WAYNE KERR

PRECISION INDUCTANCE ANALYZER 3245

OPERATING INSTRUCTIONS

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MANUAL FOR THE PRECISION INDUCTANCE ANALYZER 3245

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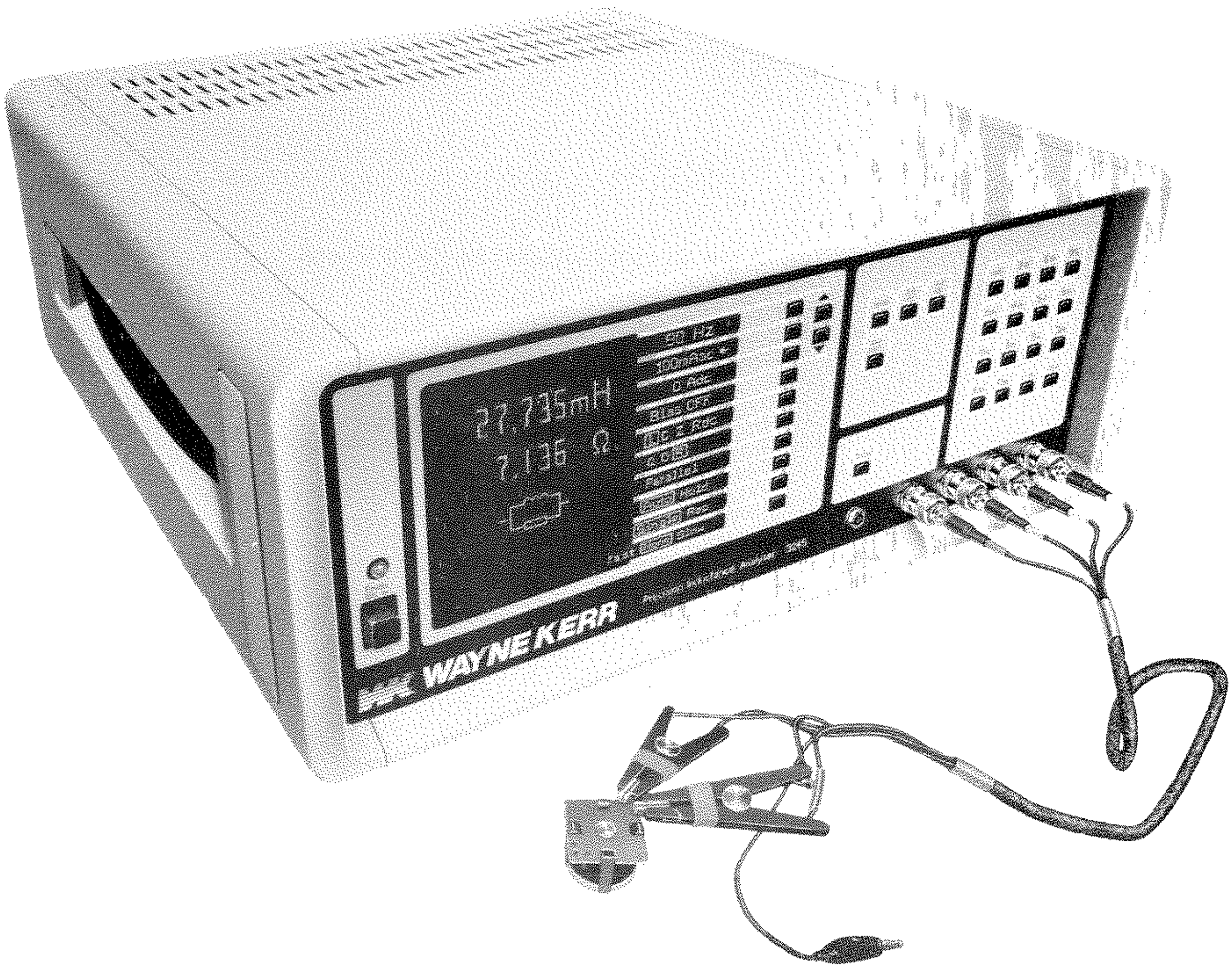

Figure 2 Precision 4-terminal measurement:
the 3245 Analyzer with Kelvin leads

MANUAL FOR THE PRECISION INDUCTANCE ANALYZER 3245

2. INTRODUCTION

The 3245 inductance analyzer design is based on precision measurement circuits controlled by a micro-processor. The resulting instrument, with a basic ac measurement accuracy of Ø.1%, yet requiring the minimum of skill to operate, is intended primarily for wound component measurements. It can also deal with measurements of resistance and capacitance.

There are several operating modes for different types of measurement. Pressing MAIN INDEX at any time displays the list of modes against their respective selection keys.

Operating conditions cover wide ranges of ac level, dc bias, frequency and selection criteria (binning and deviation) whilst measurements and displays can be for series, parallel or polar interpretations.

Trimming adjustment and ranging are achieved automatically. Trim (O/C and S/C) and MAIN INDEX functions are selected from a group of four buttons; the fourth permits local override of remote operation.

The standard facilities include limits for go/no go testing, deviation, binning (1Ø classes - 8 for passes), repetitive and single shot measurements. Measurement parameters, e.g. drive, bias current, frequency and mode, are indexed on a screen, each alongside a soft-key to control automatic adjustment (settings may also be entered via a numeric key-board).

A component fixture unit (1ØØ5) for rapid connection of components with axial or radial leads is available but normally the analyzer is supplied with two sets of measurement leads:-

a) A pair of Kelvin clip leads (14Ø5) for normal four-terminal measurements.

b) A set of crocodile connector leads (13Ø5) for use with transformers and also for situations where two and three terminal measurements suffice.

The instrument requires ac power.

The portable version, illustrated opposite in figure 2, can be mounted on runners in a standard 19-inch rack after fitting 'ears' to the sides and removing the feet. (There must be runners to take the weight.) This arrangement is suitable for a more permanent installation.

Finally, various plug-in options permit interfacing with other computer controlled equipment and remote control operation is possible.

3. SPECIFICATIONS

3.Ø1. MEASUREMENT FEATURES

3.Ø1.Ø1 MEASURING SYSTEM

The 3245 measuring system and soft-key controls are micro-processor based. All selected functions are retained in non-volatile memory when the instrument is powered-down. Keys can be 'locked out' to prevent accidental or unauthorised modification to measurement conditions. Remote triggering of measurement, by contact closure, is possible. Plug-in options are available for interfacing to external equipment such as controllers, printers etc.

3.Ø1.Ø2 MEASUREMENT DISPLAY

A 175mm CRT displays measured values and other user data. Resolution of displayed results is up to five digits depending on measurement accuracy.

3.Ø1.Ø3 MEASUREMENT PREPARATION - TRIMMING

TRIM S/C and TRIM O/C initiate procedures which automatically compensate for residual series impedance and parallel capacitance in the measuring leads, up to 1.25Ω and 5ØpF maximum. Trim values are retained in non-volatile store.

3.Ø1.Ø4 MEASUREMENT FUNCTIONS

The functions available are:-

L with Q, D or R (Series or parallel equivalent circuit)
C with Q, D or R (Series or parallel equivalent circuit)
Z with $\underline{/\theta}$, Vac/Iac
Rdc
Lm
TRANSFORMER turns-ratio (measured as a voltage ratio)
TRANSFORMER secondary turns (for user specified primary turns)

For non-transformer functions the following modes are also available:-

DEVIATION	- Absolute or % deviation from nominal
LIMITS	- Absolute or % limits for GO/NO GO testing
BINNING	- Sorts into 1Ø bins, 8 for different values, 1 for MAJOR term rejects, 1 for MINOR term rejects. Sorted results are displayed (with or without a handler)

3.Ø1.Ø5 MEASUREMENT CONDITIONS - ac

Frequency (Hz): A built-in pattern of specific values at

2Ø, 25, 3Ø, 4Ø, 5Ø, 6Ø, 8Ø, 1ØØ, 12Ø, 15Ø, 2ØØ

The pattern repeats each decade up to 6Ø kHz, then frequencies of 75, 1ØØ, 12Ø, 15Ø, 2ØØ and 3ØØkHz complete the set. When a frequency is keyed-in the system automatically selects the nearest value from the built-in range.

3.01.05 MEASUREMENT CONDITIONS - ac - (Continued)

Drive level: The drive mode (current/voltage) changes automatically, depending on the test impedance. The Z function display includes either the voltage developed across the unknown impedance (current drive selected) or the current through the unknown impedance (voltage drive selected).

1mA - 50mA	in 1mA steps)	Zu ≤ 10Ω
50mA - 100mA	in 2mA steps)	
10mV - 500mV	in 10mV steps)	Zu ≥ 10Ω
500mV - 1.0V	in 20mV steps)	
1V - 2.5V	in 50mV steps)	Zu ≥ 80Ω
2.5V - 5.0V	in 100mV steps)	Subject to 3V maximum at 300kHz

BIAS (dc): Internal supply has a separate on/off control and uses a rear panel mounted safety link. BIAS is always OFF at power-up.*

1mA - 50mA	in 1mA steps
50mA - 100mA	in 2mA steps
100mA - 250mA	in 5mA steps
250mA - 500mA	in 10mA steps
500mA - 1A	in 20mA steps

External option 3220 is an alternative dc BIAS source. It provides 200mA to 20A in steps of 100mA, for use with frequencies up to 20kHz. Up to five units may be paralleled with the 3245, replacing the internal BIAS supply.

3.01.06 MEASUREMENT CONDITIONS - dc resistance

The dc drive level depends on the measured value; it is always less than 100mV and 16mA.

3.01.07 MEASUREMENT CONDITIONS - ACCURACIES

Frequency accuracy: ±0.01%

Level accuracy - ac

Frequency Range:	O/C Voltage Accuracy		S/C Current Accuracy	
30Hz - 120kHz	±4%	±2mV	±5%	±200µA
20Hz - 25Hz) 150kHz - 200kHz)	±7.5%	±2mV	±8.5%	±200µA
300kHz	±11.5%	±2mV	±12.5%	±200µA

Loading effect: - ac
Maximum change in level occurs at Zu=10Ω. For reactive unknown impedances (Q≮25) maximum falls in level are voltage 4% and current 3%.

Current accuracy - dc BIAS: ±2.5%, ±0.25mA

* New safety features: see Chapter 8, page F:2.

3.Ø1.Ø8 MEASUREMENT RANGES, ACCURACY and RESOLUTION

Range matching to measured items is automatic unless inhibited by HOLD. If HOLD is selected, a RANGE ERROR message shows when a change of range could produce better measurement accuracy.

Seven ac impedance ranges are available.

Range No.	Impedance Coverage	Maximum Level
1	<1.25Ω	1ØØmA
2	<1ØΩ	1ØØmA
3	>1ØΩ	1V
4	>8ØΩ	5V
5	>64ØΩ	5V
6	>5k12Ω	5V
7	>41kΩ	5V

Notes: Maximum level at 3ØØkHz is 3V.
Range 7 is unavailable above 6ØkHz.
At <25ØmV range 7 is unavailable; also range 6 is unavailable above 6ØkHz.
At >25mA range 1 is unavailable.

Two dc resistance ranges are available.

Range	Resistance coverage	Maximum Level
Normal	>2Ω	1ØØmV or 2mA
Low	<2Ω	1ØØmV or 16mA

On all ranges, accuracy and resolution depend on the specific test conditions and impedance being measured. The basic ac measurement accuracy is ±Ø.1%. This applies, assuming proper trim, to any component with an impedance between Ø.16 and 33Øk in the frequency range 1ØØHz to 5kHz, normal speed, for levels of 25ØmV to 5V or 1ØØmA, no dc BIAS applied. Figures 3 - 5 show inductance accuracies with other drive conditions. Accuracy changes obtained from these charts apply equally to Q and D measurements. Except where stated, the standard conditions above apply to the following accuracy ranges. All resolution figures improve by 2:1 with SLOW selected.

Inductance:

Resolution: Ø.5nH at 1ØkHz and above

Accuracy:	Frequency	Max.Value	Min.Value
±0.1%*	1ØØHz	5ØØH	25ØµH
	1kHz	5ØH	25µH
	1ØkHz	5H	4µH
±Ø.5%*	1ØØHz	4ØØØH	25µH
	1kHz	4ØØH	2.5µH
	1ØkHz	4ØH	Ø.6µH
	4ØkHz	1.8H	Ø.6µH
±1%*	1ØkHz	6ØH	Ø.3µH
	5ØkHz	2.5H	Ø.6µH
	1ØØkHz	4ØmH	Ø.9µH

Q-Factor:

Maximum display with ±5% resolution: Q = 13ØØ
Accuracy: ±Ø.1(Q + 1/Q)%

* When Q > 1Ø. If Q < 1Ø, multiply accuracy figures by (1 + 1/Q).

3.Ø1.Ø8 MEASUREMENT RANGES, ACCURACY and RESOLUTION (Continued)

Capacitance:

Resolution: Ø.Ø1pF at 1ØkHz

Accuracy:

	Frequency	Max.Value	Min.Value
±Ø.1%*	1ØØHz	1ØmF	5nF
	1kHz	1mF	5ØØpF
	1ØkHz	5ØμF	5ØpF

Dissipation Factor:

Resolution: Ø.ØØØ2
Accuracy: Ø.ØØ1(1+D^2)

Impedance/ac Resistance:

Resistance: Ø.Ø2mΩ

Accuracy:

	Frequency	Range
±Ø.1%**	1ØØHz - 5kHz	Ø.16Ω to 33ØkΩ
	5kHz - 1ØkHz	Ø.33Ω to 33ØkΩ

Phase Angle:

Resolution: Ø.1°
Accuracy: ±Ø.2°

Turns Ratio (as a voltage ratio):

Accuracy: ±Ø.1% over range 1:1ØØ to 1ØØ:1

dc Resistance:

Resolution: Ø.2mΩ
Accuracy: ±Ø.5% in range Ø.2Ω to 5kΩ

3.Ø1.Ø9 MEASUREMENT REPETITION SELECTION

Measurement sequence is free-running or single shot; selection is by soft-keys, see figure 12. Single shot measurements are triggered by front panel button or remote contact closure.

Measurement speed: The reading rate affects the accuracy and resolution; choices, at 1 kHz ac drive, are:-

Normal	3/sec	approximately
Fast speed (reduced accuracy)	8/sec	
Slow speed (improved resolution)	1/sec	

At the fast speed setting, line frequency rejection worsens and basic accuracy worsens by 5:1, subject to adequate supply screening.

At the Slow speed setting, line frequency rejection is enhanced and all resolutions improve by 2:1.

With Normal or Fast settings, speed slows progressively below 3ØØHz to about 1.6/second at 2ØHz.

* When D < Ø.1. If D > Ø.1, multiply accuracy figure by (1 + D).

** When Q < Ø.1 (D > 1Ø). For loss resistance of an inductor, multiply accuracy figure by (1 + Q). For loss resistance of a capacitor, multiply accuracy figure by (1 + 1/D).

3.01.10 MEASUREMENT TERMINALS

Four BNC connectors provide 2, 3 and 4 terminal connections. Lead connection diagrams are available on the crt display. As a safety feature, measurement terminals are internally protected against accidental connection of charged capacitors and inductor back emf.

Single-pole Remote Triggering Contacts connect to the 3245 via a 3.5mm jack-socket mounted below the front panel trigger button, see figure 1. Contact current is mA only; neither side is grounded.

An external link - suitable for 1A current - is necessary for use of the internal BIAS supply. Terminals are on the rear panel, see figure 32.

3.02 ANCILLARY FEATURES

3.02.01 NON-VOLATILE MEMORY

The non-volatile memory is powered by a lithium battery with a service life exceeding 10 years. The parameters retained are:-

TRIM
MAIN INDEX mode selection
FREQUENCY
DRIVE (ac, dc)
BIAS level (But on re-powering, BIAS will be OFF)
MAJOR TERM)Measurement
MINOR TERM)parameters
AUTO-RANGE or RANGE-HOLD
Selected Range (In RANGE-HOLD)
SINGLE-SHOT/REPETITIVE
SPEED
LIMITS
BIN SET DATA
BIN COUNT DATA
Parity checking at power-up ensures that non-volatile data is valid

3.02.02 ACCESSORIES

1. Type 1405 - Four-terminal leads terminated with Kelvin clips.

2. Type 1305 - Four-terminal leads terminated with Crocodile clips. These may also be used for connection to 3- or 2-terminal networks and transformers.

3. Type 1005 - Component fixture unit, suitable for both radial and axial components.

4. Rack Mounting Kit - 2 mounting brackets and screws. Part number 25539

Standard shipment: The 3245 analyzer plus accessories 1405 and 1305.

3.Ø2.Ø3 OPTIONS (See also Appendices)

Various options for interconnection to other equipments are available. All are accessed on the back panel.

1. 322Ø dc Extension (2ØAmp). Comprises a separate unit of the same physical dimensions as the 3245. Up to five units may be stacked as a BIAS source (currents to 1ØØAmp) replacing the internal 1Amp dc source. Operationally the analyzer and soft-keys control the units. All 3245 measurement functions are available up to 2ØkHz.*

2. RS232C interface - provides:-

   Serial output of measurement data conforming to RS232C format to, for example, a printer.

3. GPIB interface - is implemented to the IEEE standard 488 (198Ø) (basic Talker and Listener) - and provides either:-

   (i) Full remote control of all functions including data entry and read-out, or

   (ii) Automatic output of measurement data to, for example, a printer.

4. Analogue output - provides one or two analogue outputs corresponding to selected measurement functions.*

5. Binning Handler Interface - provides connections to automatic component handlers.

3.Ø2.Ø4 TEMPERATURE RANGE

Storage	-4Ø°C to +7Ø°C	-4Ø°F to +158°F
Operating	Ø°C to +4Ø°C	+32°F to +1Ø4°F
Full Accuracy	+1Ø°C to +3Ø°C	+5Ø°F to +86°F

3.Ø2.Ø5 SUPPLY VOLTAGE

115V ±1Ø% or 23ØV ±1Ø% ac only (Must be correctly selected)

Power consumption 7ØVA nominal. The instrument may be converted for 5ØHz or 6ØHz operation by means of an internal wire link. (If this is not set correctly the instrument will continue to operate but not to full specified accuracy.)

3.Ø2.Ø6 DIMENSIONS

Width:	443mm	17.5in
Height (including feet):	195mm	7.5in
Depth (overall):	47Ømm	18.5in
Weight:	16kg	35lbs

3.Ø2.Ø7 DISCLAIMER

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.

* New safety features: see Chapter 8, page F:2.

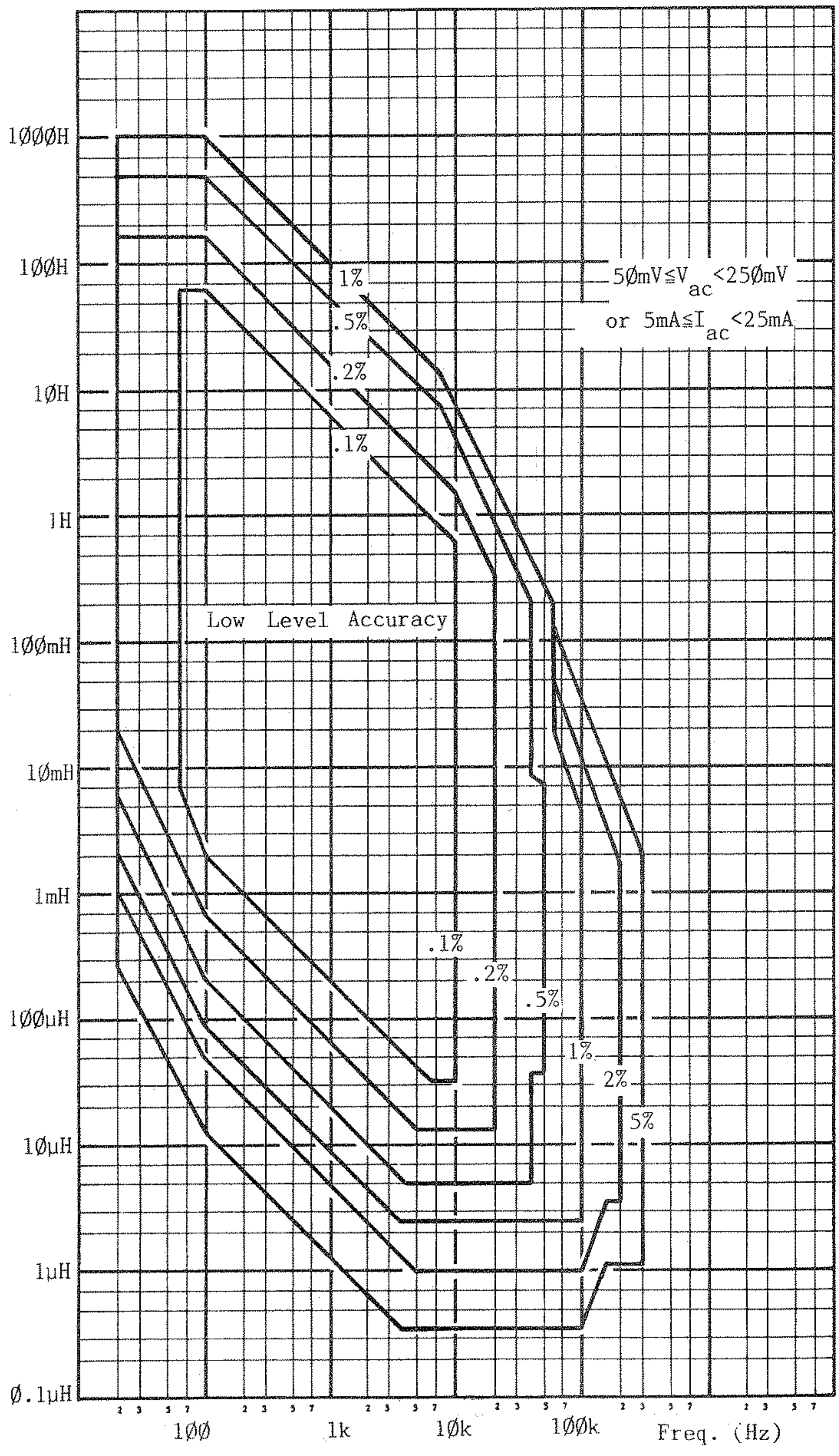

Figure 3 Accuracy Chart - low level drive, no BIAS

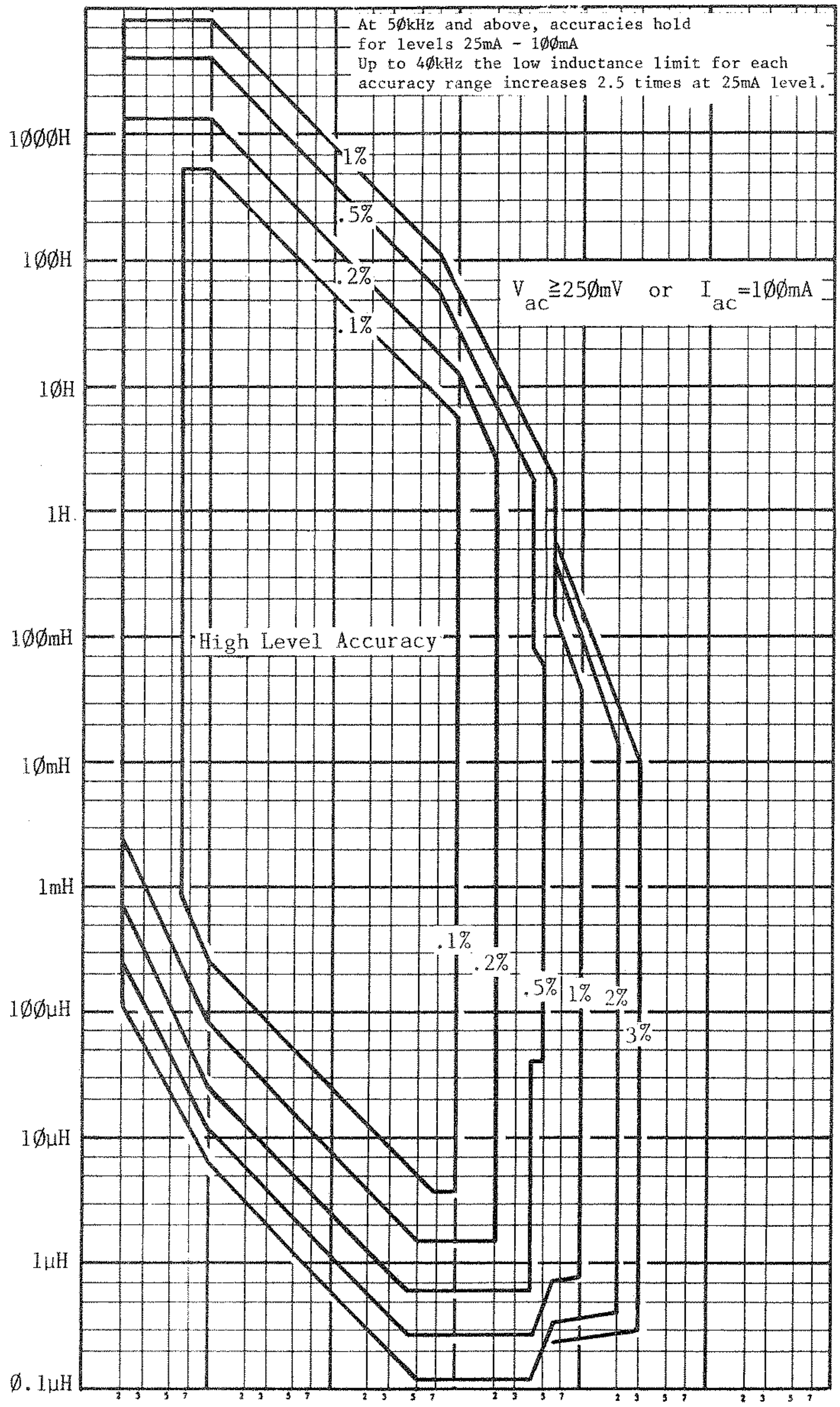

Figure 4 Accuracy Chart - high level drive, no BIAS

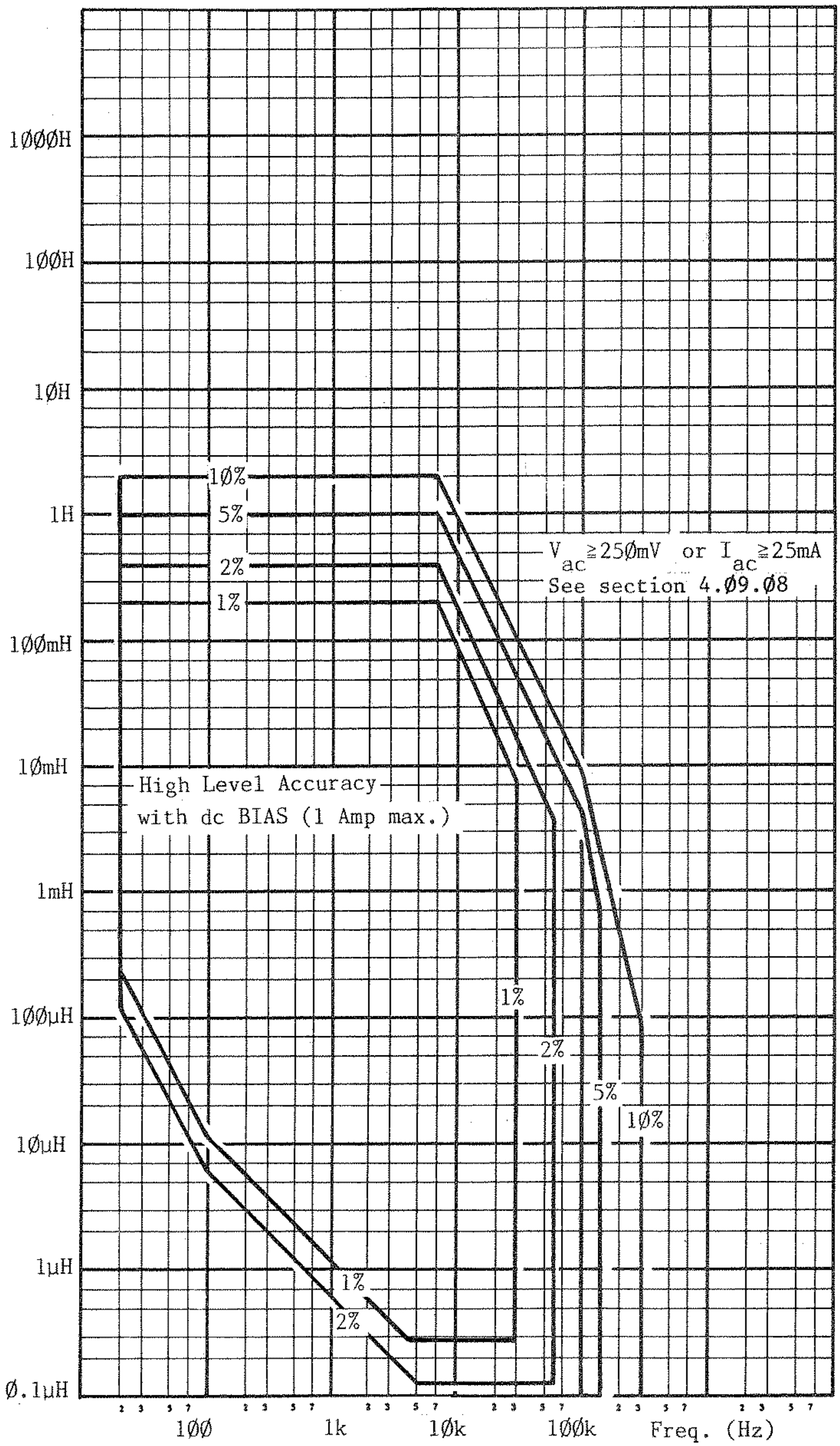

Figure 5 Accuracy Chart - high level drive, with 1Amp dc BIAS

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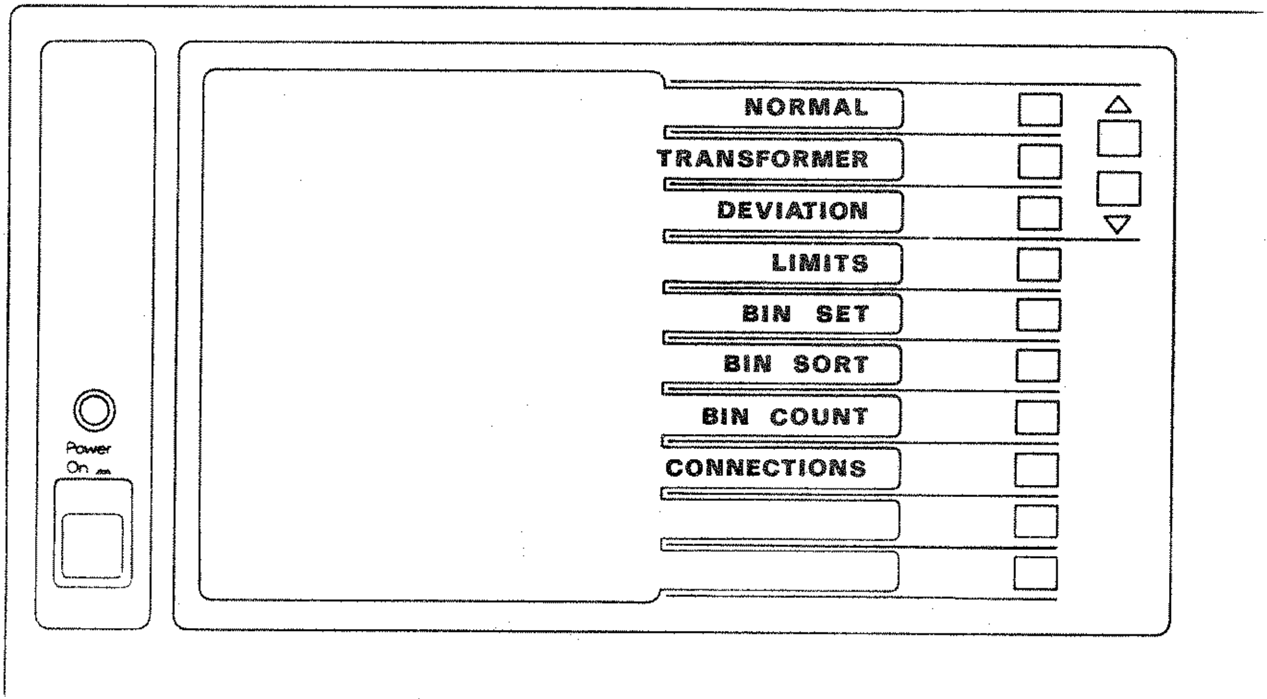


Figure 6 MAIN INDEX

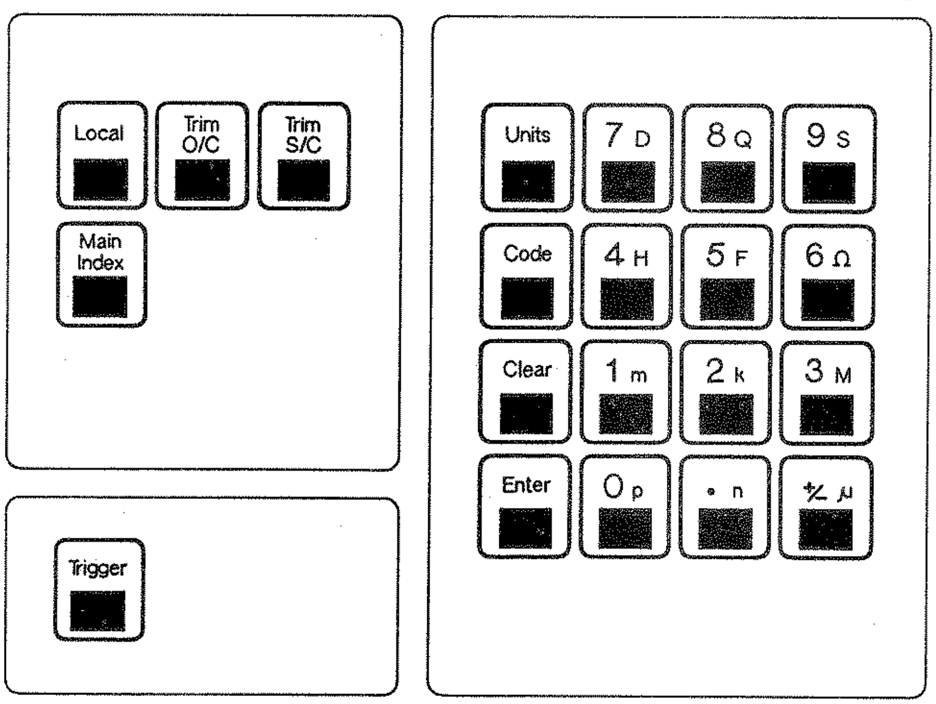


Figure 7 Main Function Keys and Key-Board

4. OPERATION

4.Ø1 BASIC INFORMATION

4.Ø1.Ø1 POWER SUPPLY - Leads and Adjustments - and INITIAL USE

The power lead shipped with the analyzer has a moulded supply plug. Users fitting an alternative plug should note the lead colour code:-

LINE → BROWN; NEUTRAL → BLUE; GROUND → GREEN/YELLOW

For operator safety the GREEN/YELLOW lead must be grounded.

Before first use of the 3245 Analyzer, ensure that the supply frequency, voltage settings and fuse rating are correct, then connect the supply and switch on. The instrument will operate with the power frequency incorrectly selected but for full specified accuracy correct setting is essential.

Operation is monitored on and prompted by screen displays e.g.figures 6, 13 etc. The display brightness control is on the back panel (figure 32).

The TRIM state, as last set in the factory, will normally be applied at power-up. Since the supplied connections may not be those used for the pre-despatch test, connect the operating leads and retrim. (When connecting the supplied test leads, match coloured sleeves to coloured sockets. Alternative leads should be constructed as described in section 4.Ø9.Ø2.)

The analyzer may be rack mounted on suitable runners; a kit of brackets and screws is available (see 3.Ø2.Ø2). Adequate ventilation is required but the top and bottom covers must stay fitted during use.

4.Ø1.Ø2 BASIC FEATURES

Display at power-up is normally as at last usage except that the BIAS will be turned OFF and, when SINGLE SHOT was operative, there will be no measurement result. If the previous 'set-up' has been lost - arising from corruption of non-volatile RAM - then a warning is displayed; see section 7.Ø2.Ø2. At this state TRIM, then key-in new data.

1. Press MAIN INDEX to display the operating modes. Any may be selected by pressing the button adjacent to its displayed legend. The keyboard, figure 7, is for entry of data not otherwise selected.

2. Maximum ac signal level varies with selected impedance range:-

Z < 1Ø ohms;	1ØØmA rms maximum
1Ø < Z < 8Ø ohms;	1V rms maximum
Z > 8Ø ohms;	5V rms maximum (3V at 3ØØkHz)

   The displayed MINOR TERM on the Z function can be the drive dependent parameter - unknown voltage (current drive selected) or unknown current (voltage drive selected).

3. A suitable test item must be connected before BIAS can be enabled. To avoid risk of shock from back emf, always turn OFF the BIAS before disconnection. The 3245 is internally protected against back emfs.

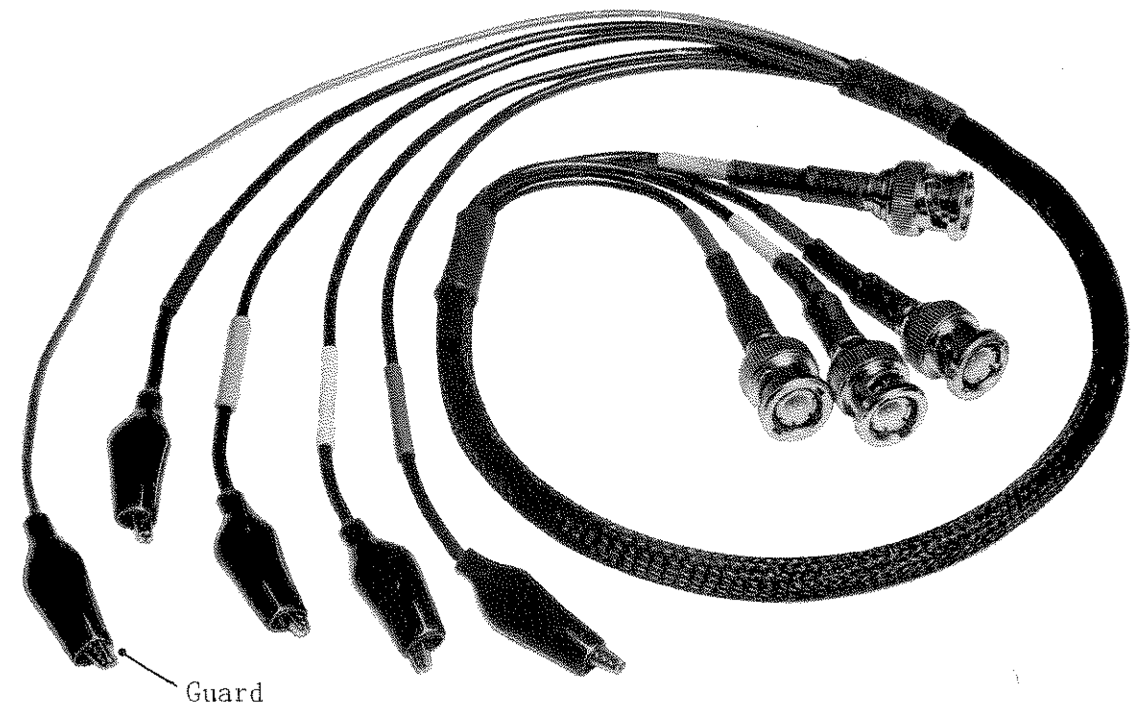


Figure 8 Crocodile clip leads (13Ø5)

Figure 9 Component Fixture Unit (1ØØ5)

4.01.02 BASIC FEATURES (Continued)

4. Link the BIAS terminals on the rear panel (figure 32) if measurements using the internal BIAS current are intended. Before measuring inductors which may be damaged by dc BIAS e.g. tape heads, microphone inserts etc., remove the link as a safety precaution.

5. A fixed low level dc of <100mV, from a source impedance of approximately 55 ohms (NORMAL range) or 7 ohms (LOW range), is used for Rdc measurements. There is no MINOR TERM. Selecting Rdc extinguishes the frequency and BIAS displays and turns BIAS OFF.

6. The analyzer continuously seeks the appropriate working range when in AUTO mode. The HOLD state permits user selection of any range by code via the key-board; see section 7.02 for codes and ranges.

7. Alternative measurement speeds can be selected - NORMal, FAST or SLOW - by pressing the adjacent key. All speeds slow progressively for frequencies below 300Hz.

   NORMal speed makes approximately three readings per second and provides full measurement accuracy.

   FAST speed makes approximately eight readings per second, suited to initial settings of adjustable components. Accuracy and resolution are reduced.

   SLOW speed makes approximately one reading per second and results in the highest resolution. This speed is suitable for situations where test components are susceptible to power supply pick-up.

8. Key-board data entries are echoed on the bottom (data) line of the screen.

9. Messages and warnings appear as appropriate at the upper and lower levels of the screen. Do not ignore them.

Comparative and selective measurements can be made by the analyzer (DEVIATION, LIMITS and BINNING); these are particularly useful in production work, especially when used with the component fixture accessory.

4.01.03 CONNECTIONS

The available types of connection between the analyzer and test item are:-

Kelvin clip leads (figure 10, 1405) for 4-terminal measurements.
Crocodile clip leads (figure 8, 1305) provide connections for 2- and 3-terminal measurements and transformer measurements.
Component fixture accessory (figure 9, 1005); for 4-terminal measurements.

The standard kit for shipment includes the first two (1305 and 1405); the fixture (1005) is available to order.

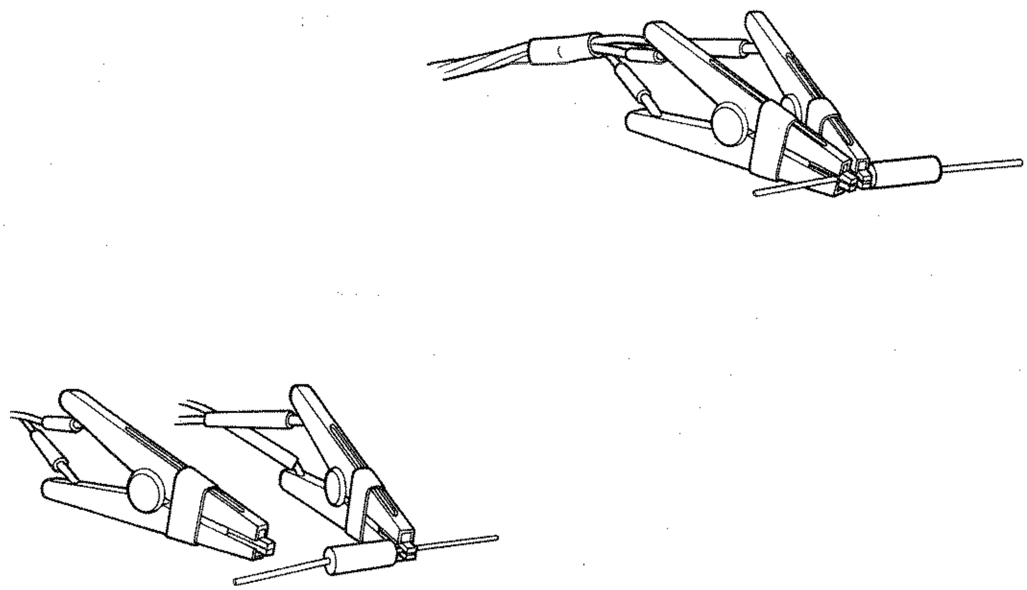


Figure 1Ø KELVIN clip leads (14Ø5) arranged for O/C and S/C TRIM

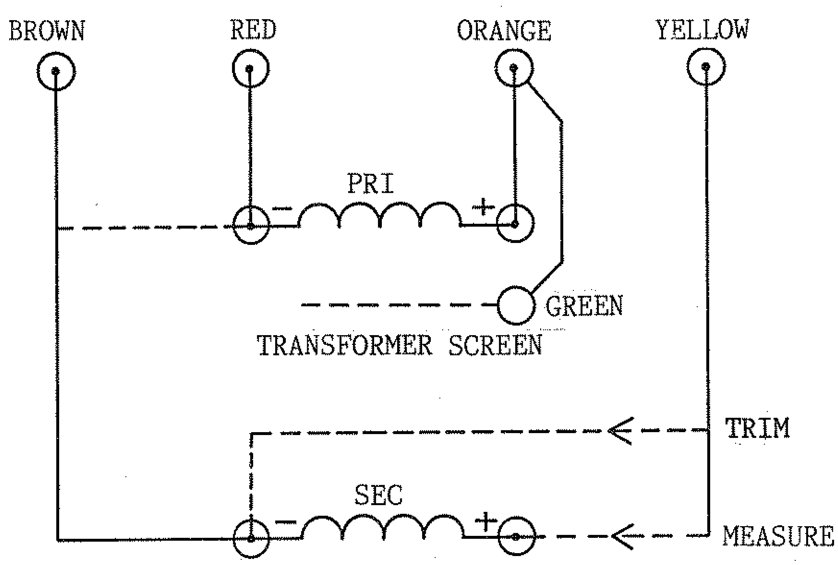


Figure 11 Component and lead arrangement for MUTUAL INDUCTANCE trim and measurement

(Preferably connect the GREEN clip-lead to the transformer screen or frame.) Note the indicated polarity (+) of the windings; non-compliance with this will result in a negative TURNS RATIO display.

4.01.04 TRIMMING

The purpose of trimming is to eliminate the effects of stray capacitance or series impedance in the connecting leads or fixture. It must be done each time that lead sets or component fixtures are changed.

At power-up the previously used trim values are immediately re-established from non-volatile memory. If the re-instated trim values will not be applicable or if maximum accuracy is required, automatic re-trim (S/C for low impedance measurements or O/C for high) can be obtained by pressing the appropriate TRIM button and complying with the ensuing prompts.

The connector jaws should be as close as possible for S/C trim and at least 5 cm from each other and anything else for O/C trim. See figures 10 and 11 alongside for connection arrangements.

DO NOT connect the Kelvin clips together for S/C TRIM.

All of the settings - trim values and interpolations - will hold for all styles and ranges of measurement except for transformer measurements for which a mutual inductance TRIM is available.

Trimming in preparation for measurements on MUTUAL inductance is controlled by soft-key (TRIM Lm). The leads must be placed as near as practical to the positions they will occupy during measurement (see figure 11 for connection arrangement) because the instrument cannot distinguish coupling between connecting leads from coupling in the device under test. The secondary winding should be short-circuited.

Trimming is done with ac drive of 1V or 100mA. Best measurement results are obtained under these conditions.

Greatest accuracy at a given measurement frequency is attained when trim operation is initiated with that frequency selected. The 3245 has available 42 set frequencies, any of which can be used during measurement. Trimming is performed for a sub-set of the 42, comprising 14 frequencies selected from an internal table <u>plus the specific one in use when trimming is initiated</u>. The sub-set frequencies have full trimming established. Frequencies excluded from the sub-set have trimming assessments made by interpolation thereby avoiding the need to re-trim when changing frequency. Initiating trim with the measurement frequency in use ensures a non-interpolated correction will be applied at that frequency.

Check trimming in the following manner:-

1) Clamp the test leads onto a heavy gauge conductor as for S/C trim; make a series inductance/resistance measurement. The results should be near zero.

2) Position the test leads for O/C trim, then make a capacitance measurement in parallel configuration. The results should be near zero for capacitance and OVER RANGE for resistance (implying a result close to infinity).

When measuring low inductive impedances or low capacitances very stable lead arrangements are essential.

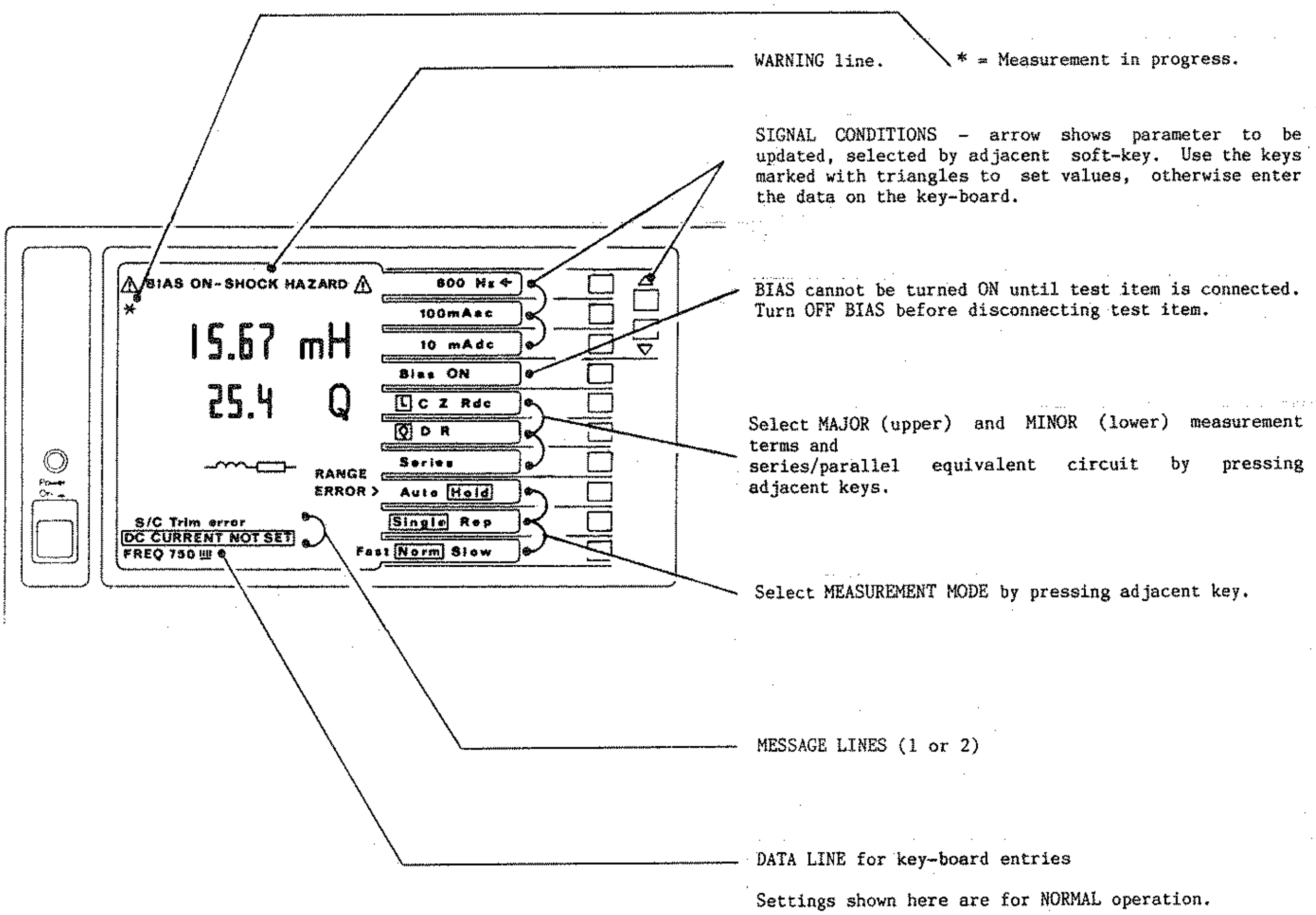


Figure 12 Composite display, NORMAL, series L, R measurement

4.Ø2 BASIC MEASUREMENT PROCEDURE

Measurements start with the MAIN INDEX display, see figure 6. Formats of other displays are shown in figure 12 (which is a specially prepared composite illustration). Operator actions for all measurement procedures of the 3245 are broadly similar. Detailed below are the actions for measuring an isolated component - typical model - series L,R. Figure 1 has the controls annotated.

a) Plug into the analyzer the appropriate set of leads; match colours
b) Switch on power to the 3245 analyzer
c) Trim the instrument if necessary - section 4.Ø1.Ø4
d) Connect the test item; the guard lead to frame or screen
e) Press MAIN INDEX BUTTON (16); display like fig. 6
f) Press the NORMAL button (1); display like fig. 12
g) Press the frequency button (1); arrow points to frequency
h) Press either 'Δ' button (11) to increment the parameter
or '∇' button (12) to decrement it (see note 3)
i) Repeat (h) to scan for a suitable frequency
j) Press the MAJOR TERM button (5); select function e.g. 'L'
k) Using the AUTO/HOLD button (8) select AUTO
l) Using the SINGLE/REP button (9) select REP
m) Press the ac drive button (2)
n) Repeat (h) to scan for a suitable drive level
o) BIAS: if dc bias is not required skip to (p)
oa) The BIAS should be OFF. <u>ON</u> would be a fault state
ob) Select BIAS LEVEL button (3)
oc) Repeat (h) to obtain the required BIAS level
p) Press the MINOR TERM button (6) to step to required item
q) Using configuration button (7) select form required
r) Press the SPEED button (1Ø) to select measuring rate
s) If BIAS is required ensure link is fitted before
switching the BIAS ON with (4)
t) Read the measurement from the screen
u) If BIAS is ON, switch it OFF with (4)
v) Disconnect the test item
w) Similar tests may be made by repeating from (c, d or g)
x) The analyzer may now be turned OFF.

Notes:

1) Single-shot option at (1) requires TRIGGER after (s)

2) The instrument indicates measuring is in progress by displaying an asterisk "*" in the top left-hand corner of the screen. In single-shot mode the result is blanked until the process is complete. In repetitive mode the previous result remains displayed until the asterisk "*" extinguishes.

3) Alternatively measurement conditions may be entered directly using the key-board. See section 4.Ø9.11.

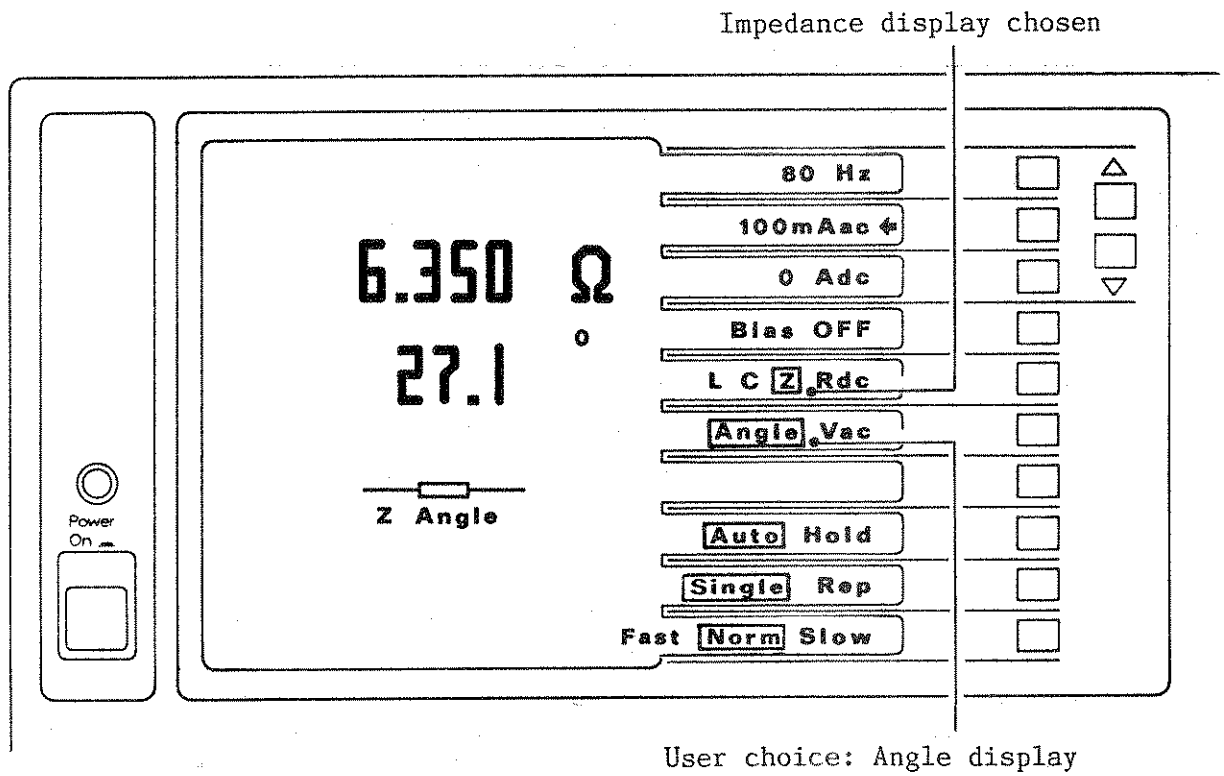


Figure 13 NORMAL, Z, angle

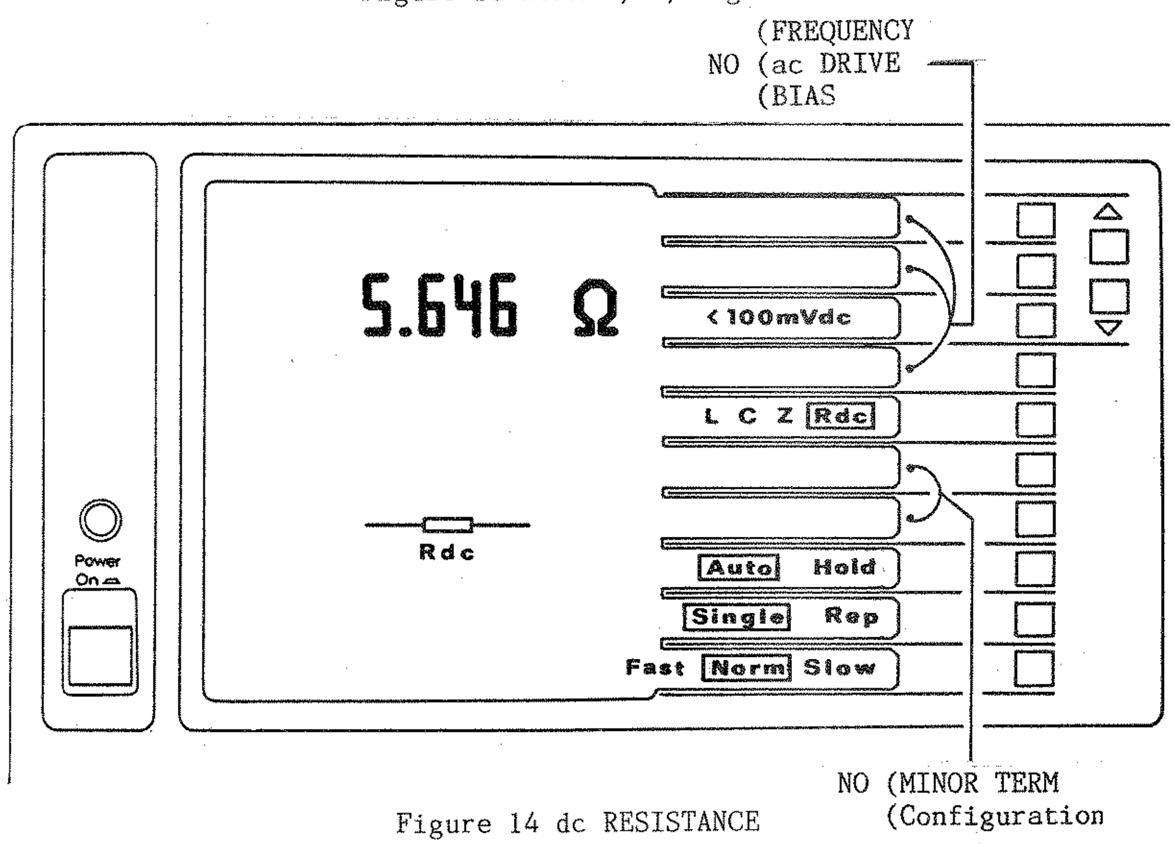


Figure 14 dc RESISTANCE

4.02 BASIC MEASUREMENT PROCEDURE (Continued)

The display shown in figure 13 is typical of Z/θ presentations; note the boxed Z and ANGLE together with the single element configuration. The angle value shows the impedance to be highly resistive; the polarity (implied +ve) indicates that the impedance is inductive at the applied frequency (80Hz).

As an alternative to ANGLE two other Z displays are available. The selection is shown in the box next to ANGLE. When current drive is applied then Vac, the voltage developed across the unknown, can be displayed. When voltage drive is used then Iac, the current through the unknown, can be displayed.

The 3245 has two ranges for measurements of dc resistance e.g. of the intrinsic resistance of coils. When in the NORMAL mode select the MAJOR TERM as Rdc. The frequency, ac drive level and BIAS soft-key legends extinguish together with those for MINOR TERM and configuration. The dc drive level is automatically limited to a maximum of 100mV or 16mA. Figure 14 depicts the screen display for a resistance measurement.

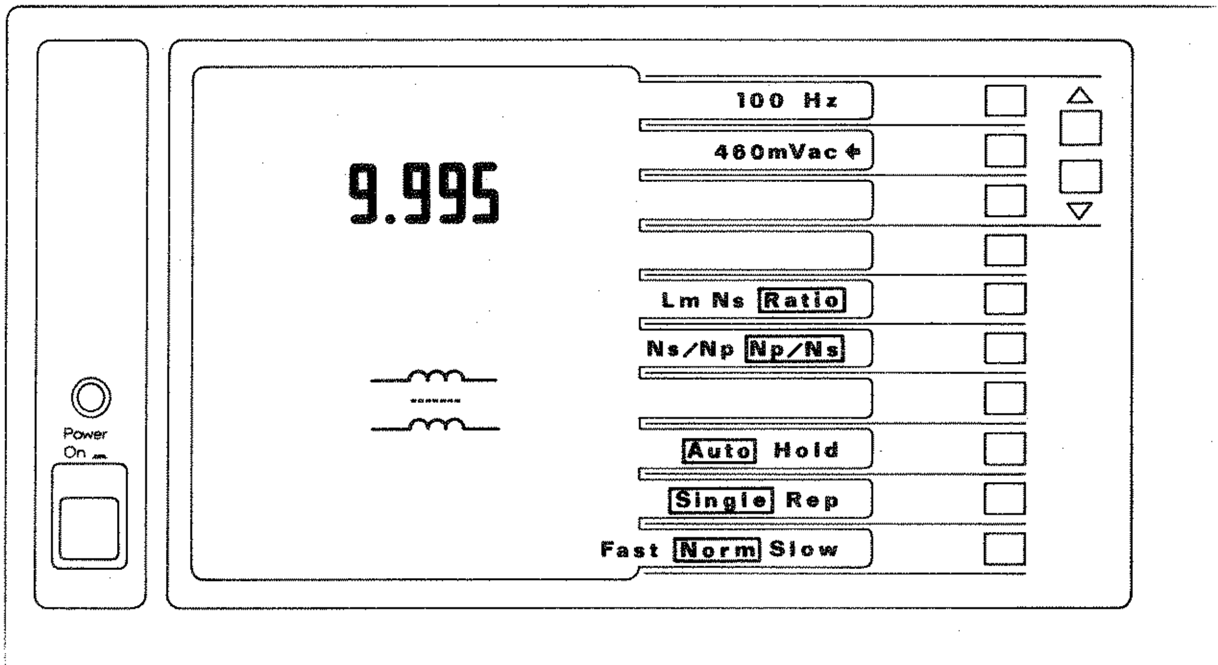


Figure 15 Np/Ns Ratio

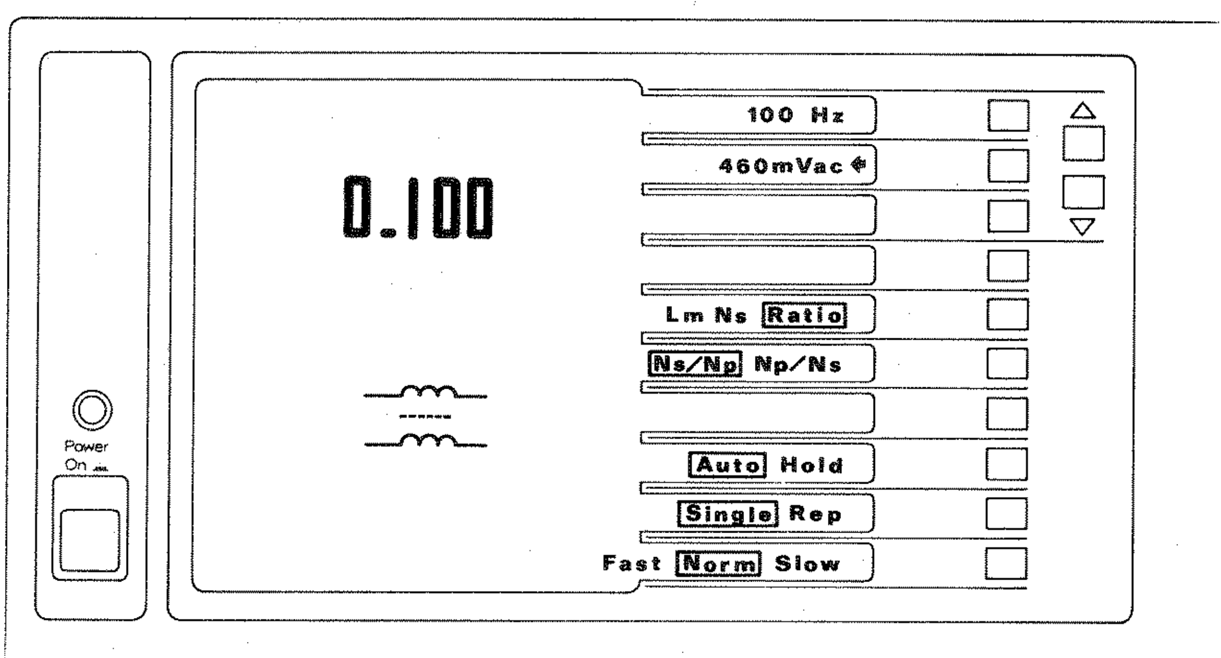


Figure 16 Ns/Np Ratio

4.Ø3 TRANSFORMER MODE

Use crocodile clip leads for transformer winding ratio measurements. RATIOs can be displayed as Np/Ns or Ns/Np. When maximum resolution is required choose the display which is greater than unity. The value displayed is the ratio of measured voltages, hence non-integer results are likely. Trimming (TRIM Lm) is not necessary for RATIO measurements.

For measurement purposes the PRIMARY is the winding connected to the RED and ORANGE sockets, see figure 11.

The connections to the test item for figure 16 were identical to those for figure 15, only the display requirement was changed. Note the result is of only three figures resolution.

If a negative reading occurs when measuring ratio it implies a reverse connected winding; see figure 11 for winding sense convention.

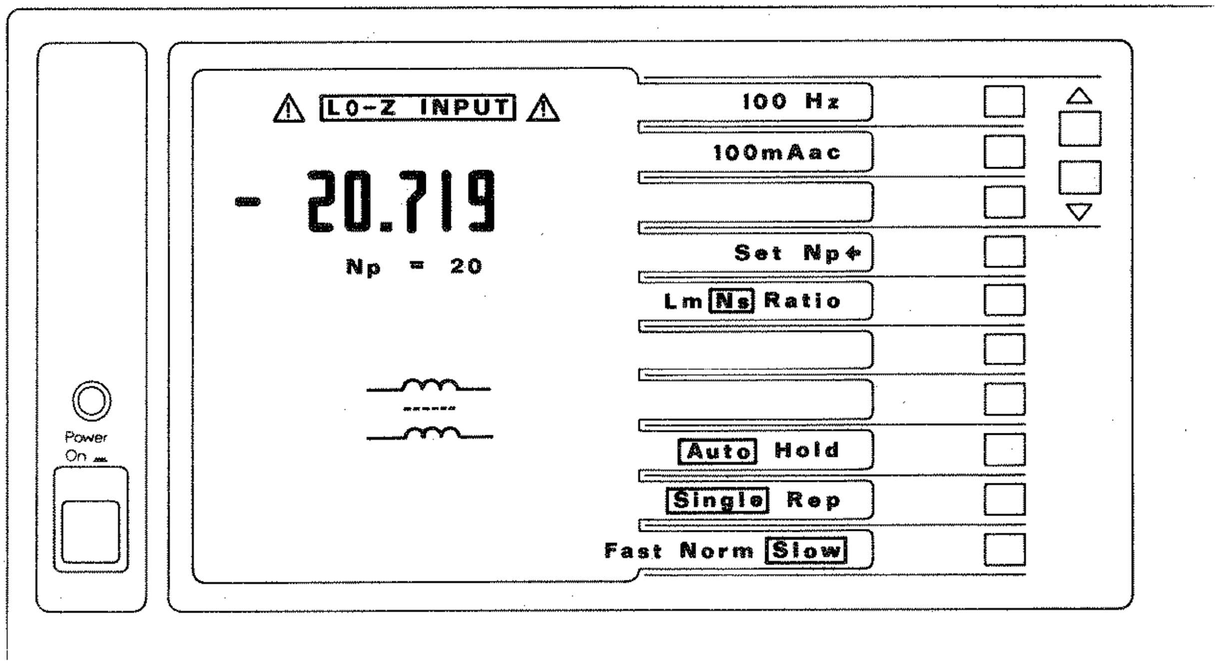


Figure 17 SET Np (Primary turns)

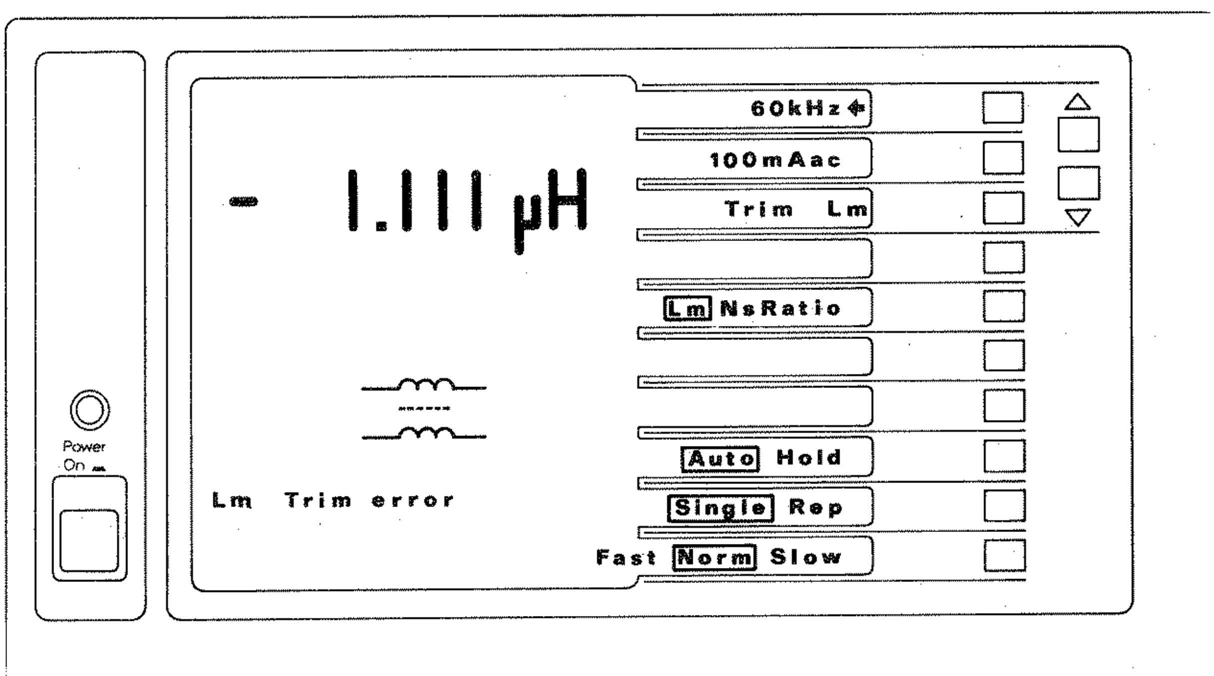


Figure 18 MUTUAL INDUCTANCE

4.Ø3 TRANSFORMERS (Continued)

A SECONDARY turns (Ns) measurement is shown in figure 17. The PRIMARY turns (Np=2Ø, arrowed SET Np) are set via key-board.

The negative reading for SECONDARY turns shows that the measurement connections to the two windings are not in accordance with figure 11 (note the polarity indications).

The upper warning (LO-Z INPUT) means that the measured PRIMARY impedance is particularly low (<5 ohms reactive in this case). Transformer measurements are made under 2-terminal operation so the effects of connection leads cannot be removed. See section 4.Ø9.Ø7 for critical aspects of transformer measurements.

A MUTUAL INDUCTANCE display is shown in figure 18. When Lm is selected the TRIM Lm option appears on screen. Lead positioning during performance of this trim requires extra care; see section 4.Ø1.Ø4.

The negative result in figure 18 arises from one of two possibilities. Either the frequency is above resonance, or a winding connection is reversed. Another measurement at a lower frequency is needed for resolution.

PRIMARY inductance can be measured as a two-terminal operation when using the analyzer on any of the above transformer measurements; simply remove the analyzer connections to the SECONDARY then select NORMAL mode and INDUCTANCE measurement.

A negative reading when measuring PRIMARY inductance indicates that the frequency used is above resonance, consequently the test item is effectively capacitive.

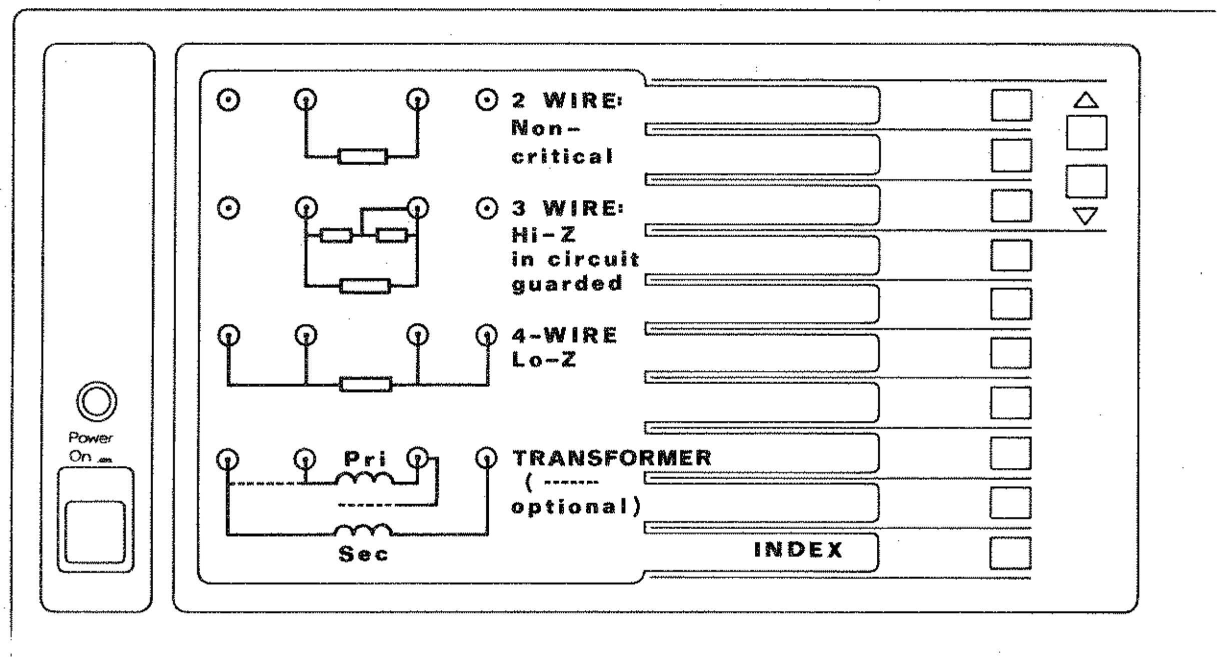


Figure 19 CONNECTIONS

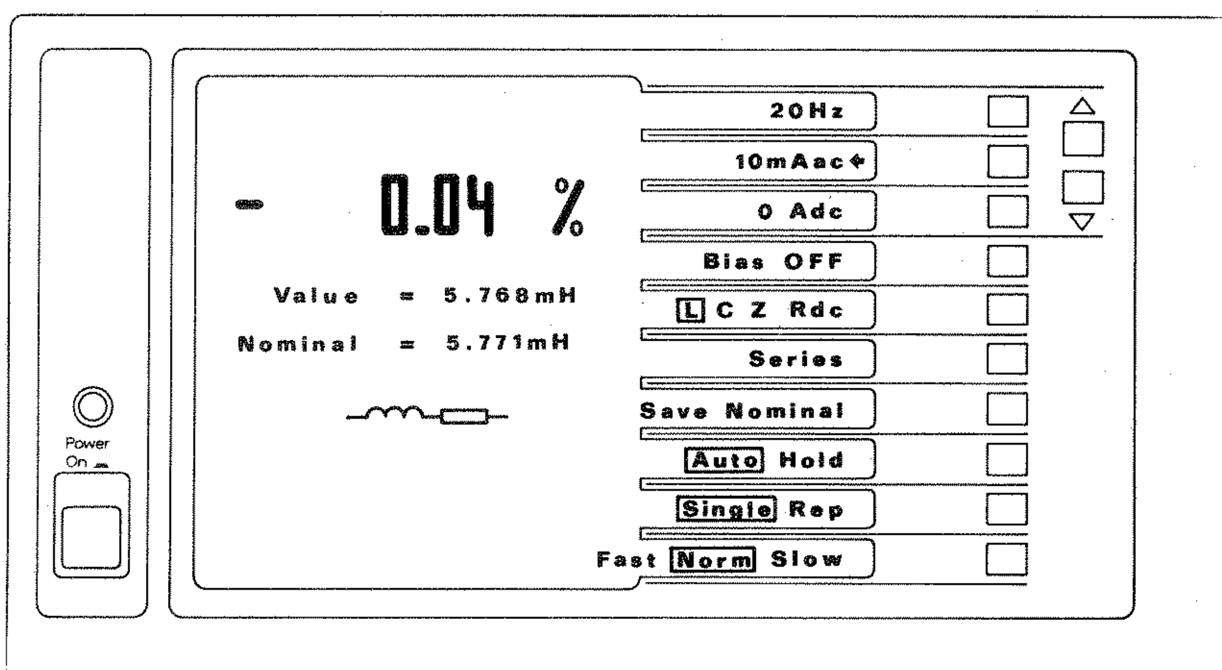


Figure 2Ø DEVIATION

4.Ø3 TRANSFORMERS (Continued)

Connections for transformer measurements are shown in figure 11 but for immediate access the CONNECTIONS display (figure 19), which illustrates the various arrangements, is available from the MAIN INDEX. The four rings represent, from left to right, the front-panel BNC connectors, BROWN, RED, ORANGE and YELLOW. The bottom arrangement, for TRANSFORMERS, requires the use of the crocodile clip leads. Note the optional connection to the winding screen and particularly the arrangement for inter-connected windings.

The phase interpretation for the windings is that the free (non-common) end of each is of the same phase - marked with a '+' in figure 11.

In the case of auto-transformers, it is preferable to measure them in step-down configuration, connected as follows:-

The YELLOW lead connects to the winding TAP.
RED and ORANGE leads go to the winding OUTER connections.
The BROWN lead connects to the same terminal as the RED lead.

The display in figure 19 provides a direct return to the main index - useful during the course of establishing measurement conditions.

4.Ø4 DEVIATION MODE (Single component behaviour)

The prime purpose of DEVIATION mode is to measure parameter variations of a single component as drive conditions etc. change. Batch sorting of components is done in the LIMITS mode, see section 4.Ø5.

To make DEVIATION measurements first establish the nominal value of the component under reference conditions - frequency, BIAS, drive etc. The result will appear against the VALUE legend on the screen. Pressing the SAVE NOMINAL soft-key will store the measured value and also copy it to the NOMINAL display. Measurements at other test conditions can then be made. Results are presented as percentage differences between the nominal and actual values for the MAJOR TERM. A negative value shows that the test result is low compared to the nominal.

Figure 2Ø illustrates this presentation. Any MAJOR TERM can be assessed in this manner.

A MIS-MATCH message appears if the units used for the test do not match the units of the saved NOMINAL. Omitting to save a freshly established NOMINAL - the first step above - is a common cause. The omission results in use of NOMINAL units saved from some other test.

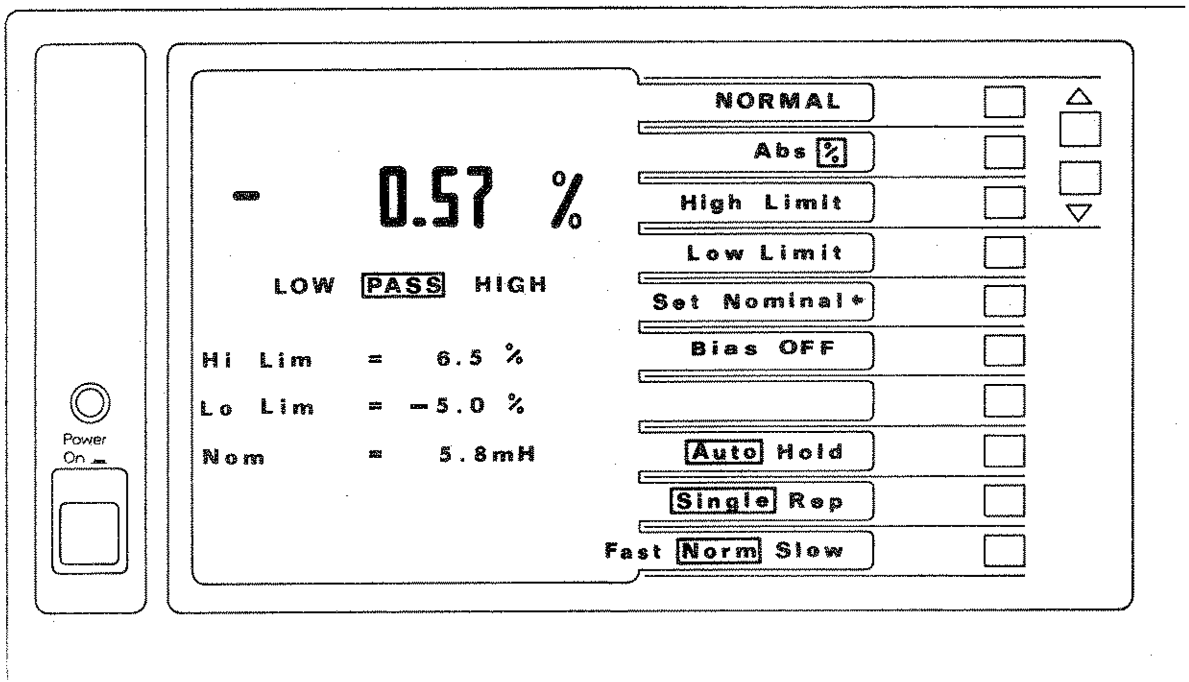


Figure 21 LIMITS % (Percent)

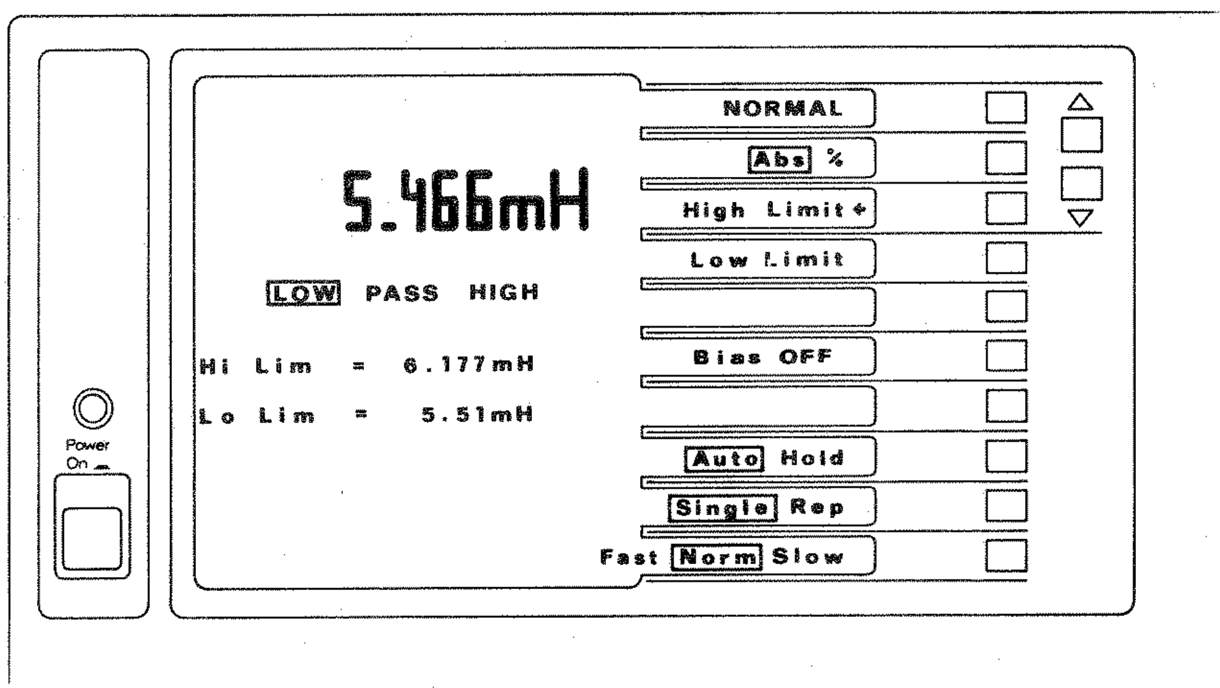


Figure 22 LIMITS Abs (Absolute)

4.05 LIMITS MODE (Batch measurements)

LIMIT measurements are displayed in either of two forms - percentage or absolute. The limits and the nominal value have to be entered via the key-board - there is no facility for saving a measured NOMINAL as DEVIATION mode.

The high limit value must be higher than the low limit value; 'crossed-over' limits are not acceptable in this mode.

A nominal is required only for percentage measurements. Generally symmetric limits will be used, but asymmetric percentage limits can be established. However, the two displays are linked; whichever form is used the values of the limits are maintained.

When absolute limits are set, the analyzer operates without a nominal value. When operation is changed to percentage mode, the display will show the corresponding pair of limits and a mid-way nominal value. If required, specific nominal and/or percentage limits may then be set; they will be reflected in revised absolute values.

The function settings which apply in the LIMITS operation are not directly displayed. They are whatever were last set in the NORMAL mode and can be found by switching to that mode.

Measurement parameters (L, R etc.) and units (mH, ohms etc.) for HIGH, LOW and NOMINAL in the LIMITS mode are compared with those used for the MAJOR and MINOR terms in the NORMAL mode. The message 'MEAS/NOM UNITS MIS-MATCH' is displayed if the settings do not match either.

Figure 21 shows a percentage limit display; the limits are asymmetric. The measurement (PASS) is just a little below the nominal value but well above the lower limit.

Figure 22 illustrates the same settings but with ABS display selected. In this case the measurement value is below the LOW limit.

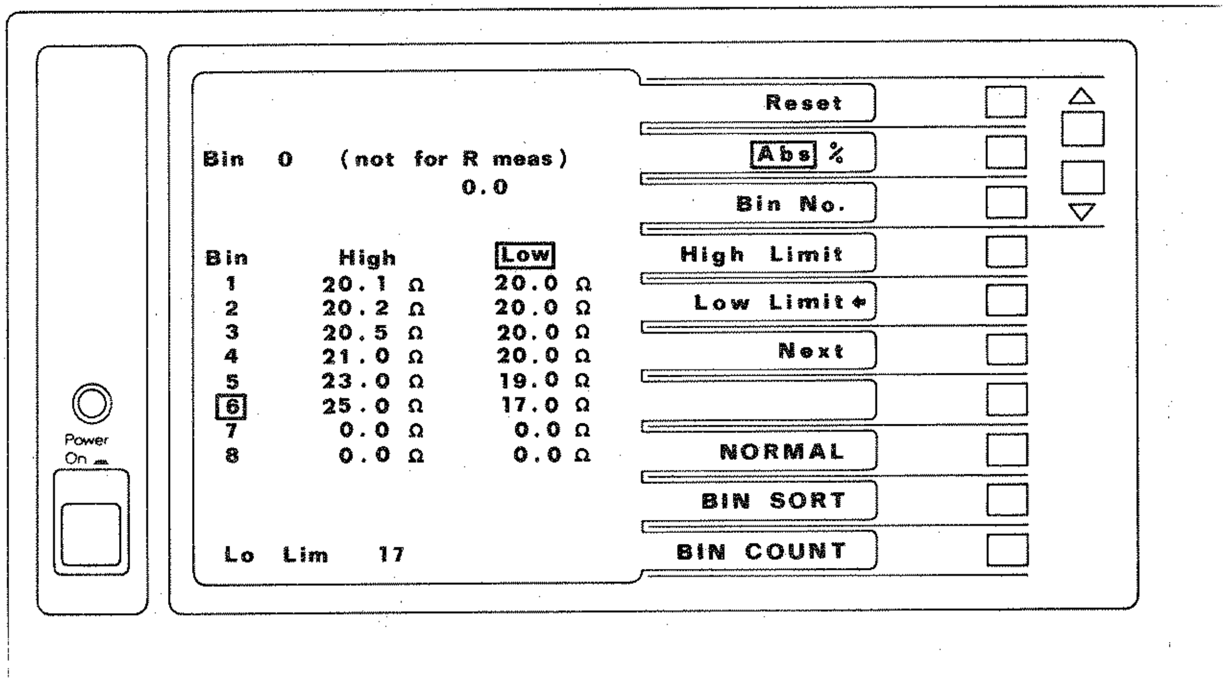


Figure 23 BIN SET Abs (Absolute)

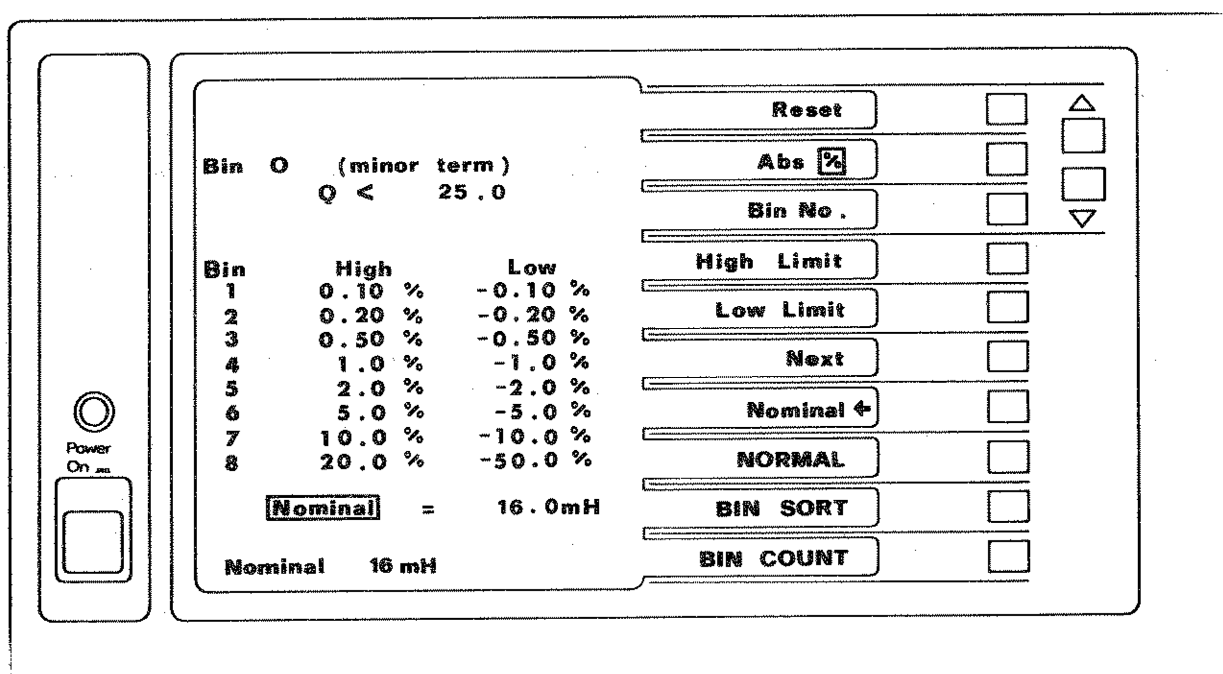


Figure 24 BIN SET % (Percent)

4.Ø6 BIN SET

There are three features concerned with binning - setting the discrimination limits, sorting measured values and displaying the consequent counts. Associated with the second is the electrical interface to binning equipment.

Binning can be done either on an absolute or percentage limits basis. Select BIN SET mode via the MAIN INDEX and choose ABS or % as required; the display should be similar to figure 23 or 24. In ABS mode, units for the limits must be keyed-in (the same for each limit, e.g. all sorting on Ω). In percentage mode, the nominal must have units keyed-in. The parameters and units used for binning must match those in the NORMAL mode (as is the case in the LIMITS mode). Any necessary correction can be made from NOMINAL mode after setting the limits.

Each choice (ABS or %) has its own set of limits although there is one common set of bins. Unlike the LIMITS function, the two sets of binning limits are not linked. Whichever set is chosen, existing limits for that mode can then be reset for a specific bin number, either by explicitly entering zero values in each limit or by pressing the RESET soft-key (button 1). Although RESET puts both the high and low limits to zero (useful for removing old values), it is primarily intended for shutting off unwanted bins after setting other values. If percentage binning is intended, the nominal value should be entered at this point by selecting the NOMINAL soft-key (button 7) then entering the desired value on the key-board.

To select a specific bin, press the BIN NO. soft-key. The actual number may then be chosen via the key-board or either of the AUTO SWEEP keys can be used - they provide a controlled cycling through the bin number range. The latter method of selecting bin numbers is always operational. When a bin number has been selected, press either the HIGH limit or LOW limit soft-key to allow entry of a value via the key-board (units will be required when ABS is used). The current selection remains boxed. Enter the required value and units on the key-board. Another bin may then be selected.

Usually the bins will be dealt with in sequence; selection of the next limit for data entry is achieved by pressing the NEXT soft-key. This steps selection, column by column, row by row. Note that in % mode, symmetrical limits are obtained by default by double use of the NEXT key.

Figure 23 depicts the result of BIN SET actions for ABSolute values - in this case, ohms. Note the asymmetric limits and the partial use of the bin range. The bins with zero limits will not be used.

Figure 24 is for a typical percentage limits case. It shows the nominal data entry and the use of Bin Ø.

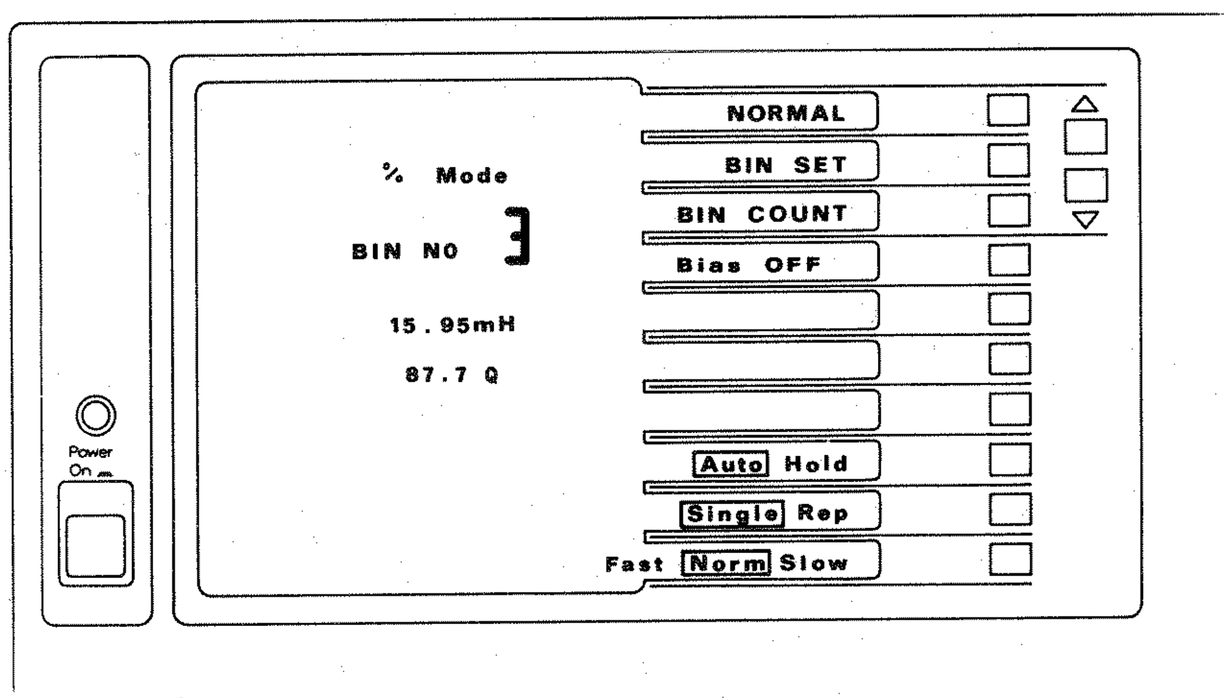


Figure 25 BIN SORT

4.Ø6 BIN SET (Continued)

Once satisfactory sets of limits and units are established, test items can be assessed by selecting BIN SORTing mode or BIN COUNTing mode.

Note the following points about BIN SET operations:-

a) The limits do not have to be symmetric.

b) The limits do not have to be unique. If there are more than one of a particular value, that with the lower bin number will be considered first.

c) When bins 1 to 8 are used for inductance or capacitance, bin Ø is used for MINOR TERM rejects. The rejects occur if the measured magnitude is below the selected limit (in the case of Q or parallel resistance), or above the selected limit (in the case of D or series resistance).

d) Bin 9 by default is for measurement results outside the limits of bins Ø to 8 inclusive.

4.Ø7 BIN SORT

The BIN SORT mode operates under SINGLE SHOT and REPetitive modes. In use, the screen display shows the result of the current measurement and the corresponding individual classification; see figure 25. Note the provision of soft-keys for direct switching to NORMAL, BIN SET and BIN COUNT.

A mis-match message will be displayed if either the units for BIN Ø limits (MINOR term) or units for the BIN 1 to 8 limits (MAJOR term) do not match the units set for NORMAL measurement. Hence even if BIN Ø is not being used, it must be given a default limit e.g. Q=1, which matches the NORMAL mode, otherwise the BIN SORT function will not operate.

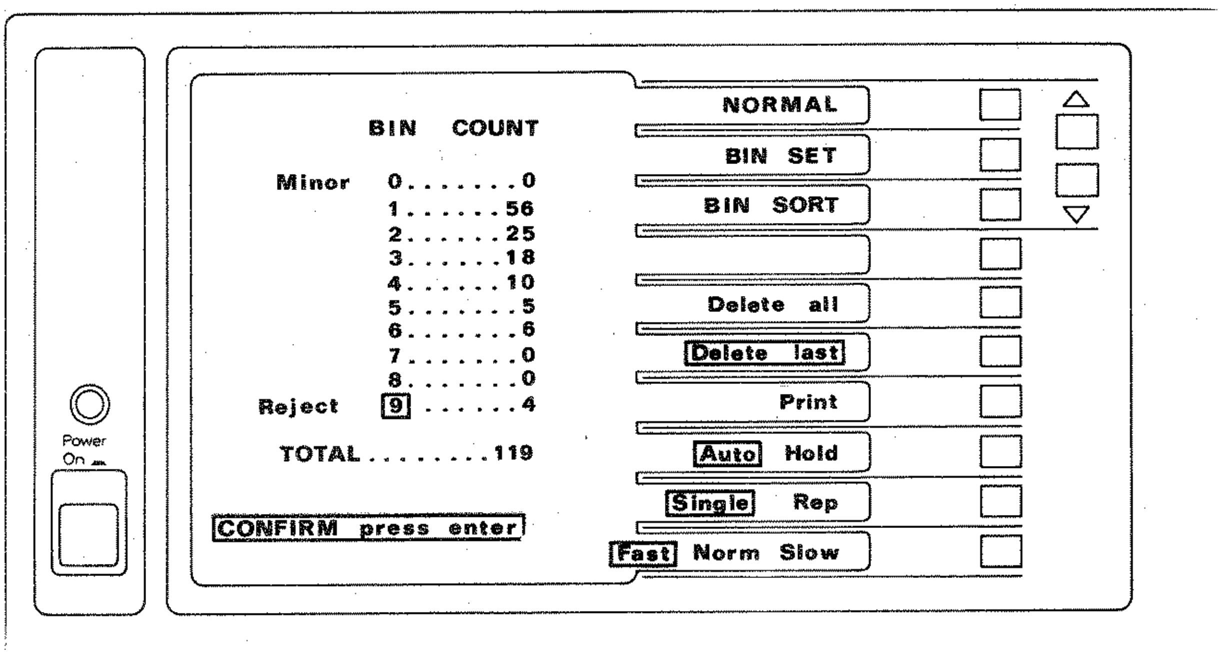


Figure 26 BIN COUNT (match)

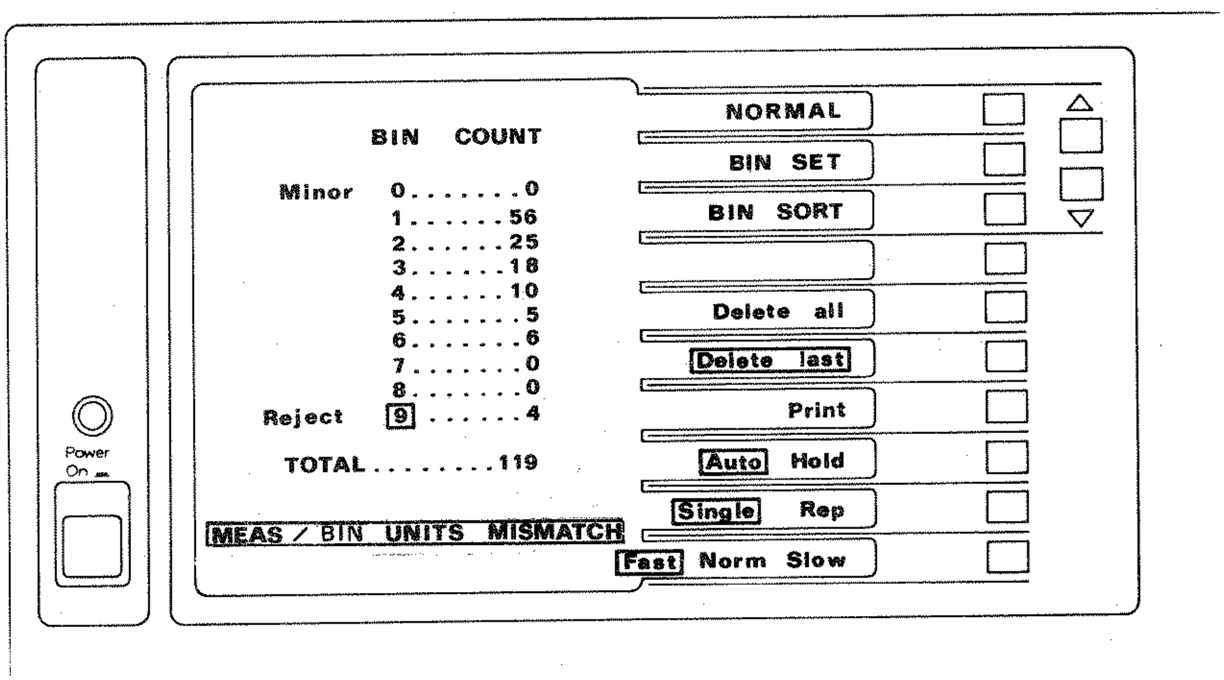


Figure 27 BIN COUNT (mis-match)

4.Ø8 BIN COUNT - Data Logging

BIN COUNTing operates under SINGLE SHOT mode. (It also operates, transparently to the user, when BIN SORT is used in SINGLE SHOT mode.) The screen displays data for all bins simultaneously, together with a batch total. Each measurement, as made, is allocated to the appropriate bin.

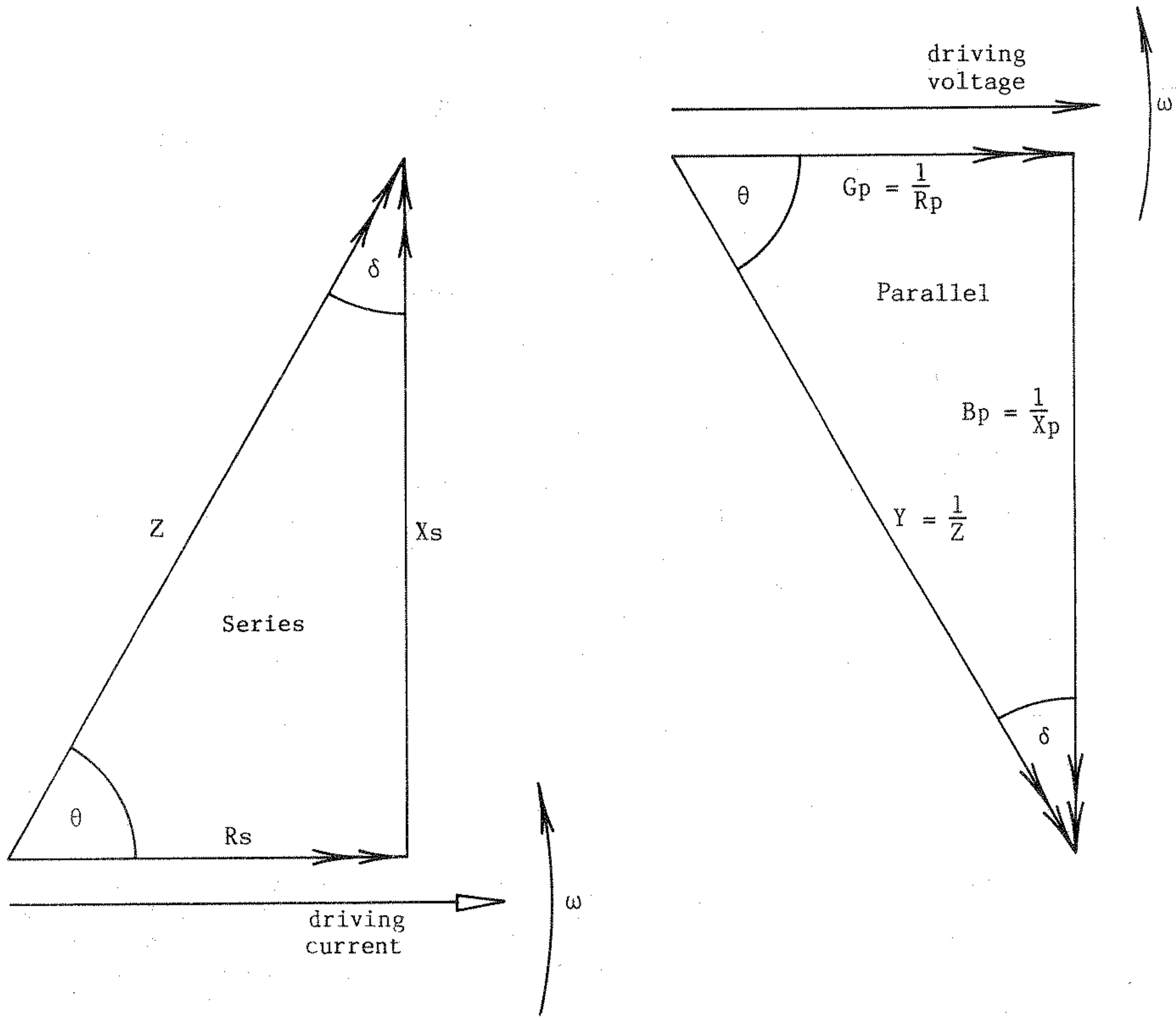
All BINning data stay in non-volatile memory until they are deleted. Hence the DELETE ALL key is used when setting-up for a new batch.

The DELETE LAST key is primarily meant for erasing the measurement result for a wrongly connected component.

Confirmation of a delete function has specifically to be given via ENTER (on the key-board) before the function is put into effect. The verification request is illustrated in figure 26. Note that there were four rejects on MAJOR TERM , none at all on MINOR. Also note the provision for direct switching to NORMAL, BIN SET and BIN SORT.

Figure 27 illustrates the situation where the settings for nominal and measurement units differ. This type of operator error can arise in BIN SORT and BIN COUNT modes, and happens from incompatibility of the units for BINs Ø and 1 to 8 and the units for NORMAL measurement. The analyzer maintains a constant check for this kind of error and a warning is issued if necessary.

The PRINT soft-key legend appears on the BIN COUNT display if the RS232C option is fitted or if the GPIB option is fitted and operating in PRINT ONLY fashion. See appendix B section 6.4 for details.



$$Q = \frac{Xs}{Rs} = \tan(\theta)$$

$$D = \frac{Rs}{Xs} = \tan(\delta)$$

$$Q = \frac{1/Xp}{1/Rp} = \tan(\theta) = \frac{Rp}{Xp}$$

$$D = \frac{1/Rp}{1/Xp} = \tan(\delta) = \frac{Xp}{Rp}$$

Figure 28 Impedance/Admittance Vector relationships

4.Ø9 ADVANCED USAGE

4.Ø9.Ø1 BASIC THEORY

A passive linear complex circuit presents to alternating currents an impedance which is a function of frequency. At any one frequency, the impedance can be represented by two components - resistance and reactance - or as a polar function having magnitude and phase angle. The reactance may be inductive or capacitive corresponding to +ve or -ve phase angles respectively in the polar configuration. The theoretical values of the components for extremes of frequency may not be practically realisable, but the following definitions hold:-

a) Polar parameters are impedance (Z) and phase angle (θ).

b) The impedance may be represented by either a series or parallel circuit - a resistance (R) and a reactance (X).

c) Current passing through the reactance results in stored energy, but current passing through the resistance results in dissipated energy. These two energy terms are related by the quality factor Q or dissipation factor D as defined below.

d) For the series case $R = Z\cos(\theta)$ and $X = Z\sin(\theta)$

where $Z^2 = R^2 + X^2$

i.e. $\tan(\theta) = X / R = Q = 1 / D$

e) For the parallel case $R = Z / \cos(\theta)$ and $X = Z / \sin(\theta)$

where $(1 / Z)^2 = (1 / R)^2 + (1 / X)^2$

and $\tan(\delta) = X / R = D = 1 / Q$

f) For the energy terms:-

$Q = X / R$ (series)

or $Q = R / X$ (parallel)

and $D = 1 / Q$

g) For inductances, $X = \omega L$

and for capacitances, $X = - 1 / (\omega C)$

where $\omega = 2\pi f$ (frequency)
and the '-' sign represents a voltage phase lag with respect to current as opposed to a leading phase for inductances.

h) Diagrams representing these relationships are in figure 28, opposite.

Section 4.Ø9.1Ø covers the effects of self-capacitance and resonance.

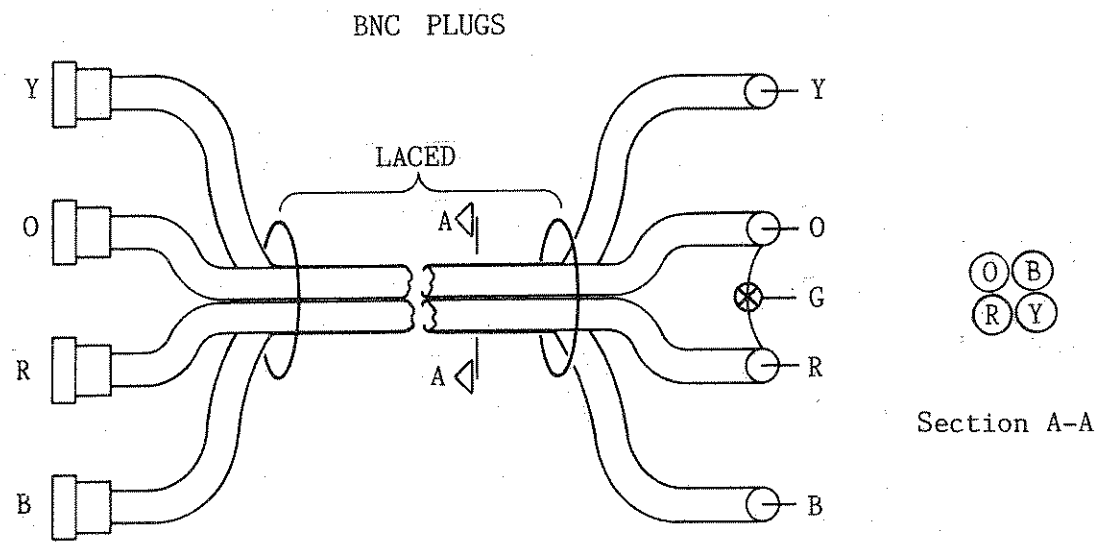


Figure 29 Test Lead arrangement

4.Ø9.Ø2 CONNECTIONS

Measurement connections may be 2, 3 or 4-terminal. The CONNECTIONS display, figure 19, shows some common arrangements. Choose 2-T for non-critical work, the guarded 3-T arrangement for in-circuit and high impedance measurements, and 4-T for low impedance work. A guard-wire at ground potential is available for guard or screen connection, see above. Note the lead bundling. Choose frequencies to minimise extraneous effects if measuring small impedances.

a) Impedances (at test frequencies) within 1ØØohms and 1Økohms are suited to 2-T connection. Unscreened leads should be shorter than approximately 15cm long. Longer leads should be separately screened; use a common connection of both braids ('RED' and 'ORANGE' leads) at the test item end. The crocodile clip accessory 13Ø5 is recommended.

b) 3-terminal connections remove the effect of shunt capacitance of the connecting leads. The common point of the shunting components should be connected to the common point of the braids on the 'RED' and 'ORANGE' leads. The crocodile clip accessory 13Ø5 is recommended.

c) 4-terminal connection circumvents series resistance of the leads, and diminishes series inductance effects. Stable lead positioning is important when measuring low value inductors. Long leads worsen series errors. The KELVIN clip-lead accessory 14Ø5 is recommended.

d) Connect transformer windings with crocodile clip leads (2-T fashion); apply ratio correction (section 4.Ø9.Ø7) if the primary winding impedance is low. (No correction is required in this respect for MUTUAL inductance measurements.) The errors are due to shunt impedances. A reverse-connected winding will lead to a negative reading for turns or ratio. See section 4.Ø3 for further details.

4.Ø9.Ø2 CONNECTIONS (Continued)

e) Braid screening of the 'RED' and 'ORANGE' leads should be joined at the test item end. Connect the common point to component guards and/or screens. The 'BROWN' and 'YELLOW' leads' braids must NOT be connected at the test item end. All the braids are earthed internally at the instrument end. The KELVIN clip-leads accessory is constructed so; it has a 'fifth' (GREEN) wire (with a crocodile clip) for use as the common connection; see figures 2 and 29.

Leads made for special measurement situations may present problems when the unknown impedances are either low or high. Any extra series resistance and shunt capacitance will result in additional errors. The type of error will depend on the connection configuration.

Extending lengths of measuring cable has two adverse effects:-

1) Resistance of the central conductor reduces the effectiveness of the 4-T configuration; degradation is linear with lead resistance. For example: After trimming with connections of Ø.45ohms/lead, variation in contact resistance will be reduced by 1ØØ times compared with a 2-T connection.

2) Cable capacitance increases measurement errors at high impedances and high frequencies. A capacitance of 1.5nF/cable gives performance within 2:1 of claimed specification on the highest measurement range available at any level/frequency combination. At lower ranges and at a frequency less than 5kHz errors are negligible. Where use is restricted to impedances greater than about 1ØØ ohms the 2-T configuration may be used with capacitance up to 3nF/cable.

Bundling the cables affects low impedance TRIM, mainly on inductance. The arrangement shown in figure 29 is preferred.

4.Ø9.Ø3 MANUAL RANGE SELECTION (and DRIVE LEVELS)

Manual range selection (RANGE HOLD mode) is by codes 1 - 7, see section 3. Manual ranging for transformer tests is not feasible. The present range can be determined via the key-board using CODE 9; see section 7.Ø2.

Use of the RANGE HOLD is recommended for the following measurements:-

a) Inductors of extreme non-linearity; these may lead to the AUTO-RANGE routines hunting, trying to resolve inductance variations caused by changes in drive levels.

b) Impedance values near to a range boundary may lead to the drive switching between voltage and current modes when successive test items are similar in value. (Hysteresis in the drive decision system avoids this problem when any one component is being measured.)

Small variations in drive level at the connections, as the unknown impedance changes, arise from regulation inherent in the source. The effect is insignificant except when the unknown is about 1Øohms.

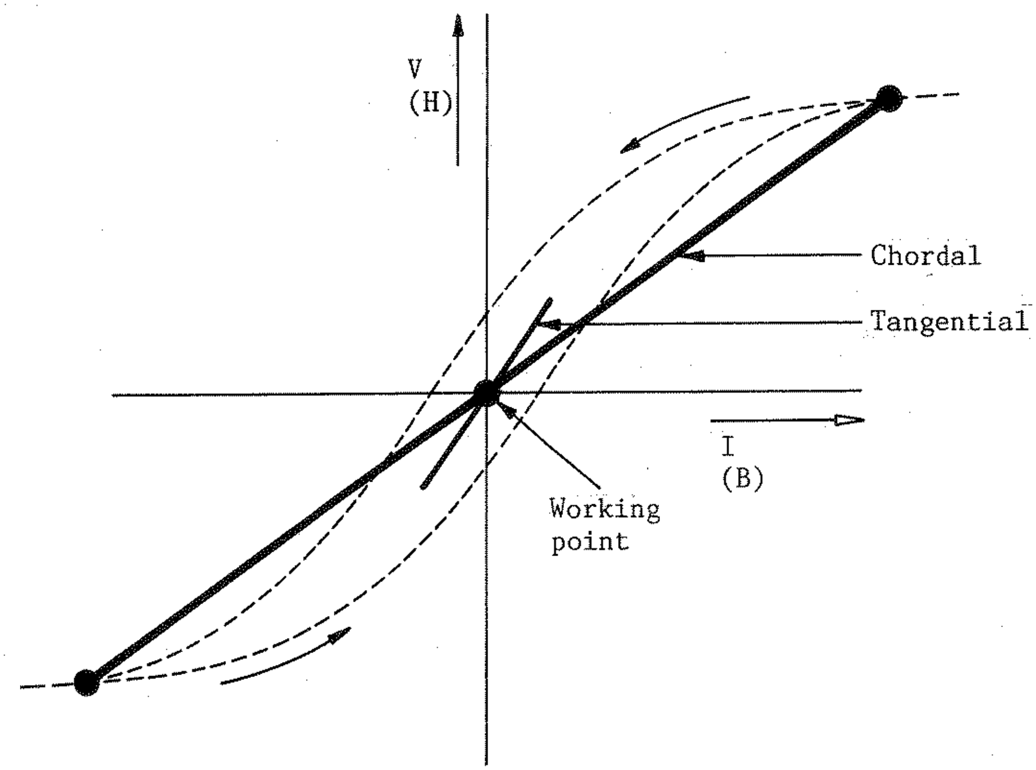


Figure 3Ø V/I Characteristic of Iron-cored Coils. Measurement is integral of curve - between chordal and tangential values

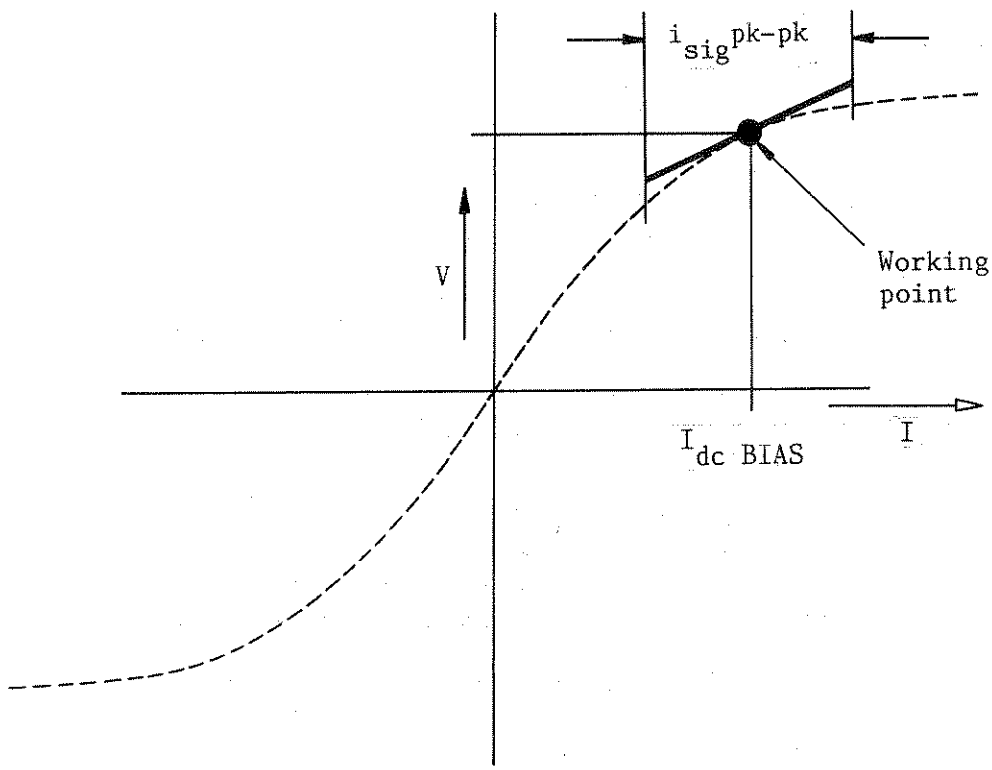


Figure 31 High Flux measurement
Small i_{sig}: Large $I_{dc\ BIAS}$

4.Ø9.Ø4 IRON-CORED (and FERRITE-CORED) INDUCTORS

Measurement accuracy, in part, depends on the linearity of the test item response. Gapped cores usually give good linearity. The level and frequency can be chosen to suit the application.

Un-gapped cores always cause non-linearity. Inductance usually rises with increasing flux level until saturation is approached. Once saturation is reached, the inductance falls rapidly as drive level continues to rise.

Non-linearities arise from the curved nature of the V/I characteristic of iron-cored coils. The 3245 analyzer filters out the distortion, consequently it measures the integrated value of the curved characteristic, see figure 3Ø.

Iron-cored inductors, including transformers, are susceptible to disaccommodation arising from electrical, magnetic, mechanical and thermal shock; any of which can produce transient or permanent change in inductance. The effect is worst in un-gapped iron-cored inductors at low drive levels. Obviously the shocks can be caused by large changes in level of the driving signal, it is therefore advisable to change the drive level in small increments. The transient changes have long recovery time-constants, so successive measurements (at the same conditions) on a shocked inductor, will show unidirectional changing values. The time taken for the overall change of level, will depend on the component itself and the accuracy required.

A change in frequency may lead to a change in drive mode e.g. from current to voltage. Since constant flux arises from constant current application, not constant voltage, note the displayed drive condition.

The 3245 uses low power levels. High operational flux conditions are beyond the specification but high level performance can be indicated using a combination of ac drive and dc BIAS, see figure 31. The working point slope will differ from that for full ac drive condition, see figure 3Ø. This technique allows, for example, flux saturation levels to be found. Note that an external safety link must be fitted (on the rear panel) for BIAS operation, see 4.Ø9.Ø8.

Pick-up of power-supply frequency can be minimised by avoiding strong external fields (this includes keeping the test item away from the 3245) and by grounding the core. (There is a ground connection with the clip leads.) Effects of the pick-up can be minimised by running at SLOW speed.

4.Ø9.Ø5 AIR-CORED INDUCTORS

Problems in measuring air-cored inductors can be minimised by exercising care over the following points:-

a) Keep the coil away from supply transformers and metal in general.

b) Keep the coil away from TV scan coils - at the LH side of 3245.

c) If power-supply or TV scan frequencies are a nuisance, use the SLOW measuring speed, the maximum available drive level and avoid measuring at the local supply frequency and its harmonics.

d) Q is often low due to series resistance. For best results in Q measurement, choose the highest possible frequency consistent with avoiding self-capacitance problems - see section 4.Ø9.1Ø.

e) Operate at 1ØkHz in series configuration for best accuracy in inductance measurement.

4.Ø9.Ø6 LOW 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 1ØØ5, 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 Ø.Ø5µH.
A 5cm length of 2mm wire has an inductance of Ø.Ø4µH.

The Q is always low but self-capacitance is not a problem at the 3245 measurement frequencies. For best inductance measurement results, work at 1ØkHz in series configuration.

4.Ø9.Ø7 TRANSFORMER MEASUREMENTS

Transformer turns ratios are measured in 2-terminal fashion thereby presenting the problems which 4-terminal techniques aim to overcome. In essence the effects of measurement lead impedances and transformer shunt impedances cannot be avoided.

Turns-ratio is assessed by comparing the measured open circuit output voltage with a selected driving voltage. Hence magnetising current flowing in the primary winding renders the observed turns ratio less than the true value; the true ratio is determined from:-

$$\text{Ratio(true)} = \text{Ratio(obsvd)} \cdot \sqrt{1 + (Rt/\omega Lp)^2}$$

Where Rt is the sum of lead and primary series resistances,
Lp is the primary inductance measured at ω and
ω is 2π•frequency of measurement.
Supplied leads:- total series resistance typically less than Ø.25ohm.

The effect is most serious at frequencies where $\omega Lp < 10Rt$ and, for a given set of leads, is worse for low impedance transformers.

4.Ø9.Ø7 TRANSFORMER MEASUREMENTS (Continued)

Many audio transformers self-resonate within their working frequency band. Measurement errors will be minimised by working at the resonant frequency which can be found by separate measurements on the primary impedance, seeking where the phase angle changes from positive to negative.

Example of correction at a 34% resistance/reactance ratio.

Transformer, wound 65:1Ø; measured at 5ØØHz
Observed ratio = 65:9.5
Lp = 35ØµH, Rdc = Ø.121Ω, Lead resistance = Ø.25Ω

Correction factor $= \sqrt{1+(0.121+0.250)^2/(2\cdot\pi\cdot 500\cdot 350E-6)^2}$
= 1.Ø5539
Corrected Sec.wndg = 1Ø.Ø26
Corrected ratio = 65:1Ø.Ø3

The correction for parallel resistance is given by:-

Ratio(true) = Ratio(obsvd)•(Rppr + Rt)/Rppr
Where Rppr is the measured ac parallel primary resistance.

The overall effect of the two ratio corrections is given by their product (or sum, if percentage terms are used). If the lead resistance to impedance or inductance ratio is liable to produce errors of greater than Ø.5% then the 3245 outputs a warning:-

⚠ LO-Z INPUT ⚠

The 2-terminal primary impedance can be measured at any specific drive conditions simply by disconnecting the secondary and selecting NORMAL operation with Z display.

Overload may occur at frequencies having prominent harmonics near resonance of the primary inductance and the effective self-capacitance of the transformer. Therefore in order to minimise measurement errors, choose a suitable frequency and drive level.

For step-up transformers, the measured secondary voltage is limited to 5V rms.

Use of the AUTO-RANGE function is more complex for transformers. The display is blanked while the readings settle. Measurement of batches of transformers of similar ratios under similar frequency and drive level conditions may well be simplified by working in the RANGE HOLD mode, see figure 12. Manual ranging for transformer tests is not feasible.

Leakage inductance can be measured for a pair of windings by short circuiting one and making a NORMAL inductance measurement on the other. The result is independent of their roles.

4.09.08 INTERNAL dc BIAS FACILITY

The dc BIAS facility is a constant current which is injected in parallel with the ac drive signal. The internal source is rated to 1Amp; the optional external BIAS unit is rated at up to 20Amp for measurement purposes up to 20kHz.

For safety purposes the current cannot be turned ON until after a test item with an ac impedance of less than 41kohm is connected. To avoid shock hazard do NOT remove the coil during a measurement with the dc BIAS ON. Turn OFF the BIAS current and wait for the 'BIAS ON - SHOCK HAZARD' warning to extinguish before disconnecting the test item. Also note that the 3245 turns OFF the current when the test ac impedance is too high.*

The 3245 changes current levels in a ramped fashion. When a steady level has been achieved the message:-

DC CURRENT NOT SET

is extinguished. The settling delay lets the Analyzer recover from overloading caused when BIAS is switched ON. The delay is a function of the measuring range selected. Ranges 1 to 4 settle in 2 seconds, range 5 in 5.5 seconds and range 6 in 7 seconds. If the impedance to be measured is above the normal range 4 limit of 640ohms, it may still be measured on range 4 with reduced accuracy to obtain fastest settling. For fastest response, use RANGE HOLD and select an appropriate range using the CODE function. Range 7 is not available with dc BIAS. Disaccommodation occurs with iron-cored inductors, see section 4.09.04.

The maximum permissible BIAS induced dc voltage drop depends on the ac drive level. Avoid 'bottoming' the combination of BIAS and drive signal. When the sum of dc and peak ac (1.414 x Vrms) is greater than 13V nominal the message:-

EXCESS VOLTAGE DROP

is displayed. (This value is nominal only. The internal supply is unregulated and hence varies with the ac supply voltage.)

Note that use of the dc BIAS facility inherently reduces the measurement accuracy, see figure 5.

Fit a safety link to the Analyzer whenever the internal BIAS facility is to be used. Before measuring inductors which may be damaged by dc BIAS e.g. tape heads, microphone inserts etc., remove the link as a safety precaution. Terminals for the link are on the rear panel; if BIAS ON is selected with the link absent, 'EXCESS VOLTAGE DROP' is reported.*

When operating with voltage drive, it is possible to select conditions giving ac current values very small compared with the dc current bias. This situation can give rise to excessive measurement errors or noise. To obtain the accuracy figures shown in fig. 5, the rms ac current should be not less than 1% of the selected dc bias value. This current can be calculated, or measured directly as a minor term with Z selected. For very high impedance inductors, it may not be possible to achieve the required conditions, in which case the highest available drive voltage must be selected.

* New safety features: see Chapter 8, page F:2.

4.Ø9.Ø9 Rdc MEASUREMENTS

The two dc resistance ranges were designed to cover the inherent resistance of inductor windings. The Analyzer limits the drive current to 16mA maximum and the drive voltage to 1ØØmV - thereby avoiding self-heating and the magnetising of iron-cored inductors.

When in AUTO-RANGE mode, the LOW range is selected for resistance values below 2ohms. The NORMAL range operates for higher resistance values; see section 3 for full specification. When in RANGE HOLD mode, LOW or NORMAL Rdc ranges may be selected by codes 21 or 22 respectively.

Accuracy within the specified ranges is Ø.5% at NORMal speed; outside those ranges accuracy is lower. For best LO-Z and HI-Z coverage use SLOW speed.

4.Ø9.1Ø SELF-CAPACITANCE and RESONANCE

Self-capacitance resonates with inductance at a frequency f_0. At frequencies below resonance, the effective inductance is increased. Above resonance the impedance becomes capacitive, giving a negative inductance reading. The values of each of the two L components in the expressions below, may be either positive or negative. The signs must be included with the values.

To establish the effect, measurements must be made at two frequencies. If inductances L_1 and L_2 are measured at two frequencies f_1 and f_2 near resonance (in parallel representation), then the self-capacitance is given by:-

$$C_0 = \frac{(L_2 - L_1)}{L_2 L_1} \cdot \frac{1}{(\omega_2{}^2 - \omega_1{}^2)}$$

The resonant frequency is given by:-

$$f_0 = \sqrt{\left(\frac{f_2{}^2 L_2 - f_1{}^2 L_1}{L_2 - L_1}\right)}$$

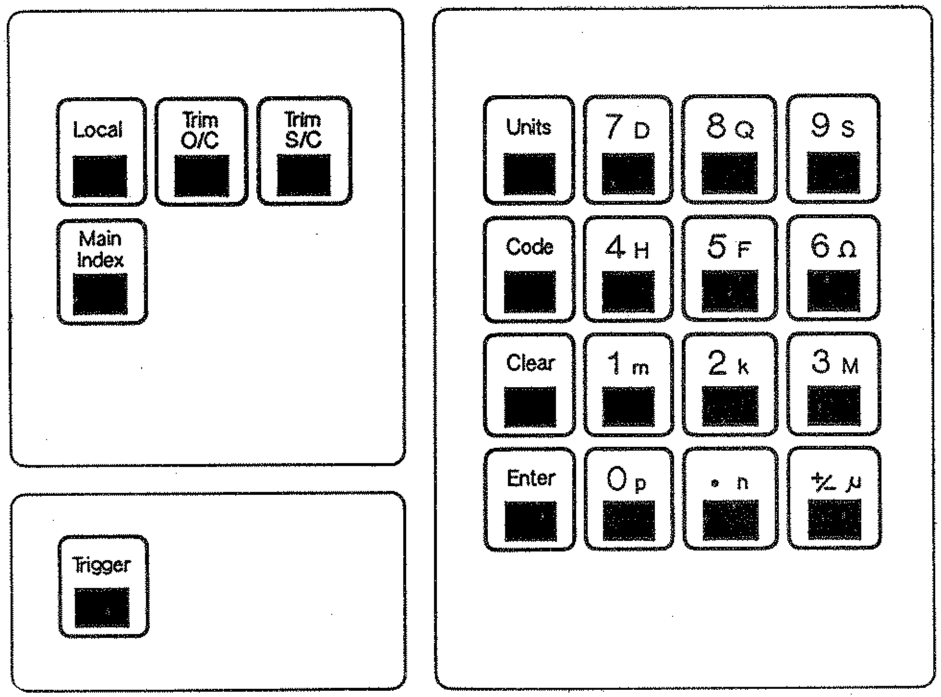


Figure 7 Main Function Keys and Key-Board

4.Ø9.11 DATA ENTRY KEY-BOARD

The data-entry key-board, illustrated in figure 7, uses a multi-function key-set permitting manual entry of data values, measurement units and control codes. The layout for digits keys is a common arrangement for hand-held calculators but the 'UNITS' key has a 'shift' purpose. When it is pressed the numeric keys change roles to units or multipliers. The alternative roles are:-

a) Top row; MINOR TERMs 'D' and 'Q'

b) Next row; measurement units 'H', 'F', 'Ω' (ohms)

c) The other two rows have normal value power multiplier symbols:-

Mega	$1Ø^{6}$	'M'
kilo	$1Ø^{3}$	'k'
milli	$1Ø^{-3}$	'm'
micro	$1Ø^{-6}$	'µ'
nano	$1Ø^{-9}$	'n'
pico	$1Ø^{-12}$	'p'

4.Ø9.11 DATA ENTRY KEY-BOARD (Continued)

The Keys in the left-hand numeric column are single function:-

d) UNITS key equates to 'shift'. Use it prior to keying a unit or multiplier e.g. H or m. Terminate mode with ENTER.

e) CODE implies a code number to follow; ENTER terminates the mode.

f) The CLEAR key erases any entry made since last use of ENTER.

g) Pressing the ENTER key accepts the entry just made (echo in data line), given that the present mode permits data entry.

Warnings:

Key-board data entry inhibits measurement. A leading decimal point is unobtrusive; easy to overlook if keyed inadvertently; the analyzer will wait for more data. Keyed data should be terminated or CLEARed.

Any process interupted by keying, recommences when keying ends.

Examples of keyed sequences (characters in [ ]) using the convention:-

U for UNITS, K for CODE, C for CLEAR and / for ENTER.

Example 1: Supply the analyzer with a value of 27.39mH.
(Assume that the code is suitably set)

[.] [Ø] [2] [7] [3] [9] [U] [H] [/])These two versions
)
[2] [7] [.] [3] [9] [U] [m] [H] [/])use U for multipliers.

Notice that at U the grating appears and then is overwritten by m.

The +/- key may be used before or after a value to change its sign.

If a mistake is made in a sequence, before pressing / (ENTER), press C (CLEAR) to restart the section. This would, for example, prevent an erroneous measurement being made while in REPetitive mode.

Confirm that the data entry line display is correct; re-key if not.

Example 2: Set the frequency to 1ØØkHz.
(Arrow display must be at frequency.)

[1] [Ø] [Ø] [Ø] [Ø] [Ø] [/]

[1] [Ø] [Ø] [U] [k] [/])These two versions
)
[Ø] [.] [1] [U] [M] [/])use U for Units

Example 3: Set a CODE value of 3245
(This code is always accepted; it sets/resets)
('electronic' lock on other key-board entries.)

[K] [3] [2] [4] [5] [/]

4.1Ø INTERFACES

4.1Ø.Ø1 RS232C INTERFACE: Printer

This option outputs measurement data in serial form i.e. suited to printers, via a standard 25-way 'D' connector. Data transfer rates, word length parity choices and pin connections are detailed in appendix B.

4.1Ø.Ø2 GPIB INTERFACE: Printer/Full Control

The GPIB option conforms to the IEEE Std. 488-1978 (including the 198Ø Supplement) 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	
TEØ	No Extended Talker	
L4	Basic Listener, No Listen Only, Unaddressed if MTA	
LEØ	No Extended Listener	
SR1	Service Request	
RL1	Remote/Local Function	- Complete Capability
PPØ	No Parallel Poll	
DC1	Device Clear	
DT1	Device Trigger	- Complete Capability
CØ	Not Controller	

Available also, 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 Appendix A, section B). LOCAL TRIGGER OFF inhibits this mode. No controller is needed in Talker Only mode when GPIB compatible printers are used.

Full details of commands and output facilites are given in appendix A.

4.1Ø.Ø3 ANALOGUE OUTPUT OPTION (Ø - 1.ØVdc Full Scale)

The analogue option gives two dc outputs scaled Ø to 1V corresponding to the measured parameters in any operating mode. Zero and full scale values can be set via the front panel key-board. Details are provided in Appendix F.

4.1Ø.Ø4 BINNING HANDLER OPTION

The Handler option provides hand-shake signals and relay outputs for use with automatic handlers. It operates in BIN SORT and BIN COUNT modes. Details are provided in Appendix E.

4.1Ø.Ø5 EXTERNAL dc BIAS UNIT (OPTION 322Ø)

Internal dc BIAS current from the 3245 is limited to 1A maximum. The 322Ø dc BIAS option is rated for measurement purposes to 2ØA up to 2ØkHz. Several of these options can be used in parallel for BIAS levels up to 1ØØA maximum. In use the options and 3245 are stacked to keep the leads as direct as possible (dimensions are common). The analyzer controls all operations of the option, keeping its own internal 1A BIAS supply switched off (hence the 3245 BIAS safety link is not required). Full operational details for the external BIAS unit are given in its handbook.

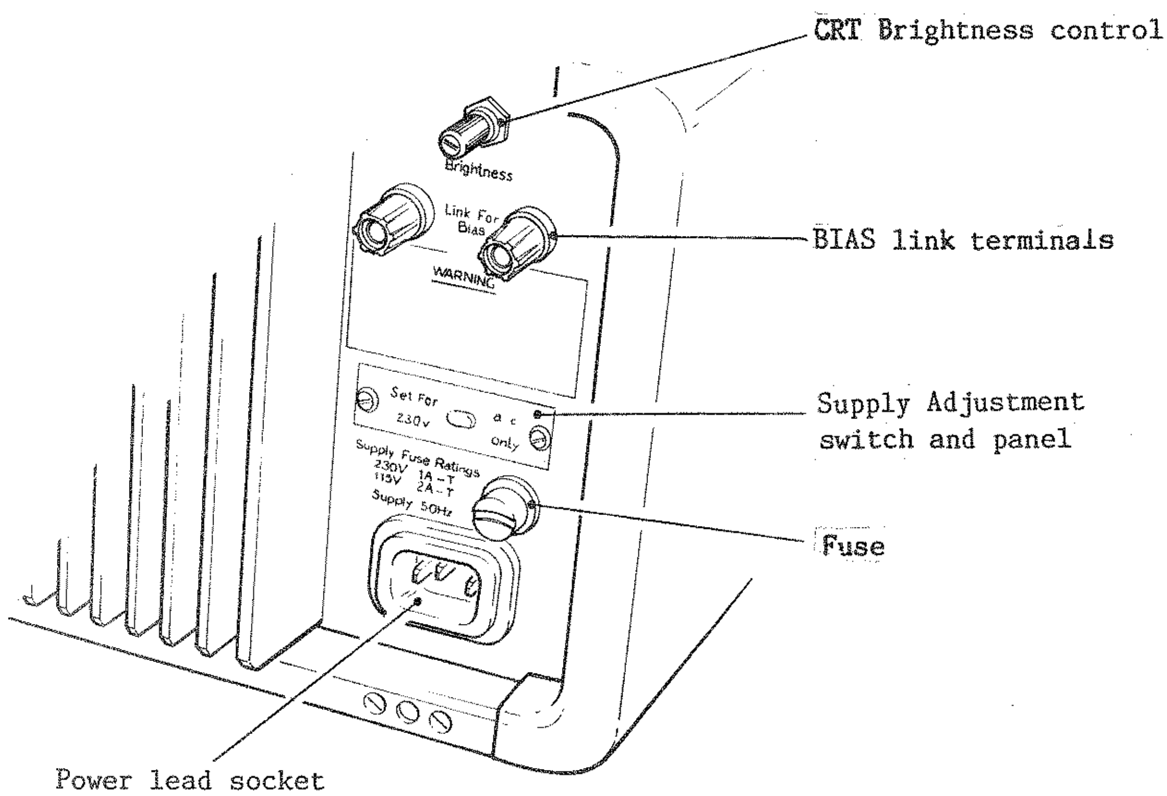


Figure 32 Backpanel

7 FUNCTIONS, TERMS and CODES

7.Ø1 FUNCTIONS and TERMS

⚠	Refers operator to handbook
δ	Loss angle; 'delta'
θ	Phase angle; 'theta'
ω	Angular frequency 'omega'
Accuracy charts	Contour charts relating measurement accuracy to frequency, drive level, dc BIAS and test component value
BIN COUNT	Mode for logging binning results
BIN SET	Mode for setting binning classifications
BIN SORT	Mode for binning operations
Binning	Component value classification MAJOR and MINOR TERM limits
Binning Handler	Component sorting equipment, 3245 controlled
C	Capacitance
D	Dissipation factor: $D=\tan(\delta)=1/Q$
DEVIATION	1) MAJOR TERM percentage difference between actual value and previously defined nominal 2) Mode for initial settings for above
Drive	Signal, ac or dc, applied to test item
f	Frequency
GPIB	See IEEE 488 (General Purpose Interface Bus)
Iac	Current drive
Idc	Direct Current bias
IEEE 488	A standard parallel interface system linking computers and peripheral equipment
KELVIN clips	Twin clip-leads; each clip having one jaw as part of the drive circuit, and the other as part of the sensor circuit; 4-terminal measurement conditions are implicit
L	Inductance
LIMITS	1) The boundaries for acceptance measurements 2) Mode for setting the above boundaries
Lm	Mutual inductance
LOCAL	Part of the GPIB option facilities; restores front panel operation when in remote control

7.01 FUNCTIONS and TERMS (Continued)

MAJOR TERM	Z, Rdc For inductance and capacitance: L, C For resistance: R
MINOR TERM	$\underline{/\theta}$ For inductance and capacitance: Q, D, and also loss resistance, Rac
N	Turns ratio: N=Np/Ns or Ns/Np
NORMAL	Mode for measurement of parameters of single windings
Np	Primary turns
Ns	Secondary turns
Parity check	Check performed at power-up to ensure that non-volatile data is valid
PRI	Primary
Q	'quality' factor: Q=1/D
Rac	apparent resistance to ac stimulus
Rdc	dc resistance
Rp	PRIMARY resistance
Rppr	Transformer primary parallel resistance
Rs	SECONDARY resistance
RS232C	A standard, unbalanced, asynchronous communication link for serial data
SEC	Secondary
Soft-keys	Variable function push-buttons, see figure 1
TRANSFORMERS	Mode for measurement of parameters of coupled windings
TRIMming	Compensating for parasitic errors due to the measuring leads
Vac	Voltage drive
Z	Impedance

7.Ø2 CODES

The CODE facility provides user access to functions which are not available via the labelled keys. Examples of this are manual selection of measurement range, locking or unlocking the key-board, enabling or disabling the printer output and self-test routines.

To implement any CODE function, press the CODE key followed by the appropriate number, then ENTER. See section 7.Ø2.Ø2 for a full list of available CODE numbers and their effects.

7.Ø2.Ø1 MANUAL RANGE SELECTION

Manual ranging, in place of AUTO-RANGE is possible except in TRANSFORMER mode. First ensure that HOLD is selected, then enter the CODE number corresponding to the ac measurement range required (see section 3.Ø1.Ø8 for details). For the dc resistance function use CODE 21 or CODE 22 respectively to select LOW or NORMAL measurement range. It is not necessary to have the corresponding ac or dc measurement function selected when entering these CODEs.

An on-screen range indicator is available in all measurement modes. Enter CODE 9 to obtain this function. The display will show, at the top left hand corner, the present range number. If Rdc is selected, the indicator will show either L or N corresponding to the LOW or NORMAL range.

Enter CODE 9 again to extinguish this indicator. Note that it will always be disabled at POWER ON.

7.02.02 CODES: EFFECTS and INTERPRETATIONS

CODE	EFFECT
0.1	Character set
0.2	Grid Test Pattern
0.3	Non-destructive RAM test) Later instruments
0.4	Key-board test) only
0.5	EPROM test - displays memory checks, old and new
1*	1)
2*	2)
3*	3)
4*	4) Range Number
5*	5)
6*	6)
7*	7)
9	Display/Extinguish present range number
9.1	Clears data in non-volatile memory
10	Printer ON
11	Printer OFF
21	Rdc, low range - maximum 2Ω resistance
22	Rdc, normal range - above 2Ω resistance
3245	Set/Reset electronic lock on keys

Notes: (a) Range number/level limitations are detailed in the specifications, section 3.
(b) Codes marked (*) not applicable to TRANSFORMER mode; manual ranging for transformer tests is not feasible.

The setting of the 'electronic' lock is maintained during POWER OFF. Should the data in the non-volatile memory be found corrupted at POWER ON, the following display will appear, the asterisks identifying corrupted data blocks.

```
                          *      NORMAL
                          *  TRANSFORMER
                          *    DEVIATION
    PREVIOUS  SET UP      *       LIMITS
    CONDITION  LOST       *      BIN SET
       FOR MODES          *     BIN SORT
       INDICATED          *    BIN COUNT
                             CONNECTIONS
```

This condition may be forced by using CODE 9.1.

The MAIN INDEX button may be used to exit from the test displays.

Appendix A (Section A)

GPIB Interface for 3245 Analyzer

Definition of Command and Data Formats (Issue 1)

1. The GPIB Option

The GPIB option conforms to the IEEE Std. 488-1978 (including 198Ø Supplement) 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	
TEØ	No Extended Talker	
L4	Basic Listener, No Listen Only, Unaddressed if MTA	
LEØ	No Extended Listener	
SR1	Service Request	
RL1	Remote/Local Function	- Complete Capability
PPØ	No Parallel Poll	
DC1	Device Clear	
DT1	Device Trigger	- Complete Capability
CØ	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 Appendix A, section B). LOCAL TRIGGER OFF inhibits this mode.

2. COMMAND FORMAT

2.1 The command set (Appendix A, section B) contains both full commands and recommended abbreviations. No other forms should be used. The full commands are designed to generate self-documenting command strings.

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

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

2.4 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.

2.5 Whilst a command string is being executed, no further commands can be accepted.

2.6 If a measurement is in progress when a command is received, the measurement will be aborted. The MESS? command (See Clause 4.3) is the only exception to this rule.

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

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

Appendix A (Section A continued)

Definitions (Continued)

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

2.1Ø Upper and lower case letters are interpreted as being the same.

2.11 Only commands which are normally available in the selected mode will be accepted. Otherwise a command error will be reported. e.g. 'NOMINAL' cannot be selected in NORMAL mode. Except that modes can always be directly accessed without first calling INDEX.

2.12 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.

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

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

2.15 If 'Bias On' is selected when the measurement terminals are open circuited, this is treated as a command error (See Section 3).

2.16 Under Local Control a safety feature is incorporated which automatically turns off the dc bias when certain error conditions persist for more than a few seconds. This function does not operate under Remote Control.

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

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

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

2.2Ø Typical command strings for setting the instrument might be:

a) FREQ3ØØE3;LEVEL7ØØE-3V;L;R;SERIES;AUTO;NORMALSPEED;TRIG

B) BIN 1;HILIM 1Ø;LOWLIM-1Ø;NOMINAL 3E-6 FARADS;BINSORT;TRIGGER

3. COMMAND ERRORS

3.1 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 Appendix A, section C.

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

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

Appendix A (Section A continued)

Definitions (Continued)

4. DATA Output

4.1 Output consists of measurement results and displayed messages. The messages will be encoded as a single numeric value (see Appendix A, section D).

4.2 Output comprises four numeric values. The first value will be the encoded messages. The remaining three 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.

4.3 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 Ø.ØØEØØ.

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

4.5 All values output that are surplus to the displayed measurement mode will have value Ø.ØØEØØ.

For example: NORMAL mode which usually displays two results the fourth value will be Ø.ØØEØØ.

4.6 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.

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

4.8 At the end of any Trim sequence the encoded message value will be output with the three data values set to Ø.ØØEØØ.

4.9 If data is available for output when not addressed to talk SRQ will be generated. Only one SRQ will be generated for the 4 data values. 'Output Data Available' is indicated in the Status Byte (in response to a Serial Poll). See Appendix A, section C.

4.1Ø 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 at 999.9E15.

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

4.12 If a serial poll is received when the instrument is busy, the Busy condition is indicated by the Status Byte (See Appendix A, Section C). Busy conditions include processing commands, waiting to start a measurement, measurement in progress, outputting data.

Appendix A (Section A continued)

Definitions (Continued)

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

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

4.14 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 Ø to 9 followed by the total.

5. TALK ONLY STATE

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

5.2 Data output to the printer will be formatted as detailed by the RS232C printer option. See Appendix B, sections 5 and 6.

Appendix A (Section B)

GPIB COMMAND SET

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

FUNCTION	ABBREVIATION
ABS	ABS
AUTO	AUT
ANGLE	ANG
BIAS ON	BSON
BIAS OFF	BSOF
BIN SET	BNSE
BIN SORT	BNSR
BIN COUNT	BNCO
BIN NO 'VALUE'	BN
BIAS 'VALUE'	BA
C	C
CODE 'VALUE'	COD
CONNECTIONS	CON
D	D
DELETE ALL	DALL
DELETE LAST	DLAS
DEVIATION	DEV
DOWN	DOW
FAST SPEED	FAS
FREQUENCY 'VALUE'	FRE
G	G
HIGH LIMIT 'VALUE'	HIL
HOLD	HOL
IAC	IAC
INTERROGATE	INT
INDEX	IND
KEYLOCK	KL
KEY UNLOCK	KU
L	L
LM	LM
LEVEL 'VALUE'	LEV
LIMIT 'VALUE'	LMT
LIMITS	LMS
LOCAL	LCL
LOW LIMIT 'VALUE'	LOWL
LOCAL TRIGGER ON	LTON
LOCAL TRIGGER OFF	LTOF
MESS?	M?

Appendix A (Section B continued)

GPIB COMMAND SET (Continued)

FUNCTION	ABBREVIATION
NEXT	NEX
NORMAL	NOR
NORMAL SPEED	NORS
NP/NS	NP/S
NS/NP	NS/P
NS	NS
PARALLEL	PAR
PRINT	PRI
Q	Q
R	R
RATIO	RAT
RDC	RDC
REPEAT	REP
RESET	RES
SAVE NOMINAL	SAV
SCALE OFF	SCF
SCALE ON	SCN
SET NP 'VALUE'	SNP
SET LIMIT 'VALUE'	SLI
SET NOMINAL 'VALUE'	SNO
SET ANALOG	SAN
SINGLE	SIN
SERIES	SER
SLOW SPEED	SLO
TRANSFORMER	TRA
TRIGGER	TRG
TRIM LM	TLM
TRIM OPEN CIRCUIT	TOC
TRIM SHORT CIRCUIT	TSC
UP	UP
VAC	VAC
Y	Y
Z	Z
%	%

Appendix A (Section C)

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 O C C

'X' = not used and set false

'S' = Service request

'B' = Busy bit

'R' = Output data available

'M' = Message bit

'O' = Open circuit when 'BIAS ON' selected.

'CC' = Command error bits

The command error bits indicate the following command error conditions.

ØØ = No error

Ø1 = Syntax error

1Ø = not available

11 = buffer overflow

where Ø = false, 1 = true

Examples:-

Ø 1 Ø Ø Ø Ø Ø 1 = service request and command syntax error

Ø Ø 1 Ø 1 Ø Ø Ø = busy and there is a message displayed.

Appendix A (Section D)

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

Ø = 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
8 = Lm Trim Error or Trim Failed:Out of Range
9 = Range Error plus Lm Trim Error.

M indicates the messages displayed on the warning line

Ø = No message
1 = Lo-z input
2 = Bias on Shock Hazard

L indicates messages relating to 322Ø Option.

Ø = No message
1 = 2ØA Unit: No Power
2 = 2ØA Unit Fuses
3 = 2ØA Over Temp.

The digit pair KK indicates the message on the message line

ØØ = No message
Ø1 = Nearest Available
Ø2 = Voltage Drive Selected
Ø3 = Current Drive Selected
Ø4 = Drive Level Reduced
Ø5 = DC Current Not Set
Ø6 = Excess Voltage Drop
Ø7 = Safety Bias Turned Off
Ø8 = Meas/Bin Units Mismatch
Ø9 = Meas/Nom Units Mismatch
1Ø = Level Too High
11 = (Code) Not Defined.
12 = AC Signal Changed

J is reserved for future expansion

Appendix A (Section D continued)

ENCODED MESSAGE SET (Continued)

I indicates data valid or invalid or check measurement status.

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

Examples:

ØØØ4ØØ2 = Drive Level reduced and S/C Trim Error

1ØØ9ØØ5 = Data invalid plus Meas/Nom Units Mismatch plus Range Error and O/C Trim Error.

Appendix A (Section E)

INSTRUCTIONS FOR 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 first be removed from the inductance analyzer; this may be done in the following manner:-

1) Release the top cover

2) Release the option card retaining screws

3) Release the option card from the flexible bus connector

4) Withdraw the option card

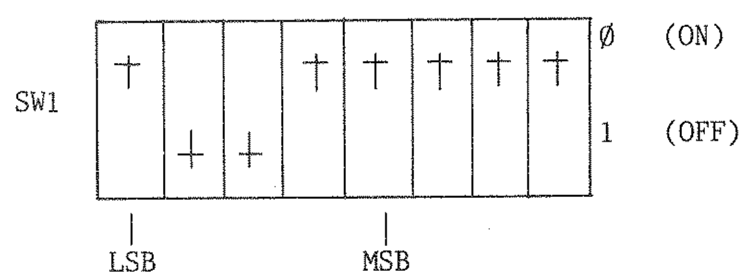
If it is desired to use the analyzer as a talk only device, i.e. without a controller on the bus, set SW1 pole 8 to off. The other switch settings are unimportant.

If it is desired to use the analyzer with a controller.

1) Set SW1 pole 8 to on, 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, the other poles represent succeeding bits, and a '1' is pole OFF.

e.g. With controller, device address 6



Appendix B (Section A)

RS-232-C Interface for 3245 Analyzer

DEFINITION OF RS232C OUTPUT OPTION

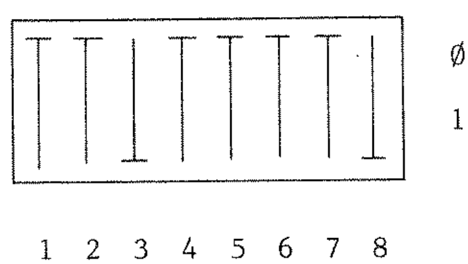
1.Ø General

When fitted with this option the instrument may be used to drive a printer or other recording device conforming to EIA Standard RS-232-C.

The option card is common to other Wayne Kerr equipment and there are links and switches on the card which have been set during installation to allow it to work in the instrument. Further switches on the option card set up characteristics of the RS232C link (data rate, parity checking etc.) which must have corresponding settings at the sending and receiving equipment before data can be transmitted.

2.Ø Setting Data Characteristics

To gain access to the option card first remove the instrument cover. S2Ø3 (located rear left) sets the characteristics of the transmitted data, which should 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 the instrument must be powered 'off' whenever these settings are changed.



S2Ø3

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

Switch 2
Not used.

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

Appendix B (Section A Continued)

DEFINITION (Continued)

2.Ø Setting Data Characteristics (Continued)

Switch 4

Most equipment uses a single parity bit to check for possible data errors. Switch 4 selects this function 1 = ON, Ø = OFF.

Switch 5

Parity check may be odd or even 1 = EVEN, Ø = 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.

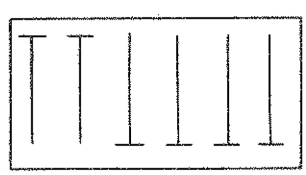
Switches 6, 7, 8

These set the Baud rate (data rate). The fastest rate which can be handled by the peripheral equipment should always be used.

Baud rate	6	7	8
11Ø	Ø	Ø	Ø
15Ø	1	Ø	Ø
3ØØ	Ø	1	Ø
6ØØ	1	1	Ø
12ØØ	Ø	Ø	1
24ØØ	1	Ø	1
48ØØ	Ø	1	1
96ØØ	1	1	1

3.Ø Cable Connectors and Data Flow Direction

The RS232C 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, so the instrument option card should be wired as a computer. Ensure that S2Ø4 (located rear right) is set as follows.



1 2 3 4 5 6

S2Ø4

Appendix B (Section A Continued)

DEFINITION (Continued)

3.0 Cable Connectors and Data Flow Direction (Continued)

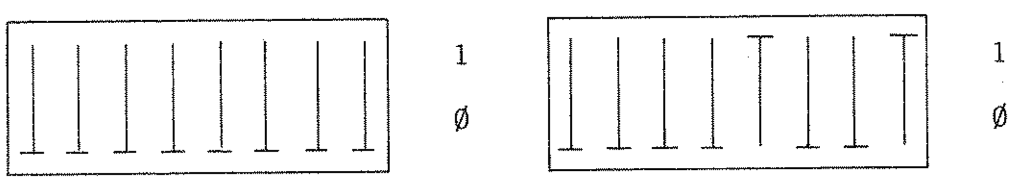
Connections for the 25-way output socket are as follows:

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 the RS232C interface.

4.0 Card Address

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



1 2 3 4 5 6 7 8
S201

1 2 3 4 5 6 7 8
S202

5.0 Enabling the Printer Output

When the RS232C option is fitted, output can be enabled or disabled by entering 'Code 10' or 'Code 11' respectively. When entered the timed message 'PRINTER ON' or 'PRINTER OFF' appears, indicating the current status of the output function.

Appendix B (Section A Continued)

DEFINITION (Continued)

6.Ø Printer Format

When operating in the Single mode the instrument will generate a single printed line up to 4Ø characters, terminated by CRLF.

```
1.ØkHz      1Ø.98µH     Ø.3622 Q
8ØØ Hz      16.ØØµH     Ø.2946 Q
6ØØ Hz      28.Ø6µH     Ø.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.

6.1 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.ØkHz	1ØØmA	OFF	L Q	Par

The measurement mode is NORMAL.
The measurement functions are L and Q.
The measurement parameters are Frequency 1.ØkHz, Level 1ØØmA,
Bias Off, the speed is Fast and Parallel equivalent circuit selected.

Also the instrument is in the auto range state.

6.2 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 CRLF, any displayed results are then output on the new line terminated with CRLF. If no results are displayed then the output is a blank line.

```
6ØØ Hz      -Ø.6nF      15Ø.Ø Ohm
6ØØ Hz      -Ø.4nF      15Ø.Ø Ohm
Range Error
6ØØ Hz      -Ø.4nF      851.5 Ohm
Range Error
6ØØ Hz       Ø.4nF      85Ø.Ø Ohm
Range Error

Range Error
```

Appendix B (Section A Continued)

DEFINITION (Continued)

6.3 Units Prefixes

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

F = femto $1Ø^{-15}$
P = pico $1Ø^{-12}$
N = nano $1Ø^{-09}$
U = micro $1Ø^{-06}$
M = milli $1Ø^{-03}$
K = kilo $1Ø^{+03}$
MG = mega $1Ø^{+06}$
G = giga $1Ø^{+09}$

6.4 Printing Bin Data

When BINSET mode is selected there are no facilities provided for making a measurement, also BIN COUNT has no result to output. Therefore when the RS232C option is fitted a new soft key is provided in the BIN COUNT mode. The key is labelled PRINT. 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 absolute limits (no Nominal).

Bin	High Limit	Low Limit	Count
Ø		Ø.Ø H	Ø
1	11Ø.Ø Ohm	1ØØ.Ø Ohm	2Ø
2	12Ø.Ø Ohm	11Ø.Ø Ohm	4
3	13Ø.Ø Ohm	12Ø.Ø Ohm	4
4	14Ø.Ø Ohm	13Ø.Ø Ohm	5
5	15Ø.Ø Ohm	14Ø.Ø Ohm	4
6	175.Ø Ohm	15Ø.Ø Ohm	13
7	2ØØ.Ø Ohm	175.Ø Ohm	8
8	25Ø.Ø Ohm	2ØØ.Ø Ohm	16
9	Reject		11
		Total	85

Appendix B (Section B)

Additional Examples

6.5 Further Printer Output Examples

Example 1. Single measurements

```
  Freq    Level    Bias     Slow     Auto
6ØØ Hz    1.ØØV     OFF      C R      Par

6ØØ Hz        -Ø.ØØnF      99.95Ø Ohm
6ØØ Hz         Ø.Ø2nF      99.955 Ohm
6ØØ Hz        -Ø.ØØnF      99.955 Ohm
```

Example 2. Updating the Level parameter in Normal Mode

```
  Freq    Level    Bias     Slow     Auto
6ØØ Hz    1.ØØV     OFF      C R      Par

1.ØØVac        Ø.1ØnF      99.955 Ohm
1.Ø5Vac        Ø.Ø2nF      99.95Ø Ohm
1.1ØVac        Ø.Ø4nF      99.955 Ohm
```

Example 3. Measuring an open circuit then short circuit in Rdc

```
Lev <1ØØmV DC Rdc       Slow     Auto

 OVER RANGE Ohm
 OVER RANGE Ohm
          4mOhm
          3mOhm
```

Example 4. Measuring Lm in Transformer Mode indicating Trim Errors

```
  Freq    Level    Lm    Norm    Auto
6ØØ Hz    1.ØØV

Lm Trim error
6ØØ Hz        7.Ø91mH
6ØØ Hz        7.Ø9ØmH
6ØØ Hz        7.Ø9ØmH
```

Example 5. Measuring Ns response to changing Np value

```
  Freq    Level    Ns    Fast    Auto
6ØØ Hz    1.ØØV    Np =  1ØØ

Np =  1ØØ        99.95
Np =  15Ø        149.9
Np =  2ØØ        199.9
```

Appendix B (Section B Continued)

Examples (Continued)

Example 6. Deviation Mode with Bias On measuring response to changing current

Freq	Level	Bias	Norm	Auto
6ØØ Hz	1.ØØV	Ø A	L	Par
Nominal	9.268mH			

Ø Adc	-Ø.ØØ %	9.268mH
5ØØmAdc	-11.25 %	8.225mH
76ØmAdc	-21.41 %	7.284mH

Example 7. Limits Mode Absolute limits

Hi Lim = 385.Ø Ohm
Lo Lim = 315.Ø Ohm
Slow Auto Abs Mode

33Ø.12 Ohm PASS
312.1Ø Ohm LOW

Example 8. Limits Mode Percent limits

Hi Lim = 1Ø.Ø %
Lo Lim = -1Ø.Ø %
Nom = 35Ø.Ø Ohm
Slow Auto % Mode

Ø.Ø3Ø5 % PASS
11.46Ø % HIGH

Example 9. Bin Sort

Norm Auto Abs Mode

Bin no. 4	Ø.Ø5nF	13Ø.92 Ohm
Bin no. 2	Ø.ØØnF	11Ø.92 Ohm
Bin no. 3	Ø.Ø5nF	12Ø.94 Ohm

Example 1Ø. 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

Appendix C

Analog Bar Display

1 INTRODUCTION

The Analog Bar Display provides a visual representation of measurement results in the form of a horizontal bar of varying length. This function, which is useful for adjustment of preset components, is available only in Limits mode and is enabled/disabled by the Scale ON/OFF soft-key.

The Analog Bar Display incorporates 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 up to 9 times the pass band to be displayed.

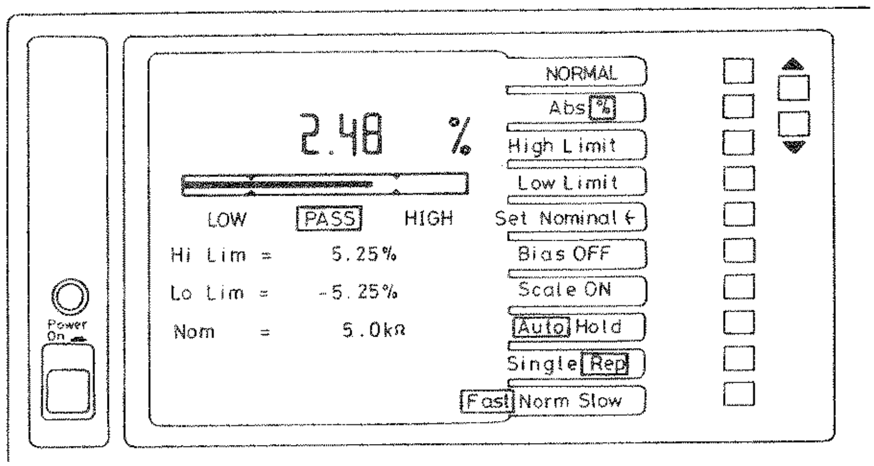


Figure C1 Limits Mode Display with Analog Scale ON

Appendix D

New Binning Software Specification

1 INTRODUCTION

The binning software has been revised. This Appendix gives details of how to operate the new Bin Set mode.

In the previous software, when binning on a major term of Capacitance (F) or Inductance (H), it was possible to specify only one limit on the minor term (for bin Ø). If this limit was set to, say, a Q of 1ØØ, then all components having a Q of less than 1ØØ would be grouped in bin Ø regardless of their major term, so making bin Ø a "reject on minor term" bin.

The new software enables a minor term limit to be specified independently for each of the bins Ø to 9 (bin Ø now being treated exactly as the other bins). This provides more flexibility and makes it possible to create classes of component, graded according to minor as well as major terms while making a single measurement.

2 OPERATION

Bin limits are entered in BIN SET mode, the high and low limits being specified absolutely or as a percentage of a given nominal. High or Low limits are entered by first pressing the appropriate soft-key and then entering the relevant limit. The NOMINAL value must be entered when binning is in percentage mode.

The bin to be updated is specified by moving the update cursor with the ▲ and ▼ keys. The update cursor is a box drawn around the specified limit of the current bin and it shows precisely which value will be altered by entering a number.

If major term units of F or H are selected, then the option is given of binning on minor term limits. The limit is entered after pressing the "Set Minor" soft-key. The minor term can only be specified absolutely with units of ohms, D or Q. If the user attempts to enter F or H then the entry will be ignored and the message "BAD MINOR TERM UNITS" will be displayed.

If the major term units are neither F nor H, then it is not possible to bin on minor term and the specified minor term limits will disappear and be replaced by a message. The "Set minor" soft-key label will also extinguish.

The RESET soft-key resets all three limits to zero for the selected bin. The NEXT key is used when entering limits in order, starting with Bin Ø High Limit, and selects the next Limit or Bin number in sequence.

3 USE

BIN SORT and BIN COUNT modes allow component sorting and update of bin information. The latter applies only in Single mode.

The binning is done by measuring a component and comparing the result obtained with the bin limits in order from Ø to 9. First the major term result is compared with the High and Low limits. If it does not lie between them, then the search goes immediately to the next bin.

The minor term result will only be tested against the major term limit if:

i) The major term units are F or H, and

ii) The minor term limit is not exactly zero.

If these conditions are not met, then the minor term is ignored and the component is "placed" in the current bin. Specifying a minor term limit of zero (the default value) provides a way of selectively ignoring the minor term for each bin.

The minor term result will be compared with the limit according to the label displayed at the head of the minor term limits column in BIN SET mode. For all of these labels x represents the minor term limit, ' ' means the result must be greater than the limit, and ' ' means the result must be less than the limit. The possible labels are listed below, together with the pass condition they represent:

Q > x :	The Q of component must be greater than the limit
D < x :	The D of the component must be less than the limit.
Rp > x :	The parallel resistance must be greater than the limit.
Rs < x :	The series resistance must be less than the limit.

Series or Parallel resistance is determined from NORMAL mode.

If the component meets the minor term conditions, it will be "put" in the relevant bin; otherwise, it will be tested against the limits of the next bin.

Sorting continues until either the component is placed in one of the bins Ø to 8 or, if none of them is found to be suitable, the component is placed in the reject bin, i.e. bin 9.

4 GPIB AND RS232 OPERATION

The only special points regarding the control of the instrument via the GPIB option are:

i) A command

BIN NO "value" (abbreviation BN)

to enable the controller to specify a bin number for updating.

ii) A command

SET MINOR "value" (abbreviation SMR)
enables the minor term limit to be specified. This will generate a command error if minor term limits are not available.

iii) If an attempt is made to set minor term units of F or H, then a command error will be generated along with the message number 13 in bytes KK of encoded messages, meaning "BAD MINOR TERM UNITS".

If the GPIB option card is set to talk only mode, or if an RS232 option card is fitted, then the PRINT command in BIN COUNT mode will generate a bin listing including the minor term limits.

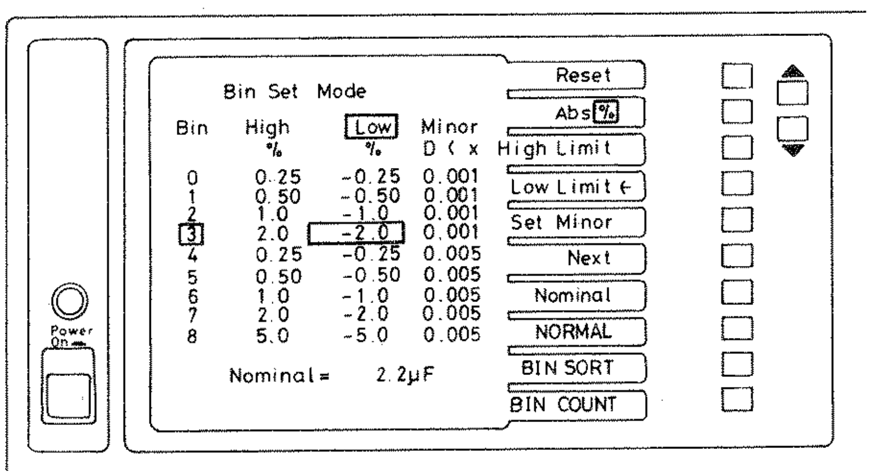


Figure D1 Sample Screen Display from Bin Set Mode

Appendix E

Standard Handler Interface (SHI)

1 INTRODUCTION

The SHI option card may be fitted into the option slot at the rear of a 3245. 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 Appendix "low" refers to a TTL logic level between Ø and Ø.8V and "high" is a TTL level between 2.4 and 5V.

2 OPERATION

When the SHI card is fitted into an instrument, there will be no noticeable difference in its operation. If Code Ø.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.

3 INTERFACE DETAILS

The functions of the Interface lines are defined in Table E1. The two output signal lines BUSY and Bin Data Available (BDA) will at any time assume one of four different states:

(1) Null State

The null state is defined as

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

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

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

This state is adopted when the instrument is unable to perform binning due to one of the following reasons:

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

ii) There is a MEAS/NOM 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 BIN lines are invalid and should be ignored and also that the instrument is not ready for an external TRIGGER signal.

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

(2) Ready for Trigger

In this state:

BUSY is high (i.e. not busy)

BDA is low (i.e. bin data is valid)

All BIN lines will be unchanged. If the previous state was a null then all bin lines will be high, meaning no bin selected, although 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 TRIGGER line.

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

(3) Busy

In this state:

BUSY is low (i.e. the instrument is busy)

BDA is low (i.e. bin data is valid)

All BIN lines are unchanged.

The 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 BUSY line goes high again, when the instrument enters the next state.

(4) Not Busy

In this state:

BUSY is high (i.e. the instrument is not busy)

BDA is high (i.e. bin data is not valid)

All BIN lines high (i.e. no bins selected).

In this state the instrument has finished with 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 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 BDA line and the relevant BIN line, which will occur only when a component has been successfully measured and sorted. Note that if the component is removed, after the 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 BIN lines are available, although 1Ø are provided in the software. Results indicated in bins 7, 8, and 9, will all make the BIN 7 line go low.

4 EXTERNAL TRIGGER

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

If continuous measurements are required, a circuit such as that shown in figure E2 may be used to trigger a measurement from the completion of the last binning operation.

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.

Note 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 2Ø 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".

5 HARDWARE DETAILS

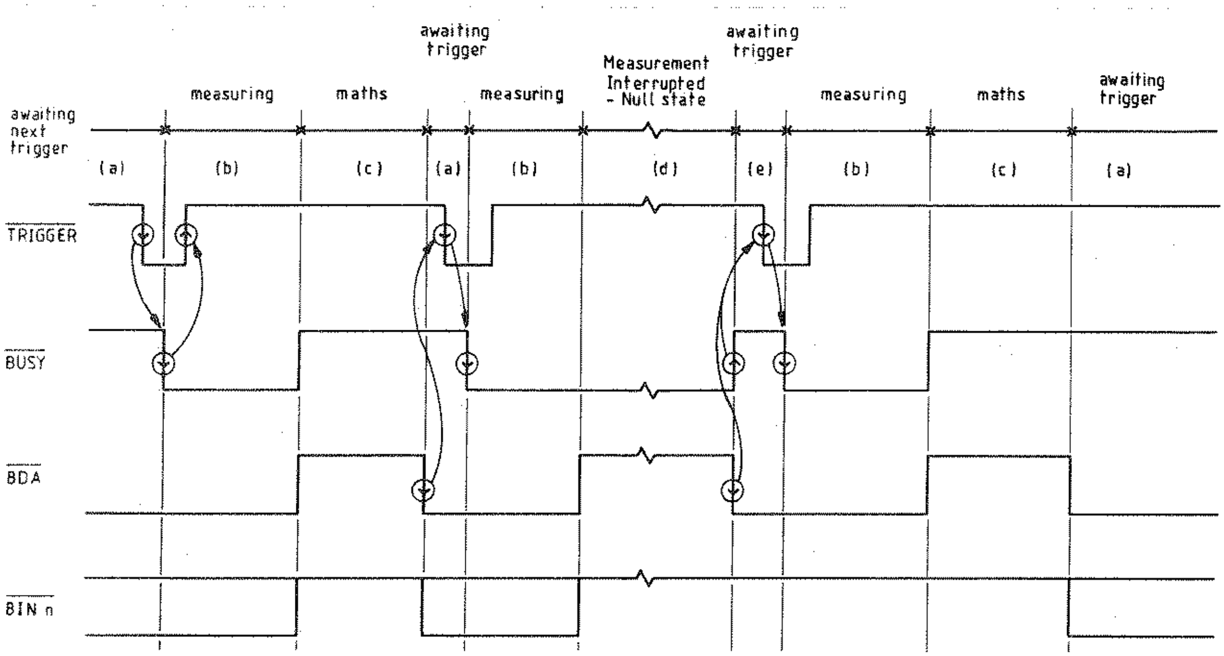
Output drive levels:

Low state : < Ø.5V at 48mA

High state : $\overline{\text{BIN Ø}}$ 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.ØV is required, and the relay coils must be fitted with suitable shunt diodes to absorb back emf energy.



(a) - Awaiting trigger. Previous results available.

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

(c) - Measurement done - Remove component.

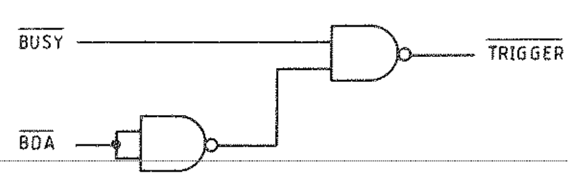
(d) - Measurement interrupted - enter 'null' state.

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

Figure E1 Standard Bin Handler Timing

TABLE E1 Standard Handler Interface Signal Definitions

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



I.C. = 74LS00

Figure E2 Circuit to generate Continuous Trigger

Appendix F

Analog Output Option

1 INTRODUCTION

The Analog Output option provides two analog output voltages which vary from Ø to 1 volt d.c. 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 d.c. 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 1Ø may be interpreted as 1Ø Henrys, 1Ø ohms or 1Ø Farads in Normal mode, or 1Ø% in Deviation and Limits mode.

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 figure F1.

When the maximum and minimum limits have been entered, the user may switch the Analog Output to 'ON'. A measurement mode, for example "Limits", may 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" (ØV), "Mid" (Ø.5V) or "Max" (1.ØV) 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.

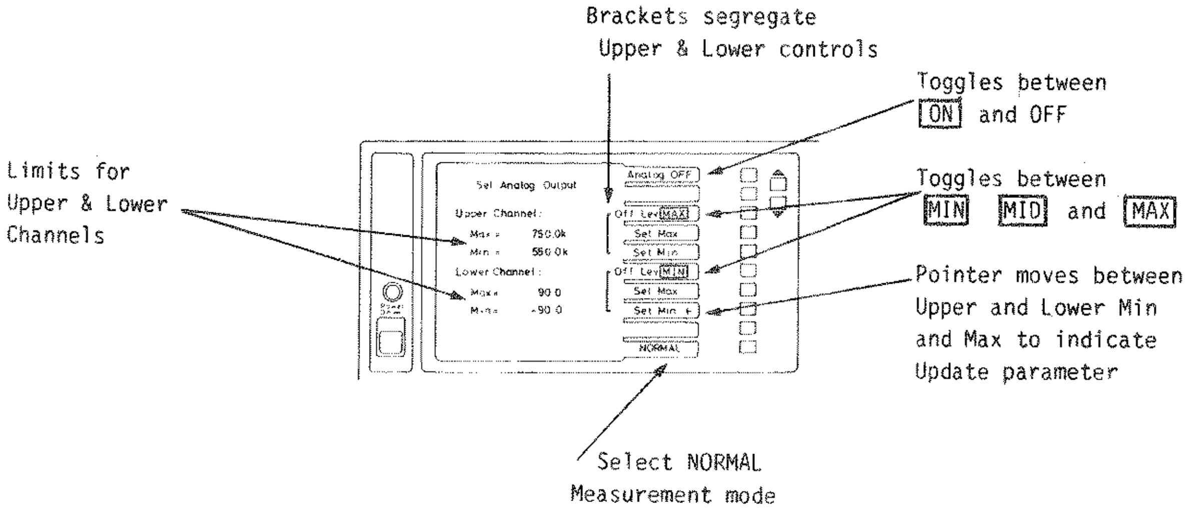


Figure F1 Analog Set Mode Display

New Safety Features

Analyzers with software revisions later than 7.Ø (to check, use CODE Ø.5 - see page 7:4) have two additional safety features, Safety Interlock and Bias Status, applicable to the control of internal bias and (via 3220) external bias. Both these new features require an Analog Output board (AOP) to be fitted in order to use the digital I/O lines available. If an Analog Output board is not fitted, operation of the 3245 will be as for previous revisions.

Safety Interlock - In order to turn the bias on it will be necessary to engage the Safety Interlock. If a switch is connected between pins 5 and 12 of the Analog Output Socket, then the bias can be turned on only if the switch is closed. If the component under test is, for example, an inductor that may generate dangerous back-EMF's due to a change in bias current, then it may be placed in a protective box. Closing the lid on this box will close the switch and so enable the bias current to be applied. Opening the lid will break the switch, causing the current to be turned off automatically and the SAFETY INTERLOCK message to be displayed.

Bias Status - Pin 6 of the Analog Output board will reflect the state of the bias current. When the 3245 is first turned on, the bias current will be off and safe so this line will be high. When the bias is turned on, this line will immediately go low, indicating that the bias is UNSAFE. Only then will the 3245 attempt to turn the bias current on. This line will stay low until the bias has been turned off, whether as the result of a command or automatically due to a fault condition. The line will then go high only when the bias current has been turned off. The line does not, therefore, indicate when the current is at its set value but when the bias current is SAFE or turned off.

This line is intended to drive a solenoid or similar device to lock a box, such as referred to above, and so prevent access to a potentially dangerous component.

In summary:

Pin 6	HIGH = SAFE	: the bias is off
	LOW = UNSAFE	: current may be flowing

TABLE F1 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 = ØV, MID = Ø.5V, MAX = 1.ØV
	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"	UML "Value"	

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

3 SOCKET DETAILS

15 pin D-type Female.

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

4 HARDWARE DETAILS

The Analog Option card is slotted into one of the expansion ports in the rear of the instrument.

5 ANALOG OUTPUT

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

Output Resolution : Ø.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 ØV 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.

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