7010

High Speed Component Tester

OPERATING INSTRUCTIONS

WAYNE KERR

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HIGH SPEED COMPONENT TESTER 7010

OPERATING INSTRUCTIONS

The reference number of this publication is TP229/2
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These Instructions apply to 7010's having software version 3 (or later).

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CONTENTS

(Continued)

CONTENTS (Continued)

(Continued)

CONTENTS (Continued)

ILLUSTRATIONS

SAFETY

GENERAL

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

The remainder of this section on safety provides information and warnings which must be followed by the user to ensure safe operation and to maintain the equipment in a safe condition.

A.C.POWER SUPPLY

1) If it is necessary to fit a suitable a.c. power plug to the power cable, the user must observe the following colour codes:
   LIVE terminal to BROWN lead
   NEUTRAL terminal to BLUE lead
   EARTH terminal to GREEN/YELLOW lead.
   The user must also ensure that the protective earth lead would be the last to break should the cable be subject to excessive strain.
2) If the power cable electrical connection to the a.c. power plug is through screw terminals then, to ensure reliable connections, any solder tinning of the cable wires must be removed before fitting the plug.
3) WARNING! Any interruption of the protective earth conductor inside or outside the equipment or disconnection of the protective earth terminal is likely to make the equipment dangerous. Intentional interruption is prohibited.
4) Before switching on the equipment, ensure that it is set to the voltage of the local a.c. power supply.

ADJUSTMENT, REPLACEMENT OF PARTS, MAINTENANCE AND REPAIR

1) When the equipment is connected to the local a.c. power supply, internal terminals may be live and the opening of covers or removal of parts (except those to which access can be gained by hand) is likely to expose live parts. The equipment must be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance or repair.

2) Capacitors inside the equipment may still be charged even if the equipment has been disconnected from all voltage sources.
3) Any adjustment, maintenance and repair of the opened equipment under voltage must be carried out only by a skilled person who is aware of the hazards involved.
4) Ensure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders is prohibited.

STATIC ELECTRICITY

Where necessary, the Maintenance Manual for this equipment contains a warning in the parts lists "*STATIC*", to alert service personnel to components which require handling precautions to avoid damage by static electricity discharge.

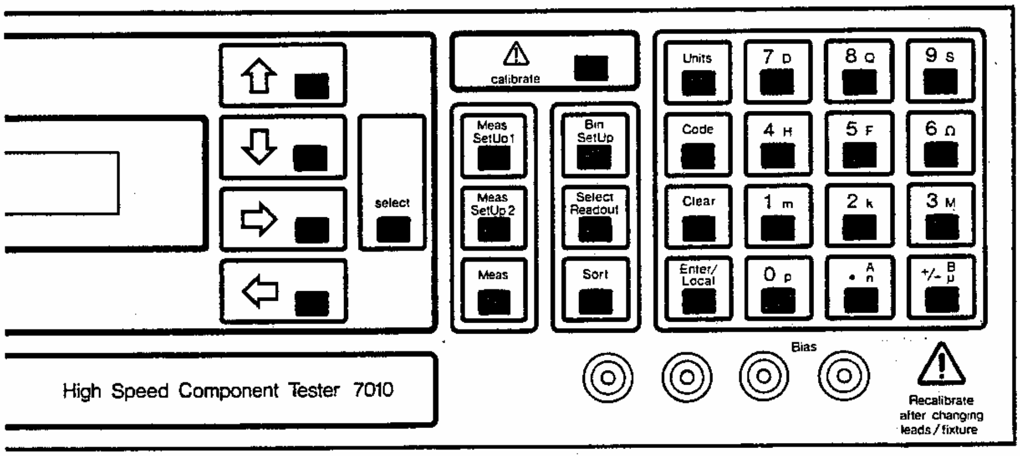
Before handling these components or printed circuit board assemblies containing these components, personnel should observe the following precautions:

1) The work surface should be a conductive grounded mat.
2) Soldering irons must be grounded and tools must be in contact with a conductive surface to ground when not in use.
3) Any person handling static-sensitive parts must wear a wrist strap which provides a leaky path to ground, impedance not greater than 1 megohm.
4) Components and printed circuit board assemblies must be stored in or on conductive foam or mat while work is in progress.
5) New components should be kept in the supplier's packaging until required for use.

DISPOSAL HAZARDS

Service personnel should be aware of the following:

1) Cathode ray tubes can implode if subject to excessive mechanical shock.
2) Batteries should be disposed of intact and never incinerated.
3) Beryllium oxide washers must be disposed of intact as toxic waste.
4) Many components contain polymers which will give rise to toxic fumes if incinerated.



calibrate
select
Meas SetUp1
Meas SetUp2
Meas
Bin SetUp
Select Readout
Sort
Units
7 D
8 Q
9 S
Code
4 H
5 F
6 Ω
Clear
1 m
2 k
3 M
Enter/ Local
0 p
• A n
+/- B μ
Bias
Recalibrate after changing leads/fixture
High Speed Component Tester 7010

1 INTRODUCTION

High Speed Component Tester 7010 has two areas of application: high-speed component sorting, and close-tolerance analysis in the Laboratory. A basic accuracy of 0.05% applies to measurements at all of the four test frequencies available: 1kHz, 10kHz, 100kHz and 1MHz. Also, four drive levels are available: 0.1V, 0.3V, 0.5V and 1V rms. Provision is made for the application of dc bias up to 200V.

Used in conjunction with an automatic handler, the 7010 can achieve test rates of up to 180,000 per hour, sorting components into as many as thirty categories. Checks are made on the major term and on the minor term: for the latter, two checks can be made under different conditions, including a change of frequency if required. Setting-up the conditions applicable to each category can be from a computer (RS232C or IEEE 488 link) or by use of the 7010 keypad and display.

In manual operation, for direct measurements in the laboratory, the 7010 provides simultaneous display of major and minor terms, with the ability to trade measurement speed for enhanced resolution (up to 10ppm). Dissipation factor accuracies as high as ±0.0002 are obtained in this mode.

In each of these two modes of use, all set-up conditions are stored, independently and indefinitely, in non-volatile memory. For the sort mode, separate memories are provided for percentage and absolute limits on the major term.

Outstanding characteristics of the 7010 include: its intrinsic ability to measure the esr of large-value capacitors at 100kHz and 1MHz; an accuracy capability as good as 10ppm, attainable by offsetting the instrument's calibration against a known good component; it is proof against hang-ups caused by electrical noise.

First-time users will find it helpful to read through the Functional Specification to learn the features and capabilities of the 7010. In order to provide an easier introduction to the diverse methods of use, operating procedures are given first for direct measurements (the 'stand-alone' mode) and secondly for sorting using ancillary equipment.

2 FUNCTIONAL SPECIFICATION

Measurement Frequencies	1kHz, 10kHz, 100kHz, 1MHz
Frequency Accuracy	±0.005%
Drive Levels (open circuit)	0.1V, 0.3V, 0.5V, 1.0V rms
Level Accuracy	±5%

The ±5% drive level tolerance applies for capacitors up to:

820 nF at 1kHz

82 nF at 10kHz

8.2 nF at 100kHz

1 nF at 1MHz

For larger capacitors / lower impedance, the level falls, becoming a constant current into a short-circuit.
With 1V selected the short-circuit current is 10mA nominal.

DC Bias - External dc bias between +200V and -200V may be applied via the bias terminals.

Fixture and Lead Compensation - The following automatic compensation functions are provided:

Open-Circuit Trim	compensates for residual parallel capacitance of the component fixture.
Short-Circuit Trim	compensates for residual series resistance/inductance of the component fixture and measurement leads.
Lead Compensation	compensates for hf attenuation and phase errors in the measurement leads. Leads may be any length up to 2 metres.

FUNCTIONAL SPECIFICATION (Continued)

Transfer Standards (for Fixture and Lead Compensation)

Capacitance Standard	has accurately-defined frequency characteristics. Provided in both chip (0505) and wire ended (5mm radial) styles.
Short Circuit	Mechanical styles in accordance with Capacitance Standard.

Reading OFFSET

When selected, this feature enables the user to adjust the instrument calibration over a range of ±0.1% for a MAJOR TERM. In addition the MINOR TERM may be adjusted over a range equivalent to a D factor change of ±0.0010. Used in conjunction with Range Hold, this reading offset will remain valid for component values up to 15% away from the set value.

2.1 SORT MODE FUNCTIONS

A component may be measured at any one of the four frequencies and sorted according to its MAJOR and MINOR TERM values. A subsequent measurement at an alternative frequency (frequency hopping) may be performed to allow additional MINOR TERM assessment. For each frequency selected, the level, speed and ranging mode may be chosen independently.

The measurement functions available at the first selected frequency are:

Major term C or L, with minor term ESR, EPR, Gp, Q or D

OR

Major term R or G, with minor term Cp, Ls or Q

Note: ESR/EPR are equivalent series/parallel resistance. Gp is parallel conductance.
Cp/Ls are equivalent parallel capacitance/series inductance.

At the second frequency any MINOR TERM from the appropriate list is available.

FUNCTIONAL SPECIFICATION - SORT MODE (Continued)

When sorting components, up to 27 MAJOR TERM selection bins are available together with three bins for MAJOR/MINOR TERM rejects. MAJOR TERM limits may be entered as a nominal value with individual percentage tolerances, or alternatively as separate absolute values. For either method of entry the user has the choice of allocating a Global MINOR TERM rejection limit or individual MINOR TERM acceptance limits for each of the bins 1 to 27.

Handler Interface

30 individual bin outputs - open collector relay drivers with pull-ups.
Max. continuous output current 100mA
Typical saturation voltage at I max = 0.9V
Max. voltage (including transients) +50V
Handshake outputs ($\overline{\text{BUSY}}$ and $\overline{\text{DATA OUT}}$) - open collector TTL level with pull-ups.

Trigger input - TTL level with pull-up.

Options: These fall into two groups. The first group (a) comprises alternative configurations which users can select (usually by re-setting internal switches). The second group (b) comprises factory options, available only if specified at the time of ordering the 7010.

(a) Handshake & trigger logic inversion
Remove pull-ups on handshakes
Remove pull-ups on bin outputs
Handshake timing change to SHI standard
Pull-up level change (+5V, +12V or EXT to +50V max)

(b) Relays (n/o contacts) for each bin output
Max. continuous current ±0.5A
Max. voltage (including transients) ±50V
Opto-isolation of trigger/handshake lines
Logic inversion of bin outputs.

FUNCTIONAL SPECIFICATION - SORT MODE (Continued)

2.1.1 OPERATING SPEEDS

There are 16 speeds available in Sort mode to allow the optimum match between measurement speed and handler speed. The highest speeds provide fast, accurate component assessments, the lower speeds offer better resolution and rejection of environmental noise. A High Speed Option allows faster component throughput without compromising resolution.

The table shows typical total measurement times from receipt of trigger pulse to completion of sorting (DOUT asserted). They apply when binning components under the following conditions:

High speed option not fitted.
Single frequency selected.
Range Hold selected.
Components being sorted into only 1 pass bin.
Display inhibited.
Printer output disabled and no data output to controller.

Speed No	Time	Rejection	Speed No	Time	Rejection
0 = MAX	26ms		8	92ms	
1	32ms		9	101ms	60Hz
2	37ms		10	110ms	
3	44ms		11 = SLOW	121ms	50Hz
4 = FAST	50ms		12	122ms	60Hz
5	56ms		13	140ms	50Hz
6	68ms	60Hz	14	167ms	60Hz
7 = MED	80ms	50Hz	15	203ms	50Hz

Notes: 1 Some of the slower speeds are optimised for rejection of 50 or 60Hz line frequency pickup, as shown in the table.

2 All times are reduced by approx 1ms when operating at 10kHz or 1MHz.

3 Fitting high speed option reduces all times by 6ms.

4 Add 0.3 to 0.4ms per bin when sorting into more than 1 pass category.

5 When two-frequency operation (frequency hopping) is in use, total time is the sum of the individual measurement and additional settling delay of up to 10ms.

6 If a display readout (see 2.1.4) is required when binning, add the following approximate times:

Pass/Fail	+ 6ms
Bin number only	+ 9ms
Bin number & selected term	+ 26ms
Main sort & minor term	+ 32ms.

2.1.2 RANGING MODE

Two types of Range Selection are available while sorting. The Auto-Predict mode selects the most appropriate measurement range from the bin limits and frequency entered. This mode provides the optimum accuracy in situations where component tolerances may span more than one range. Range Hold enables the user to select from up to 12 ranges. In frequency hopping mode, separate ranges are available for each frequency. Range Hold is the recommended mode for optimised high component throughput, particularly when operating with a fixed speed, non-handshaking handler.

FUNCTIONAL SPECIFICATION - SORT MODE (Continued)

2.1.3 SORTING ACCURACY

1V signal level, Speed No. 4 (FAST), display inhibited.

C Accuracy	1kHz	±0.05%, ±20fF for values up to 150µF ($fF = 10^{-15}F$)
	10kHz	±0.05%, ±15fF for values up to 20µF
	100kHz	±0.05%, ±20fF for values up to 50nF
	"	±0.1% for values between 50nF and 1µF
	1MHz	±0.05%, ±5fF for values up to 500pF
	"	±0.1% for values between 500pF and 2.5nF
D Accuracy	1kHz	±0.0005 for C values between 100pF and 400µF
	10kHz	±0.0005 for C values between 50pF and 40µF
	100kHz	±0.0005 for C values between 100pF and 1.5µF
	1MHz	±0.0005 for C values between 20pF and 1nF
	"	±0.001 for C values between 8pF and 20pF and for C values between 1nF and 50nF

The above accuracies apply for pure capacitors, ie $D < 0.1$. For higher D values, multiply C accuracy by $(1 + D)$ and D accuracy by $(1 + D^2)$.

See also curves on pages 2-9 to 2-12

FUNCTIONAL SPECIFICATION - SORT MODE (Continued)

R Accuracy	1kHz	±0.05% ±0.1mΩ for values up to 500kΩ ±0.1% for values between 500kΩ and 4MΩ ±0.2% for values between 4MΩ and 10MΩ
	10kHz	±0.05% ±0.1mΩ for values up to 100kΩ ±0.1% for values between 100kΩ and 500kΩ
	100kHz	±0.1% ±0.2mΩ for values up to 40kΩ
	1MHz	±0.1% ±1mΩ for values up to 25kΩ

The above accuracies apply for pure resistors having $Q < 0.1$. For higher Q values multiply the accuracy figure by $(1 + Q)$.

When measuring the ESR of a capacitor, the ESR accuracy can be derived from the D accuracy, using the expression

$$\text{ESR accuracy} = \pm(\text{D accuracy}/2\pi fC)\Omega$$

The ESR resolution obtained varies with the capacitance range selected. At 20 components/second the resolution on the lowest impedance range is as follows:

1kHz	±0.1mΩ for C values above 100µF
10kHz	±0.1mΩ for C values above 10µF
100kHz	±0.1mΩ for C values above 1.5µF
1MHz	±0.2mΩ for C values above 150nF

FUNCTIONAL SPECIFICATION - SORT MODE (Continued)

L Accuracy	1kHz	±0.1%	±20nH for values up to 400H
	10kHz	±0.1%	±2nH for values up to 5H
	100kHz	±0.1%	±2nH for values up to 50mH
	1MHz	±0.15%	±1nH for values up to 2mH

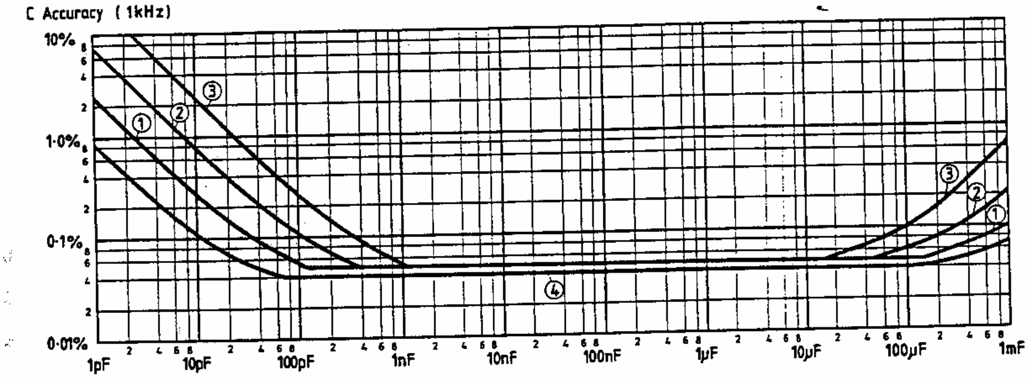
The above accuracies apply for pure inductors, ie Q> 10.
For lower Q values, multiply this L accuracy by (1 + 1/Q).

Q Accuracy	1kHz	±0.05 (Q + 1/Q)%	for L values between 100μH and 150H
	10kHz	±0.05 (Q + 1/Q)%	for L values between 10μH and 3H
	100kHz	±0.05 (Q + 1/Q)%	for L values between 2μH and 20mH
	1MHz	±0.1 (Q + 1/Q)%	for L values between 1.5μH and 2.2mH

Note: All of the above accuracy figures apply for an instrument which has been correctly trimmed and calibrated after a warm-up period of ≥30 minutes, at an ambient temperature of 23 ±5°C. For 100kHz and 1MHz accuracies the temperature change after trim and calibration should not exceed ±5°C.
Accuracies are reduced for values above or below the quoted ranges, or at reduced signal levels.
For maximum sorting speed, multiply all accuracy figures by 2.

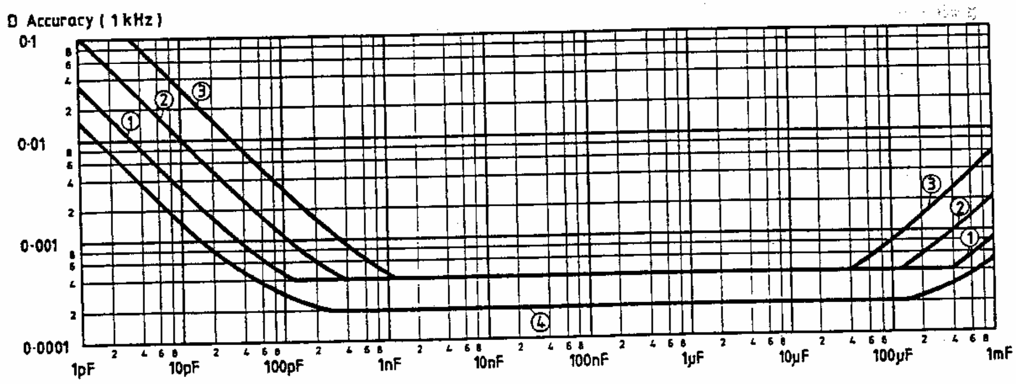
FUNCTIONAL SPECIFICATION (Continued)

Capacitance Accuracy - 1kHz



1: Sort speed No. 4 (FAST) 1V level
2: " " " 0.3V "
3: " " " 0.1V "
4: Direct, Slow mode 1V "

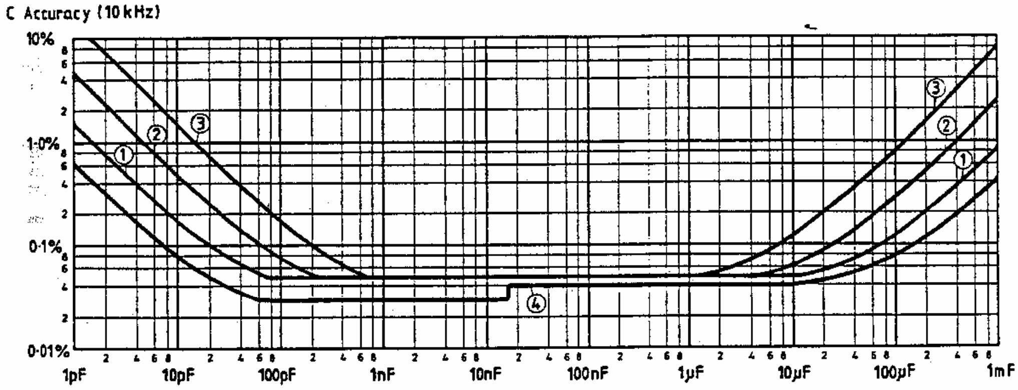
Dissipation Factor Accuracy - 1kHz



1: Sort speed No. 4 (FAST) 1V level
2: " " " 0.3V "
3: " " " 0.1V "
4: Direct, Slow mode 1V "

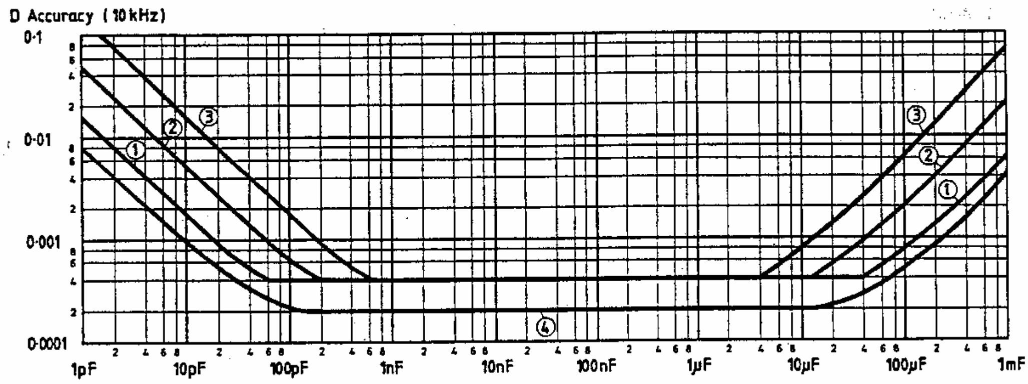
FUNCTIONAL SPECIFICATION (Continued)

Capacitance Accuracy - 10kHz



1:	Sort speed No. 4 (FAST)	1V	level.
2:	" " "	0.3V	"
3:	" " "	0.1V	"
4:	Direct, Slow mode	1V	"

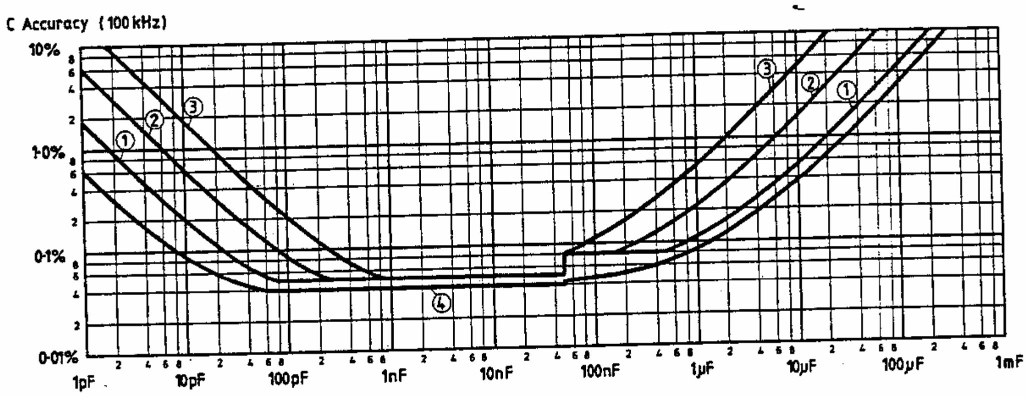
Dissipation Factor Accuracy - 10kHz



1:	Sort speed No. 4 (FAST)	1V	level.
2:	" " "	0.3V	"
3:	" " "	0.1V	"
4:	Direct, Slow mode	1V	"

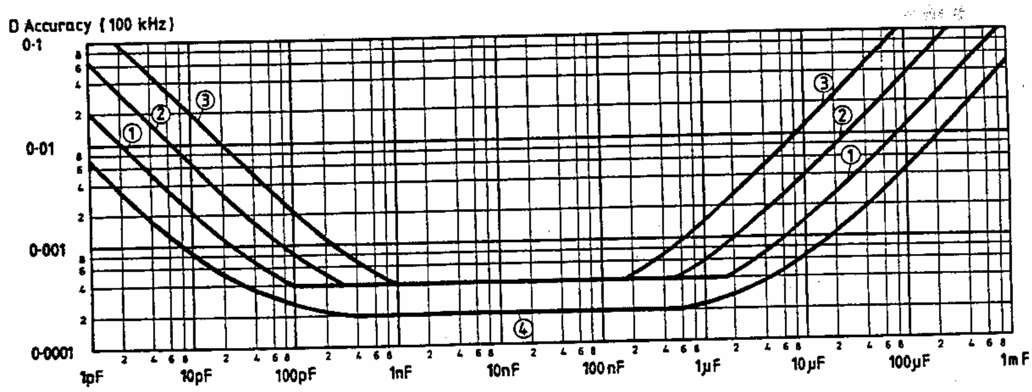
FUNCTIONAL SPECIFICATION (Continued)

Capacitance Accuracy - 100kHz



1: Sort speed No. 4 (FAST) 1V level.
2: " " " 0.3V "
3: " " " 0.1V "
4: Direct, Slow mode 1V "

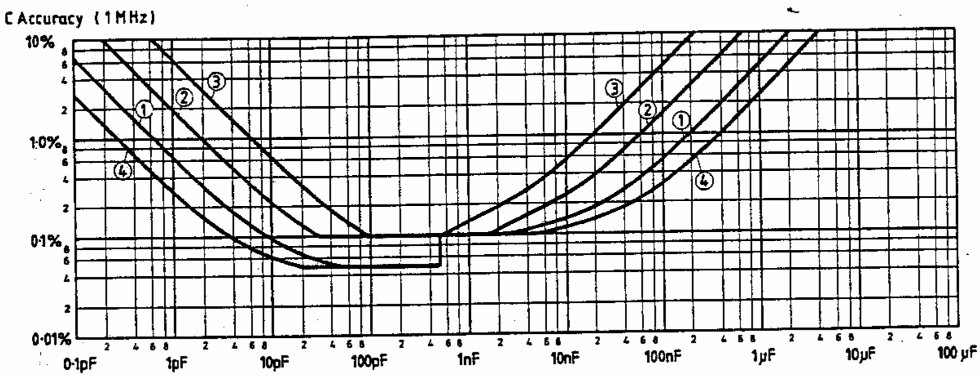
Dissipation Factor Accuracy - 100kHz



1: Sort speed No. 4 (FAST) 1V level.
2: " " " 0.3V "
3: " " " 0.1V "
4: Direct, Slow mode 1V "

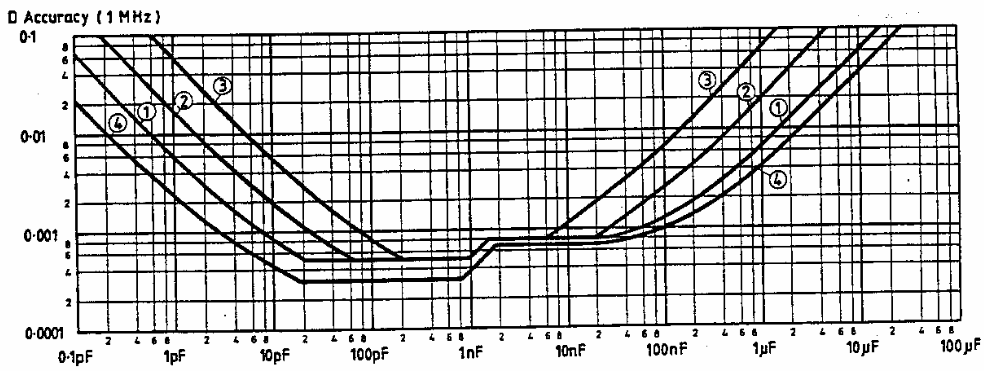
FUNCTIONAL SPECIFICATION (Continued)

Capacitance Accuracy - 1MHz



1: Sort speed No. 4 (FAST) 1V level.
2: " " " 0.3V "
3: " " " 0.1V "
4: Direct, Slow mode 1V "

Dissipation Factor Accuracy - 1MHz



1: Sort speed No. 4 (FAST) 1V level.
2: " " " 0.3V "
3: " " " 0.1V "
4: Direct, Slow mode 1V "

FUNCTIONAL SPECIFICATION - SORT MODE (Continued)

2.1.4 READ-OUT FUNCTIONS

When in Sort mode, one of the following display formats may be selected:

PASS/FAIL
Bin number only
Bin number plus MAJOR TERM at first or only selected frequency
Bin number plus MINOR TERM at first or only selected frequency
Bin number plus MINOR TERM at second frequency
Bin number plus batch total
MAJOR* and MINOR TERMS at first or only selected frequency
Display OFF. This is recommended for optimised component throughput.

2.1.5 DATA-LOGGING (Bin Count)

The 7010 keeps an internal record of component quantities in each bin, and the batch total. These totals may be re-set at any time and the data may be transferred to a computer, printer or to the 7010 display. This information, together with all relevant set-up parameters, is maintained indefinitely within the non-volatile memory.

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* When sorting by % limits, the major term will appear as + or - the percentage deviation from the stored nominal value. In the absolute mode, the measured value of the major term will be displayed. In both situations (% and absolute), the minor term is shown as an absolute measured value.

FUNCTIONAL SPECIFICATION (Continued)

2.2 DIRECT MODE FUNCTIONS

In Direct or Hand-operated mode, single or repetitive measurements may be made at a single frequency on individual components with simultaneous display of MAJOR and MINOR TERM results.

Four speeds are available:

MAX	Approx.	10/second.	Mid-range resolution* approx.	100ppm
FAST	Approx.	5/second.	Mid-range resolution* approx.	50ppm
MED	Approx.	3/second.	Mid-range resolution* approx.	20ppm
SLOW	Approx.	1/second.	Mid-range resolution* approx.	10ppm

The measurement functions available are:

C + D, C + Q, L + D, L + Q, L + R (series or parallel equivalent)
C + G, L + G (parallel equivalent circuit).

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* For major term measurements, resolution is the ppm number shown, multiplied by the measured value.

For dissipation factor measurements on pure capacitors,

resolution is D	± 0.0001	(MAX speed)
	± 0.00005	(FAST ")
	± 0.00002	(MED ")
	± 0.00001	(SLOW ")

For other minor term functions (ESR, EPR Gp and Q), the display resolution is adjusted to be approximately equivalent to the above D figures.

2.2.1 ACCURACY AND RESOLUTION

The accuracy and resolution for the highest speed available in the Direct mode are the same as for speed No. 4 in Sort mode.

Slow setting, 1V signal level:

C accuracy is better than ±0.05% under the following conditions:

1kHz for	40pF to 320µF
10kHz for	20pF to 32µF
100kHz for	30pF to 200nF
1MHz for	20pF to 500pF

D accuracy is as follows

1kHz	±0.0002 for C values between 300pF and 100µF
	±0.0004 for C values between 150pF and 400µF
10kHz	±0.0002 for C values between 150pF and 10µF
	±0.0004 for C values between 35pF and 70µF
100kHz	±0.0003 for C values between 70pF and 2µF
	±0.0005 for C values between 25pF and 5µF
1MHz	±0.0005 for C values between 10pF and 1.5nF
	±0.001 for C values between 3pF and 100nF

The above accuracies apply for pure capacitors, ie $D < 0.1$. For higher D values, multiply C accuracy by $(1 + D)$ and D accuracy by $(1 + D^2)$.

See also curves on pages 2-9 to 2-12.

FUNCTIONAL SPECIFICATION - DIRECT MODE (Continued)

R Accuracy	1kHz	±0.04%	±60μΩ for values up to 300kΩ
		±0.06%	for values between 300kΩ and 2.2MΩ
		±0.1%	for values between 2.2MΩ and 6.5MΩ
		±0.2%	for values between 6.5MΩ and 15MΩ
	10kHz	±0.05%	±60μΩ for values up to 500kΩ
		±0.1%	for values between 500kΩ and 1.5MΩ
	100kHz	±0.06%	±75μΩ for values up to 50kΩ
		±0.1%	for values between 50kΩ and 150kΩ
	1MHz	±0.1%	±1mΩ for values up to 40kΩ
		±0.2%	for values between 40kΩ and 120kΩ

The above accuracies apply for pure resistors having Q < 0.1. For higher Q values multiply the accuracy figure by (1 + Q).

When measuring the ESR of a capacitor, the ESR accuracy can be derived from the D accuracy, using the expression

$$\text{ESR accuracy} = \pm(\text{D accuracy}/2\pi fC)\,\Omega$$

The ESR resolution obtained varies with the capacitance range selected. On Direct Slow setting the resolution on the lowest impedance range is as follows:

1kHz	±0.05mΩ	for C values above	100μF
10kHz	±0.05mΩ	" " " "	10μF
100kHz	±0.05mΩ	" " " "	1.5μF
1MHz	±0.1mΩ	" " " "	150nF

FUNCTIONAL SPECIFICATION - DIRECT MODE (Continued)

L Accuracy	1kHz	±0.06%	±10nH	for values up to 600H
	10kHz	±0.06%	±2nH	for values up to 6H
	100kHz	±0.06%	±1nH	for values up to 60mH
	1MHz	±0.1%	±0.6nH	for values up to 3.5mH

The above accuracies apply for pure inductors, ie $Q > 10$.
For lower Q values, multiply this L accuracy by $(1 + 1/Q)$.

Q Accuracy	1kHz	±0.03 (Q + 1/Q)%	for L values between 100μH and 150H
	10kHz	±0.03 (Q + 1/Q)%	for L values between 10μH and 3H
	100kHz	±0.04 (Q + 1/Q)%	for L values between 2μH and 60mH
	1MHz	±0.05 (Q + 1/Q)%	for L values between 30μH and 1.5mH
		±0.1 (Q + 1/Q)%	for L values between 1.5μH and 30μH and between 1.5mH and 5mH

Note: All of the above accuracy figures apply for an instrument which has been correctly trimmed and calibrated after a warm-up period of ≥30 minutes, at an ambient temperature of 23 ±5°C. For 100kHz and 1MHz accuracies the temperature change after trim and calibration should not exceed ±5°C.
Accuracies are reduced for values above or below the quoted ranges, or at reduced signal levels.

2.2.2 RANGING MODE

The high-speed Auto-Range algorithm selects the most appropriate measurement range for the component under test. Alternatively the user can select and HOLD any one of up to 12 ranges.

FUNCTIONAL SPECIFICATION (Continued)

2.3 FEATURES COMMON TO BOTH SORT AND DIRECT MODES

2.3.1 Protection of Measurement Terminals

The 7010 will withstand repetitive connection of charged capacitors of up to 10μF at 500 volts. Additional protection is afforded by rear-panel fuses.

2.3.2 Protection of Bias Terminals

For bias voltages up to ±20V the unknown component may be short-circuited indefinitely. For bias voltages between ±20 and ±200V the 7010 circuits are protected by a self-resetting thermal trip.

2.3.3 Keyboard Lock-Out

To avoid corruption of set-up data, a code may be entered to inhibit keyboard operation with the exception of measurement Trigger facilities.

2.3.4 Data Communications (IEEE & SIO/RS232C)

The 7010 has an IEEE 488 port, and an SIO port conforming to RS232C. The latter has two sockets, wired to standards DTE (full control) and DCE (printer output), respectively. Full remote control can be via either port (IEEE or SIO), and a printer can be driven from either port, but these two functions cannot be served simultaneously by the same port. Also, only one of the two RS232 sockets may be used at one time.

FUNCTIONAL SPECIFICATION (Continued)

Remote control parameters (addresses for IEEE 488; baud rate, parity, start and stop bits, etc, for RS232C) are set up using the front-panel keys of the 7010.

Commands and output data are both formatted according to IEEE 488.2. Inherent in this Standard is the ability of the controller to read the instrument set-up.

A printer (connected to whichever port is not in use for remote control) can receive the output of measurement data in Direct or Sort modes, the Sort mode settings or Bin count results.

FUNCTIONAL SPECIFICATION (Continued)

2.4 MECHANICAL CONFIGURATION

Standard 19" rack-mount unit with 3U high panel section. Feet are provided for bench-top use.

Measurement Terminals	Guarded four wire measurement. The BNC terminal block may be located on the front or rear panel.
Overall width excluding handles	19.0 inches - 483 mm
Overall depth	18.5 inches - 470 mm
Depth behind panel	16.75 inches - 425 mm
Overall height (including feet)	5.5 inches - 140 mm
Panel section height	5.2 inches - 132 mm
Weight	23.1 lb - 10.50kg

2.5 ENVIRONMENTAL CONDITIONS

Operating temperature	+ 5 °C to + 50°C
Storage temperature	- 40°C to + 70°C
Temperature coefficient for C or D measurements	≤10ppm/°C or 0.0001/°C ≤30ppm/°C or 0.0003/°C at 1MHz
AC supply 50-400Hz	115V ±10% 230V ±10%
Power rating	< 80 VA

The 7010 is designed to operate in an electrically noisy environment and is protected by special circuits to ensure continued microprocessor operation.

3 POWER CONNECTIONS

VOLTAGE SETTING

A reversible plate on the rear shows the voltage selected. To change the setting, remove the plate, slide the switch to the alternative setting, and re-fit the plate, reversed to show the voltage selection made.

INSTRUMENT FUSES

For 115V operation, the fuse is 800mA-T.

For 230V operation, the fuse is 400mA-T.

PLUG CONNECTIONS

The power lead supplied with the instrument may have the appropriate plug, to suit local a.c. supplies, moulded on. Otherwise, the connections should be as follows:

Yellow/Green	to	Earth (Ground)
Brown	to	Live
Blue	to	Neutral

If the plug is fused, a 3-amp fuse should be fitted.
The instrument is not suitable for battery operation.
The power on/off switch is on the back panel.

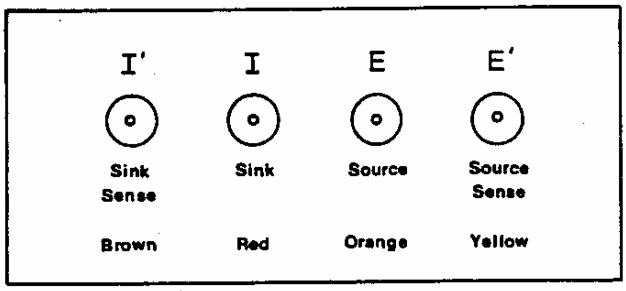
SAFETY

Always observe ALL the precautions as detailed in the SAFETY pages at the front of this manual.

4 MEASUREMENT CONNECTIONS

4.1 FOUR-TERMINAL PAIR

The 7010 has a sub-panel carrying four BNC sockets. This sub-panel can be fitted to the front or rear of the 7010: the latter position may be more convenient for rack-mounted use with automatic sort systems. The disposition, function and colour-coding of the four sockets is as shown:



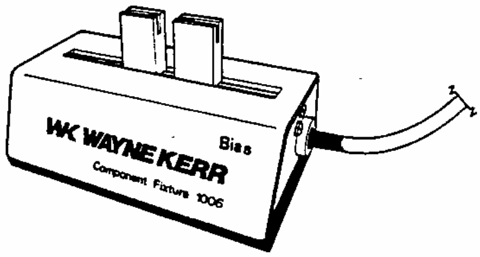
The use of individual coaxial leads from each of these four sockets provides electric and magnetic screening, and allows the accuracy available at the panel to be available up to 2 metres away. Various methods of connection are described in the next three sections:

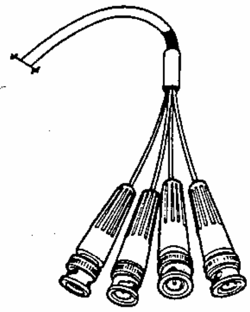
Accessories available
Custom leads
Minimising lead errors

It must be emphasised that the information in these three sections is applicable to all measurements, but is of critical importance when operating at 1MHz. Any leads used should be colour-coded to ensure that all four connections are always made to the same four corresponding sockets: any transposition of leads may introduce errors.

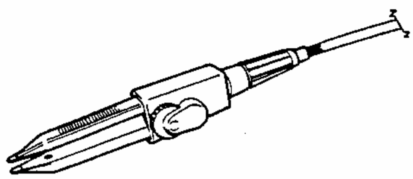
4.2 ACCESSORIES AVAILABLE

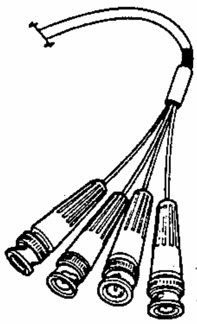
Component Fixture 1006, illustrated below, has spring-loaded jaws which can be adjusted sideways to suit various lengths of radial or axial-wired components, including bandoliered axial components. When the leads are inserted, four-terminal connections are made automatically.



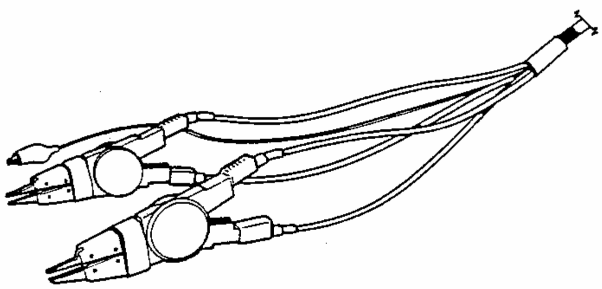


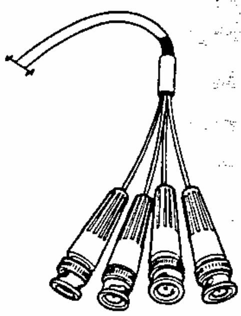
Chip Component Tweezers type 2705, illustrated below, provide two-terminal connections for the measurement of chip capacitors.





Kelvin-clip Leads, illustrated below, are available in two forms. Type 2605 has fine-pointed jaws, allowing connections to be made where clearances are minimal. Type 2405 has heavy-duty jaws for components having large measurement terminals. Both types provide four-terminal connections. The individual crocodile-clip lead provides a Guard connnection for use when making in-situ measurements. Note that, in general, neither type of Kelvin lead is recommended for accurate measurements at 1MHz.





4.3 CUSTOM LEADS

The test signal applied to the component under test is carried by the inner conductors of the E and I leads (orange and red, respectively), and the conditions at the component are sensed by the inners of the E' and I' leads (yellow and brown, respectively). These four inner conductors must be screened up to the closest possible point to the test component. At this point the four screens (braids) must be connected together, and this establishes the measurement reference plane, extended from the 7010.

It is necessary to define this position for all measurements, especially those at 1MHz, because the shorter wavelength becomes significant compared with the lead length. The reference plane will be mechanically coincident with the braid common.

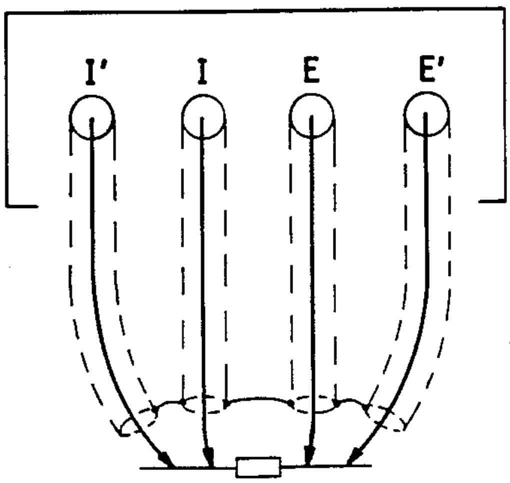
For these four screened leads, any good quality 50-ohm or 75-ohm coaxial cable can be used: type RG 174 is recommended. Maximum length of each lead is 2 metres, provided that the capacitance does not exceed 110pF per metre.

The unscreened leads from the inners, extending beyond the reference plane, can introduce serious errors, especially at 1MHz, and these measurement errors can be minimized in two ways.

1. Keep lead lengths as short as possible.

2. Avoid any unnecessary movement between the calibration and measurement operations.

Four-terminal connections should be made as shown below:



As drawn, the sense leads make the outermost connections to the test component: they could equally well be the innermost connections. Do not, however, mix the two and, once a convention is adopted, keep to it for all calibration and measurement procedures.

If the screened leads are extended, any intermediate connectors must not be mounted on a common conducting panel. As already stated, the screens should be linked ONLY at the remote end (as near as possible to the measurement point).

4.4 MINIMISING LEAD ERRORS

Design of the 7010 is such that differing lead characteristics are automatically allowed for, once the trimming and calibration procedures are repeated. This greatly simplifies operation with various types of component fixtures, test rigs or handler systems. The following points will assist users in achieving the best possible accuracy in all measurement situations.

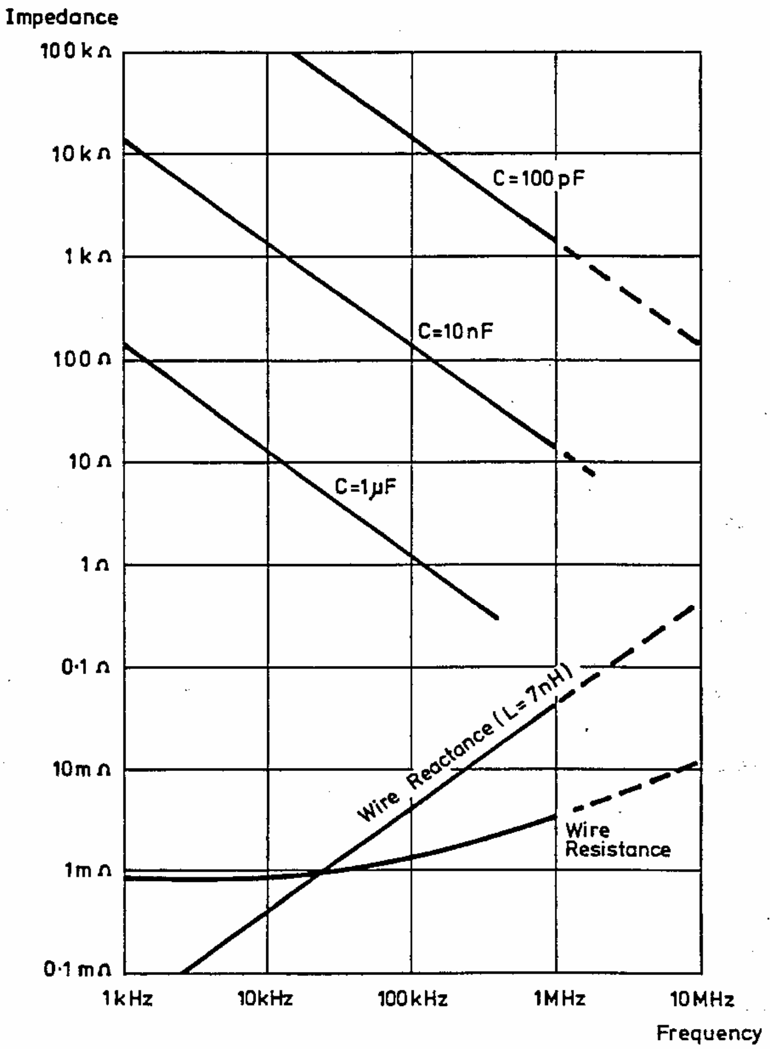
1 As stated earlier, the four measurement leads should be screened continuously from the 7010 to the nearest possible point adjacent to the component under test. The four screens should be connected together at this point, and only here. They must not be connected to ground.

2 So far as is practicable, keep the four leads close to each other (so all are affected to a similar extent by any stray electric or magnetic fields).

3 Avoid running the leads close to possible sources of electrical noise or electro-magnetic radiation.

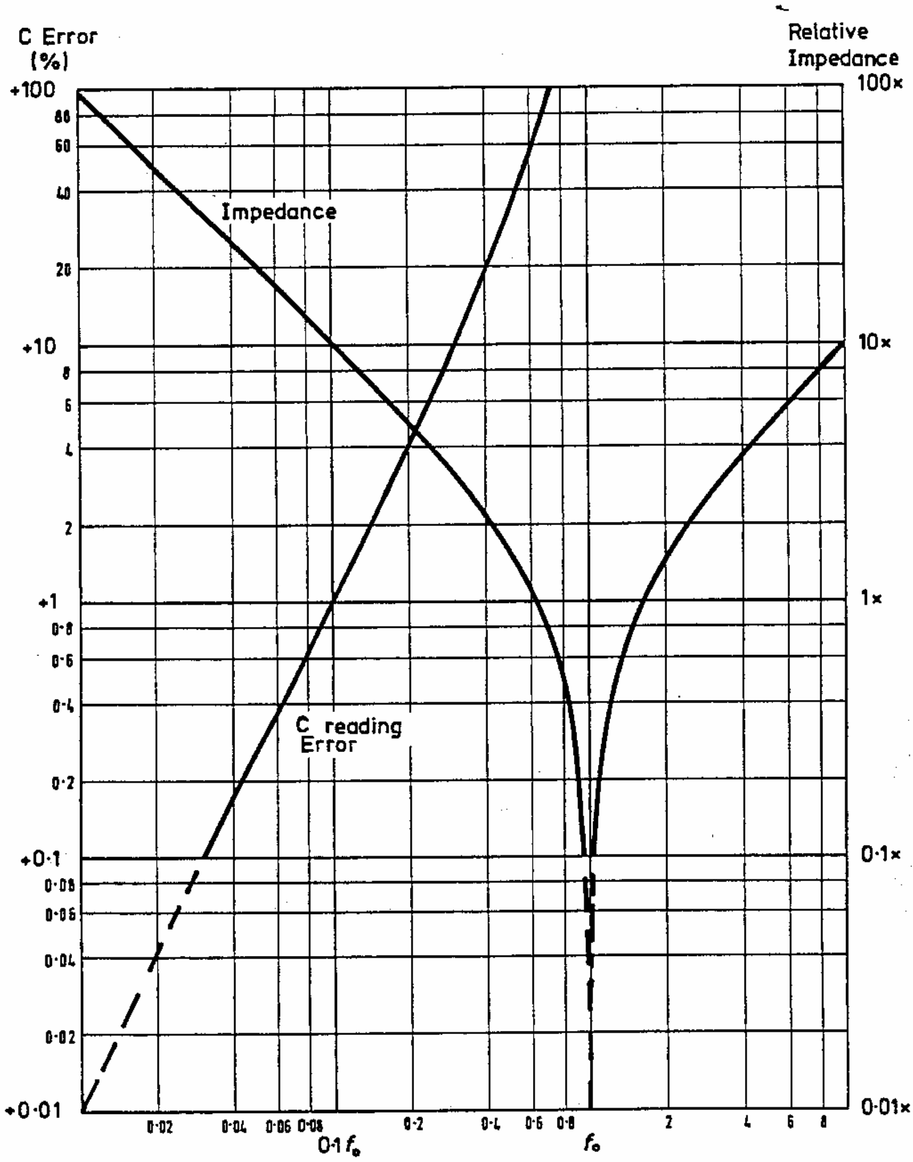
4 Any metal-work adjacent to the test fixture should ideally not be grounded but should be connected to the common point of the screens, preferably at the end of the I' (brown) lead braid. If the grounding is an inherent part of the design, do NOT make any connection to the measurement leads as this would introduce an undesirable ground loop.

5 Always keep any movement of the leads, or a change of length, between the trimming/calibration operations and the actual measurement, to the absolute minimum. Graph 1 shows how the reactance and resistance of just 1cm of wire increase at higher frequencies. Also plotted is the falling reactance of three values of capacitance. It can be seen that the wire reactance at higher frequencies becomes comparable with the capacitor reactance, resulting in substantial errors in capacitance measurement. Wire resistance rises less steeply than the wire reactance, but will introduce an error in the dissipation factor measurement.



Graph 1 - Effect of introducing 1cm length of 0.5mm diameter wire to the connecting leads.

The frequency selected for measurements must be well below the point where the capacitor under test becomes self-resonant with its own lead inductance. Graph 2 shows how the C reading error rises dramatically as resonance is approached. However, accurate measurement of esr may be made at or close to resonance.



Graph 2 - Effect of Series Resonance

Steps 5 and 6, with Graphs 1 and 2, illustrate the importance of choosing the appropriate frequency for a particular measurement. Dissipation factor (D) is defined by esr/Xc = esr x ωC, therefore esr = D/ωC (ie esr falls with rising frequency). From these considerations it is obvious that, in order to separate certain characteristics of a component, measurements are best made at two different frequencies. This facility, known as 'frequency hopping', is a feature of the 7010. When measuring capacitors, it allows

a) separation of dielectric losses (at lf) from series resistance losses (at hf), and

b) accurate C measurements (at lf) combined with series resistance losses (at hf).

Although the prime application of the 7010 is for the measurement and sorting of capacitors, it can be used to sort resistors and inductors. For the latter, frequency hopping can be used 'in reverse' - the first measurement at hf and a second one at a lower frequency for measuring the series resistance of a coil.

8 Whenever possible, the leads used to connect a Transfer Standard for calibration should be the same as those used for connections to the test component. This is particularly important at 1MHz. However, if this not possible, the second-best procedure is:

a) For connecting the Transfer Standard to the end of the four-terminal pair, use cable of the same type and length, and from the same batch, as will be used for the measurement.

b) Using the Transfer Standard's leads, perform the Trim O/C, Trim S/C and Calibration operations.

c) Substitute the measurement leads, repeat the two trimming operations, then make the measurement.

9 When using Component Fixture 1006, set the jaws to minimum spacing to carry out the calibration procedure. If the component to be tested requires a different spacing, the open-circuit and short-circuit routines only should be repeated. In this case, use a substantial conductor for the short-circuit (thick wire or, preferably, metal foil) to replace the component under test.

10 The four-terminal method of connection always minimises contact resistance variations (achieving the smallest D error). With small-value capacitors such variations are of no significance, and two-terminal connections (provided by linking the inner of I' to I for one connection, and the inner of E' to E for the second connection) may be preferable. At 1MHz, the four-terminal-pair configuration always gives a small error compared to two-terminal, depending on the type of fixture.

5 TRIMMING & CALIBRATION

IMPORTANT The trimming and calibration corrections are held in non-volatile store and applied automatically to all measurements made in the Direct or Sort modes. It is always important that trimming and calibration are performed correctly: this is particularly true when operating at 1MHz (see also the section 'Minimising lead errors' on page 4-4). The Operating Instructions for Transfer Standard 7010TSK are printed inside the lid of the box: these are repeated below. They apply to handlers/tweezers/fixtures which can be set to accept the Standards and Short Circuits provided. The requirement for the O/C Trim is that the E lead is shorted to E' and (independently) that I is shorted to I'. For the S/C Trim, it is essential that the Short Circuit used (ie Chip or Leaded) is of the same type as the Transfer Standard to be substituted.

TRANSFER STANDARD 7010TSK

OPERATING INSTRUCTIONS

For use at 100kHz or 1MHz, the 7010 must be recalibrated whenever the component fixture or connecting leads are changed.

PREPARATION

Chip handlers or tweezers require use of chip transfer standard 7010 CTS and chip short-circuit 7010 CSC. Adjust the handler/tweezers to accept these 0505 sized components. Always use vacuum pickup or tweezers provided when handling these chips.

Wire-ended component fixtures require use of the 5mm radial transfer standard 7010 LTS and matching short-circuit 7010 LSC.

For larger radial/axial fixtures, extend leads by soldering on straight lengths of tinned copper wire. Always use the same wire for both components.

OPERATION

For complete recalibration, perform O/C Trim, S/C Trim and Cal functions in order. Press Cal. button on the 7010 to start this sequence.

O/C TRIM

Set the fixture jaw spacing to suit transfer standard to be used. For 4-terminal fixtures ensure an electrical connection exists between the two halves of each pair of jaws. One pair on either side of the component to be measured. Then follow the instructions on the 7010 display.

S/C TRIM

Ensure contacts are clean, especially with 2-terminal fixtures/tweezers. Fit appropriate short-circuit (7010 CSC or 7010 LSC). Then follow the instructions on the 7010 display.

CAL

Fit the appropriate transfer standard (7010 CTS or 7010 LTS). Then follow the instructions on the 7010 display.

After calibration the jaws spacing may need altering to suit the components to be tested. In this case, repeat O/C Trim and S/C Trim only.

NOTE: When operating with fixtures that cannot accept the Transfer Standard as supplied, the same diameter and lengths of tinned copper wire as used to extend the leads of the Transfer Standard must also be used to extend the leads of the Short Circuit in exactly the same way. Also, for maximum accuracy at 1MHz, when the above procedures have been completed, the S/C Trim should be repeated using foil to provide a true low-inductance short-circuit.

A typical trimming and calibration procedure, and the associated resulting displays on the 7010, is as follows.

1 Connect all four cables from the fixture to the corresponding BNC sockets of the 7010 (see page 4-1) and set the jaw spacing to suit the Transfer Standard to be used.

2 Press 'calibrate'. The display will show:

Open Fixture Key 1.

Remove any component from the fixture (but ensure that, on 4-terminal fixtures, E is connected to E' and - separately - that I is connected to I', at the fixture). Then press the 1 key. The next display is:

O/C Trim busy.

3 After a short time the display will change to <u>either</u>:

O/C FAIL Retry=Key 1 (see Note 1, below)

<u>or</u> the next display:

Short Fixture Key 2.

Connect the appropriate Short Circuit, as described above, across the measurement jaws and then press the 2 key. The display will show:

S/C Trim busy.

4 After a short time the display will change to <u>either</u>:

S/C FAIL Retry=Key 2 (see Note 2, below)

<u>or</u> the next display:

Connect Std 3 Key 3.

Connect the appropriate Transfer Standard between the jaws and then press the 3 key. The display will show:

Calibrate busy.

5 After a few seconds the display will change to <u>either</u>:

Cal FAIL Retry=Key 3 (see Note 3, below)

<u>or</u> the next display:

CALIBRATION COMPLETE

If the jaws have to be re-set to suit the component to be tested, repeat both trim operations (see Note 5).

<u>Note 1</u> If repeated use of the 1 key again produces the O/C FAIL message, check that there is no excessive shunt loading across the measurement leads or fixture. Also check that there is continuity across the two halves of each jaw (E to E', I to I').

<u>Note 2</u> If repeated use of the 2 key again produces the S/C FAIL message, check that there is nothing introducing excessive series impedance in the measurement leads or fixture.

<u>Note 3</u> Calibration can only be effected after the O/C and S/C Trim operations have been completed successfully. If the Cal FAIL message persists after repeated use of the 3 key, check that the correct Standard has been selected and that it is properly connected.

Note 4 If required, the up/down arrow keys can be used to select any one of the three operations just described (O/C Trim, S/C Trim and Calibrate) but, if all three are necessary, they should be carried out in the sequence given.

Note 5 When measuring wire-ended components at hf, readings will include effect of wire inductance and resistance ONLY if a substantial foil short-circuit was used for the final trim.

Note 6 The trim and calibration routine can be exited at any point by pressing the appropriate set-up button or by triggering a measurement.

6 DIRECT COMPONENT MEASUREMENT

6.1 SETTING MEASUREMENT CONDITIONS

The measurement conditions are held in non-volatile store and can be inspected or updated by pressing Meas SetUp1 and/or Meas SetUp2, as appropriate. Meas SetUp1 comprises five parameters:

Major term
Minor term
Equivalent parallel or series terms (Par or Ser)
Test signal frequency
Test signal level

A typical display line could be:

C R Par → 10kHz 0.3V

where → represents the cursor, here pointing to frequency. To re-position the cursor, use the Left/Right arrow buttons.

To update the term pointed out by the cursor, press the 'select' button. Each term is part of one of five rolling menus:

C	D	Par	1kHz	1.0V
L	Q	Ser	10kHz	0.1V
C etc	R	Par etc	100kHz	0.3V
	G *		1MHz	0.5V
	D etc		1kHz etc	1.0V etc

---

* G available only on Par. If G is selected while on Ser, display changes Ser to Par.

Meas SetUp2 comprises two terms:

Measurement speed
Range selection

In this situation, the rolling menus are:

Slow	Hold N
Med	Auto
Fast	Hold N etc
Max	
Slow etc	

where N is Range Number (see table of ranges on the next page).

Details of the speeds are on page 2-14. Slow produces the more accurate results because noise fluctuations are averaged out. Fast is useful when pre-set controls are being adjusted. The number of digits displayed - up to a maximum of six - is automatically adjusted to be commensurate with the accuracy.

Auto refers to automatic range selection.

With the cursor pointing to Hold, the required range is selected by pressing Clear followed by any digit 0-9 on the keypad. At 1kHz only, two additional ranges are available, A and B, selected via the decimal and +/- keys, respectively. The coverage of each range, in terms of impedance, and in terms of capacitance at each of the four frequencies, is shown in the table on the next page.

With either of the Meas SetUp modes in use (1 or 2), the up/down arrow buttons can be used to change-over between 1 and 2.

When the trimming and calibration procedures have been completed successfully, to suit the measurement leads, fixture or handler to be used, and the required measurement conditions have been set-up, connect the component and press the Meas button. A single press will initiate a measurement: if the button is held depressed for the duration of a measurement, the Tester will enter a repetitive mode, indicated by a flashing asterisk. A further short press of the Meas button will recall the single measurement mode.

6.2 TABLE OF MEASUREMENT RANGES

Range Number	Impedance range	C at 1kHz	C at 10kHz	C at 100kHz	C at 1MHz
0	<3.16Ω	>50μF	>5μF	>500nF	>50nF
1	<10Ω	>16μF	>1.6μF	>160nF	>16nF
2	<31.6Ω	>5μF	>500nF	>50nF	>5nF
3	<100Ω	>1.6μF	>160nF	>16nF	>1.6nF
4	>100Ω	<1.6μF	<160nF	<16nF	<1.6nF
5	>316Ω	<500nF	<50nF	<5nF	<500pF
6	>1kΩ	<160nF	<16nF	<1.6nF	<160pF
7	>3.16kΩ	<50nF	<5nF	<500pF	<50pF
8	>10kΩ	<16nF	<1.6nF	N/A	N/A
9	>31.6kΩ	<5nF	<500pF	N/A	N/A
A	>100kΩ	<1.6nF	N/A	N/A	N/A
B	>316kΩ	<500pF	N/A	N/A	N/A

The above range breaks are nominal, as used by the Auto-range routine. In range Hold, the limits can be exceeded by at least 15% without overloading.

Ranges 4 to B operate down to zero capacitance (ie open-circuit) without overloading.

Ranges 0 to 3 operate up to the largest capacitance values (ie approaching short-circuit) without overloading. These ranges do not have a constant-voltage drive.

NOTE. The ranges shown in the above table apply for test voltages of 1.0V and 0.5V. At 0.3V, the top and bottom ranges specified in each column become 'not available' (N/A). At 0.1V, the top two and bottom two ranges specified above become N/A.

6.3 MEASUREMENT DISPLAY

Measurement results are always displayed reactive term first, followed by the resistive (or D, or Q) term. This applies even if the resistive term is the major term. Usually, results will be required in equivalent series terms for low impedances (ranges 0 to 3 inclusive) and parallel for all higher ranges.

Examples of possible results are as follows:

* 1.2345nF 1.2345mΩ

*-0.1234pF -1.2345nS

* 12.345 H 12Ω

* 1.2345μF 0/RΩ

* Range Error

*1.23456μF 0.00001D

The asterisk (* - replaced by Δ if a finite offset is ON - see page 8-2) indicates measurement in progress. Hence a flashing * (or Δ) indicates repetitive mode selected.

O/R (outside range) appears in place of a numeric term if the calculated result is too large to display.

Range Error shows in place of both displays when Hold is selected and the measurement overloads.

The number of digits displayed - up to a maximum of six - is automatically adjusted to be commensurate with the accuracy.

6.4 DC VOLTAGE BIAS

For Direct Component Measurements, if a dc polarising voltage is required across a capacitor during measurement, or if a dc bias is required for characterisation tests on semiconductor capacitances, this can be applied to a pair of terminals on the rear panel of the 7010. The lower terminal is at chassis potential: up to 200 volts positive or negative can be applied from a power supply to the upper terminal. This voltage will appear at the E (Orange) measurement socket, via an internal source resistance of approximately 400 ohms. (With Component Fixture 1006 the bias voltage appears on the right-hand jaws: with Kelvin-clip leads it appears on the red-coded lead - regardless of polarity).

When measuring large-value capacitors with bias applied, due regard must be paid to the charging time through the 400-ohm source resistance.

Note that there is no overvoltage protection if more than 200 volts is applied to the rear terminals. With bias levels up to 20V, the instrument is continuously protected against a short-circuit at the measurement terminals. With bias levels between 20V and the maximum permitted of 200 volts, a short-circuit is likely to cause an internal thermal trip to operate. Other than the disappearance of bias at the measurement terminals, the user has no indication of this. The trip will automatically re-set after a few seconds.

Bias should not be used during measurements on resistors or inductors.

If no power supply is connected to the rear terminals, they must be connected together using the shorting link supplied.

The above text applies only to measurements in the Direct mode. Users wishing to apply bias during Sort operations should contact their supplier for further information.

COMPONENT SORTING

This section describes the alternative methods of setting the limits for sorting components into categories (or "bins") and gives the setting-up procedure for the binning functions, using the panel controls. (Details of the corresponding functions under the control of ancillary equipment are described separately).

The setting-up procedure for component sorting can be regarded as consisting of two parts:

A The conditions under which the component is measured

B The method by which components are sorted.

Before detailing the alternatives available for A and B it has to be stated that all settings made for Component Sorting are held in non-volatile store, independently from the stored parameters for Direct Component Measurements (Chapter 6). To some extent, settings made in A determine the options in B. In both parts, the options are in the form of a menu which can be examined and, if required, amended by first setting a 'window' to the appropriate line.
In part A, the options are:

(i) One frequency (f1) or
two frequencies (f1 and f2)

Each frequency can be 1kHz, 10kHz, 100kHz or 1MHz. Also, when two frequencies are used, options (ii) (iii) and (iv) are available separately at both frequencies.

(ii) Test signal level
0.1V, 0.3V, 0.5V or 1.0V rms (open circuit values, ±5%).

(iii) Speed
As detailed in section 2.1.1 of the Functional Specification.

(iv) Range
This can be selected by the operator or selected automatically.

In part B, the options are:

(v) Percentage limits or Absolute limits

(vi) Single minor term reject limit or individual minor term acceptance limits per bin

(vii) Nested limits or stacked limits

Before a component is sorted into a particular bin, it must meet the two or three conditions applicable to that bin.

1 The first condition is that the MAJOR term lies within defined limits, which can be set-up in two ways:

Nested or Stacked

Nested limits are usually set-up using a single nominal value and a series of % tolerances, becoming wider for each succeeding bin number. For example:

Nominal value	100pF	
Bin 1 limits	(+)0.1%	-0.1%
Bin 2 limits	(+)0.25%	-0.25%
Bin 3 limits	(+)0.5%	-0.5%

and so on, as required.

(For clarity of explanation, the % limits shown in the example are symmetrical; in practice, they need not be).

Note, however, that Nested limits can, alternatively, be set up in absolute terms which, for a 100pF capacitor and the limits shown above, would be:

Bin 1 limits	100.10pF	99.900pF	
Bin 2 limits	100.25pF	99.750pF	
Bin 3 limits	100.50pF	99.500pF	etc

(The 7010 displays the upper limit first).

Stacked limits are usually set-up in absolute terms, the upper limit for one bin coinciding with the lower limit for the next bin. For example:

Bin 1	12.000pF	10.000pF
Bin 2	14.000pF	12.000pF
Bin 3	16.000pF	14.000pF etc

(As already stated, 7010 displays the upper limit first).

Note, however, that Stacked limits can, alternatively, be set up in percentage terms which, for the example above, could be:

Nominal value	10pF	
Bin 1 limits	(+)20.0%	0.0%
Bin 2 limits	(+)40.0%	(+)20.0%
Bin 3 limits	(+)60.0%	(+)40.0%

(If the nominal value were defined as, say, 15pF, the % figures would begin as negative tolerances and ascend to positive tolerances commencing at Bin 3).

2 The second condition to be met before a component is sorted into a particular bin is related to its MINOR term. This can be defined, for sorting purposes, in either of two ways:

a) A single (Global) limit beyond which a component checked at f1 is rejected into Bin A.

b) Individual acceptance limits assigned to each bin. This arrangement allows sorting by combinations of minor and major term values.

In either case, the minor term limit(s) are always expressed in absolute values (not % tolerance) and are the checks made at frequency f1. All limits set, in a) and b), define an acceptable maximum value for D, esr or Gp: for Q or epr they define the acceptable minimum values.

3 The third condition (which will not apply if 'None' was selected from the f2 frequency menu) is similar to 2a) and 2b), except that f2 conditions apply and that a component whose minor term lies outside a single limit is rejected into Bin B instead of Bin A.

If the 7010 is programmed as in 2b), bins A and B are inoperative.

After programming, individual bins can be disabled, and subsequently re-enabled, without reprogramming. The Tester holds all Sort parameters in non-volatile stores, including separate memories for % and Absolute limits on the major term.

Illustrated are four Sample Bin Set Ups, two for Single frequency and two for Dual frequency, with the type of limits detailed beneath each list. The rectangle represents the 'window' on to the information shown on the 7010 display at any particular time. The up and down arrow buttons will move this window to the required line. The Left and Right arrow buttons move the cursor so that it precedes an individual parameter on a line that is to be updated.

The text which follows describes the procedure for a completely new set-up: however, by using the arrow buttons as just described, selected parts of a program can be updated, using only the appropriate part of the text to revise a particular parameter.

f1 100kHz 0.1v Hold6

f1 100kHz Slow

f2 None

Absolute Limits

Minor Limits Single

A f1 D > 0.00020

1 96.000pF 95.000pF

2 97.000pF 96.000pF

3 98.000pF 97.000pF

....etc

SAMPLE BIN SET UP

Single frequency
Absolute major
limits (Stacked)
Single minor
reject limits

f1 100kHz 0.1v Auto

f1 100kHz Fast

f2 None

Percentage Limits

Nominal = 100.00pF

Minor Limits Per Bin

1 0.1 % -0.1 %

1 f1 D < 0.00100

2 0.25 % -0.25 %

2 f1 D < 0.001

3 1.0 % -0.5 %

3 f1 D < 0.00500

....etc

SAMPLE BIN SET UP

Single frequency
Percentage major
limits (Nested)
Separate minor
acceptance limits

```
f1      1kHz    0.1v   Auto
f1      1kHz    Slow
f2    100kHz    1.0v   Auto
f2    100kHz    Fast
Percentage Limits
Nominal  =  47.000µF
Minor Limits Single
A  f1   D > 0.0
B  f2 esr  >1.2345mΩ
1   0.25  %  -0.25  %
2   0.50  %  -0.50  %
3    DISABLED
....etc
```

SAMPLE BIN SET UP

Dual frequency
Percentage major limits (Nested)
Single minor reject limits for each frequency but minor reject limit for f1 disabled by setting it to zero

```
f1      10kHz 0.5v  Hold6
f1      10kHz Slow
f2      1MHz  1.0v  Auto
f2      1MHz  Fast
Absolute Limits
Minor Limits Per Bin
1    101.00pF 99.000pF
1 f1     D < 0.00500
1 f2  esr  <1.2345mΩ
2   102.00pF  98.000pF
2 f1     D <0.00500
2 f2 esr  <2.4680mΩ
....etc
```

SAMPLE BIN SET UP

Dual frequency
Absolute major limits (Nested)
Separate minor acceptance limits for each frequency

The complete procedure for setting-up the component measurement and sorting conditions is as follows:

1 Press Bin SetUp and, if necessary, use the Left arrow button to position the cursor to the left of the frequency. Press 'select' to cycle through until the required f1 frequency is obtained (1kHz, 10kHz, 100kHz or 1MHz).

2 Use the Right arrow button to position the cursor in front of the test voltage: 0.1V, 0.3V, 0.5V or 1.0V. Use 'select' to obtain the voltage required.

3 Use the Right arrow button to position the cursor in front of the range selection: HoldN or Auto (where N is the range number). Use 'select' to change-over from one condition to the other.

3a With the cursor pointing to Hold, the required range is selected by pressing any digit 0-9 on the keypad. Press Clear before making a changed selection. At 1kHz only, two additional ranges are available, A and B, selected via the decimal and +/- keys, respectively. The coverage of each range at each of the four frequencies is shown in the table on page 6-3.

3b With Auto selected (Auto-Predict), the Tester selects the most appropriate measurement range, dependent on the frequency and bin limits entered. This mode provides the best accuracy in situations where component tolerances may give values spanning more than one range. However, Auto should not be used when the Tester is operating in conjunction with a fixed-speed, non-handshaking handler.

4 Use the down arrow button to obtain the second f1 line. The frequency will be as selected for the first line: a change in either line will change both.

5 Use the Right arrow button to position the cursor in front of the measurement speed: Slow, Med, Fast or Max. Use 'select' to obtain the speed required. (See Functional Specification page 2-4 for details). For other speeds available, use Code 1 (see page 13-1). After entering this Code, press Clear before making a changed selection. The preceding operations determine the frequency, level, ranging and speed for sorting by major and minor terms at a single frequency (f1).

6 Use the down arrow button to obtain the first f2 line. This can be used, in conjunction with a second f2 line, to set up the conditions for sorting by additional minor term checks under conditions differing from those used for f1. The f2 settings can use a different frequency, level, range and speed. If required, set up the parameters in the same manner as given above for f1. If not required, select 'None' from the f2 frequency menu. For a different f2 speed, use Code 2. Any of the speeds listed on page 2-4 is available at f2.

7 Use the down arrow button until the display shows:

Percentage Limits <u>or</u> Absolute Limits.

(These descriptions apply to the major term: minor term limits are always set as absolute values).

Press 'select' to change from one to the other.

8 Use the down arrow button to obtain the next line of display, which is dependent on the selection made in step 7. Perform operations 9-17 for Percentage Limits or operations 18 & 19 for Absolute Limits.

Percentage Limits

9 There is no cursor on the display, which is of the form:

Nominal = 1.2345μF

To enter a new Nominal value, first press Clear. Use the keypad to set-up the required value (up to five digits and a decimal point). If an error is made, press Clear and re-enter the value.

10 Press Units. The digits just set-up will now be followed by: #. If required, the appropriate multiplier (m, k, M, p, n or μ) should now be keyed. The one selected will replace the # sign.

11 Key-in the required units (S, H, F or Ω). The display will show the appropriate letter after the multiplier. If no units are entered the previously defined units will be assumed. Note however that this does not include the multiplier. It is not necessary to press the Enter key.

12 Use the down arrow button to obtain the next line:

Minor Limits Single <u>or</u> Minor Limits Per Bin

Use 'select' to obtain the condition required.

<u>Minor Limits Single</u>, followed by use of the down arrow button, will produce a display line for Bin A, allowing a single minor term* REJECT limit to be set for checks at frequency f1. If f2 was programmed, a further push of the down arrow button will produce a display line for Bin B - a single minor term* REJECT limit for checks at f2. Subsequent use of the down arrow button calls up a series of display lines for Bins 1-27, for each of which only major term limits can be set.

Minor Limits Per Bin, followed by use of the down arrow button, will produce a series of display lines for Bins 1 to 27: three lines for each bin if f2 is used, otherwise two lines for each. The first of these three is for the major term limits: the other one or two for minor term* limits at f1 and (if programmed) f2.

Note that the minor term function will be the same for each bin. Different functions are available, however, for minor term tests at f1 and f2.

[Text (step 13) continues on page 7-11]

---

* The minor term selection is dependent on the units specified for the Nominal value or major term limits:

Major term units	Selection
F or H	D, Q, esr, epr, Gp
Ω or S	Q, Ls, Cp

In all cases, entries are updated by positioning the cursor using the Left/Right arrow buttons, pressing Clear and then using the keypad digits/decimal, Units key, multiplier (m, k, M, p, n or μ) and the units (D, Q, S, H, F or Ω), as appropriate. The Enter key is not used at this operation. If minor term checks are not required at frequency f1, set the limits to 0.

13 The next line relates to the major term limits and will be of the form:

1→ 0.0% 0.0%

The first character ('1' in the above example) is the bin number.** The first percentage showing will be the upper limit (even if originally the limits were entered transposed - lower first, upper second - they are displayed correctly once the line has been exited and then recalled). To update either limit, first use the Left/Right arrow button to position the cursor to the left of the appropriate set of figures and then press Clear.

14 Up to five spaces are available for each percentage number. Values are assumed positive unless a minus sign is entered. A decimal point, if included, occupies one space. Check that the cursor precedes the cleared limit (upper first, lower second) and key-in the digits and decimal point as required. After keying in either limit, do not press the Enter key.

15 Assuming the limit entered in step 14 was the upper one, using the Right arrow button to position the cursor before the lower limit will produce the same numerical value as the upper one but of opposite sign. If necessary, use Clear and the keypad to set-up a different lower limit (a minus sign must be keyed-in before the limit if required).

** The cursor can be set to precede the bin number, (it will not be displayed, but the number will flash on and off) making two alternative operations available. Firstly, pressing a number (1-27) on the keypad, followed by Enter, will move the display window to the major term limits line for that bin number (which may be quicker than using the up/down arrow buttons). Secondly, pressing 'select' will turn off that particular bin. Instead of the limits display, the word DISABLED will appear; the limits values will, however, be retained in memory and can be reinstated by further use of the 'select' button.

16 Use the down arrow button or the Right arrow button to obtain the next line.

In the Minor Limits Single mode, this line will be the major term limits for Bin 2, which can be set as described in steps 13 to 15. Further use of the down arrow button allows major term limits to be set (or the bin Disabled) for each bin up to 27.

In the Minor Limits Per Bin mode, the next two* lines will be of the form:

1 f1→ D <0.00015
1 f2→ esr <1.2345mΩ

(where → represents the cursor and
< indicates 'less than')

The first character ('1' in the above examples) is the bin number (see previous ** footnote). The other terms are set-up in the usual way, using the Left/Right arrow buttons to position the cursor in front of the parameter to be updated, followed by the appropriate use of 'select' and the keypad.

17 Use the down arrow button to step through the major and minor term lines for all other bins to be updated.

This completes the setting-up procedure for component sorting by Percentage Limits.

Absolute Limits

Operation 18 describes the procedure for updating the major term, and 19 the minor term. However, in the Absolute Limits mode, if the major term is changed from (L or C) to R, or from R to (L or C) then, in order to obtain the appropriate minor term selection, it is necessary to set the major term limits for at least one of the numbered bins (not A or B) before attempting minor term selection. If this is not done, the wrong selection of minor terms is presented.

---

* The second line, and all f2 lines, will not appear if f2 was set to 'None'.

18 With operations 1-8 of Component Sorting completed, the display will show

Minor Limits Single <u>or</u> Minor Limits Per Bin

Use 'select' to obtain the condition required.

<u>Minor Limits Single</u>, followed by use of the down arrow button, will produce a display line for Bin A, allowing a single minor term* REJECT limit to be set for checks at frequency f1. If f2 was programmed, a further push of the down arrow button will produce a display line for Bin B - a single minor term* REJECT limit for checks at f2. Subsequent use of the down arrow button calls up a series of display lines for Bins 1-27, for each of which only major term limits can be set. Enter the upper limit first, lower limit second (but if entered in reverse order, they will automatically be transposed when the line is exited).

<u>Minor Limits Per Bin</u>, followed by use of the down arrow button, will produce a series of display lines for Bins 1 to 27: three lines for each bin if f2 is used, otherwise two lines for each. The first of these three is for the major term limits: the other one or two for minor term* limits at f1 and (if programmed) f2.

Note. In the Absolute Limits mode, the units shown against the major term limits are common to all bins, although they can be changed whenever a major term is entered for any bin (affecting all others). This does not apply to the multiplier, however.

---

* The minor term selection is dependent on the units specified for the Nominal value or major term limits:

Major term units	Selection
F or H	D, Q, esr, epr, Gp
Ω or S	Q, Ls, Cp

In all cases, entries are updated by positioning the cursor using the Left/Right arrow buttons, pressing Clear and then using the keypad digits/decimal, Units key, multiplier (m, k, M, p, n or μ) and the units (D, Q, S, H, F or Ω), as appropriate. The Enter key is not used at this operation. If minor term checks are not required at frequency f1, set the limits to 0.

19 Enter the minor term limits as described in the previous section (Percentage Limits).

Note that the minor term function will be the same for each bin. Different functions are available, however, for minor term tests at f1 and f2.

20 Press Select Readout to obtain the menu of display formats. This is given in the Functional Specification (under 'Read-out Functions') but is repeated here for easy reference:

PASS/FAIL
Bin number only
Bin number plus MAJOR TERM at first or only selected frequency
Bin number plus MINOR TERM at first or only selected frequency
Bin number plus MINOR TERM at second frequency
Bin number plus batch total
MAJOR and MINOR TERMS at first or only selected frequency
Display OFF.

Use 'select' or the up/down arrows to scroll through the menu.

The PASS/FAIL mode relates to the limits set for Bin 1.

'Bin number plus batch total' refers to the total number in the bin count mode.

'Display OFF' provides the fastest throughput when operating in conjunction with a completely automatic handler. See specification (para 2.1.1) for details of speeds.

Triggering Sort Measurements

Sort measurements can be triggered in any one of three ways:

(i) Briefly pressing the Sort button

(ii) Applying a trigger signal to the handler interface (for example from a foot switch) - active only if Code 8 has been selected: inhibited by use of Code 9.

(iii) Reception of a trigger command via Remote control.

In all three situations, the trigger will actuate one measurement (or one pair if f2 is programmed). Holding in the Sort button for a second or two will put the Tester into a repetitive mode: a subsequent short trigger - as in (i) (ii) or (iii) - will return it to the 'single shot' mode.

Note that components are sorted into Bin 0 only if they are not classified as acceptable into any other bins.

Using Bin Count

The non-volatile Bin Count Registers maintain a count of the total number of components falling into each bin together with batch total. They are only updated by measurements triggered from the handler interface or via remote control and not by single or repetitive measurements triggered from the front panel. This allows 7010 setting-up to be confirmed before running a handler.

Bin Count can be read out:

a) via the display
b) via remote control
c) via a printer

Code 15 is used to send results to Display. This puts the "window" at the head of the menu:

```
CLEAR ALL?           Enter = Yes
SURE ?               1 = Yes
Bin A  =  XXXX
Bin B  =  XXXX
Bin 0  =  XXXX
Bin 1  =  XXXX
      .
      .
      .
     27 =  XXXX
Batch total =  XXXXX
```

Use the up/down arrows to scroll through the menu*. Under Remote control, commands are the same, but CLEAR ALL will not seek confirmation.

To send Bin Count information to a printer, use Code 16 (printer ON by Code 10). A full list of codes is on page 13-1; details of Printer operation are on page 10-1.

---

* Disabled bins will be omitted from the list. However, if they were disabled after performing the Sort, their total content (if any) will appear as an additional line 'Others = '.

8 READING OFFSET

Selecting the appropriate Code (see section 13-1) allows any or all of the three measurement readouts in Sort mode to be separately adjusted against a known good component.

To set one of these offsets, first select ALL the required Sort mode conditions (including frequency, level and range mode)*. Enter the appropriate Offset entry code (20, 24 or 28 - see list on page 13-1).

Response to Code 20 (major offset entry) will be a message as follows:

'Meas C (100kHz)'

Alternatives are C or L and frequency as defined by Sort Setup list. On triggering a measurement by pressing the SORT key, the result is displayed with a prompt message such as:

1.23456μF Nominal ?

The known value is now keyed in using the Units key and appropriate multiplier, and appears alongside the measured value. For example:

1.23456μF< 1.235μ>

On pressing the Enter key, both values disappear, to be replaced by:

!C OFFSET APPLIED!

- offset is calculated and stored. <u>OR</u>

C OFFSET TOO LARGE

- error is outside acceptable band, offset defaults to zero.

Any stored offset value is applied to subsequent Direct and Sort measurements made at the same frequency with the same measurement parameter selected.

---

* If subsequent measurements are to be made in the Direct mode, it is necessary to select ALL the Sort mode f1 conditions (including frequency, level and range mode) at the same required settings.

Response to either minor offset entry code (24 or 28) is identical except that the selected minor term result (D, Q, esr, epr or G) will be displayed, with the corresponding known value being keyed in by the operator.

Each offset may be disabled and re-enabled (without changing the value) by using individual codes as listed on page 13-1.

When any offset is ON and has a value other than zero, the measure busy* will be replaced by a Δ symbol to warn the user.

The above settings are retained in non-volatile memory to be automatically re-applied at power-up. When any offset is ON and has a value other than zero, a warning message will appear at power-up.

For example:

C D esr OFFSETS ON

which indicates that C and D readings are offset at f1, and esr reading is offset at f2.

Separate codes are provided to indicate the frequency, offset parameter and ON/OFF status of each offset.

For example:		Major 100kHz	C	ON
	or	f2 1MHz	esr	OFF

9 INSTRUMENT REMOTE CONTROL

9.1 IEEE 488 & RS232C

Remote Control is available via the GPIB (to IEEE 488) or the RS232C (DTE) interfaces. See page 12-1 for details of RS232C pin assignments, protocols and settings.

The remote interface to be used is determined by the Remote address. This is set by Code 14 (not available remotely). If the address is set to 31 or more, the remote interface is the RS232C, with the GPIB providing the Printer Output. If the Remote Address is set to any other number (0-30) the GPIB is the Remote Interface, at that address, with the RS232C providing the Printer function.

The protocol is designed to conform to the IEEE 488.2 specification for the GPIB which covers Codes, Formats, Protocols and Common Commands on the IEEE 488 bus. The same protocol is used for the RS232C, where possible.

The IEEE 488 subfunctions used are:

SH1	full Source Handshake
AH1	full Acceptor Handshake
T5	Basic Talker, Serial Poll, Talk Only, Unaddressed if MLA
TE0	No Extended Talker
L4	Basic Listener, No Listen Only, Unaddressed if MTA
LE0	No Extended Listener
SR1	Service Request
RL1	full Remote/Local compatibility
PP0	No Parallel Poll
DC1	Device Clear
DT1	full Device Trigger compatibility
C0	No Controller

9.2 COMMAND FORMAT

9.2.1 The Command set (see section 9.7) contains full commands and recommended abbreviations. No other forms should be used. The full commands will generate self-documenting strings. No spaces may be present in the commands. Any unrecognised command will generate a Command Error (see 9.5). However, a space is necessary between a command and its associated parameter. Note that in this context the parameter is not necessarily numeric, eg DISPLAY OFF.

9.2.2 Some commands require numeric or alpha-numeric data to follow (eg CODE 4 where 4 is numeric data, SPEED SLOW where SLOW is alpha-numeric data). If data is omitted, or of an incorrect type (eg CODE FOUR), a Command Error is generated (see 9.5). If data is out-of-range, (eg BIN 123), an Execution Error is generated. A space must be present between the command and its associated data, or an Execution Error will be generated.

9.2.3 Commands must be separated by a delimiter (;) and terminated with LF+EOI or LF or EOI (or CR,LF for RS232C).

9.2.4 Commands will be executed in the order in which they appear in the string.

9.2.5 If a command string generates response data that is not read by the time another command string is received, an Interrupted Error is generated (see 9.5).

9.2.6 If data response is read before the complete command string has been received (eg by LF, EOI etc), an Unterminated Error is generated (see 9.5).

9.2.7 If commands of greater than 128 bytes generate responses of greater than 128 bytes, a Deadlock Error is generated (see 9.5). There is no other restriction on lengths of command and response strings.

9.2.8 A command string can contain any number of MEAS? or SORT? commands, each returning a response, within a single response string (see 9.5). The commands generating a response can occur anywhere in the command string.

9.2.9 Upper and lower-case letters are interpreted as being the same.

9.2.10 Only commands available in the selected mode will be accepted. Otherwise an Execution Error will be generated (see 9.5). For example, Bin Limits cannot be set without first selecting a bin number.

9.2.11 Numeric data can be integers, real numbers or floating-point format (eg 10000, 10E3). Command multipliers (k,p etc) are not permitted. If used, an Execution Error will be generated (see 9.5).

9.2.12 Units following a number may be separated from the number by a space. Where no unit is given, a previous unit is assumed.

9.2.13 Functions requiring confirmation when selected locally do not require confirmation under remote control.

9.2.14 Code numbers less than 1 are for local testing only, and are not available under remote control.

9.2.15 Code 9.1 resets the 7010 and takes a time to operate. It should be sent and then a delay used before reading status (eg by serial poll). If this delay is not implemented in the controller, undefined operation will result.

9.2.16 (GPIB Only) Response to Device Clear is the same as Power-up. Device Clear may be sent at any time in a Command String. Response to Group-Execute-Trigger (GET) is the same as *TRG (ie a Direct measurement is made, but no result is returned). GET will only be executed after the command containing it (if any) has been executed.

9.2.17 A command must be followed by a query to generate a response (eg MEAS will perform a direct measurement, but not return a result; MEAS? will perform a measurement and return a result).

9.2.18 Typical command strings are:
DIRECT;C;D;FREQ 1E3;MEAS?
F1;FREQ 1E3;FAST;F2;FREQ 1E6;BIN 1;LOW 1.0E-9 F;HIGH 1.4E-9;HSORT

9.3 DATA OUTPUT

9.3.1 For each command which generates an output response, a Response Message Unit (RMU) will be generated. This consists of a string of numerics or alpha-numerics, terminated by a semi-colon (if followed by further RMU's) or the terminator (LF+EOI for GPIB; CR,LF for RS232C).

9.3.2 Some commands will generate an RMU containing more than one item of data (eg MEAS? will generate major and minor term data). In this case, each item of Response Data will be separated by commas.

9.3.3 If not all the response message is read, and the 7010 is addressed to listen, an Interrupted Error is produced (see 9.5).

9.3.4 The rules 9.3.1 to 9.3.3 above ensure that for each command string sent to the 7010, only one response string is returned; and that responses from a single command and from separate commands within a command string can readily be distinguished.

9.3.5 The format of numeric results will correspond to that used for the instrument display, with the engineering multiplier (if any) replaced by an equivalent 10's exponent.

9.3.6 A typical response to a command string is:

```
1.2345E-9,0.0003;1.2355E-9,123.0E-3
```

which could be a response to

```
FREQ 1E3;C;D;MEAS?;FREQ 1E6;R;SER;MEAS?
```

9.4 STATUS REPORTING

The following describes the status reporting for the 7010. It applies to GPIB and RS232C control, with the exception that Serial Polling and Service Requests are not available under RS232C control.

9.4.1 The Status Byte Register (SBR) is shown in Fig 9.1.

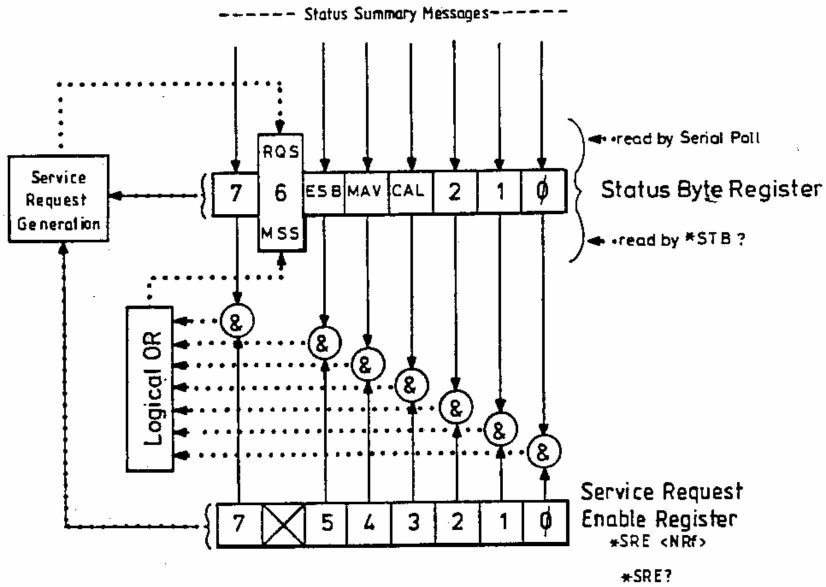


Fig. 9.1 Status Byte Register

It consists of 8 bits read by the Serial Poll or *STB? commands:

Bits 0,1 and 2 are always zero

Bit 3 is 0 if calibration status is valid
1 if calibration status is not valid

Bit 4 is 0 if no response messages are available
1 if response messages are available

Bit 5 is 0 if no Event Statuses are valid
1 if Event Statuses are valid (see below)

Bit 6 is the Message Status Summary or Service Request Bit (see below)

Bit 7 is always zero

When Bit 6 is first set to 1, the 7010 generates a Service Request, and a Serial Poll will read the SBR with Bit 6 set to 1. After this, the Service Requests will no longer be generated, and successive Serial Polls will not have Bit 6 set to 1. The *STB? command will always read Bit 6 as 1 if it has been set.

9.4.2 The Service Request Enable Register (SRE) is a mask, determining the conditions in which the SBR will generate a service request. It is ANDed bitwise with the SBR and, if the result is not zero, then Bit 6 of the SBR is set (see Fig 9.1).

The SRE is set by the *SRE command and read by the *SRE? command.

9.4.3 The Event Status Register (ESR) is shown in Fig 9.2.

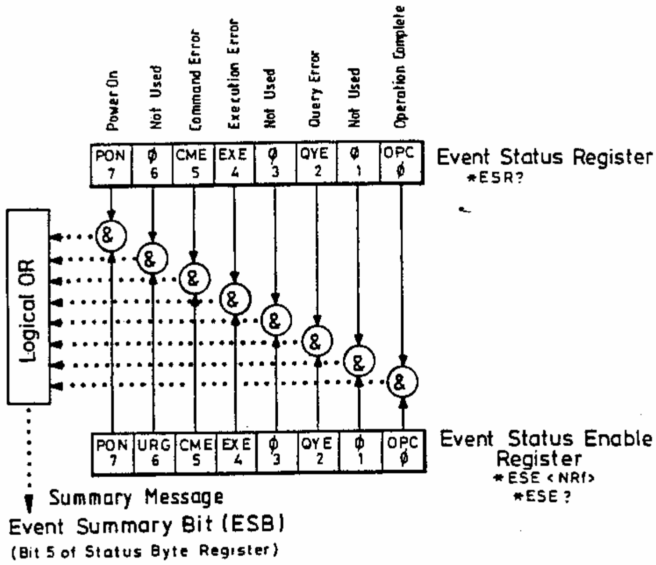


Fig 9.2
Event Status
Register

It consists of 8 bits as follows:

Bit 0 = 1 if a *OPC command has been sent (Operation Complete) and the current command string has been finished. It can be used in conjunction with the Event Status Enable Register (below) to generate Service Requests when the 7010 is ready to receive another command string.

Bit 1 = 0 , always
Bit 2 = 1 if a Query Error occurs (see 9.5)
Bit 3 = 0 , always
Bit 4 = 1 if an Execution Error occurs (see 9.5)
Bit 5 = 1 if a Command Error occurs (see 9.5)
Bit 6 = 0 , always
Bit 7 = 1 on power-up, and before any bus activity occurs

The Event Status Register is read by the *ESR? command.
It is cleared by the *ESR? or *CLS commands.

9.4.4 The Event Status Enable Register (ESE) is a mask determining the conditions in which the ESR will set Bit 5 of the SBR. It is ANDed bitwise with the ESR and, if the result is not zero, the ESB bit (Bit 5) of the SBR is set (see Fig 9.2). Thus any event affecting the ESR can be made to generate a Service Request in conjunction with the ERE and the SRE.

The Event Status Enable Register is set with the *ESE command, and read with the *ESE? command.

9.4.5 The Calibration Status Register (CSR) is shown in Fig 9.3.

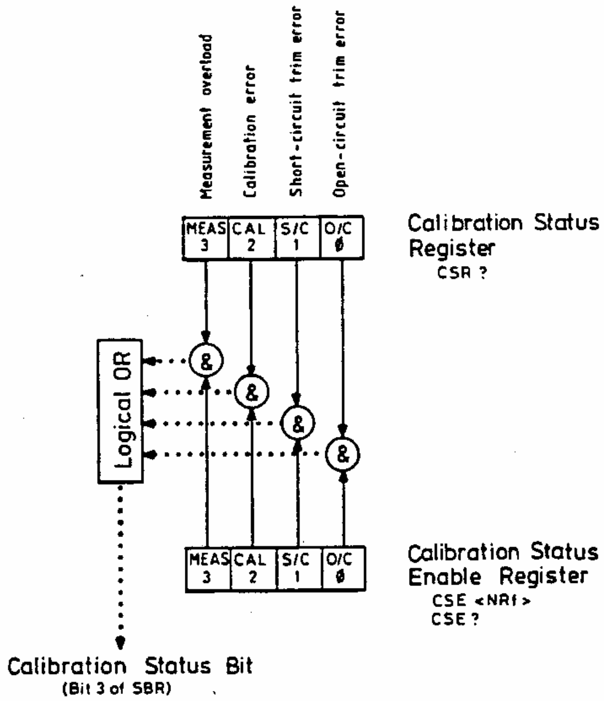


Fig 9.3 Calibration Status Register

It consists of 4 bits as follows:

Bit 0 = 1 if an Open Circuit Trim Error exists
Bit 1 = 1 if a Short Circuit Trim Error exists
Bit 2 = 1 if a Calibration Error exists
Bit 3 = 1 if a Remote Measurement Overload occurred
The Calibration Status Register is read by the CSR? command.
It is cleared by the *CLS command.

9.4.6 The Calibration Status Enable Register (CSE) is a mask determining the conditions in which the CSR will set Bit 3 of the SBR. It is ANDed bitwise with the CSR and, if the result is not zero, the CAL bit (Bit 3) of the SBR is set (see Fig 9.3). Thus Calibrate and Measurement errors can be made to generate a Service Request in conjunction with the CSE and the SRE.

The Calibration Status Enable Register is set with the CSE command, and read with the CSE? command.

9.5 ERROR REPORTING

Three types of error can generate error bits in the ESR: Command Errors, Execution Errors and Query Errors.

A Command Error occurs if an unrecognised command is received, or a GET is received within a command string. The Command Error bit is set, and the command string is processed, if possible.

An Execution Error occurs if a command is sent containing data out of range (eg BIN 123) or a command is sent when the 7010 is not in a "mode" to receive it (eg a low limit set without a bin being selected).

The Query Error bit is set if Deadlock, Unterminated or Interrupted Errors occur.

A Deadlock Error occurs when the input and output buffers are full (128 characters in each). In this case, the input string is processed as normal, but data remaining in the output buffer is lost, together with any further data, until processing of the input string is completed.

An Unterminated Error occurs when the controller tries to read data from the 7010 before the command has been completed. In this case, the command string is ignored and the output data is not sent.

An Interrupted Error occurs when a controller sends data to the 7010 before reading all of the output data. In this case, the remaining output data is not sent, and the command string is correctly processed.

COMMANDS

The 7010 responds to two types of commands: Common Commands, and Device-Specific Commands. The Device-Specific commands are detailed in section 9.7.

9.6 COMMON COMMANDS

These are prefixed by an asterisk (*), and are a requirement of the IEEE 488.2 Specification.

The following are the implemented Common Commands:

*CLS — Clear Status Command
This command clears the Event Status Register (see 9.4.3), and the Calibration Status Register, setting Bits 5 and 3 of the Status Byte Register (9.4.1) to zero.

*ESE — Event Status Enable Command
This command sets the Event Status Enable Register (9.4.4), to the value of the data following the command (eg *ESE 53 will set Bits 0, 2, 4 and 5 (Operation Complete, Query Error, Execution Error and Command Error Enable), causing an error or end-of-operation to set Bit 5 of the Status Byte Register).

*ESE? — Event Status Enable Query
Causes the contents of the Event Status Enable Register (as set by *ESE) to be output to the controller.

*ESR? — Event Status Register Query
Causes the contents of the Event Status Register to be output to the controller. (eg if Command and Execution Errors exist (Bits 4 and 5) the *ESR? command will return a value of 48).
It also clears ESR.

*IDN? Identification Query

Causes the data identifying the 7010 to be output to the controller (ie the data output will be: WAYNE KERR,7010,0,1.2 where the first field is the manufacturer, then the model number, then a zero instead of a unique serial number, then the Software Revision Number: here represented as Issue 1.2). *IDN? should be last in a command string, otherwise an execution error will be generated (see 9.5).

*OPC Operation Complete Command

Causes the Operation Complete Bit (Bit 0) to be set when the current command string has been processed: this can be used to generate a Service Request in conjunction with the *ESE and *SRE commands. This command only applies to the CURRENT command string: the *OPC command must be sent at the end of every command that is required to generate the Operation Complete status.

*OPC? Operation Complete Query

Causes data of "1" to be output to the controller when the command is executed. This enables the programmer to determine that the command string has been executed by reading data, as opposed to status, as would be required by the *OPC command. The *OPC and *OPC? commands will only give correct results if sent at the end of a command string.

*PSC Power-up Status Clear Command

Followed by data "0" or "1"

If "1", the Service Request Enable and Event Status Enable Registers are cleared on power-up, and would need to be initialised by the program before Service Requests, etc, could be generated.

If "0", the Service Request Enable and Event Status Enable Registers assume the values they had on power-down, and Service Requests, etc, can be generated immediately.

*PSC? Power-up Status Clear Query
Reads the Power-up Clear Status.
If a *PSC command with data "1" has been sent, *PSC? returns data "1", otherwise it returns data "0".

*RST Reset Command
Resets the 7010 to a default setting (see page 9-13). Does not affect any data which may be available for sending to the controller. Does not affect Trim and Calibration values.

*SRE Service Request Enable Command
Sets the Service Request Enable Register to the value following the command. The Register is set except that Bit 6 (value 64) is ignored. (eg *SRE 80 will cause the 7010 to generate Service Requests when data is available).
The Service Request Enable Register is cleared on power-up if the *PSC 1 command has been sent.

*SRE? Service Request Enable Query
Returns the value of the Service Request Enable Register. This is the same value as set by *SRE, except that Bit 6 (value 64) is always zero (ie *SRE? returns a value 0-63 or 128-191).

*STB? Read Status Byte Query
Returns the value of the Status Byte Register as a number 0-255.
This is the only way of reading the 7010 status under RS232C control, as Serial Polling is not available.

*TRG Trigger Command
Triggers a Direct measurement, but does not return the result to the controller. This is the same as a GET (Group Execute Trigger) command.

*TST? Self-Test Query

Performs a ROM test on the 7010.

Provides a numerical output (0-7) indicating good/bad for ROMs numbered 1-3, as shown below:

OUTPUT	ROMS	OUTPUT	ROMS
0	All good	4	No. 3 Bad
1	No. 1 Bad	5	Nos. 1 & 3 Bad
2	No. 2 Bad	6	Nos. 2 & 3 Bad
3	Nos. 1 & 2 Bad	7	All Bad

Default conditions established by use of remote *RST command

Direct: C,D, Par, 1kHz, 0.1V, Max

Sort: f1, 1kHz, 0.1V, Auto, Max

f2, 1kHz, 0.1V, Auto, Max

% limits

Nominal 0.0 Ω

Minor limits Single

Bin A Cp > 0.0F

Bin B Cp > 0.0F

Bins 1-27 disabled

If bins 1-27 are enabled, their limits are both 0%.

Absolute limits, bin limits become:

Bin A D >0.0

Bin B D >0.0

Bins 1-27 disabled

If bins 1-27 are enabled, their limits are both 0 F.

Other parameters are unchanged.

9.7. 7010 DEVICE-SPECIFIC COMMANDS

9.7.1 Prefixes

COMMAND	FUNCTION	ABBREVIATION
DIRECT	Following commands affect Direct Setup	DIR
F1	Following commands affect F1 Sort Setup	F1
F2	Following commands affect F2 Sort Setup	F2
BIN N	Following commands affect BIN N Setup (N = 0-27,A,B)	BIN N

9.7.2 Direct Commands

C	Capacitance is Major Term	C
L	Inductance is Major Term	L
R	Resistance is Minor Term	R
D	Dissipation is Minor Term	D
Q	"Q" Factor is Minor Term	Q
G	Conductance is Minor Term	G
SERIES	Display Series Results	SER
PARALLEL	Display Parallel Results	PAR
FREQUENCY NN	Select Frequency NN (NN = 1E3, 10E3, 100E3, 1E6 or equivalent)	FREQ NN
LEVEL M	Select Signal Level M Volts (M = 0.1, 0.3, 0.5, 1.0 or equiv)	LEV M
AUTO	Select Auto-Ranging	AUTO
HOLD	Select Range-Hold, on currently selected range	HOLD
HOLD N	Select Range-Hold, on Range N	HOLD N
SPEED SLOW	Select Slow Measurement Speed	SPD SLOW
SPEED MEDIUM	Select Normal Measurement Speed	SPD MED
SPEED FAST	Select Fast Measurement Speed	SPD FAST
SPEED MAXIMUM	Select Maximum Measurement Speed	SPD MAX

9.7.3 F1 Commands

COMMAND	FUNCTION	ABBREVIATION
FREQUENCY NN	All as DIRECT commands, affecting setup of F1 sort measurement	FREQ NN
LEVEL M		LEV M
AUTO		AUTO
HOLD		HOLD
HOLD N		HOLD N
SPEED SLOW		SPD SLO
SPEED MEDIUM		SPD MED
SPEED FAST		SPD FAST
SPEED MAXIMUM		SPD MAX
SPEED N	Select non-standard F1 sort speed (N = 0-15)	SPD N

9.7.4 F2 Commands

Same as F1 commands, affecting setup of F2 sort measurement. Exception is FREQUENCY 0 (FREQ 0) is allowed, turning F2 measurements OFF.

9.7.5 Sort Commands (Prefixed by F1 or F2)

MINOR SINGLE	One Minor Term Reject Bin per frequency	MIN SING
MINOR PERBIN	One Minor Term Reject Limit per bin, per frequency	MIN PER
PERCENT	Major term limits are deviation from nominal	PER
ABSOLUTE	Major term limits are absolute values	ABS
NOMINAL MM UNIT	(eg NOMINAL 1.0E-6 F) Set nominal value for percentage limits	NOM MM UNIT
	MM is a numeric value	
	UNIT is FARAD,HENRY,OHM,SIEMENS	F,H,O,S
	If no unit is given, the previously selected unit is used	

Sort Commands (Prefixed by F1 or F2) (Continued)

DISPLAY PASS	Select PASS/FAIL Measurements on Bin 1 only (or lowest enabled bin)	DISP PASS
DISPLAY NUMBER	Display bin-number only	DISP NUM
DISPLAY MAJOR	Display bin-number and F1 Major Term	DISP MAJ
DISPLAY F1MINOR	Display bin-number and F1 Minor Term	DISP F1M
DISPLAY F2MINOR	Display bin-number and F2 Minor Term	DISP F2M
DISPLAY MAJORF1	Display Major Term and F1 Minor Term	DISP MAJF
DISPLAY TOTAL	Display Batch Total	DISP TOT
DISPLAY OFF	No Display	DISP OFF

9.7.6 Measurement Commands

*TRG	Perform Direct Measurement, result to display	*TRG
MEASURE	Perform Direct Measurement, result to display	MEAS
MEASURE?	Perform Direct Measurement, result to display and controller	MEAS?
SORT	Perform Sort Measurement, result to display	SORT
SORT?	Perform Sort Measurement, result to display and controller	SORT?
HSORT	Perform Sort Measurement, result to display and handler	HSORT
HSORT?	Perform Sort Measurement, result to display, handler and controller	HSORT?

9.7.7 Bin N Commands

LOW	MM UNIT	Sets low limit for bin N	LO MM UNIT
HIGH	MM UNIT	Sets high limit for bin N	HI MM UNIT
		(UNIT is FARAD,HENRY,OHM,SIEMENS or PERCENT)	F,H,O,S,PCT
F1MINOR	MM UNIT	Sets F1 Minor Reject limit for bin N	F1M MM UNIT
F1MINOR	MM UNIT	Sets F2 Minor Reject limit for bin N	F2M MM UNIT
		(UNIT is EPR,ESR,Q,D,G for F or H Major unit Q,H,F for OHM or S Major Unit)	

For N = A, F1MINOR only is allowed
For N = B, F2MINOR only is allowed

ON	Enables Bin N	ON
OFF	Disables Bin N	OFF

9.7.8 Misc. Functions

KEYLOCK	Keyboard Lockout	KL
KEYUNLOCK	Release Keyboard Lockout	KU
TRIM-SHORT-CIRCUIT	Short-Circuit Trim	TSC
TRIM-OPEN-CIRCUIT	Open-Circuit Trim	TOC
CALIBRATE	Calibration	CAL
TOTALS?	Bin Totals to Controller	TOT?
DIRECT?	Direct Setup to Controller	DIR?
LIMITS?	Current Bin Limits to Controller	LIM?
BINS?	Sort Setup to Controller	BIN?
CLEAR	Clear Bin-Totals	CLR
CSR?	Read value of Calibration Status Register (See 9.4.5)	CSR?
CSE N	Set Calibration Status Enable Register to value N (See 9.4.6)	CSE N
CSE?	Read value of Calibration Status Enable Register (See 9.4.6)	CSE?
CODE N	Execute Code N function	CODE N

COMMAND	FUNCTION	ABBREVIATION
ERROR?	Returns error number of first error that occurred. Error number is reset to 0 on being read. 0 = No error 1 = Command not found 2 = Sub-command not found 3 = No parameter 4 = No unit-separator 5 = No data-separator 6 = Parameter error 7 = Illegal command for bins A and B 8 = Code not defined 9 = Offset - not F or H major 10 = Offset - F2 = none 11 = Offset - too big 12 = Nominal set in Absolute 13 = Trim / Cal failed 14 = Overload 15 = G & Series both set	ERR?

9.7.9 Remote Syntax

All commands sent to the 7010 are separated by semi-colons (;).
The end-of-command signal is line-feed (LF) or EOI for GPIB;
carriage-return (CR) or LF for RS232C.
All data received from the 7010 is separated by semi-colons.
For each command string, only one response string is allowed.
If a single command sends more than 1 result, the results
are separated by commas.

The end-of-output signal is Line-Feed + EOI for GPIB;
CR + LF for RS232C.

These requirements are detailed in IEEE 488.2.

9.7.10 Examples

To measure Capacitance and Dissipation at 1kHz, Parallel, Slow Measurements, Auto-Ranging, 0.5 Volts Signal level, send the following string:

```
DIRECT;C;D;FREQ 1E3;PAR;AUTO;LEV 0.5
```

To take a measurement, then set frequency to 10kHz, and repeat the measurement, send:

```
MEAS?;FREQ 10E3;MEAS?
```

and the response will be (eg):

```
1.2345E-9,2.54E-3;1.452E-9,2.98E-2
```

which consists of the capacitance at 1kHz, a comma, dissipation at 1kHz, (from the first MEAS? command), a semi-colon, capacitance at 10kHz, a comma, dissipation at 10kHz.

To set 7010 to sort components, measuring at 10kHz at F1, 1MHz at F2, Fast Measurements, Single Minor Reject, Absolute Limits, Major Limits 1.2nF to 1.4nF Bin1, 2.85nF to 2.86nF Bin2, D of 0.0003 at 10kHz, esr of 10mOhm at 1MHz, send:

```
F1;FREQ 10E3;FAST;F2;FREQ 1E6;FAST;MINOR SINGLE;ABSOLUTE;
BIN A;F1MINOR 3E-4 D;BIN B;F2MINOR 10E-3 ESR;
BIN 1;LOW 1.2E-9 F;HIGH 1.4E-9;BIN 2;LOW 2.85E-9;HIGH 2.86E-9
```

10 PRINTER

The 7010 can be set to provide print-out information at the GPIB (to IEEE 488) or RS232C interfaces. A printer, which must be at least 40 characters wide, should be connected to whichever interface is <u>not</u> addressed for full control use. An RS232C printer should be connected to the AUX. (DCE) socket and, in this situation, the GPIB address used must lie between 0 and 30 (inclusive). With GPIB addresses higher than 30, print-out information is available only at the GPIB port which will become 'talk-only'. Information on changing the GPIB address is on page 9-1.

The RS232C pin assignments and protocols are described on pages 12-1 to 12-3. The printer is turned ON and OFF by codes 10 and 11, respectively. When ON, the result of any measurement made in the Direct or Sort modes will be output to the printer*. This may slow down the measurement process.

RS232C characteristics used when printing are stored in non-volatile memory and can be updated, using code 12, from the keyboard. An example of the first line of the display could be:

Printer 4800 baud

The baud rate can be set, by use of the 'select' button, to any of the following numbers:
110, 150, 300, 600, 1200, 2400, 4800, 9600 or 19200.

---

* A set of printed results is preceded by a header line, showing print-out conditions, only in certain circumstances. For Direct measurements, the line appears above the first measured result if this followed power-up, selection of Meas SetUp1 or Meas SetUp2, or if the printer had been turned off and then on using Codes (11 and 10, respectively). With Sort measurements, the corresponding circumstances are power-up, Bin SetUp, Select Readout and printer off-on using Codes. Typical header lines are shown in the examples of printer format (on succeeding pages).

An example of the second line of the display might be:

→8D 1S No P

→ is the cursor
D is the number of data bits, which can be 7 or 8
S is the number of stop bits, which can be 1 or 2
P is parity and can be set to any of the following:

No P	= No Parity	
Mk. P	= Mark Parity	Available only with 7D
Sp. P	= Space Parity	Available only with 7D
Odd P	= Odd Parity	
Ev. P	= Even Parity	

In addition, codes are available to allow the printer to list details of:

Bin-count data (Code 16)
Bin set-up data (Code 17)

If any bin or bins are disabled during a Sort run, Bin-count data will include a final line - "Disabled Bins" - showing the number of components classified into such bins and not included in Batch total.

Examples of printer format are:

DIRECT RESULTS

10kHz; 1.0v;Par;Auto Range ;Speed Fast

1.06235µF 0.01025D
1.08365µF 0.01030D
1.16420µF 0.01585D

etc.

BIN SET-UPS

f1 1kHz;1.0v;Hold Range 4;Speed Med
f2 100kHz;1.0v;Auto Range ;Speed Fast
Nominal = 1.0000µF

Bin	Hi Major %	Lo Major %	f1 Minor D	f2 Minor Ser Ohm
A			0.00500	
B				100.00m
1	+1.0	-1.0		
2	+2.0	-2.0		
3	+3.0	-3.0		
4	+4.0	-4.0		
5	+5.0	-5.0		
6	+10.0	-10.0		
7	DISABLED			
8	DISABLED			
9	DISABLED			
10	DISABLED			
11	DISABLED			
12	DISABLED			
13	DISABLED			
14	DISABLED			
15	DISABLED			
16	DISABLED			
17	DISABLED			
18	DISABLED			
19	DISABLED			
20	DISABLED			
21	DISABLED			
22	DISABLED			
23	DISABLED			
24	DISABLED			
25	DISABLED			
26	DISABLED			
27	DISABLED			

SORT RESULTS

f1 1kHz;1.0v;Hold Range 4;Speed Med
f2 100kHz;1.0v;Auto Range ;Speed Fast
Nominal = 1.0000μF

Bin	Major Term	f1 D factor f2	esr
1	+.2540 %	0.00358D	48mOhm
3	+2.628 %	0.00282D	56mOhm
A	-3.024 %	0.00614D	89mOhm
			etc.

BIN TOTALS

Bin	COUNT
A f1 Minor Reject	33
B f2 Minor Reject	7
0 Reject	19
1	2721
2	2318
3	1047
4	1246
5	983
6	126
Batch Total	8500

11 BIN HANDLER INTERFACE

The handler interface pin-out details are on page 11-11; a diagram showing switch locations on the Bin Handler PCB is on page 11-3.

11.1 OPTION SWITCH FUNCTIONS

SW1 Option Address

This switch is not normally fitted. The default setting is 1, this selects the card in the 7010 address map. The reason for a switch is to allow future expansion of bin lines with the addition of bin handler option cards.

SW2 VN Voltage

This switch selects the potential for "VN", the bin relay "made" voltage and the opto-isolator negative rail.

SW3 VE Voltage

As an input voltage from an external source. In this condition there is no connection through SW3.

As an output voltage VE can present all internal rails to Pin 1 of PL31 via SW3.

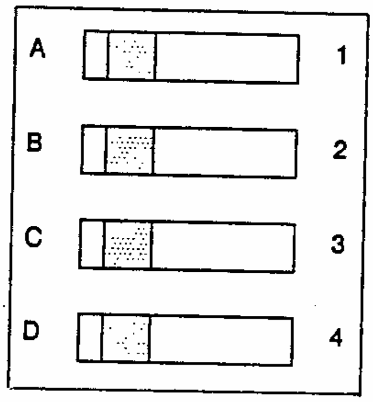
SW4 VF Voltage

This switch selects the potential for "VF", which is used as the resistor pull-up potential on the handler output lines as well as the opto-isolator positive (pull-up) rail.

Switches SW1 through SW4 offer the following conditions on their positions:

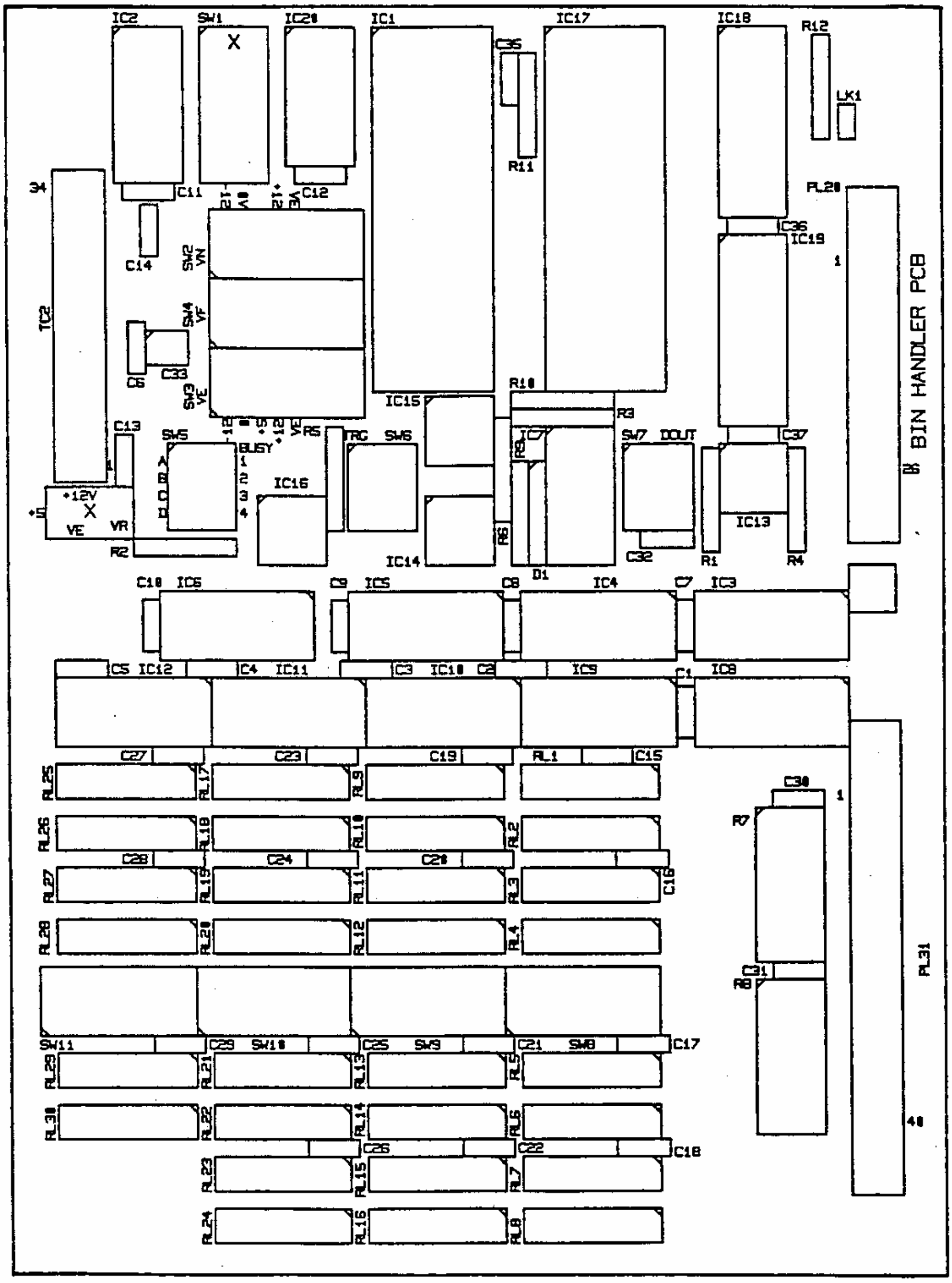
SW1 to SW4		
Posn. 1	-12V	Rail
2	0V	
3	+5V	Rail
4	+12V	Rail
5	VE	Externally connected voltage i/p Internally connected to voltage o/p
6	N.C	
7	N.C	
8	N.C	

Switches 5 through 11 in the normally closed position are represented as follows on the switches and silk screen of the PCB.



A, B, C, D normally closed

1, 2, 3, 4 normally open



Bin Handler PCB - showing switch locations

SW5 Busy Output

This is a four-section changeover switch controlling the BUSY output.

SW5-1 - Handshakes internally from BUSY
5-A - Handshakes internally from $\overline{\text{BUSY}}$ (SHI)

SW5-2 - Selects $\overline{\text{BUSY}}$ output
5-B - Selects BUSY output

SW5-3 - Direct output selected
5-C - Opto-coupled output selected

SW5-4 - Pull-up on output not selected
5-D - Pull-up on output selected, R5-4K7

SW6 TRIG INPUT

This is a four-section c/o switch controlling the TRIG input line.

SW6-1 - No input series resistor selected
6-A - Selects series resistor R6-330R

SW6-2 - Selects $\overline{\text{TRG}}$ input*
6-B - Selects TRG input*

SW6-3 - Direct input selected
6-C - Opto-coupled input selected

SW6-4 - Pull-up on input not selected
6-D - Extra pull-up on input selected, R10-120R

SW7 DOUT OUTPUT

This is a four-section c/o switch controlling the DOUT line.

SW7-1 }
7-A } - N.C.

SW7-2 - Selects $\overline{\text{DOUT}}$ output
7-B - Selects DOUT output

---

* These two functions are transposed if the opto-isolator function is operational.

SW7-3 - Direct output selected
7-C - Opto-coupled output selected

SW7-4 - Pull-up on output not selected
7-D - Pull-up on output selected, R4-4K7

SW8, 9, 10, 11 - BIN OUTPUTS

Switches 8 through 11 represent 30 output lines for the Bin Handler.

In the closed position the output line selects a direct drive from output drive ICs. If relays are fitted, then respective switches must be opened.

In the open position, the bin outputs are driven from the VN voltage via relays RL1-RL30. The output driver ICs control the respective relay coils.

SWITCH DEFAULT SETTINGS

SW1-	not fitted	
SW2-	VN set to 0V	
SW3-	VE set to no connection	
SW4-	VF set to 5V - pull-up potential	
SW5-	1 set	Normal handshake
	2 set	BUSY
	3 set	Direct
	D set	Pull-up resistor selected
SW6-	1 set	No series resistor
	2 set	TRG
	3 set	Direct
	4 set	No extra pull-up resistor
SW7-	1 set	N.C
	2 set	DOUT
	3 set	Direct
	D set	Pull-up resistor selected

11.2 USE OF BIN HANDLER SWITCHES

VEXT (SW3)

VEXT (or VE) is primarily an input into the bin handler from the handler itself and is distributed by the VF and VN switches with VE switch set to N.C (position 8).

However, it may be used to drive some handler circuitry with +12V or -12V, in addition to the fixed 0 and +5 volts, by setting SW3 to positions 4 or 1 respectively. Positions 0 and +5V are available but are more or less redundant. IT IS ESSENTIAL THAT THIS SWITCH IS DE-ACTIVATED (POSITION 8) IF VE IS DRIVEN EXTERNALLY.

VF (SW4)

This is the pull-up potential of the normal bin output drives and handshake lines (optional by SW5-7, section D) and may be set to -12V, 0V, +5V or VE (whatever it is set to). The -12V and 0V are meaningless except for the relay option, when inversion of the logic could be achieved by this means. Factory-set default is +5V.

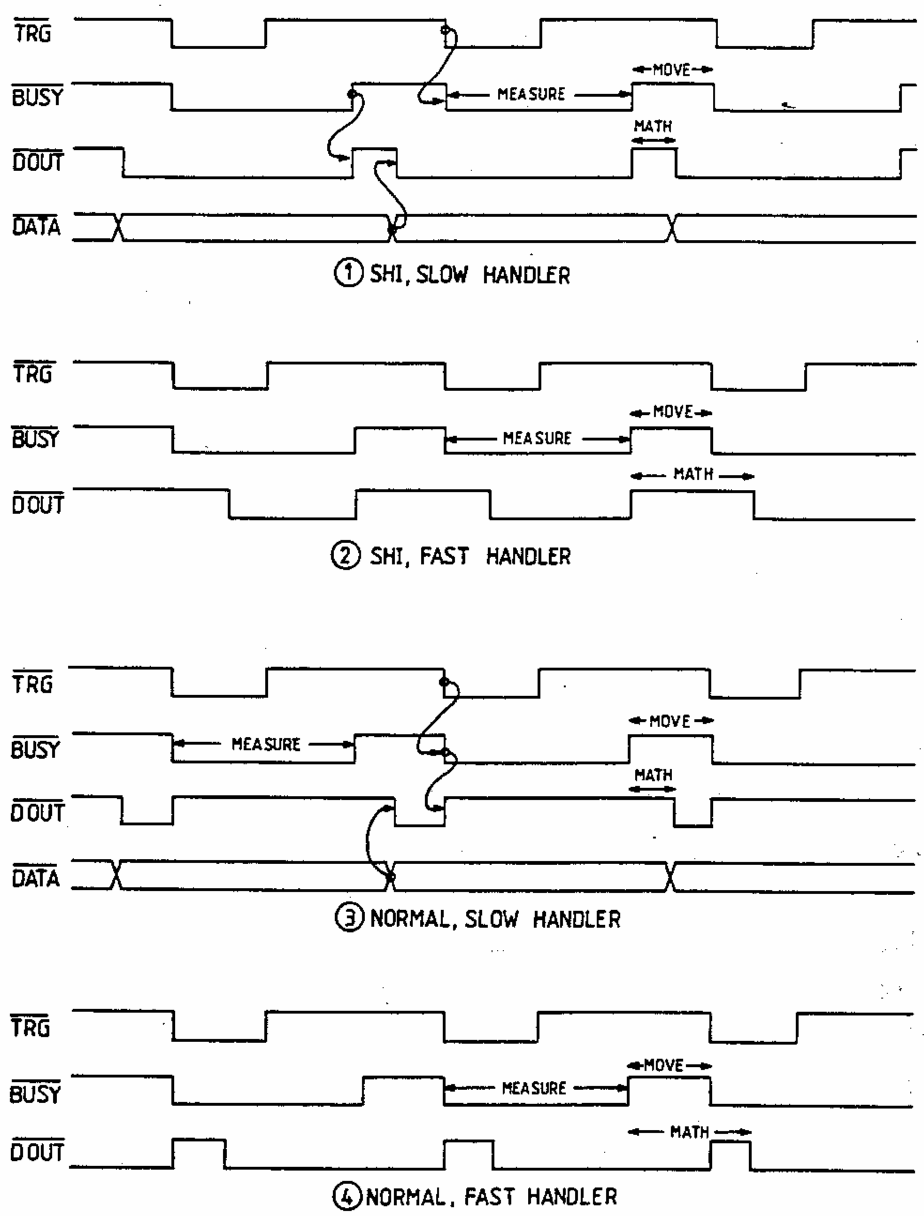
VN (SW2)

This is the relay option "make" potential and the ground reference for the opto-isolator option handshakes. It may be set to -12V, to +12V or VE and the latter is the most likely in order to achieve full isolation from the 7010 supply rails. The factory-set default is 0V, but VN does not affect non-relay or opto-isolated set conditions.

Busy (SW5)

Normal mode operation (see waveforms) is achieved with SW5/1 set position, and this is the factory-set default.

SHI handshake is induced by setting SW5/1 to 5/A.



DATA = BIN 0-27, A, B.

Bin Handler Interface Timing

The BUSY active polarity (indicating measurement taking place, do not move handler) is set, in all options, by SW5/2 and is factory-set for active low. For active high, set it to 5/B. A 4K7 pull-up to VF is factory-set as the default by SW5/D but may be converted to open collector output if moved to 5/4.

DOUT (SW7)

Active polarity (indicating the Bin Output lines are valid) is set, in all options, by SW7/2 and is factory-set for active low. For active high set it to 7/B. Generally speaking the Bin Output data is stable from just before DOUT goes true until just before the next time it goes true.

A 4K7 pull-up to VF is factory-set as the default by SW7/D but may be converted to open collector output if moved to 7/4.

TRG (SW6)

The active polarity (the transition to this state indicating the 7010 should make a measurement) is set for all non opto-isolator installations by SW6/2 and is factory-set for active low. For active high set it to 6/B. When opto-isolators are engaged (by SW6/C) this polarity is inverted, so 6/2 selects active positive current and 6/B selects no current or short-circuit.

A fixed 4K7 pull-up to +5V is fitted and may be reduced to 120 ohms by setting SW6/D, it being factory-set to 6/4.

Extra input protection (for the 74HCT input device) is available by opening SW6/A, which inserts 330 ohms in series with the input, but it is factory-set to SW6/1. The series 330 ohms cannot be used with the 120 ohms pull-up as it would need -12 volts to achieve a low input.

11.3 RELAYS & OPTO-ISOLATORS

Full isolation of Bin Outputs and handshakes is possible and component kits are available separately for both.

Bin outputs - Relay Option

Open all switches of SW8 - 11 to break the direct drive connection. Remove Resistor packs R7 and R8. Plug in relays as required (RL1 is bin 0, RL2 bin 1 etc, RL29 is bin A, RL30-bin B) observing correct orientation. Select VN (SW2) to be VE (position 5) which will be in External mode, otherwise there will not be isolation.

The binning operation will now appear as a set of normally-open contacts which make to VE.

Handshakes - opto-isolator option

Fit opto-isolator chips (from the W-K kit) into positions IC13, 14 and 16 (for DOUT, TRG and BUSY respectively) and set SW7, 6 and 5 to C.

Both BUSY and DOUT will appear as open-collector outputs referenced to VN (which in all probability should be set to VE, the external reference pin, as described under Bin Output). Pull-up resistors should be switched off (SW5/4 and 7/4). Polarity of operation is achieved in the same way as Direct output, with section B of the switch.

TRG is an input LED with cathode to ground, which means it needs a positive current to cause conduction. This current should be in the range of 5-30 mA and may be produced by an external pull-up resistor and a grounding switch (to VN), a real current drive, or a positive voltage with the 330 ohm resistor inserted (SW6/A, see TRG section above). 5 to 12 volts is sufficient drive.

Polarity of operation is reversed to normal, causing SW6/B to select no current or short-circuit (to VN), and 6/2 active on positive current.

In an exceptional situation, where the handler TRG signal is negative to VE, use socket IC15 instead of IC14. The series 330 ohm is still available on SW6/A. The input polarity is identical with regard to current flowing or not flowing, ie, SW6/B selects active on no current or short-circuit (to VN).

Relay options - non-isolated

The bin outputs may be modified for high current use using the procedure outlined on the previous page, that is:

Open Switches SW8-11
Plug-In Relays

However, the VN switch, SW2, may be set to a fixed or external potential rather than simply external. For example, it may be set to 0 volts simply to boost the switching capability, or it could be set to +12 volts to drive relays or solenoids directly.

The resistor network may be removed for pure open-collector operation or left attached to a pull-up potential set by the VF switch (SW4).

By combining the settings of VN and VF switches, inverse polarity output is available, for example with VN at +12V and VF at -12V the normal level of output will be a -12V pull-down, but the Bin signal will be a +12V.

Bin Output Inversion

Direct output polarity of operation ie normally low, selected bin high, may be achieved without the last relay option described above. It is achieved by replacing all of IC3-6 (74HCT238) with the readily available 74HCT138 and it is important that the HCT is used.

11.4 HANDLER INTERFACE PINOUT (all -ve logic as standard)

Pin	Name	Function
1	VEXT	External Voltage Supply (or voltage output)
2	BIN0	Bin 0 output
3	BIN1	Bin 1 output
4	BIN2	etc...
5	BIN3	
6	BIN4	
7	BIN5	
8	BIN6	
9	BIN7	
10	BIN8	
11	BIN9	
12	+5V	5V output to handler
13	0V	0V output to handler
14	TRG	Trigger Input from handler
15	BUSY	Busy Output to handler
16	BINA	Bin A Output
17	BINB	Bin B Output
18	DOUT	Data Ready Output to handler
19	BIN10	Bin 10 Output
20	BIN11	Bin 11 Output
21	BIN12	etc...
22	BIN13	
23	BIN14	
24	BIN15	
25	BIN16	
26	BIN17	
27	BIN18	
28	BIN19	
29	BIN20	
30	BIN21	
31	BIN22	
32	BIN23	
33	BIN24	
34	BIN25	
35	BIN26	
36	BIN27	

Connector is Amphenol LE-40360-77C0

12 RS232C PIN ASSIGNMENTS AND PROTOCOLS

Two 25-way D type connectors are fitted, both sockets, which are functionally wired in reverse, one for DTE (Data Terminal Equipment) and one for DCE (Data Communication Equipment) termination. The table below describes each function and lists the appropriate pin number and name on each connector.

Connection description		DTE		DCE	
		pin	name	pin	name
Shield or Protective Ground		1		1	
Signal Ground		7		7	
Transmission Data from 7010	(output)	2	Tx	3	Rx
Ready to send Data from 7010	(output)	4	RTS	8	DCD
Ready for Data to be sent from 7010	(input)	5	RFD/CTS	20	DTR
Reception Data into 7010	(input)	3	Rx	2	Tx
Data is waiting for your receipt	(input)	8	DCD	4	RTS
7010 is ready to accept data	(output)	20	DTR	5 and 6	RFD/CTS and DSR

NOTE The following transmit and receive protocol is written in terms of the DTE connector. For the corresponding DCE pin references, use the table above.

Transmit. When there is a character, or characters, actively waiting to be transmitted, the 7010 will assert RTS (+ve). It will not transmit data until it detects CTS asserted (+ve) (which must be achieved by some electrical connection; if unconnected it is unasserted. It may be strapped to RTS for non-handshaking, 3 wire type links). Data is always transmitted in complete characters and CTS can stop transmission only at character boundaries.

<u>Receive</u>. When the 7010 is willing to accept a character it will assert DTR (+ve). However, data cannot be accepted unless DCD is asserted (+ve) into the 7010 (but this line is asserted automatically if unconnected).

New Data characters must not be transmitted to the 7010 after DTR has been dis-asserted but any current character must be completed.

The DTE connector uses four undefined pins to provide a 20mA loop for use in very noisy conditions. Their functions are:

Pin 17 Transmit hi
Pin 16 Transmit lo
Pin 15 Receive hi
Pin 14 Receive lo

Configuration of the RS232C functions is set-up via the keyboard and stored in non-volatile memory. Two independent settings exist for Printer and for Remote Control, accessed via Codes 12 and 13, respectively. For ease of reference, information on setting the Printer configuration (see also Chapter 10) is repeated here.

On calling-up Code 12, the first line of the display could be:

Printer 4800 baud

The baud rate can be set, by use of the 'select' button, to any of the following numbers:
110, 150, 300, 600, 1200, 2400, 4800, 9600 or 19200.

An example of the second line of the display might be:

→8D 1S No P

→is the cursor
D is the number of data bits, which can be 7 or 8
S is the number of stop bits, which can be 1 or 2
P is parity and can be set to any of the following:

No P	= No Parity	
Mk. P	= Mark Parity	Available only with 7D
Sp. P	= Space Parity	Available only with 7D
Odd P	= Odd Parity	
Ev. P	= Even Parity	

In addition, codes are available to allow the printer to list details of:

Bin-count data (Code 16)
Bin set-up data (Code 17)

If any bin or bins are disabled during a Sort run, Bin-count data will include a final line - "Disabled Bins" - showing the number of components classified into such bins and not included in Batch total.

On calling-up Code 13 (via the keyboard: it is not accessible under remote control), the configuration available for Remote Control is as shown above for Printer as regards baud rate, data bits, stop bits and parity. However, Code 13 introduces an additional function - Echo. This can be toggled between OFF and ON. When displayed, it confirms that the function has been returned by the remote controller.

13 CODES

These provide functions not otherwise available from front-panel controls. To call up a particular function, press Code, the required number via the keypad, and press Enter. The Code numbers and the corresponding functions are listed below. (Code numbers of less than unity are reserved for test software).

CODE	FUNCTION
1	F1 sort speed
2	F2 sort speed
4	Bias delay ON
5	Bias delay OFF
8	Handler ON
9	Handler OFF
9.1*	Clears data in memory
10	Printer ON
11	Printer OFF
12	RS232C printer setup
13*	RS232C remote setup
14*	GPIB addresses
15	Bin-count to display
16	Print bin-count
17	Print bin setup
20	Major offset entry
21	Major offset ON
22	Major offset OFF
23	Read Major offset status
24	F1 offset entry
25	F1 offset ON
26	F1 offset OFF
27	Read F1 offset status
28	F2 offset entry
29	F2 offset ON
30	F2 offset OFF
31	Read F2 offset status
7010	Keyboard Lock/Unlock

* Codes 9.1, 13 & 14 not available under remote control.

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