKT 14WAY	28I	703-3314-01-04-10		1	
		08R	ICO-143-S8A-T			
VS16L	IC SKT 16WAY	28I	703-3316-01-04-10		3	
		08R	ICO-163-S8A-T			
VS20L	IC SKT 20 WAY	28I	703-3320-01-04-10		2	

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
VS8P	IC SKT 8WAY	28I	703-3308-01-04-10		3	
		08R	ICO-083-S8A-T			
VT182PK	NPN 50V .3W TO-92	03Z	BC182PK35(4SC0174)		2	TR504:16
VT184C	NPN 30V .3W HI GAIN TO-92				3	TR501 2:12
		03Z	BC184C			
VT212PKCR	PNP 50V .3W TO-92	03Z	BC212PK35		1	TR513
VT214C	PNP 30V .3W HI GAIN TO-92	23N	BC214C		2	TR510 1
		03Z	BC214C			
VT230	NPN 80V 12.5W 1.5A TO-126	01P	BD230		1	TR507
VT231	PNP 80V 12.5W 1.5A TO-126	01P	BD231		1	TR506
VT449	PNP 100V .625W TO-92	02M	BC449		2	TR505 9
VT450	NPN 100V .625W TO-92	02M	BC450		2	TR503 8
VTPLGP	PNP 40V .5W TO-92	03Z	BC327(3SC0148)		1	TR514
		01P	BC327(3SC0148)			

6.6 DETECTOR BOARD

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
5S3245D	DETECTOR BOARD ASSY			P11	1	
BC25663	BARE BOARD	01K	DV1/25663	D	1	
CB44N04SF	4n04F 1%0 400V	03A	M2B26A04E		2	C910:11
CB6165NMF	165nF 1%0 160V MKC	03A	MKC62/M2B		2	C912 3
CB6300NKF	300nF 1%0 63V MKC	03A	MKC62/M2B		1	C915
CBA1U20KF	1U20F 1%0 63V MKC	03A	MKC62		1	C914
CC3100PUK	100pF 10% 500V	95B	CD08DL100P+K5000		1	C918
CC3220PUK	220pF 10% 500V	95B	CD08/N4700		1	C919
CC3330PUK	330pF 10% 500V	02T	GLB604500/Y5P		1	C917
CC41N00UM	1.0nF 20% 500V K2 R050	95B	CD08K201N0MS		1	C924
CC44N70KZ	4n70F -20+80% 63V	18P	629-19472		1	C928
CC510N0IW	10n0F -25+50% 40V	95B	TD08K310N0WS		1	C927
CEB47U0GM	47U0F 20% 25V	18P	35-56479		2	C901 2
CEC470UEM2	470UF 20% 16V R050	134N	KMVB		3	C903 4 5
CR6100NKM	100nF 20% 63V MKT 3X08 R050	159W	MKS2MIN		6	C920 1 2 3 5 6
CR6330NLK	330nF 10% 100V MKT 5X18 R150	159W	MKS4+PCM15		1	C906
CS256P0MF	56p0F 1%8 160V	132S	HSC		1	C907
CS291P0MF	91p0F 1%0 160V	132S	HSC		2	C908:909
CS547N0HH	47n0F 2%5 30V	132S	HSC		1	C916
DG4148	DIODE	23N	1N4148		7	D901 2 5-9
		74T	1N4148			
HSTV5	HEATSINK TV5	19R	HSTV5		2	
RB3100RFY1	100R 0.005% 0.6W	18V	S102J		1	R902
		24R	MCY100R000V			
RB3700RFY	700R 0.005% 0.6W	18V	S102J		1	R901
		24R	MCY700R000V			
RM12R20FF	2R20 1% 0W60 100PPM 250V	18P	MRS25		2	R925 6
RM291R0FF	91R0 1% 0W60 50PPM 250V	18P	MRS25		1	R903
		53D	SMA0207TK50			
RM3330RFF	330R 1% 0W60 50PPM 250V	18P	MRS25		3	R922 3:51
		53D	SMA0207TK50			
RM3348RBF	348R 1% 0W25 100PPM	94M	H8		1	R906

COMPONENT	DESCRIPTION					MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
RM3390RFF	390R	1%	0W60	50PPM	250V	18P	MRS25		1	R905
						53D	SMA0207TK50			
RM3680RFF	680R	1%	0W60	50PPM	250V	18P	MRS25		1	R909
						53D	SMA0207TK50			
RM3887RBF	887R	1%	0W25	100PPM		94M	H8		1	R908
RM41K00FF	1K00	1%	0W60	50PPM	250V	18P	MRS25		1	R969
						53D	SMA0207TK50			
RM41K30FF	1K30	1%	0W60	50PPM	250V	18P	MRS25		1	R957
						53D	SMA0207TK50			
RM41K50FF	1K50	1%	0W60	50PPM	250V	18P	MRS25		3	R937 9:58
						53D	SMA0207TK50			
RM41K80FF	1K80	1%	0W60	50PPM	250V	18P	MRS25		1	R967
						53D	SMA0207TK50			
RM42K20BB	2K2	0.1%	0W25	25PPM		94M	H8		2	R912 3
RM42K40BB	2K4	0.1%	0W25	25PPM		94M	H8		2	R910:11
RM43K09BF	3K09	1%	0W25	100PPM		94M	H8		1	R907
RM43K30FF	3K30	1%	0W60	50PPM	250V	18P	MRS25		2	R955:68
						53D	SMA0207TK50			
RM43K40BF	3K4	1%	0W25	100PPM		94M	H8		1	R904
RM43K60EF	3K6	1%	0W5	100PPM		94M	H4		1	R938
RM43K74BF	3K74	1%	0W25	100PPM		94M	H8		2	R914 5
RM43K90FF	3K90	1%	0W60	50PPM	250V	18P	MRS25		1	R935
						53D	SMA0207TK50			
RM44K70FF	4K70	1%	0W60	50PPM	250V	18P	MRS25		2	R927 8
						53D	SMA0207TK50			
RM46K20FF	6K20	1%	0W60	50PPM	250V	18P	MRS25		1	R956
						53D	SMA0207TK50			
RM48K25BD	8K25	0.5%	0W25	25PPM		94M	H8		1	R954
RM510K0FF	10K0	1%	0W60	50PPM	250V	18P	MRS25		3	R933:40 4
						53D	SMA0207TK50			
RM510K7BF	10K7	1%	0W25	15PPM	250V	94M	H8		2	R916 7
RM512K7BF	12K7	1%	0W25	100PPM		94M	H8		1	R950
RM518K0FF	18K0	1%	0W60	50PPM	250V	18P	MRS25		1	R941
						53D	SMA0207TK50			
RM520K0BD	20K	0.5%	0W25	25PPM		94M	H8		1	R952
RM522K0FF	22K0	1%	0W60	50PPM	250V	18P	MRS25		1	R970
						53D	SMA0207TK50			
RM530K0BC	30K	0.25%	0W25	50PPM		94M	H8		1	R947
RM533K0FF	33K0	1%	0W60	50PPM	250V	18P	MRS25		1	R943
						53D	SMA0207TK50			
RM538K3FF	38K3	1%	0W60	50PPM	250V	18P	MRS25		2	R918 9
						53D	SMA0207TK50			
RM547K0BC	47K	0.25%	0W25	50PPM		94M	H8		1	R946
RM551K0BC	51K	0.25%	0W25	50PPM		94M	H8		1	R948
RM557K6BF	57K6	1%	0W25	100PPM		94M	H8		2	R920 1
RM564K9BC	64K9	0.25%	0W25	50PPM		94M	H8		1	R949
RM6100KFF	100K	1%	0W60	50PPM	250V	18P	MRS25		2	R929:30
						53D	SMA0207TK50			
RN41K00BG	1K0	2% SIL RES. NETWORK				10B	4610X-101-102		2	R931 2
RN44K70BG	4K7	2% SIL RES. NETWORK				10B	4610X-101-472		1	R924
RX522K0EF	22K0	1%	0W50	100PPM	350V	54E	NK5		1	R942
SRE2A5VD	DIL REED 5VDC DPNO 0.5ADC					04E	E-2A-5V-D		2	RL901 2
						52A	132A-2			

COMPONENT	DESCRIPTION		MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
TG10064053	DIN CONNECTOR 64 OF 96 PLUG		66C	DIN41612/C+C64M3AA+C		1	PL900
TP2137D	TEST POINT TERMINAL		90B	20-2137D		4	TP01-4
VA072CP	OP AMP DUAL	STATIC	01T	TL072CP		1	IC911
			29S	TL072CN			
VA339N	COMPARATOR QUAD LO PWR		23N	LM339N		2	IC913 4
			70H	CA339E			
VA353N	OP AMP DUAL	STATIC	23N	LF353N		1	IC904
VA412CN	OP AMP DUAL LO OFFSET	STATIC	23N	LF412CN		1	IC907
VA5534AN	OP AMP SINGLE LO NOISE		01P	NE5534AN		1	IC903
VA7805CT	+5V REGULATOR		23N	LM7805CT/LM340T5		1	IC909
			02M	MC7805CT			
VA7808CT	+8V REGULATOR		02M	MC7808CT		1	IC916
VD02CP	REF 5V0 +/-0.5% 10PPM 8DIP		55A	REF02CP		1	IC915
VD211CJ	CMOS 4X SPNO ANLG SWTCH	STATIC	41S	DG211CJ		1	IC912
VD4052B	BCMOS 2X4CH MTIPLXER	STATIC	23N	CD4052B		1	IC908
			70H	CD4052BE			
VD4053B	BCMOS 3X2CH MTIPLXER	STATIC	23N	CD4053BCN		1	IC902
			29S	HCF4053BEY			
VD5001N	DMOS FET MATCHED QUAD		41S	SD5001N		1	IC910
VD74LS26N	TTLS QUAD NAND HI-V	14-DIP	23N	SN74LS26N		2	IC905 6
VD74LS273N	TTLS OCTAL D-TYPE FLIP-FLOP		01T	SN74LS273N		1	IC901
VF2222L	MOSFET N 6R0 .4W TO-92		41S	VN2222L		4	TR901-4
VFJ113	J-FET N 100R .36W TO92		01P	J113		1	TR905
VP10171	TRANSISTOR PAD 10171-N		47M	10171-N		5	
VS14L	IC SKT 14WAY		28I	703-3314-01-04-10		4	
			08R	ICO-143-S8A-T			
VS16L	IC SKT 16WAY		28I	703-3316-01-04-10		4	
			08R	ICO-163-S8A-T			
VS20L	IC SKT 20 WAY		28I	703-3320-01-04-10		1	
			08R	ICO-203-S8A-T			
VS8P	IC SKT 8WAY		28I	703-3308-01-04-10		5	
			08R	ICO-083-S8A-T			
YL22250I	INSUL LINK 25MM 22AWG		00F	22AWG+25MM		1	LK901

6.7 MOTHER BOARD

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
5S3245M	MOTHER BOARD ASSY			B	1	
BC1845	BARE BOARD	01K	BC18450	A	1	
RM3270RFF	270R 1% 0W60 50PPM 250V	18P	MRS25		1	R1001
		53D	SMA0207TK50			
TBA3910PSS	10W PIN WAFER FRICTION LOCK SQ	07A	1-640445-0		1	PL1010
TBM2502PS	STRAIGHT PIN HEADER 2 WAY 2.54	23M	6410+22-27-2021		1	PL1012
TBM2503PS	STRAIGHT PIN HEADER 3 WAY 2.54	23M	6410+22-27-2031		1	PL1011
TBM2506PS	STRAIGHT PIN HEADER 6 WAY 2.54	23M	6410+22-27-2061		1	PL1009
TG100964433	DIN CONNECTOR 64 OF 96 SOCKET	28P	100-964-433		6	SK1001-6
TG3518	POLARISING KEY	18M	3518-0000		1	
TIH2526NR1L	26WAY PIN HEADER RT ANGLE	88M	ID101-H-26-K-06-F1		1	PL1008

6.8 SYNTHESISER BOARD

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
5S3245S	SYNTHESISER BOARD ASSY			A	1	
BC25509	BARE BOARD	01K	DV1/25509	G	1	
CC247P0UK	47pOF 10% 500V	95B	CD08WK47P0KS		1	C125
CC3220PWJ	220pF 5% 1KV SL R050	44M	DE5095+SL+221+J1KV		1	C126
CC3270PUM	270pF 20% 500V	95B	CD08/K1		1	C111
CC41N00UM	1.0nF 20% 500V K2 R050	95B	CD08K201N0MS		2	C112 3
CC44N70UX	4.7nF 40% 500V K3 R050	95B	CD10K304N7XS		1	C110
CEC220UET	220UF 50% 16V AXIAL	18P	031-35221		2	C109:24
CR6100NKM	100nF 20% 63V MKT 3X08 R050	159W	MKS2MIN		13	C101-06 8:16-21
CR6220NLM	220nF 20% 100V MKT 4X13 R100	159W	MKS4		1	C114
DG4148	DIODE	23N	1N4148		2	D101 2
		74T	1N4148			
RM220R0FF	20R 1% 0W6 50PPM 250V	18P	MRS25		1	R115
		53D	SMA0207TK50			
RM247R0FF	47R0 1% 0W60 50PPM 250V	18P	MRS25		4	R124 6:35:40
		53D	SMA0207TK50			
RM295R3BF	95R3 1% 0W25 100PPM	94M	H8		2	R113 7
RM3220RFF	220R 1% 0W60 50PPM 250V	18P	MRS25		1	R127
		53D	SMA0207TK50			
RM3510RFF	510R 1% 0W60 50PPM 250V	18P	MRS25		7	R102-08
		53D	SMA0207TK50			
RM3620RFF	620R 1% 0W60 50PPM 250V	18P	MRS25		1	R109
		53D	SMA0207TK50			
RM41K00FF	1K00 1% 0W60 50PPM 250V	18P	MRS25		8	R129-31 3 4 37-39
		53D	SMA0207TK50			
RM44K64BB	4K64 0.1% 0W25 50PPM	94M	H8		1	R116
RM44K70FF	4K70 1% 0W60 50PPM 250V	18P	MRS25		1	R136
		53D	SMA0207TK50			
RM44K99BB	4K99 0.1% 0W25 50PPM	94M	H8		2	R114 8
RM46K80BB	6K8 0.1% 0W25 50PPM	94M	H8		2	R112:20
RM513K0BB	13K 0.1% 0W25 50PPM	94M	H8		2	R110:22
RN41K00BG	1K0 2% SIL RES. NETWORK	10B	4610X-101-102		1	R128
TG10064053	DIN CONNECTOR 64 OF 96 PLUG	66C	DIN41612/C+C64M3AA+C		1	PL101
VA357	OP AMP SINGLE 20MHZ STATIC	23N	LF357		1	IC130
VA7805CT	+5V REGULATOR	23N	LM7805CT/LM340T5		1	IC131
		02M	MC7805CT			
VD40408CN	BCMOS 12-STG BIN CTR/DIV STATI	23N	CD4040BCN		1	IC112
		70H	CD4040BE			
VD74198	TTL SHIFT REG 8 BIT PAR	01P	74F198		1	IC114
VD74F161APC	FTTL 4-BIT BINARY COUNTER	02M	MC74F161A		1	IC113
		01P	74F161A			
VD74F74	FTTL DUAL D-TYPE F/F	23N	74F74PC		1	IC123
VD74F86	FTTL QUAD 2-INPUT EXCLSVE OR	23N	74F86PC		1	IC119
VD74LS00N	TTLS QUAD 2-I/P NAND 14-DIP	01T	SN74LS00N		2	IC111:35
		23N	74LS00N			
VD74LS02N	TTLS QUAD 2-I/P NOR 14-DIP	01T	SN74LS02N		2	IC116:25
		23N	74LS02N			
VD74LS04N	TTLS HEX INVERTERS 14-DIP	01T	SN74LS04N		1	IC126
		23N	SN74LS04N			
VD74LS05N	TTLS HEX INVERTERS O/C 14-DIP	01T	SN74LS05N		1	IC117

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
VD74LS245N	TTLS OCTAL BUS TRANSCEIVER	01T	DM74LS245N		1	IC134
VD74LS251N	TTLS 8-INPUT MULTIPLEXER	01T	SN74LS251N		1	IC110
		01I	SN74LS251N			
VD74LS260N	TTLS DUAL 5-INPUT NOR 14-DIP	01P	N74LS260N		1	IC124
VD74LS266N	TTLS QUAD EX-NOR O/C 14-DIP	01P	N74LS266N		1	IC118
VD74LS26N	TTLS QUAD NAND HI-V 14-DIP	23N	SN74LS26N		1	IC115
VD74LS373N	TTLS OCTAL TRANSPARENT LATCH	01T	SN74LS373N		1	IC102
		23N	SN74LS373N			
VD74LS38	TTLS QUAD NAND BUFFER O/C	01T	SN74LS38N		1	IC127
VD74LS390N	TTLS DUAL DEC COUNTERS 16-DIP	01T	SN74LS390N		1	IC108
VD74LS393N	TTLS DUAL 4-BIT BIN CTR	01T	SN74LS393N		2	IC105 9
VD74LS74N	TTLS DUAL D-TYPE F-FLOP +EDGE	01T	SN74LS74N/AN		3	IC120 1 2
		23N	74LS74NAN			
VD74LS76AN	TTLS DUAL J-K F-FLOP SET/CLR	01T	SN74LS76AN		1	IC106
VD74LS86N	TTLS QUAD EXCLUSIVE OR 14-DIP	01T	SN74LS86N		1	IC107
VD74S112N	STTL DUAL J-K F/F -EDGE	01T	SN74S112N		1	IC104
VD74S74N	STTL DUAL D TYPE +EDGE	23N	DM74S74N		1	IC133
		01T	SN74S74N			
VD81LS95	TTLS OCTAL BUFFER 3-STATE	23N	DM81LS95AN		1	IC101
VD82C54	PROG INT TIMER 5MHZ	70H	CP82C54-5		1	IC103
		85S	SAB82C54-P			
VS14L	IC SKT 14WAY	28I	703-3314-01-04-10		19	
		08R	ICO-143-S8A-T			
VS16L	IC SKT 16WAY	28I	703-3316-01-04-10		6	
		08R	ICO-163-S8A-T			
VS20L	IC SKT 20 WAY	28I	703-3320-01-04-10		3	
		08R	ICO-203-S8A-T			
VS24L	IC SKT 24 WAY	28I	703-3324-03-04-10		2	
		08R	ICO-246-S8A-T			
VS8P	IC SKT 8WAY	28I	703-3308-01-04-10		1	
		08R	ICO-083-S8A-T			
VX38M4	OSCILLATOR 38.4MHZ 0.01%	189A	970C		1	IC132

6.9 FRONT PANEL ASSEMBLY

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
4N6425FP	FRONT PANEL ASSY			B	1	
5S3245KB	KEYBOARD PCB ASSY		*	P3	1	
BC25522	BARE BOARD	01K	DV2/25522	BX	1	
CR6100NKM	100nF 20% 63V MKT 3X08 R050	159W	MKS2MIN		1	C400
HC25564	KEYBOARD CONNECTOR CABLE ASSY	57W	DV3/25564	P2	1	
SB75120	PUSH BUTTON SW 1 POLE BLACK	14T	4800		33	S400-32
VD74LS145	TTLS 1-OF-10 DECODER DRIVER	23N	74LS145		1	IC400
VS16L	IC SKT 16WAY	28I	703-3316-01-04-10		1	
		08R	ICO-163-S8A-T			
7SP25581	WINDOW PANEL EV3245A	00F	DV3/25581	P1	1	
GC1426	CABLE CLIP 4MM SELF ADHESIVE	77C	L1426		1	
HL0296	EV6425B FRONT PANEL LABEL	18G	3SC0296	A	1	
HW3245FP	FRONT PANEL + OVERLAY 3245A	10G	DV1/25552/1/2	P7	1	
		18G	DV1/25552/1/2			
LD134K	LED T1 3/4 MTG KIT	13V	MP52		1	
LD5082YEL	LED YEL HLMP3400	02H	HLMP3400		1	D1001
MT4M	S/ADHESIVE SEAL STRIP GRY 4MM	49B	4742-55		0	
TBM2502HP	CRIMP HOUSING 2 WAY 2.54MM	23M	6471+22-01-2025		1	SK1012
TBM2508HP	CRIMP HOUSING 8 WAY 2.54MM	23M	6471+22-01-2085		1	SK802
TC1402113	LOOSE GOLD CONTACT	08M	1402-113		6	
TCM25	CRIMP TERMINALS 2.5MM REEL	23M	4809-08-50-0031		2	
TK322100	2 POLE 3.5MM JACK SOCKET	31R	R322-100-00		1	SK1001
TR005N	BNC INSULATED PANEL SOCKET	02B	LX04-0503-ZZ005N		4	PL1004-7

6.10 REAR PANEL ASSEMBLY

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
4N6425RF	REAR PANEL FINAL ASSY			B	1	
4S3245CR	CAP BRKT & REAR PANEL SUB-ASSY			B	1	
7SU25574	CAPACITOR BRACKET	00F	DV2/25574	P8	1	
CA1H	CAP CLIP HORIZ 1"	92B	H1		1	C004
CA35H	HORIZONTAL 35mm CAP CLIP	06R	543-383		1	C002
CA40H	HORIZONTAL 40mm CAP CLIP	06R	601-029		4	C001 3
CED2M20IQ	2.2mF -10+30% 40V	18P	050-17222		1	C004
CED6M80IQ	6.8mF -10+30% 40V	18P	050-17682		1	C002
CEE10M0IQ	10m0F -10+30% 40V	18P	050-17103		1	C003
		92B	ALT20A103DD040			
CEE22M0EQ	22m0F -10+30% 16V	18P	050-15223		1	C001
SB15	SDDS MAINS SWITCH 5AMP	23C	SDDSA3289A		1	S001
SR602	T/TRIP TWIN FIX 70C N/C 1/4IN	06R	339-308		1	S003
TBA3908HS	8W HOUSING WITH STRAIGHT LOCK	07A	640250-8		3	SK700 1A B
TG15040219	POLARISING KEY	23M	15-04-0219		1	
7SU25556	OPTION CHASSIS	00F	DV3/25556	P2	2	
7SU25604	OPTION RETAINER D/A	00F	DV4/25604	P1	2	
FH2190	FUSEHOLDER 20MM	02B	L2190		1	FS001
FS2210	IEC INLET BOOT SHROUD	02B	L2210		1	
FT1A00123	FUSE 1 AMP ANTI-SURGE 5 X 20MM	03B	S502		1	
HK150	KNOB CAP C150 SIF BLK	01S	C150		1	
HK15025	KNOB S150250 SIF BLK	01S	S150250		1	
HS25579	HEATSINK	11D	DV2/25579	P2	1	
HW25557	GUIDE RAIL	52R	DV4/25557	P1	4	
PC41K00KN	1K00 10% NPREST LIN	02S	149A-9-08		1	R001
SS022CD03	SLIDE SWITCH DPDT	127S	SS022CD03+DPDT		1	S002
TBM2503HP	CRIMP HOUSING 3 WAY 2.54MM	23M	6471+22-01-2035		1	SK1011
TC39AMP	CRIMP TERMINAL	07A	342392-6		18	
		06A	342392-6			
TC7543	INSULATED 1/4 IN SPADE CRIMP	26H	RSVP+7543+F+6,3-1		5	
TCM25	CRIMP TERMINALS 2.5MM REEL	23M	4809-08-50-0031		7	
TG47030	CEE22 "CLIP-IN"APPLIANCE INLET	31R	R470-300-00		1	PL001
TM2BLK	TERMINAL BLACK	50C	TP2+(BLK)		1	SK002
TM2RED	TERMINAL RED	50C	TP2+(RED)		1	SK003
ZR25570	MAINS TRANSFORMER REF Z1510	01B	DV1/25570	P5	1	T001

6.11 20V BIAS BOARD ASSEMBLY

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
5N6425BB	20V BIAS BOARD ASSY			A	1	
7SU25697	HEATSINK BRACKET 20V BIAS 6425	00F	DV3/25697	P3	1	
BC25691	BARE BOARD	01K	DV1/25691	G	1	
CC222P0UK	22pOF 10% 500V	95B	CD08TH22P0KS		1	C1610
CC41N00UM	1.0nF 20% 500V K2 R050	95B	CD08K201N0MS		1	C1604
CEC100UKM	100UF 20% 63V R050	134N	KMVB		2	C1611 8
CR6100NKM	100nF 20% 63V MKT 3X08 R050	159W	MKS2MIN		13	C1601 2 7-9:12-16 19-21
CR6680NLK	680nF 10% 100V MKT 6X18 R150	159W	MKS4		1	C1603
CTB22U0GM	22U0F 20% 25V R050	95A	TAG-25		2	C1605 6
		05D	SH2225			
DG4003	DIODE	11G	1N4003		6	D1603-5 7:10 1
		47F	1N4003			
DG4148	DIODE	23N	1N4148		11	D1612 15-17 19-23 5 6
		74T	1N4148			
DZ14V70E	4.7V 5% 0W50	31I	ZPD4.7		2	D1613 8
DZ16V80E	6.8V 5% 0W50	31I	ZPD6.8		1	D1614
DZ210V0E	10V 5% 0W50	31I	ZPD10		1	D1609
DZ211V0D	11V 5% 0W40	01P	BZX79-C11V0		1	D1624
DZ215V0E	15V 5% 0W50	31I	ZPD15		2	D1601 2
DZ222V0E	22V 5% 0W50	31I	ZPD22		2	D1606 8
HC25563	BIAS UNIT CONNECTOR CABLE ASS	57W	DV3/25563	P6	1	
		88M	DV3/25563			
MB2840	M3 TOP HAT BUSH	14W	BQ2840		2	
MC1	CERAMIC BEAD SMALL	57M	IPB/1		20	
MM4170	ALUMINIUM OXIDE WASHER TO220	50S	5032-00404		2	
PM520K0KH1	20K0 10% PRESET HORZ STURN	02S	63X		2	R1612 4
RG72M70BJ	2M70 5% 0W25 200PPM 1K1V	18P	VR25		2	R1625 6
RG75M60BJ	5M60 5% 0W25 200PPM 1K1V	18P	VR25		1	R1648
RG76M80EJ	6M8 5% 0W5 250PPM 2K5V	18P	VR37		1	R1613
RM222R0FF	22R0 1% 0W60 50PPM 250V	18P	MRS25		1	R1659
		53D	SMA0207TK50			
RM3120RFF	120R 1% 0W60 50PPM 250V	18P	MRS25		2	R1610 1
		53D	SMA0207TK50			
RM3390RFF	390R 1% 0W60 50PPM 250V	18P	MRS25		2	R1601 4
		53D	SMA0207TK50			
RM3560RGF	560R 1% 1W00 50PPM 500V	53D	SMA0411S		2	R1602 5
		90A	00026737			
RM3820RFF	820R 1% 0W60 50PPM 250V	18P	MRS25		1	R1609
		53D	SMA0207TK50			
RM41K00BC	1K00 0.25% 0W25 25PPM	94M	H8		2	R1638 9
RM41K00FF	1K00 1% 0W60 50PPM 250V	18P	MRS25		2	R1637:45
		53D	SMA0207TK50			
RM41K80FF	1K80 1% 0W60 50PPM 250V	18P	MRS25		1	R1660
		53D	SMA0207TK50			
RM42K70FF	2K70 1% 0W60 50PPM 250V	18P	MRS25		2	R1608:58
		53D	SMA0207TK50			
RM43K00BC	3K0 0.25% 0W25 25PPM	94M	H8		1	R1640
RM43K30FF	3K30 1% 0W60 50PPM 250V	18P	MRS25		2	R1622 3
		53D	SMA0207TK50			
RM44K70FF	4K70 1% 0W60 50PPM 250V	18P	MRS25		2	R1630:49
		53D	SMA0207TK50			

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
RM45K60FF	5K60 1% 0W60 50PPM 250V	18P	MRS25		1	R1650
		53D	SMA0207TK50			
RM49K10FF	9K10 1% 0W60 50PPM 250V	18P	MRS25		2	R1641 2
		53D	SMA0207TK50			
RM510K0FF	10K0 1% 0W60 50PPM 250V	18P	MRS25		2	R1643 4
		53D	SMA0207TK50			
RM512K0FF	12K0 1% 0W60 50PPM 250V	18P	MRS25		2	R1634:57
		53D	SMA0207TK50			
RM513K0FF	13K0 1% 0W60 50PPM 250V	18P	MRS25		2	R1627 9
		53D	SMA0207TK50			
RM518K0FF	18K0 1% 0W60 50PPM 250V	18P	MRS25		1	R1635
		53D	SMA0207TK50			
RM527K0FF	27K0 1% 0W60 50PPM 250V	18P	MRS25		2	R1631 2
		53D	SMA0207TK50			
RM533K0FF	33K0 1% 0W60 50PPM 250V	18P	MRS25		1	R1651
		53D	SMA0207TK50			
RM539K0FF	39K0 1% 0W60 50PPM 250V	18P	MRS25		1	R1633
		53D	SMA0207TK50			
RM551K0FF	51K0 1% 0W60 50PPM 250V	18P	MRS25		1	R1615
		53D	SMA0207TK50			
RM582K0BC	82K0 0.25% 0W25 25PPM	94M	H8		2	R1620 1
RM6120KBC	120K 0.25% 0W25 25PPM	94M	H8		2	R1618 9
RM6120KFF	120K 1% 0W60 50PPM 250V	18P	MRS25		2	R1653 4
		53D	SMA0207TK50			
RM6470KFF	470K 1% 0W60 50PPM 250V	18P	MRS25		3	R1624 8:55
		53D	SMA0207TK50			
RM71M80FF	1M80 1% 0W60 50PPM 250V	18P	MRS25		2	R1647:52
RM73M90FF	3M90 1% 0W60 50PPM 250V	18P	MRS25		1	R1646
RM74M70FF	4M70 1% 0W60 50PPM 250V	18P	MRS25		1	R1656
RN44K70BG	4K7 2% SIL RES. NETWORK	10B	4610X-101-472		1	R1636
RW0R680JJ	0R68 5% 2W50	02W	W21		2	R1603 6
		94M	74ER+0R68+5%			
RW210R0NJ	10R0 5% 12W	94M	W24		1	R1607
		02W	W24			
RW227R0JJ	27R0 5% 2W50	04E	74ER		1	R1616
		94M	74ER			
RW41K00JJ	1K00 5% 2W50	04E	74ER		1	R1617
		94M	74ER			
SR24VDC	POWER 24VDC DPCO 5AAC PC MNT	44P	11-752-232-740		2	RL1601 2
SRE1A5VD	DIL REED 5VDC SPNO 0.5ADC	52A	131A-4		1	RL1603
		04C	PRMA1A05			
TBM2504PS	STRAIGHT PIN HEADER 4 WAY 2.54	23M	6410+22-27-2041		1	PL1602
TCM39	CRIMP TERMINAL 3.9MM 18-24 AWG	23M	2478-08-50-0105		2	
TP210501	TERMINAL PIN	01H	H2105-01		11	
VA339AN	COMPARATOR QUAD LO OFFSET	23N	LM339AN		1	IC1602
		02M	LM339AN			
VA339N	COMPARATOR QUAD	23N	LM339N		1	IC1608
		70H	CA339E			
VA412CN	OP AMP DUAL LO OFFSET	23N	LF412CN		1	IC1601
VA7805CT	+5V REGULATOR	23N	LM7805CT/LM340T5		1	IC1603
		02M	MC7805CT			
VD0808LCN	DAC 8 BIT 150NS 0.19% 16-DIP	23N	DAC0808LCN		1	IC1605
VD4052B	BCMOS 2X4CH MTIPLXER STATIC	23N	CD4052B		1	IC1604
		70H	CD4052BE			

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
VD74LS175N	TTLS QUAD D-TYPE FL-FLOP	01T	SN74LS175N		1	IC1606
		01I	SN74LS175N			
VD74LS26N	TTLS QUAD NAND HI-V 14-DIP	23N	SN74LS26N		1	IC1609
VD74LS273N	TTLS OCTAL D-TYPE FLIP-FLOP	01T	SN74LS273N		1	IC1607
VF2222LM	MOSFET N 6R .4W TO-92	41S	VN2222LM		2	TR1607 8
VP10171	TRANSISTOR PAD 10171-N	47M	10171-N		8	
VS14L	IC SKT 14WAY	28I	703-3314-01-04-10		3	
		08R	ICO-143-S8A-T			
VS16L	IC SKT 16WAY	28I	703-3316-01-04-10		3	
		08R	ICO-163-S8A-T			
VS20L	IC SKT 20 WAY	28I	703-3320-01-04-10		1	
		08R	ICO-203-S8A-T			
VS8P	IC SKT 8WAY	28I	703-3308-01-04-10		1	
		08R	ICO-083-S8A-T			
VT182PK	NPN 50V .3W TO-92	03Z	BC182PK35(4SC0174)		2	TR1604 5
VT184C	NPN 30V .3W HI GAIN TO-92				1	TR1610
		03Z	BC184C			
VT203	BD203 60V 12A 30G NPN TO220	01P	BD203		1	TR1606
VT204	BD204 60V 12A 30G PNP TO220	01P	BD204		1	TR1603
		24S	BD204SM			
VT212PKCR	PNP 50V .3W TO-92	03Z	BC212PK35		2	TR1601 2
VT228	NPN 60V 12.5W 1.5A TO-126	01P	BD228		1	TR1609
VT449	PNP 100V .625W TO-92	02M	BC449		1	TR1611

6.12 POWER SUPPLY BOARD

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
5S3245PS	POWER SUPPLY BOARD ASSY			B	1	
7SU25569	HEATSINK BRACKET PSU	00F	DV3/25569	P3	1	
BC1749	BARE BOARD	01K	BC17490	B	1	
CEB33U0EM	33UF 20% 16V R020	134N	SMVB		3	C710-12
CEC220UEM	220UF 20% 16V R050	18P	035-55221		5	C705-09
CR6330NLM	330nF 20% 100V MKT 5X18 R150	159W	MKS4		3	C713 4 5
DBW02M	BRIDGE RECTIFIER	11G	W02G		1	D713
DG4003	DIODE	11G	1N4003		8	D714-21
		47F	1N4003			
DG5401	DIODE	10I	1N5401		4	D705-08
DG752	DIODE	02M	MR752		8	D701-04 09-12
FH1426	FUSE HOLDER 5 X 20MM PCB MTG.	02B	L1426		1	FS701
FT5A00123	FUSE 5 AMP ANTI-SURGE	03B	S504		1	F701
		31W	19195			
GCNX2	P CLIP 6.4MM I/D	04H	NX2		1	
MB1218	TOP HAT BUSH 6BA	27K	A1218		2	
MC1	CERAMIC BEAD SMALL	57M	IPB/1		4	
MM103C	TRANSISTOR MICA TO220	24M	MI6108		2	FIT TO IC703 4
		70H	DF103C			
MM3055	TRANSISTOR MICA TO3	70H	DF377A		2	FIT TO IC701 2
RASOT	#### SELECT ON TEST ####	00F	RASOT		1	R710
RM233R0FF	33R0 1% 0W60 50PPM 250V	18P	MRS25		1	R709
		53D	SMA0207TK50			
RM3100RBD	100R 0.5% 0.25W 100PPM	94M	H8		2	R703 8
RM3120RBD	120R 0.5% 0.25W 100PPM	94M	H8		2	R701 5
RM3348RBD	348R 0.5% 0.25W 100PPM	94M	H8		1	R702
RM41K00BD	1K0R 0.5% 0.25W 100PPM	94M	H8		1	R706
RM41K10BD	1K1R 0.5% 0.25W 100PPM	94M	H8		2	R704 7
TBA3903PSS	3W PIN WAFER FRICTION LOCK SQU	07A	640445-3		1	PL702
TBA3908PSS	8W PIN WAFER FRICTION LOCK SQU	07A	640445-8		3	PL700 1A B
TBM2510HP	CRIMP HOUSING 10 WAY 2.54MM	23M	6471+22-01-2105		1	
TP1510	CIRCUIT BOARD PIN 10mm	26P	B1.5X0.25X10MS		2	R10(X2) HOLES 1-3:5-8:10,11
VA317T	+ REGULATOR 3 TERM ADJ	23N	LM317T		1	IC703
		02M	LM317T			
VA337T	- REGULATOR 3 TERM ADJ	23N	LM337T		1	IC704
VA350K	+ REGULATOR 3A 3 TERM ADJ	23N	LM350K		2	IC701 2
GCNX0	P CLIP 3.4MM I/D	04H	NX0		1	
GT23	CTY001/NT20 75C UL	28P	PLT1M-M		1	
TBA3903HS	3W HOUSING WITH STRAIGHT LOCK	07A	640250-3		1	SK702
TBM2503HP	CRIMP HOUSING 3 WAY 2.54MM	23M	6471+22-01-2035		1	PL11
TBM2504HP	CRIMP HOUSING 4 WAY 2.54MM	23M	6471+22-01-2045		1	SK602
TV1867	SHROUD	28B	L1867		1	

6.13 MEMORY BOARD

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
5N6425MB	MEMORY BOARD MKIII ASSY			A	1	
BC26667	BARE BOARD	01K	DV2/26667	B	1	
CC247P0UK	47p0F 10% 500V	95B	CD08WK47P0KS		1	C219
CC41N00UM	1.0NF 20% 500V K2 R050	95B	CD08K201N0MS		1	C218
CEB10U0GT1	10U0F 50% 25V AXIAL	18P	030-36109		2	C200:21
CR6100NKM	100nF 20% 63V MKT 3X08 R050	159W	MKS2MIN		19	C201-217:20 3
CTB22U0DM	22U0F 20% 10V	95A	TAG22/10		1	C222
		05D	SH2210			
DG4148	DIODE	23N	1N4148		4	D200 2 3 4
		74T	1N4148			
DZ13V00D	3V0 5% 0W40	01P	BZX79-C3V0		1	D201
EB6117	LITHIUM BATTERY	06V	6117501501		1	B200
RM239R0FF	39R0 1% 0W60 50PPM 250V	18P	MRS25		1	R217
		53D	SMA0207TK50			
RM3100RFF	100R 1% 0W60 50PPM 250V	18P	MRS25		1	R213
		53D	SMA0207TK50			
RM41K00FF	1K00 1% 0W60 50PPM 250V	18P	MRS25		2	R209:10
		53D	SMA0207TK50			
RM42K70FF	2K70 1% 0W60 50PPM 250V	18P	MRS25		1	R211
		53D	SMA0207TK50			
RM44K70FF	4K70 1% 0W60 50PPM 250V	18P	MRS25		4	R207 8:15 6
		53D	SMA0207TK50			
RM510K0FF	10K0 1% 0W60 50PPM 250V	18P	MRS25		1	R212
		53D	SMA0207TK50			
RM547K0FF	47K0 1% 0W60 50PPM 250V	18P	MRS25		1	R214
		53D	SMA0207TK50			
RN41K00BG	1K 2% SIL RES. NETWORK	10B	4610X-101-102		4	R200-2 6
RN44K70BG	4K7 2% SIL RES. NETWORK	10B	4610X-101-472		1	R205
RN547K0BG	47K 2% SIL RES. NETWORK	10B	4610X-101-473		2	R203 4
SS8023	DIL SWITCH 8WAY	04E	SDS8-023		1	S201
TG10064053	DIN CONNECTOR 64 OF 96 PLUG	66C	DIN41612/C+C64M3AA+C		2	PL200 2
TG3518	POLARISING KEY	18M	3518-0000		1	
TIH2510WR1L	10 WAY PIN HEADER RT ANGLE	25V	008289-010-004-141		1	PL201
		18M	3793-5302UN			
TP210501	TERMINAL PIN	01H	H2105-01		2	
TP2137D	TEST POINT TERMINAL	90B	20-2137D		2	
TP78	SNAP LOCK PIN 7.8N	29R	SLP100-307-01		4	
VA78L05ACZ	+5V REGULATOR	23N	LM78L05ACZ		1	IC217
VD27C128J	EPROM 16KX8 150NS 28-D STATIC	01T	TMS27C128-15JL		3	IC203-5 PROGRAMMED
VD6264LP15	SRAM 8KX8 150NS 28-D STATIC	76H	HM6264ALP15		1	IC207
VD74HC00N	HCMOS 4X2-I/P NAND 14-D STATIC	01T	74HC00N		1	IC214
		23N	74HC00N			
VD74HC08N	HCMOS 4X 2-I/P AND 14-D STATIC	23N	MM74HC08N		1	IC213
VD74HC11	HCMOS 3X 3-I/P AND STATIC	23N	74HC11		1	IC202
VD74HC138N	HCMOS 3-8 LINE DEMPLXR STATIC	23N	74HC138N		1	IC215
		01T	SN74HC138N			
VD74HC139	HCMOS 2-4 LINE DEMPLXR STATIC	01T	SN74HC139N		2	IC212 6
		23N	MM74HC139N			
VD74HC175N	HCMOS 4X D-TYP F-F STATIC	01T	74HC175N		1	IC211
		23N	MM74HC175N			
VD74HC273	HCMOS OCTAL D-TYPE F-F STATIC	23N	74HC273		1	IC208

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
VD74HC32	HCMOS QUAD 2-INPUT OR STATIC	01P	74HC32N		1	IC201
		01T	SN74HC32			
VD74HC540	HCMOS 8X INV BUF 3-STAT STATIC	70H	CD74HC540E		1	IC210
		29S	M74HC540B1R			
VD74HC541	HCMOS OCTAL DRVR 3-STAT STATIC	29S	M74HC541B1R		1	IC209
		23N	MM74HC541N			
VD74LS245N	TTLS OCTAL BUS TRANSCEIVER	01T	DM74LS245N		1	IC200
VP10171	TRANSISTOR PAD 10171-N	47M	10171-N		4	
VS14L	IC SKT 14WAY	28I	703-3314-01-04-10		4	
		08R	ICO-143-S8A-T			
VS16L	IC SKT 16 WAY	28I	703-3316-01-04-10		4	
		08R	ICO-163-S8A-T			
VS20L	IC SKT 20 WAY	28I	703-3320-01-04-10		4	
		08R	ICO-203-S8A-T			
VS28L	IC SKT 28 WAY	01H	D282801		5	
VT182PK	NPN 50V .3W TO-92	03Z	BC182PK35(4SC0174)		3	TR200-2
		90A	00054571			

6.14 CPU AND TV BOARD

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
5S3245CTV	CPU & TV BOARD ASSY			A	1	
BC1729	BARE BOARD	01K	1CJRBT17290	C	1	
CC3120PUM	120PF 20% 500V N4700 R050	95B	CD06EM120PMS		1	C321
CC3220PUM	220PF 20% 500V K1 R050	95B	CD08K1220PMS		2	C302 3
CC3220PWJ	220PF 5% 1KV SL R050	44M	DE5095+SL+221+J1KV		1	C320
CC41N00UM	1.0NF 20% 500V K2 R050	95B	CD08K201N0MS		1	C301
CEC220UDT	220UF 50% 10V AXIAL	18P	030-34221		1	C300
CR6100NKM	100nF 20% 63V MKT 3X08 R050	159W	MKS2MIN		16	C304-319
DG4003	DIODE	11G	1N4003		1	D300
		47F	1N4003			
DGBAT85	DIODE BAT85	01P	DO34		1	D302
DZ15V60E	5.6V 2% 0W50	31I	ZPD5.6		1	D301
PM520K0KH1	20K0 10% PRESET HORZ STURN	02S	63X		1	R312
RM3100RFF	100R 1% 0W60 50PPM 250V	18P	MRS25		1	R302
		53D	SMA0207TK50			
RM3470RDF	470R 1% 0W40 50PPM 200V	18P	MRS16T		1	R316
		53D	NK3			
RM3470RFF	470R 1% 0W60 50PPM 250V	18P	MRS25		3	R308 9:15
		53D	SMA0207TK50			
RM3560RFF	560R 1% 0W60 50PPM 250V	18P	MRS25		1	R307
		53D	SMA0207TK50			
RM41K00FF	1K00 1% 0W60 50PPM 250V	18P	MRS25		4	R303 4 6:14
		53D	SMA0207TK50			
RM41K20FF	1K20 1% 0W60 50PPM 250V	18P	MRS25		2	R310 1
		53D	SMA0207TK50			
RM44K70FF	4K70 1% 0W60 50PPM 250V	18P	MRS25		1	R301
		53D	SMA0207TK50			
RM539K0FF	39K0 1% 0W60 50PPM 250V	18P	MRS25		1	R313
		53D	SMA0207TK50			
RN42K20BG	2K2 2% SIL RES. NETWORK	10B	4610X-101-222		1	R305
RN44K70BG	4K7 2% SIL RES. NETWORK	10B	4610X-101-472		1	R300
SA69957RD	BUTTON RED	30S	069957R		1	S300
SB69955B	PUSH BUTTON SWITCH MDP	30S	069955B		1	S300
TBM2503PO	STRAIGHT PIN HEADER 3 WAY 2.54	23M	4030+22-03-2031		1	J301
TG10064053	DIN CONNECTOR 64 OF 96 PLUG	66C	DIN41612/C+C64M3AA+C		1	PL301
TL2W	HEADER 2 WAY LINK	23M	7859-15-38-1024		1	J301 FIT TO "6M" SIDE
TP2137D	TEST POINT TERMINAL	90B	20-2137D		2	
VA311N	COMPARATOR SINGLE	23N	LM311N		1	IC337
		29S	LM311N			
VA78L12CP	+12V REGULATOR	23N	LM78L12ACZ		1	IC300
		02M	MC78L12CP			
VA79L12CP	-12V REGULATOR	02M	MC79L12CP		1	IC304
		23N	LM79L12ACZ			
VD27C64	EPROM 8KX8 250NS 28-D STATIC	05F	MBM27C64-25Z		1	IC324 PROGRAMMED
		23N	NMC27C64Q25			
VD6116P4	SRAM 2KX8 200NS 24-DIP STATIC	43G	HM6116P-4		1	IC317
		76H	HM6116P-4			
VD68B45	CRT CONTROLLER 8-BIT 6800CPU	76H	HD6845SP		1	IC312

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
VD74LS00N	TTLS QUAD 2-I/P NAND 14-DIP	01T	SN74LS00N		2	IC329:31
		23N	74LS00N			
VD74LS02N	TTLS QUAD 2-I/P NOR 14-DIP	01T	SN74LS02N		1	IC334
		23N	74LS02N			
VD74LS04N	TTLS HEX INVERTERS 14-DIP	01T	SN74LS04N		2	IC335 6
		23N	SN74LS04N			
VD74LS08N	TTLS QUAD 2-INPUT AND 14-DIP	01T	SN74LS08N		1	IC328
		23N	74LS08N			
VD74LS09	TTLS QUAD 2-INPUT AND O/C	23N	DM74LS09N		1	IC311
VD74LS10N	TTLS TRIPLE 3-INPUT NAND 14-DP	01T	SN74LS10N		1	IC306
		23N	74LS10N			
VD74LS132N	TTLS QUAD SCHMIT NAND 14-DIP	01T	SN74LS132N		2	IC330 2
		23N	DM74LS132N			
VD74LS138N	TTLS 3-8 LINE DEMULTIPLEXER	01T	DM74LS138N		1	IC302
VD74LS157N	TTLS QUAD 2-1 LINE MULTIPLEXER	01T	SN74LS157N		3	IC314-16
		23N	SN74LS157N			
VD74LS161AN	TTLS 4-BIT BINARY COUNTER	01P	N74LS161AN		1	IC322
VD74LS166N	TTLS 8-BIT SHIFT REG P-IN/S-O	23N	DM74LS166N		1	IC323
VD74LS193N	TTLS 4-BIT UP/DN BIN CTR	01T	SN74LS193N		1	IC338
		01I	SN74LS193N			
VD74LS244N	TTLS OCTAL BUFFER 3-STATE O/P	01T	DM74LS244N		4	IC308-10 9
VD74LS245N	TTLS OCTAL BUS TRANSCEIVER	01T	DM74LS245N		1	IC307
VD74LS26N	TTLS QUAD NAND HI-V 14-DIP	23N	SN74LS26N		1	IC303
VD74LS32N	TTLS QUAD 2-INPUT OR 14-DIP	01T	SN74LS32N		2	IC327:33
		23N	74LS32N			
VD74LS373N	TTLS OCTAL TRANSPARENT LATCH	01T	SN74LS373N		1	IC320
		23N	SN74LS373N			
VD74LS74N	TTLS DUAL D-TYPE F-FLOP +EDGE	01T	SN74LS74N/AN		1	IC321
		23N	74LS74NAN			
VD74LS76AN	TTLS DUAL J-K F-FLOP SET/CLR	01T	SN74LS76AN		1	IC313
VD81LS95	TTLS OCTAL BUFFER 3-STATE	23N	DM81LS95AN		1	IC301
VD8400BPS	MICRO 8BIT Z80 8MHZ STATIC	05Z	Z0840008PSC		1	IC305
VP10171	TRANSISTOR PAD 10171-N	47M	10171-N		3	

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
VS14L	IC SKT 14 WAY	28I	703-3314-01-04-10		14	
		08R	ICO-143-S8A-T			
VS16L	IC SKT 16 WAY	28I	703-3316-01-04-10		8	
		08R	ICO-163-S8A-T			
VS20L	IC SKT 20 WAY	28I	703-3320-01-04-10		7	
		08R	ICO-203-S8A-T			
VS24L	IC SKT 24 WAY	28I	703-3324-03-04-10		1	
		08R	ICO-246-S8A-T			
VS28L	IC SKT 28 WAY	01H	D282801		1	
VS40L	IC SKT 40 WAY	28I	703-3340-03-04-10		2	
		08R	ICO-406-S8A-T			
VS8P	IC SKT 8 WAY	28I	703-3308-01-04-10		1	
		08R	ICO-083-S8A-T			
VT2369	NPN 15V .36W HI FT TO-18	01P	2N2369A		1	TR300

6.15 RS232-C (PRINTER OUTPUT) OPTION

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
2EV32003	RS232 INTERFACE ASSY			A	1	
BC24110	BARE BOARD	01K	D02/24110	F	1	
CC6220NDW	220nF -25+50% 10V	95B	TD16K3220NWS		1	C221
CEB10U0GT1	10U0F 50% 25V AXIAL	18P	030-36109		2	C201 3
CR6100NKM	100nF 20% 63V MKT 3X08 R050	159W	MKS2MIN		11	C200 2 4-12
CS3390PMH	390pF 2%5 160V	132S	HSC		4	C217-20
HB12525B	BRACKET	90B	173-12525B		1	
HR20418	SCREW LOK ED20418-2/TB8	84A	ED20418-2+SL8		2	
HW24229	FRONT PANEL RS232C OPTION	52R	D04/24229	P3	1	
RM42K20FF	2K20 1% 0W60 50PPM 250V	18P	MRS25		1	R200
		53D	SMA0207TK50			
RM42K70FF	2K70 1% 0W60 50PPM 250V	18P	MRS25		1	R208
		53D	SMA0207TK50			
RM43K00FF	3K00 1% 0W60 50PPM 250V	18P	MRS25		1	R203
		53D	SMA0207TK50			
RM575K0FF	75K0 1% 0W60 50PPM 250V	18P	MRS25		1	R205
		53D	SMA0207TK50			
RN44K70HG2	4K70 2% DIL RES N/WORK 14-DIP	10B	4114R-002+4K7		2	R210 1
SS60231	DIL SLIDE SWITCH 6-WAY C/O	04E	SCS-6-023		1	S204
SS8023	DIL SWITCH 8WAY	04E	SDS8-023		3	S201 2 3
TG10064053	DIN CONNECTOR 64 OF 96 PLUG	66C	DIN41612/C+C64M3AA+C		1	PL200
TK2517DB	SOCKET PCB MOUNT 25WAY D-TYPE	53A	DB25S-1A-1N		1	SK201
		45L	SDS25R3			
TP210501	TERMINAL PIN	01H	H2105-01		1	
TP2137D	TEST POINT TERMINAL	90B	20-2137D		3	TP1 2 3
TS6B43	SOLDER TAG 6BA STC402307DM	05R	RC43/6BA		1	
VD1488N	LINE TRANSMITTER	01T	MC1488N		1	IC209
VD1489N	LINE RECEIVER	01T	MC1489N		1	IC210
VD74LS04N	TTLS HEX INVERTERS 14-DIP	01T	SN74LS04N		1	IC204
		23N	SN74LS04N			
VD74LS10N	TTLS TRIPLE 3-INPUT NAND 14-DP	01T	SN74LS10N		1	IC202
		23N	74LS10N			
VD74LS136	TTLS QUAD EX-OR O/C 14-DIP	23N	SN74LS136N		3	IC200 1 3
VD81LS95	TTLS OCTAL BUFFER 3-STATE	23N	DM81LS95AN		3	IC205 6 7
VD8250AN	MICRO INTERFACE	23N	PC16450/INS8250AN		1	IC208
VP10171	TRANSISTOR PAD 10171-N	47M	10171-N		2	
VS14L	IC SKT 14WAY	28I	703-3314-01-04-10		7	
		08R	ICO-143-S8A-T			
VS20L	IC SKT 20 WAY	28I	703-3320-01-04-10		3	
		08R	ICO-203-S8A-T			
VS40L	IC SKT 40 WAY	28I	703-3340-03-04-10		1	
		08R	ICO-406-S8A-T			
VT184C	NPN 30V .3W HI GAIN TO-92	03Z	BC184C		2	TR200 1
VT3053	NPN 40V .8W .7A TO-39	29S	2N3053		1	TR202

6.16 GPIB/HANDLER INTERFACE OPTION

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
5S32002IE	IEEE 488 INTERFACE BOARD ASSY			G	1	
5N32002PB	EV32002 PAL BOARD ASSY			A	1	
BC2053	BARE PAL BOARD	01K	BC20530	A	1	
		16U	BC20530			
CR6100NKM	100nF 20% 63V MKT 3X08 R050	159W	MKS2MIN		3	C1-3
VD22V10	PROGRAMMABLE LOGIC	197A	PALCE22V10H25PC4		1	IC1 PROGRAMMED
VD74LS05N	TTLS HEX INVERTERS O/C 14-DIP	01T	SN74LS05N		1	IC3
VD74LS14	TTLS HEX SCHMITT TRIGGERS	23N	DM74LS14N		1	IC2
VS14L	IC SKT 14WAY	28I	703-3314-01-04-10		2	IC2 3
		08R	ICO-143-S8A-T			
VS24LMIN	IC SKT 24WAY 0.3 PITCH	01T	24W+0.3"+PITCH		1	IC1
		28I	703-3324-01-04-10			
VS5468	PIN STRIP 0.1 PITCH	28I	702-5468-01-04-16		3	
BC1725	BARE INTERFACE BOARD	01K	1NJRBT17250	C	1	
CC3220PLG	220pF 2% 100V N750 R050	18P	683+58221		1	C16
CEB10U0JM2	10U0F 20% 50V R050	134N	KMVB		1	C1
CR6100NKM	100nF 20% 63V MKT 3X08 R050	159W	MKS2MIN		15	C2-15,17
HB12525B	BRACKET	90B	173-12525B		1	
HC0232	GPIB OPTION CABLE	88M	4SC0232	A	1	SK1
TK57F20	IDC CONNR PANEL MTD CENTRONICS	38D	57FE2024020N(D35)		1	
HW4599	IEEE FRONT PANEL MODIFIED	52R	4SU004599	C	1	
RM41K00FF	1K00 1% 0W60 50PPM 250V	18P	MRS25		1	R3
		53D	SMA0207TK50			
RN41K00BG	1K0 2% SIL RES. NETWORK	10B	4610X-101-102		1	R2
RN44K70CG	4K7 2% SIL RES. NETWORK	01F	4610X-101-472		1	R1
SS8023	DIL SWITCH 8WAY	04E	SDS8-023		2	SW1 2
TG10064053	DIN CONNECTOR 64 OF 96 PLUG	66C	DIN41612/C+C64M3AA+C		1	PL1
TP1510	CIRCUIT BOARD PIN 10mm	26P	B1.5X0.25X10MS		1	P1
VAOMIT	TRANSISTOR / IC OMITTED	00F			5	IC9-13
VD3448A	QUAD 3-STATE BUS TRANSCEIVER	02M	MC3448A		4	IC2-5
VD68488P	INTERFACE ADAPTER IEEE-488	02M	MC68488P		1	IC1
VD74LS136	TTLS QUAD EX-OR O/C 14-DIP	23N	SN74LS136N		1	IC8
VD74LS244N	TTLS OCTAL BUFFER 3-STATE O/P	01T	DM74LS244N		1	IC6
VD74LS245N	TTLS OCTAL BUS TRANSCEIVER	01T	DM74LS245N		1	IC7
VS14L	IC SKT 14WAY	28I	703-3314-01-04-10		1	IC8
		08R	ICO-143-S8A-T			
VS16L	IC SKT 16WAY	28I	703-3316-01-04-10		4	IC2-5
		08R	ICO-163-S8A-T			
VS20L	IC SKT 20 WAY	28I	703-3320-01-04-10		2	IC6 7
		08R	ICO-203-S8A-T			
VS40L	IC SKT 40 WAY	28I	703-3340-03-04-10		1	IC1
		08R	ICO-406-S8A-T			

6.17 ANALOG OUTPUT OPTION

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
2EV32001	ANALOGUE O/P ASSY			E	1	
BC25706	BARE BOARD	01K	DV2/25706	D	1	
CC247P0UK	4p70F 10% 500V	95B	CD08WK47P0KS		1	C1814
CC6100NLM	100nF 20% 100V X7R R050	62S	8133Z-100-104-OM-X7R		2	C1815 6
CC6220NDW	220nF -25+50% 10V	95B	TD16K3220NWS		1	C1813
CR533N0PJ1	33n0F 5%0 250V MKT 4X13 R100	159W	MKS4		2	C1805 8
CR568N0PJ	68n0F 5%0 250V MKT 4X13 R100	159W	MKS4		2	C1811 2
CR6100NKM	100nF 20% 63V MKT 3X08 R050	159W	MKS2MIN		4	C1801-4
CR6150NLJ1	150nF 5%0 100V MKT 4X13 R100	159W	MKS4		2	C1806 7
CTB10U0GM	10U0F 20% 25V R050	95A	TAG-25		2	C1809:10
		05D	SH1025			
DG329CZ	PRECISION REF. DIODE	23N	LM329CZ		1	D1801
HB12525B	BRACKET	90B	173-12525B		1	
HW25708	FRONT PANEL ANALOG OPTION	52R	DV4/25708	P3	1	
PM510K0KH2	10K0 10% PRESET HORZ STURN	02S	63X		2	R1814:24
PM520K0KH1	20K0 10% PRESET HORZ STURN	02S	63X		2	R1810 5
RAOMIT	RESISTORS OMITTED				1	R1 3 4
RG74M70EJ	4M70 5% 0W5 250PPM	18P	VR37		2	R1811 6
RM210R0FF	10R0 1% 0W60 50PPM 250V	18P	MRS25		2	R1826 7
		53D	SMA0207TK50			
RM247R0FF	47R0 1% 0W60 50PPM 250V	18P	MRS25		2	R1818 9
		53D	SMA0207TK50			
RM3560RFF	560R 1% 0W60 50PPM 250V	18P	MRS25		1	R1806
		53D	SMA0207TK50			
RM44K70DF	4K70 1% 0W40 50PPM 200V	18P	MRS16T		4	R28-31
		53D	NK3			
RM44K70FF	4K70 1% 0W60 50PPM 250V	18P	MRS25		2	R1802 5
		53D	SMA0207TK50			
RM510K0FF	10K0 1% 0W60 50PPM 250V	18P	MRS25		3	R1812 7:25
		53D	SMA0207TK50			
RM522K0FF	22K0 1% 0W60 50PPM 250V	18P	MRS25		2	R1809:13
		53D	SMA0207TK50			
RM6100KFF	100K 1% 0W60 50PPM 250V	18P	MRS25		4	R1820-3
		53D	SMA0207TK50			
RM6180KFF	180K 1% 0W60 50PPM 250V	18P	MRS25		2	R1807 8
		53D	SMA02076TK50			
SAOMIT	SWITCHES/RELAY OMITTED				1	SW01
TG10064053	DIN CONNECTOR 64 OF 96 PLUG	66C	DIN41612/C+C64M3AA+C		1	SK1801
TK1517DA	15W RH. D TYPE PCB SOCKET	53A	17-DB15S-1A-1N		1	SK1802
TP210501	TERMINAL PIN	01H	H2105-01		1	
TS6B43	SOLDER TAG 6BA STC402307DM	05R	RC43/6BA		1	
VA412CN	OP AMP DUAL LO OFFSET STATIC	23N	LF412CN		2	IC1808 9
VD4053B	BCMOS 3X2CH MTIPLXER STATIC	23N	CD4053BCN		1	IC1807
		29S	HCF4053BEY			
VD74LS04N	TTLS HEX INVERTERS 14-DIP	01T	SN74LS04N		1	IC1805
		23N	SN74LS04N			
VD74LS139N	TTLS 2-4 LINE DEMULTIPLEXER	01T	SN74LS139N		1	IC1802
VD74LS244N	TTLS OCTAL BUFFER 3-STATE O/P	01T	DM74LS244N		1	IC1803
VD74LS75N	TTLS 4-BIT D-TYPE LATCH 16-DIP	01T	SN74LS75N		1	IC1806

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
VD74LS85N	TTLS 4-BIT MAGNITUDE COMP	23N	DM74LS85N		1	IC1801
VD82C54	PROG INT TIMER 5MHZ	70H	CP82C54-5		1	IC1804
		85S	SAB82C54-P			
VF2222L	MOSFET N 6R .4W TO-92	41S	VN2222L		1	TR1801
VP10171	TRANSISTOR PAD 10171-N	47M	10171-N		2	
VS14L	IC SKT 14WAY	28I	703-3314-01-04-10		1	
		08R	ICO-143-S8A-T			
VS16L	IC SKT 16WAY	28I	703-3316-01-04-10		4	
		08R	ICO-163-S8A-T			
VS20L	IC SKT 20 WAY	28I	703-3320-01-04-10		1	
		08R	ICO-203-S8A-T			
VS24L	IC SKT 24 WAY	28I	703-3324-03-04-10		1	
		08R	ICO-246-S8A-T			
VS8P	IC SKT 8WAY	28I	703-3308-01-04-10		2	
		08R	ICO-083-S8A-T			

6.18 U.S. ARMY OPTION (CONTRACT DAAH01-94-D-0014)

COMPONENT	DESCRIPTION	MAN.	MAN. PART NUMBER	ISS	QU	CIRCUIT REFERENCE
1EV32005	RACK MOUNTING EAR	00F	DV3/25669	P2	2	
7SU10364	TRAY	00F	1SUAJ10364	A	1	
7SU10365	BOTTOM BLANKING PANEL	00F	2SUAJ10365	A	1	
7SU10367	FIXING BRACKET	00F	3SUCB10367	A	2	
7SU10368	TOP BLANKING PANEL	00F	2SUAJ10368	A	1	
HW5043	SLIDE	21K	M5.043.005.9		2	
HA5498	HANDLE	90B	54910008		1	
HC60140	POWER CORD(HOSFELT ELECTRONICS)	102W	60-140		1	

6.19 SUPPLIER CODES

00F	FARNELL INSTRUMENTS LTD
01B	BBH COIL & TRANSFORMER CO LTD
01F	FARNELL ELECTRONIC COMP PLC
01H	HARWIN ENGINEERING LTD
01I	INTERNATIONAL LAMPS LTD
01K	KELAN CIRCUITS LTD
01P	PHILIPS SEMICONDUCTORS
01S	SIFAM LTD
01T	TEXAS INSTRUMENTS LTD
02B	BELLING & LEE LTD
02H	HEWLETT-PACKARD LTD
02M	MOTOROLA LTD
02S	SPECTROL-RELIANCE LTD
02T	THOMSON COMPONENTS LTD
02W	WELWYN ELECTRIC LTD
03A	MPE (LIVERPOOL) ASHCROFT
03B	BESWICK COOPER UK LTD
03Z	ZETEX PLC
04C	C P CLARE ELECTRONICS LTD
04E	ERG INDUSTRIAL CO LTD
04H	HELLERMAN INSULOID LTD
04J	JACKSON BROS LTD
04M	MAJORTEK PRODUCTS LTD
04V	VEROSPEED LTD
05A	ACE PACKAGING DESIGNS LTD
05D	DUBILIER COMPONENTS
05F	FUJITSU MICROELECTRONICS LTD
05R	ROSS COURTNEY & CO LTD
05Z	ZILOG(UK)LTD
06A	AMP OF GREAT BRITAIN LTD
06R	R S COMPONENTS LTD
06V	VARTA (GB) LTD
07A	AMP OF GREAT BRITAIN LTD
08I	VONROLL ISOLA LTD
08M	METHODE
08R	ROBINSON NUGENT LTD
102W	WAYNE KERR INC. (USA)
108U	UNITED MICROELECTRICS CORP
10B	BOURNS ELECTRONICS LTD.
10G	L.T. GILBERTSON ASSOCIATES LTD
10I	INTERNATIONAL RECTIFIER CO LTD
10P	PERMANOID LTD
119A	THE ASBESTOS & RUBBER CO
11D	DAU COMPONENTS LTD
11G	GENERAL INSTRUMENTS (UK) LTD
127S	STACKPOLE COMPONENTS
12H	VIC HALLAM PLC
132S	SUFLEX CAPACITORS LIMITED.
134N	EUROPE CHEMICON (DEUTSCHLAND)
13V	VSI ELECTRONICS UK LTD
14T	TRS INTERNATIONAL LTD
14W	WARTH INTERNATIONAL LTD
159W	WILHELM WESTERMAN
15P	PHILIPS COMPONENTS MAGNETICS

SUPPLIER CODES CONTINUED

16R	RAYFAST LTD
16U	UK ELECTRONICS LTD
17S	SAFEPACK LTD
189A	AEL CRYSTALS LTD
18G	GRAPHIC ARTS LTD
18M	3M UNITED KINGDOM LTD
18P	PHILIPS COMPONENTS LTD
18V	VISHAY-MANN & SFERNICE LTD
197A	AMD (UK) LTD
197S	SOAG MACHINERY LTD
19R	REDPOINT LTD
20R	REED CORRUGATED CASES LTD
21K	KNURR UK LTD
23C	CIRKIT DISTRIBUTION LTD
23M	MOLEX ELECTRONICS LTD
23N	NATIONAL SEMICONDUCTORS
24M	MOULDED ELECTRONIC COMPONENTS
24R	RHOPOINT COMPONENTS DIV
24S	SEMELAB
25V	ELCO EUROPE LTD.
26H	HESTO (HENKELS-STOCKO) LTD
26P	PRESTINCERT FASTENERS
27K	KARELIA LTD
28B	A F BULGIN & CO LTD
28I	INTERCONNECTION PRODUCTS LTD
28P	PANDUIT LTD
29R	RICHCO INTERNATIONAL CO.
29S	SGS THOMSON MICROELECT LTD
30S	ESD
31I	ITT SEMICONDUCTORS LTD
31R	RENDAR ELECTRONICS
31W	WICKMANN COMPONENTS LTD
32R	ROMANS ENGINEERING
38D	DISTRIBUTED TECHNOLOGY
41S	SILICONIX LTD
43G	G E C PLESSEY SEMICONDUCTORS
44M	MURATA ELECTRONICS
44P	PED LTD
45L	LORLIN ELECTRONICS LTD
47F	S.C.I.
47M	MILTON ROSS & CO LTD
49B	BEIERSDORF UK (TESA DIV)
49L	LDW UK LTD
50A	ARROW ELECTRONICS UK LTD
50C	CLIFF ELECTRONIC COMP LTD
50S	SWALLOW METALS & COMP LTD
51A	ALSAMEX PRODUCTS LTD
51D	DONPRINT
52A	ALSAMEX PRODUCTS LTD
52R	REDFERN ENGINEERING
53A	AMPHENOL LTD
53D	DSM (U.K.) LTD
53M	MOSS PLASTICS PARTS LTD
54E	ELBATEX AG
55A	ANALOG DEVICES LTD

SUPPLIER CODES CONTINUED

55M	MSS LTD
57D	XCEL CORPORATION LTD
57M	METWAY ELECT INDUSTRIES
57W	WAYNE KERR ATE LTD
60C	THE CONCORDIA & WIRE CO LTD
62S	SYFER TECHNOLOGY LTD
65S	SPIROL INDUSTRIES LTD
66C	CONEC (UK) LTD
70H	HARRIS SEMICONDUCTORS LTD
72H	HI-TECH MOULDING
74T	TEMIC UK (TELEFUNKEN GMBH)
76H	HITACHI EUROPE LTD
77C	CRITCHLEY LTD
84A	ACTIVE ELECTRONICS INT LTD
85S	SIEMENS PLC.
88M	MCMURDO INSTRUMENTS LTD
89C	CLIFFORD WHATMOUGH LTD
90A	ADVANCE POWER SUPPLIES LTD
90B	BICC-VERO ELECTRONICS LTD
92B	B H COMPONENTS (WEYMOUTH)
94M	MEGGITT ELECT COMPONENTS LTD
95A	AVX LTD UK SALES
95B	BECK ELECTRONICS LTD

7 PCB LAYOUTS & CIRCUIT DIAGRAMS

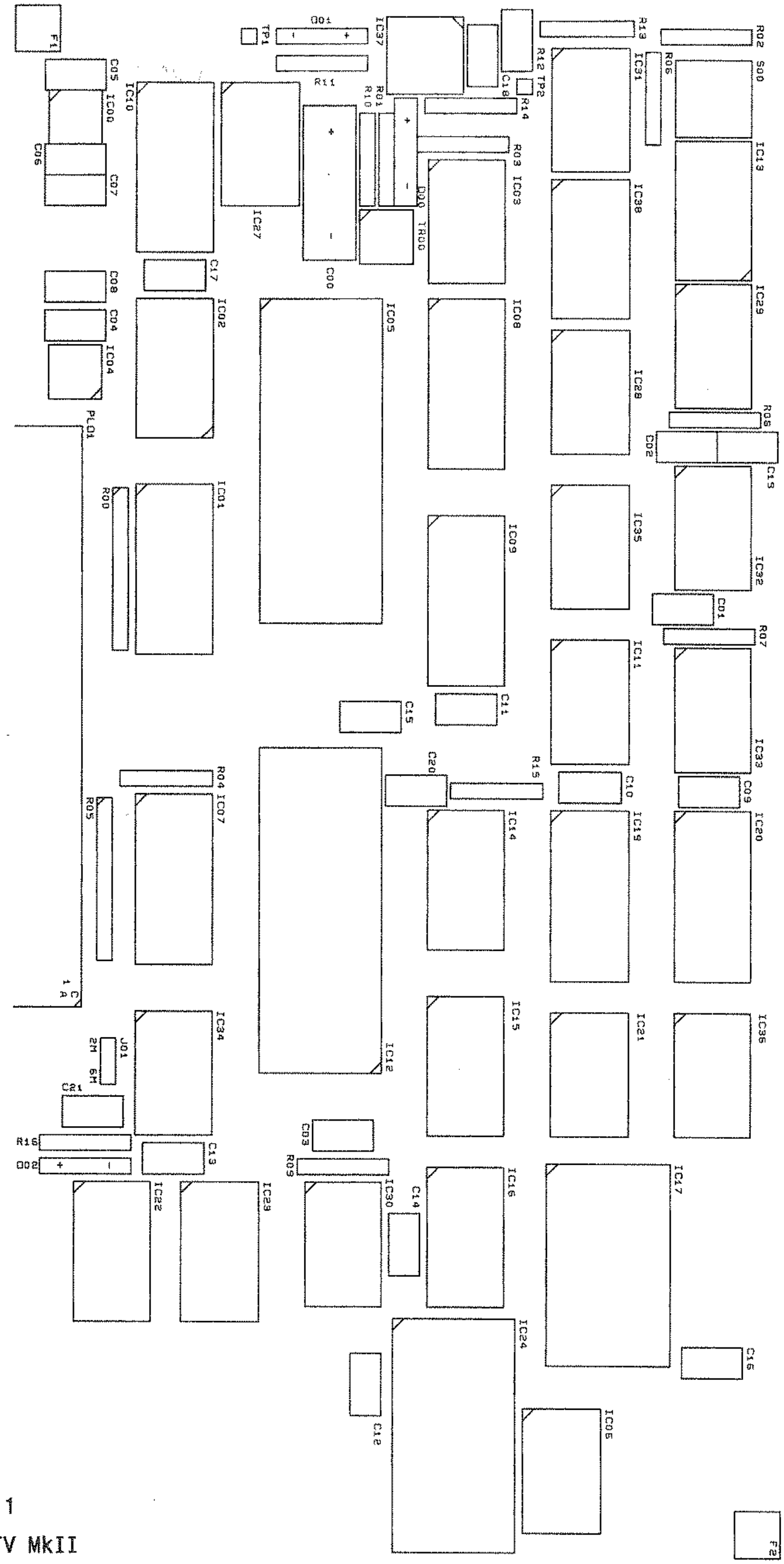


Fig. 7.1

CPU & TV MkII

PCB Layout

APPENDIX A

COMPUTRON CRT ASSEMBLY

Part no 115 - DMK - 8 (circuit board + deflection yoke)
+ 115 - 533 (cathode ray tube).

WARNING

> At no time should the CRT Drive Board be run without the flashover protection system fully connected, (the crt base socket), otherwise extensive damage may result and, because high voltages are generated within the unit, no attempt should be made by unskilled personnel to service a unit whilst it is switched on.

This display unit is supplied as a complete OEM assembly. Except for normal adjustments as described in sections 5.5 to 5.8, no servicing operations are recommended and faulty units should be replaced as complete assemblies.

The circuit diagram (fig. 7.23) and PCB layout (fig. 7.22) are given for information purposes only. No separate parts list is available. Because the circuit board is common to several different applications, a few components are located in positions that have inapplicable silk screening (for example capacitors are fitted in positions R201A and R202A).

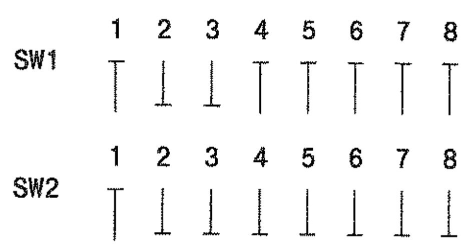
Note that the metallized bulb of the CRT is directly connected to the mounting lugs and hence to the chassis. The flashover protection circuits built in to the satellite board have a direct ground connection via a black flexible wire which terminates on the chassis close to one of the mounting lugs.

APPENDIX B

TEST PROCEDURE FOR GPIB OPTION

A.1 SWITCH SETTINGS AND CONNECTIONS

With power disconnected from the 6425B, remove the GPIB option board (see section 3.3). Set the GPIB address to 6 by setting SW1 as shown below. Also ensure that SW2 is set as shown below to obtain GPIB operation. Replace the option board.



Connect the GPIB cable between the GPIB option board connector and the GPIB controller. Using suitable test leads, connect a 1kΩ resistor to the instrument measuring terminals.

A.2 TEST PROCEDURE

Switch on power to 6425B and GPIB controller. Install the test software in the GPIB controller and run the file 'WKGPIB6.EXE'. The screen should show a choice of instruments as follows:

B905
4210/4250
3245/6425
7010

Set the arrow to 3245/6425 and hit the RETURN key. The software will then test the GPIB function by writing set-up instructions to the instrument, triggering a measurement and reading back the value of the resistor connected to the test leads. At the end of this test the controller screen will show PASS or FAIL.