1990

Operator Handbook

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OPERATORS MANUAL

1990

NANOSECOND
UNIVERSAL COUNTER

RACAL-DANA

RACAL
The Electronics Group

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1990
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HANDBOOK AMENDMENTS

Amendments to this handbook (if any), which are on coloured paper for ease of identification, will be found at the rear of the book. The action called for by the amendments should be carried out by hand as soon as possible.

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Input Characteristics

Frequency Range

Input A	DC to 120MHz DC coupled 10Hz to 120MHz AC coupled
Input B	DC to 100MHz DC coupled 10Hz to 100MHz AC coupled

Sensitivity

Sine Wave	25mVrms DC to 100MHz 50mVrms to 120MHz
Pulse	75mV p-p, 5ns min. width

Dynamic Range (x 1 attenuation)	75mV to 5V p-p to 50MHz 75mV to 2.5V p-p to 100MHz 150mV to 2.5V p-p to 120MHz

Signal Operating Range

x 1 attenuation	±2.5V
x 10 attenuation	±25V

Input Impedance (nominal)

Separate Mode (x1/x10)	1 Mohm //≤45pF
Common Mode (x1)	500kohm //≤55pF
Common Mode (x10)	1 Mohm //≤55pF

Maximum Input (without damage)

x1 attenuation	260V(DC + ACrms), DC to 2kHz Decreasing to 5Vrms, at 100kHz and above
x10 attenuation	260V(DC + ACrms), DC to 20kHz Decreasing to 50Vrms at 100 kHz and above
Coupling	AC or DC
Low Pass Filter	50kHz nominal (Input A selectable)
Trigger Slope	+ve or –ve
Attenuator	x1 or x10 nominal

Trigger Level Range

Manual

x1 attenuation	±2.8V typical
x10 attenuation	±28V typical

Trigger Level Output

Range	±2.8V typical

Accuracy*

x1 (sep/common)	±10mV ± 5% of V output
x10 (separate mode)	±100mV ± 7% of V output
Impedance	10kohm nominal

Measurement Modes

Frequency A

Range	DC to 120MHz
Digits Displayed	3 to 8 digits plus overflow
LSD Displayed (Hz)	$F \times 10^{-D}$ (D = No. of digits, F = Freq. rounded up to next decade)*
Resolution *(Hz)	± LSD ± (Trig. Error* x Freq.)/Gate Time
Accuracy *(Hz)	± Resolution ± (Timebase Error x Freq.)

Time Interval

Range

Single	100ns to 8×10^5 sec
Averaged	10ns to 8×10^5 sec

Input

Common	Input A START and STOP
Separate	Input A START Input B STOP
Trigger Slopes	+ve or –ve Selectable START and STOP
LSD Displayed	100ns min. (10ns with averaging)
Resolution* (sec)	± LSD ± 5ns rms ± Trig Error*
Accuracy* (sec)	± Resolution ± (Timebase Error x TI) ± Trigger Level Timing Error* ± 2ns**

Time Delay

Available on Time Interval and Totalise

Range	200μs to 800ms nominal
Step Size	1ms nominal. (Extra step to 200μs)
Accuracy	± 0.1% setting ± 50μs

Period A

Range	8.3ns to 1.7×10^3 sec
Digits Displayed	3 to 8 digits plus overflow
LSD Displayed (sec)	$P \times 10^{-D}$ (D = No. of digits, P = Period rounded up to next decade)*
Resolution* (sec)	± LSD ± (Trig. Error* x Period)/Gate Time
Accuracy* (sec)	± Resolution ± (Timebase Error x Period)

Ratio A/B

Specified for higher frequency applied to Input A

Range	DC to 100MHz on both inputs
LSD Displayed (for 4-8 digits selected)	$\left(\frac{10}{\text{Freq. B} \times \text{Gate Time}}\right)$, rounded to nearest decade*
Resolution*	± LSD ± (Trig. Error B*/Gate Time) x Ratio
Accuracy*	± Resolution

*see definitions **A differential delay between amplifiers

Totalise A by B and Total A

Input	Input A
Start/Stop	Electrical (Input B) or Manual
Range	10^{12} - 1 (8 most significant digits displayed)
Maximum Rate	10^{8} events/sec.
Minimum Pulse Width	5ns min. at trigger points
Accuracy	±1 count

Phase (A rel. to B)

Range	0.1° to 360°
LSD Displayed	Normal (averaged) 1° (0.1°) to 100kHz 10° (1°) to 1MHz 100° (10°) to 5MHz
Resolution* (degrees)	±LSD ± (TI Resolution/Period A) x 360°
Accuracy* (degrees)	±LSD ± (TI Accuracy/Period A) x 360°

Time

Start/Stop	Manual
Range	40ms to 8 x 10^{5} sec.
Resolution	±40ms
Accuracy	±Resolution ± (Timebase Error x Time)

100 Average

Function	Displays average value of 100 measurements
Averaging Time	2.5 sec. + (100 x single measurement time)

Null

Available on all measurements except Phase and Check

Function	Displays (Result – Null)
Entry Range	±1 x 10^{-9} to ±1 x 10^{10} to 8 significant figures

Single Cycle (Hold)
Enables a single measurement to be initiated and held

General

Internal Timebase
Crystal Controlled

Frequency	10MHz
Aging	2 x 10^{-6} in the first year
Temperature Stability	±1 x 10^{-5} over the range 0 to +50°C
Adjustment	Internal

Gate Time

(Frequency, Period and Ratio modes) Automatically determined by resolution selected.
(Range 1msec-10sec)

Resolution Selected (Digits)	Gate Time*(s)
8	10
7	1
6	0.1
5	0.01
4,3	0.001

Display 8 – digit, high brightness, 14mm LED display in engineering format with exponent digit

Power Requirements

Voltage (AC)	90–110V 103-127V 193-237V 207-253V } externally selectable
Frequency	45-440Hz
Rating	35VA Max

Operating Temperature Range	0° to +50°C (0° to +40°C with battery pack)
Storage Temperature Range	–40°C to +70°C (–40°C to +60°C with battery pack)
Environmental	Designed to meet MIL-T-28800, DEF-STD 66/31 and IEC 68
Safety	Designed to meet the requirements of IEC348 and follow the guidelines of UL1244
RFI/EMC	MIL-STD-461B
Weight	Net 3.6kg (8lb) excl. battery 6.8kg (15lb) incl. battery Shipping 5.5kg (12lb) excl. battery 8.75kg (19.3lb) incl. battery
Dimensions	331 x 218 x 101mm (13.03 x 8.58 x 3.98 ins)
Shipping Dimensions	430 x 360 x 280mm (16.9 x 14.2 x 11.0 ins)

Options

Option 02

Frequency Standard Input/Output

Frequency Standard Output

Frequency	10MHz
Amplitude	TTL levels giving approx. 1Vp-p into 50 ohms
Impedance	90 ohms nominal
Reverse Input	±15V max

*see definitions

External Standard Input

Frequency	10MHz (see also Option 10 for other frequencies)
Single Amplitude (Sine Wave)	300mVrms min. 10Vrms max.
Impedance	1 kohm nominal at 1V p-p

Option 04T

Temperature Compensated Crystal Oscillator

Frequency	10MHz
Aging Rate	3×10^{-7}/month 1×10^{-6} in the first year
Temperature Stability	$\pm 1 \times 10^{-6}$ over the range 0 to 40°C (operable to +50°C)
Adjustment	Via rear panel

Option 04A

Ovened Oscillator

Frequency	10MHz
Aging Rate	3×10^{-9}/day averaged over 10 days after 3 months continuous operation
Temperature Stability	$\pm 3 \times 10^{-9}$/°C averaged over range 0° to +45°C (operable to +50°C)
Warm Up	Typically $\pm 1 \times 10^{-7}$ within 6 minutes
Adjustment	Via rear panel

Option 04B

High Stability Ovened Oscillator

Frequency	10MHz
Aging Rate	5×10^{-10}/day averaged over 10 days after 3 months continuous operation
Temperature Stability	$\pm 6 \times 10^{-10}$/°C averaged over range 0° to 50°C
Warm Up	$\pm 1 \times 10^{-7}$ within 20 minutes
Adjustment	Via rear panel

Option 07

Rechargeable Battery Pack and External DC Operation

Battery Type	Sealed lead-acid cells
Battery Life	Typically 5.75 hours at +25°C (24 hrs on standby)
Battery Condition	Display indicates battery low
External DC	11-16V via socket on rear panel (–ve ground, not isolated)

Option 10

Reference Frequency Multiplier

Input Frequency	1,2,5 or 10MHz ($\pm 1 \times 10^{-5}$)
Input Amplitude and Impedance	As for external standard input

Option 55

GPIB Interface	Designed to comply with IEEE-STD-488 (1978) and to conform with the guidelines of IEEE-STD-728 (1982)
Control Capability	All functions and controls programmable except power on/off, trigger levels and standby/charge
Output	Engineering format (11 digits and exponent)
IEEE-STD-488 Subsets	SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E2
Handshake Time	250μs to 1ms/character dependent on message content.
Read Rate	Typically 22/sec dependent upon measurement function

Definitions

LSD
(Least Significant Digit) In Frequency and Period modes display automatically upranges at 1.1 x decade and downranges at 1.05 x decade

Accuracy and Resolution Expressed as an rms value,

Trigger Error = (seconds)

$$\sqrt{\left(\frac{(e_i^2 + e_n^2)}{S^2}\right)_1 + \left(\frac{(e_i^2 + e_n^2)}{S^2}\right)_2} \text{ (rms)}$$

where e_i = input amplifier rms noise (typically 200μVrms in 120MHz bandwidth)
e_n = input signal rms noise in 120MHz bandwidth
S = Slew rate at trigger point V/sec
Suffix 1 denotes START edge
Suffix 2 denotes STOP edge
In Frequency A and Period A, triggering is always on positive going edge

Trigger Level Timing Error

$$\text{Trigger Level Timing Error (Seconds)} = 0.035 \left(\frac{1}{S1} - \frac{1}{S2}\right)$$

$$\text{typically} = 0.018 \left(\frac{1}{S1} - \frac{1}{S2}\right)$$

S1 = Slew rate on START edge V/sec.
S2 = Slew rate on STOP edge V/sec.

Trigger level output accuracy is referenced to the centre of the hysteresis band.

Gate Time
The nominal gate time indicated is set by the resolution selected in Frequency, Period, Ratio and Check modes. It is the value which is used in the calculation of LSD and Resolution. The true gate time will be extended from this value by up to one period of the input signal(s) on Frequency A, Period A and Ratio A/B.

Supplied Accessories

Power Cord
Spare Fuse
Operator's Manual

Ordering Information

1990	120MHz Universal Counter

Options and Accessories

02	Frequency Standard Input/Output	11-9000
04T**	TCXO	11-1713
04A*	Oven Oscillator	11-1710
04B*	High Stability Oven Oscillator	11-1711
07†	Battery Pack	11-1625
***10**	Reference Frequency Multiplier	11-1645
55†	GPIB Interface	11-9001
60	Handles	11-1730
60A	Rack Mounting Kit (Fixed, Single)	11-1648
60B	Rack Mounting Kit (Fixed, Double)	11-1649
61	Hard Carrying Case	15-0773
61M	Protectomuff Case	15-0736
65	Chassis Slides (incl. Rack Mounts)	11-1716
	Telescopic Antenna	23-9020
	High Impedance Probe (1MΩ)	23-9104

* Option 02 must also be purchased with these options

** Only one frequency standard may be fitted at any one time. The standard reference will be supplied unless option 04T, 04A or 04B is specified

† The battery pack and GPIB options cannot both be fitted

INTRODUCTION

1 The Racal-Dana universal counter Model 1990 is a microprocessor controlled instrument using reciprocatic measurement techniques. The instrument offers a comprehensive range of functions and easy to use controls.

MEASUREMENT FUNCTIONS

Frequency A Function

2 The Frequency A function is used to measure the frequency of the signal applied to the channel A input. A resolution of seven digits is available with a one-second gate time.

Period A Function

3 The Period A function is used to measure the period of the waveform applied to the A channel input. A number of periods, depending upon the resolution (and therefore the gate time) selected, are measured, and the average value is displayed.

Time Interval Function

4 The Time Interval function is used to make single-shot measurements of the time interval between:

(1) An event occurring at the channel A input and a later event at the channel B input (using separate input channels).

(2) Two events occurring at the channel A input (using a common input channel).

5 The arming of the stop circuit can be delayed for a time set by the operator. This prevents the measurement interval being stopped prematurely by spurious pulses, such as those caused by contact bounce.

Total A by B Function

6 The Total A by B function permits events occurring at the channel A input to be totalized. The counting interval is controlled by electrical start and stop signals applied to the channel B input, where alternate edges start and stop the measurement.

7 Delayed arming of the stop circuit is available in the Total A by B mode to prevent spurious triggering.

Phase A rel B Function

8 The Phase A rel B function is used to measure the phase difference between the waveform applied to the A channel input and that applied to the channel B input. The phase difference is displayed in degrees, and indicates the phase lead at the channel A input.

Ratio A/B Function

9 The Ratio A/B function is used to measure the ratio of the frequency applied to the channel A input to that applied to the channel B input.

Total A Function

10 The Total A function totalizes events occurring at the Channel A input. The counting interval is controlled by successive operations of the front panel Hold (start/stop) key.

Time Function

11 The time function is used to measure the time interval between successive operations of the front panel Hold (start/stop) key, ie. stop watch.

CHECK FUNCTION

12 With the Check function selected a number of functional tests of the instrument's circuits can be made without the use of additional test equipment. Although these tests do not check the instrument's performance to its published specification, they can be used to verify that the equipment is operating correctly following receipt or transportation to a new location. A suitable functional check procedure is given in Section 3.

SIGNAL INPUT CHANNELS

13 Signal input channels A and B are fully independent, but provision is made for connection of the signal at the channel A input into both channels. When this is done, the channel B input socket is isolated from channel B.

14 Each channel is provided with independent controls to permit the selection of:

(1) AC or DC input coupling.

(2) X1 or X10 input attenuation.

(3) Positive- or negative-slope trigger.

(4) Manually-set input trigger level.

The trigger levels are set by the front panel potentiometers which also have a set zero position.

The trigger voltage levels in use are also available at pins mounted on the front panel of the instrument. The input trigger voltage range is typically ±2.8 V. The voltage should be multiplied by 10 when the attenuator is selected.

LOW-PASS FILTER

15 An internal low-pass filter can be introduced to reduce the bandwidth of channel A to 50 kHz (nominal).

NULL FUNCTION

16 With the NULL function active the instrument displays the difference between the measured value and the value held in the internal NULL store.

DELAY FUNCTION

17 In Time Interval and Total A by B, the stop circuit can be delayed. With the delay function active, the stop circuit is prevented from being triggered prematurely by spurious signals.

100 AVERAGE FUNCTION

18 Enabling this function increases the resolution by taking 100 measurements and displaying the averaged value. The signal must be repetitive and asynchronous with the counter standard.

SPECIAL FUNCTIONS

19 A number of special functions are available to the operator. These provide test procedures and operating facilities additional to those available by operation of the front panel controls. Details are given in Section 4 of this manual.

ERROR INDICATION

20 Certain errors in the operation of the instrument will result in the generation of error codes, which will be displayed. Details are given in Section 4 of this manual.

DISPLAY FORMAT

21 The display uses an engineering format, with an eight digit mantissa and one exponent digit. Overflow of the most significant digits can be used to increase the display resolution.

HOLD FEATURE

22 The hold feature allows readings to be held indefinitely. A new measurement cycle is initiated using the RESET key.

RESOLUTION AND GATE TIME

23 In the Total A by B, Total A and Time modes, the counting interval (gate time) is controlled by the time interval between the start and stop signals at the channel B input, or between successive operations of the HOLD key. In the Frequency A, Period A and Ratio A/B modes, the gate time is determined by the display resolution selected. In Phase mode, the gate time is fixed and the display resolution is determined by the input signal frequency. Details of the relationship between gate time and resolution for each measurement mode are given in Section 4 of this manual.

STANDBY MODE

24 When the instrument is switched to standby, the internal frequency standard continues to operate but the measuring circuits are switched off. If the battery pack option is fitted and an external power supply is connected, the battery is charged at the full rate.

INITIALIZATION

25 When the instrument is first switched on, or when it is initialized via the GPIB, it is set to the following conditions:

Measurement Function	FREQ A
Display Resolution	6 digits
Channel A and B Inputs	AC coupling Positive-slope trigger LF filter disabled Common input disabled
Delay	Disabled
Delay Store	1 ms
Null Function	Disabled
Null Store	0
100 Avg	Disabled
Hold	Disabled
Special Functions	Off

OPTIONS AVAILABLE

Frequency Standards (04X Options)

26 A wide range of internal frequency standard options is available. The technical specifications are given in Section 1 of this manual. The frequency standard can be changed, if required, by the customer: instructions are given in Section 3.

Reference Frequency Multiplier (Option 10)

27 The reference frequency multiplier is an internally-mounted, phase-locked multiplier, which permits the use of external frequency standard signals at 1 MHz, 2 MHz, 5 MHz or 10 MHz. The multiplier can be fitted by the customer: instructions are given in Section 3.

Reference Input and Output (Option 02)

28 The instrument may be operated using an external frequency standard. The instrument will operate from the external standard, in preference to the internal standard, whenever the signal at the EXT STD INPUT socket is of sufficient amplitude. It will revert to operation from the internal standard automatically if the external standard is removed. The 10 MHz STANDARD OUTPUT connector provides a signal derived from whichever standard is in use at the time.

GPIB Interface (Option 55)

29 An internally mounted IEEE-488-GPIB interface is available. This permits remote control of all the instrument's functions except the power ON/OFF, standby switching and trigger levels. The interface can be fitted by the customer: instructions are given in Section 3. The GPIB interface cannot be fitted to an instrument already fitted with the battery pack option. An adapter, Racal-Dana part number 23-3254, to convert the connector to the IEC 625-1 standard is available as an accessory.

Battery Pack (Option 07)

30 Fitting the internal battery permits the instrument to be used in locations where no suitable AC supply is available. The option also allows operation from an external DC supply with the INT/EXT switch set to EXT position.

31 The battery is trickle-charged whenever the instrument is operated from an AC supply. Charging at the full rate is carried out when the instrument is switched to the standby mode. A full charge requires approximately 14 hours.

32 The instrument will operate continuously for approximately $5\frac{3}{4}$ hours from a fully-charged battery. It will switch off automatically when the battery approaches the discharged condition. The STBY/CHRG indicator starts to flash approximately 15 minutes before this occurs. The battery life can be extended by use of the Battery-Save facility.

33 The battery pack can be fitted by the customer. Instructions are given in Section 3. The battery pack cannot be fitted to an instrument already fitted with the GPIB interface option.

Rack Mounting Kits

34 The following kits, permitting the instrument to be mounted in a standard 19-inch rack are available:

(1) Single instrument, fixed-mount kit (Option 60A).
(Racal-Dana part number 11-1648).
The mounted instrument occupies half the rack width and is two rack units (3.5 inches) in height. The instrument is mounted offset in the rack and may be at either side.

(2) Double instrument, fixed-mount kit (Option 60B).
(Racal-Dana part number 11-1649).
The panel of the mounting kit occupies the full rack width and is two rack units (3.5 inches) in height. Two instruments can be mounted side-by-side.

35 All the kits can be fitted by the customer. Instructions are given in Section 3.

UNPACKING

1 Unpack the instrument carefully to avoid unnecessary damage to the factory packaging.

2 If it becomes necessary to return the instrument to Racal-Dana Instruments for calibration or repair, the original packaging should be used. If this is not possible, a strong shipping container should be used. Ensure that sufficient internal packing is used to prevent movement of the instrument within the container during transit.

POWER SUPPLY

AC Line Voltage Setting

3 Before use, check that the AC voltage selector is set correctly for the local AC supply. The voltage range already set can be seen through a window in the selector board retaining clamp to the left of the AC power plug.

4 If it is necessary to change the setting, proceed as follows:

(1) Undo the selector board retaining clamp on the rear panel.

(2) Withdraw the board.

(3) Replace the board with the required voltage setting positioned so that it will show through the window in the retaining clamp.

(4) Replace the retaining clamp.

Line Fuse

5 Check that the rating of the line fuse is suitable for the AC voltage range in use. The fuse should be of the $\frac{1}{4}$ in x $1\frac{1}{4}$ in, glass cartridge, surge-resisting type. The required rating is:

90 V to 127 V: 500 mAT (Racal-Dana part number 23-0052).
193 V to 253 V: 250 mAT (Racal-Dana part number 23-0056).

Power Cord

6 The 1990 is a Safety Class 1 instrument, which is designed to meet international safety standards. A protective ground terminal, which forms part of the power-input connector on the rear panel, is provided. Each instrument is supplied with a 3-core power cord. Only the power cord supplied should be used to make electrical connection to the power-input connector.

7 AC power for the instrument must be taken from a power outlet incorporating a protective ground connector. When the green/yellow conductor of the power cord is joined to this connector, the exposed metalwork of the instrument is grounded. The continuity of the protective ground connection must not be broken by the use of 2-core extension cords or 3-prong to 2-prong adapters.

8 Connection of the power cord to the power outlet must be made in accordance with the standard color code.

	European	American
Line	Brown	Black
Neutral	Blue	White
Ground (Earth)	Green/Yellow	Green

FUNCTIONAL CHECK

9 The check given in paragraph 10 tests the operation of most of the instrument's circuits to establish whether the instrument is functioning correctly. The procedure should be followed when the instrument is first taken into use, and after transportation to a new location. It does not check that the instrument is operating to the published specification. Detailed specification tests are given in Section 7 of the maintenance manual.

10 (1) Connect the instrument to a suitable AC supply.

(2) Switch the instrument on. Check that the instrument type-number appears in the display for approximately two seconds, followed by a number which indicates the software version and issue number.

(3) Press the FUNCTION ↓ key until the CHECK indicator lights. Check that the display shows 10.00000 E 6 Hz and that the GATE indicator is flashing.

(4) Verify that the RESOLUTION indicator is lit. Press the RESOLUTION ↓ key three times, ensuring that the resolution of the display is decreased by one digit each time.

(5) Press the RESOLUTION ↑ key four times to increase the resolution to seven digits, and check that the GATE indicator flashes about once a second.

(6) Press the RECALL key. Check that all LEDs, with the exception of REM, ADDR, SRQ, GATE, TRIG A, TRIG B and STBY/CHRG flash on and off every two seconds. If the GPIB option is installed, the REM, ADDR and SRQ indicators should be lit.

(7) Press the RESET/CONTINUE key to return to the check functions.

FREQUENCY STANDARD (Input/Output) Option 02)

11 If it is intended to use an external frequency standard, the output of the frequency standard should be connected to the EXT STD INPUT connector on the rear panel of the instrument. The connection should be made using coaxial cable. Switch on the frequency standard and the instrument: check that the EXT STD indicator on the front panel of the instrument lights.

12 A 10 MHz signal, derived from the frequency standard in use, is available at the 10 MHz STD OUT connector on the rear panel of the instrument. If this signal is used, the connection should be made using coaxial cable.

TRIGGER LEVEL OUTPUT

13 The trigger levels in use on channels A and B are available via pins on the instrument front panel. If required, connection to the pins should be made using a clip-on probe or small crocodile clip.

PREPARATION FOR USE WITH THE GPIB

Introduction

14 The instrument must be prepared for use in accordance with the instructions given in Paragraphs 3 to 8 before the instructions given in this section are implemented.

Connection to the GPIB

15 Connection to the GPIB is made via a standard IEEE-488 connector, mounted on the rear panel. The pin assignment is given in Table 3.1. An adapter, Racal-Dana part number 23-3254, to convert the connector to the IEC 625-1 standard is available as an optional accessory.

TABLE 3.1

GPIB Connector Pin Assignment

Pin	Signal Line	Pin	Signal Line
1	DIO 1	13	DIO 5
2	DIO 2	14	DIO 6
3	DIO 3	15	DIO 7
4	DIO 4	16	DIO 8
5	EOI	17	REN
6	DAV	18	Gnd (6)
7	NRFD	19	Gnd (7)
8	NDAC	20	Gnd (8)
9	IFC	21	Gnd (9)
10	SRQ	22	Gnd (10)
11	ATN	23	Gnd (11)
12	SHIELD	24	Gnd (5 and 17)

Address Setting and Display

16 The interface address is set using five switches, A1 to A5, which are mounted on the rear panel. The permitted address settings, in binary, decimal and ASCII character form, are given in Table 3.2. The GPIB address set can be displayed, in decimal form, by pressing

[RECALL] [LOCAL]

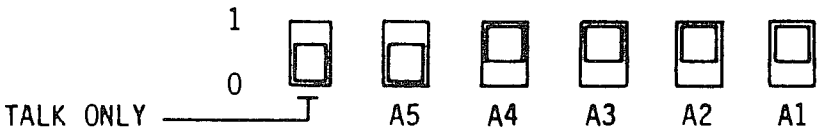
If the address is changed, this key sequence must be repeated to display the new address. The instrument is returned to the measurement mode by pressing

[CONTINUE]

17 For addressed operation, the TALK ONLY switch must be in the logic '0' position (down). When this switch is in the logic '1' position, the interface is switched to the talk-only mode. The settings of switches A1 to A5 are then irrelevant.

TABLE 3.2

Address Switch Settings



SWITCH SETTINGS					ADDRESS CODES		
A5	A4	A3	A2	A1	DECIMAL	ASCII LISTEN ADDRESS	ASCII TALK ADDRESS
0	0	0	0	0	0	SP	@
0	0	0	0	1	1	!	A
0	0	0	1	0	2	"	B
0	0	0	1	1	3	#	C
0	0	1	0	0	4	$	D
0	0	1	0	1	5	%	E
0	0	1	1	0	6	&	F
0	0	1	1	1	7	'	G
0	1	0	0	0	8	(	H
0	1	0	0	1	9	)	I
0	1	0	1	0	10	*	J
0	1	0	1	1	11	+	K
0	1	1	0	0	12	,	L
0	1	1	0	1	13	-	M
0	1	1	1	0	14	.	N
0	1	1	1	1	15	/	O
1	0	0	0	0	16	0	P
1	0	0	0	1	17	1	Q
1	0	0	1	0	18	2	R
1	0	0	1	1	19	3	S
1	0	1	0	0	20	4	T
1	0	1	0	1	21	5	U
1	0	1	1	0	22	6	V
1	0	1	1	1	23	7	W
1	1	0	0	0	24	8	X
1	1	0	0	1	25	9	Y
1	1	0	1	0	26	:	Z
1	1	0	1	1	27	;	[
1	1	1	0	0	28	<	\
1	1	1	0	1	29	=	]
1	1	1	1	0	30	>	^

GPIB CHECK

18 The procedure which follows checks the ability of the instrument to accept, process and send GPIB messages. The correct functioning of the instrument under local control should be verified before the procedure is attempted.

19 The recommended test equipment is the Hewlett-Packard HP-85 GPIB controller, with the I/O ROM in the drawer. It is assumed that the select code of the controller I/O port is 7, and that the address of the instrument is 15 (to change the address, see Paragraph 16). If any other controller or select code/address combination is used, the GPIB commands given in the following paragraphs will require modification. The controller should be connected to the GPIB interface of the instrument via a GPIB cable. No connection should be made to the channel A or B inputs.

20 Successful completion of the GPIB check proves that the instrument's GPIB interface is operating correctly. The procedure does not check that all the device-dependent commands can be executed. However, if the GPIB interface works correctly and the instrument operates correctly under local control, there is a high probability that it will respond to all device-dependent commands.

Remote and Local Message Check

21 Switch the instrument on. Check that the REM, ADDR and SRQ indicators flash on and off once. If the indicators do not flash, or if they flash continuously, there is a fault on the GPIB board.

22 Test as follows:

Action	HP-85 Code	Your Controller
Send the REN message true, together with the instrument's listen address	REMOTE 715	

Check that the REM indicator lights.

23 Test as follows:

Action	HP-85 Code	Your Controller
Send the device-dependent command CK	OUTPUT 715; "CK"	

Check that the ADDR indicator lights and that the Check mode is selected.

24 Test as follows:

Action	HP-85 Code	Your Controller
Send the instrument's listen address followed by the GTL message	LOCAL 715	

Check that the REM indicator is off. The ADDR indicator will also be off if the controller used sends the unlisten message (UNL) true automatically. This is the case when using the HP-85.

Local Lockout and Clear Lockout Check

25 Test as follows:

Action	HP-85 Code	Your Controller
Send the REN message true, together with the instrument's listen address	REMOTE 715	
Send the LLO message	LOCAL LOCKOUT 7	

Check that the REM indicator lights. Operate the LOCAL key on the front panel and verify that the REM indicator remains lit.

26 Test as follows:

Action	HP-85 Code	Your Controller
Send the REN message false	LOCAL 7	

Check that the REM indicator is off.

27 Test as follows:

Action	HP-85 Code	Your Controller
Send the REN message true, together with the instrument's listen address	REMOTE 715	

Check that the REM indicator lights. Press the LOCAL key and verify that the REM indicator turns off.

Data Output Check

28 Test as follows:

Action	HP-85 Code	Your Controller
Set the instrument to the check mode by sending the listen address, followed by the device-dependent command CK	OUTPUT 715; "CK"	
Prepare a store to receive a 21-byte data string	DIM Z$ 21	
Send the instrument's talk address. Store the 21-byte data string in the prepared store	ENTER 715; Z$	
Display the contents of the store	DISP Z$	

Check that the display reads CK+000010.00000E+06 with the cursor moved to the next line, indicating that carriage return (CR) and line feed (LF) have been accepted.

SRQ and Status Byte Check

29 Test as follows:

Action	HP-85 Code	Your Controller
Send the REN message true	REMOTE 7	
Set the instrument to send the SRQ message when an error is detected, and force the generation of error code 05 by sending the device-dependent commmand XXX	OUTPUT 715;"IPXXX"	
Store the status of the GPIB interface of the controller, in binary form, as variable T	STATUS 7, 2; T	
Display the status of the SRQ line	DISP"SRQ=";BIT(T,5)	

Check that the HP-85 displays SRQ=1, the SRQ status bit is at logic '1' or the SRQ line is 0.8 V). Check that the SRQ indicator on the instrument is lit.

30 Test as follows:

Action	HP-85 Code	Your Controller
Conduct a serial poll and store the status byte as variable R	R = SPOLL (715)	
Display variable R	DISP "R="; R	

Check that the SRQ indicator is turned off when the serial poll is made. The value of R should be 101 (in binary form, R should be 0000000001100101). If using an HP-85 controller, check that the ADDR indicator is turned off.

Device Clear and Selected Device Clear Check

31 Test as follows:

Action	HP-85 Code	Your Controller
Set the instrument to the Total A by B mode by sending the listen address, followed by the device-dependent command TA	OUTPUT 715;"TA"	
Send the DCL message true	CLEAR 7	

Check that the function indicated on the instrument front panel changes to FREQ A.

32 Test as follows:

Action	HP-85 Code	Your Controller
Reset the instrument to the Total A by B mode by sending the listen address, followed by the device-dependent command TA	OUTPUT 715;"TA"	
Send the SDC message true	CLEAR 715	

Check that the function indicated on the instrument front panel changes to FREQ A.

IFC Check

33 Test as follows:

Action	HP-85 Code	Your Controller
Send the ATN message false Send the IFC message true	RESUME 7 ABORTIO 7	

Check that the ADDR indicator is turned off.

TALK ONLY Selector Test

34 (1) Set the TALK ONLY switch in the instrument rear panel to '1'. Check that the REMOTE indicator is turned off and the ADDR indicator lights.

(2) Set the TALK ONLY switch to '0'. Check that the ADDR indicator turned is off.

OPTION FITTING INSTRUCTIONS

Single-Instrument Fixed Rack Mounting Kit 11-1648 (Option 60A)

35 The kit comprises:

Item	Qty	Racal-Dana Part Number
Short mounting bracket	1	16-0643
Long mounting bracket	1	16-0644
Screw, M4 x 16	4	24-7733
Crinkle washer M4	4	24-2802
Spacer, plain M4x5	4	24-4112
Screw, M6 x 16	4	24-7995
Cup washer, M6	4	24-2809
Caged nut, M6	4	24-2240

36 Assemble the kit to the instrument as follows:

(1) Disconnect the AC power cord at the rear panel.

(2) Remove the two screws which secure the bezel to the rear panel: remove the bezel.

(3) Remove the bottom cover by sliding it towards the rear of the instrument.

(4) Remove the instrument's feet from the bottom cover.

(5) Replace the bottom cover. Replace and secure the bezel.

(6) Remove the four blind grommets from the sides of the instrument. This will reveal two threaded holes in each side frame.

(7) At one side of the instrument, secure a mounting bracket to the side frame, using two spacers, M4 screws and crinkle washers. Position the spacers between the mounting bracket and the side frame.

(8) Repeat step (7) at the other side of the instrument.

(9) Fit the cup washers to the M6 screws. Offer the instrument up to the rack in the required position, and secure the brackets to the rack using the M6 screws and nuts.

Double-Instrument Fixed Rack Mounting Kit 11-1649 (Option 60B)

37 The kit comprises:

Item	Qty	Racal-Dana Part Number
Short mounting bracket	2	16-0643
Screw, M4 x 16	4	24-7733
Crinkle washer, M4	4	24-2802
Spacer, plain, M4 x 5	4	24-4112
Spacer, female	2	14-1583
Spacer, male	2	14-1584
Mating plate	1	13-2000
Rivet, plastic	4	24-3211
Screw, M6 x 16	4	24-7995
Cup washer, M6	4	24-2809
Caged nut, M6	4	24-2240

38 Prepare both instruments as follows:

(1) Disconnect the AC power cord at the rear panel.

(2) Remove the two screws which secure the bezel to the rear panel: remove the bezel.

(3) Remove the bottom cover by sliding it towards the rear of the instrument.

(4) Remove the instrument's feet from the bottom cover.

(5) Replace the bottom cover. Replace and secure the bezel.

(6) Remove the four blind grommets from the sides of the instrument. This will reveal two threaded holes in each side frame.

(7) Remove two buffers from the bezel at the side which is to be at the centre of the rack.

39 Assemble the kit to the instruments as follows:

(1) At the sides which are to be at the centre of the rack, secure the female spacers to one instrument and the male spacers to the other. The spacers screw into the threaded holes in the side frames.

(2) At the other side of each instrument, secure a mounting bracket to the side frame, using two plain spacers, M4 screws and crinkle washers. Position the spacers between the mounting bracket and the side frame.

(3) Fit the male spacers on one instrument into the female spacers on the other.

(4) Position the mating plate to bridge the gap between the bezels. Secure it by pushing the plastic rivets through the plate into the buffer holes.

(5) Fit the cup washers to the M6 screws. Offer the two instruments up to the rack in the required position, and secure the brackets to the rack using the M6 screws and nuts.

TCXO Frequency Standard, 11-1713 (Option 04T)

40 The kit comprises:

Item	Qty	Racal-Dana Part Number
Plate assembly	1	11-1610
Oscillator PCB	1	19-1208
Crinkle washer M3	3	24-2801
Screw, M3 x 6	3	24-7721

Installation

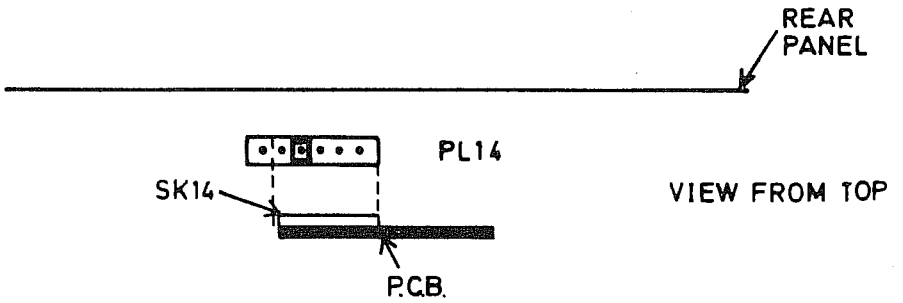
41 (1) Disconnect the AC power cord at the rear panel.

(2) Remove the two screws which secure the bezel to the rear panel: remove the bezel.

(3) Remove the top cover by sliding it towards the rear of the instrument.

(4) If an ovened frequency standard is fitted, remove this. If the basic frequency standard is in use, remove link LK1 and the frequency controls blanking plate from the rear panel.

(5) Secure the PCB to the plate assembly, using an M3 screw and washer from the kit. The screw should be passed through the mounting hole in the board and screwed into the threaded spacer of the plate assembly. The component side of the board should be towards the plate assembly.



(6) Connect the PCB to the motherboard at PL14, ensuring that the socket fits over the portion of PL14 indicated.

(7) Secure the plate assembly to the rear panel, using two M3 screws and washers. The screws pass through the holes adjacent to the FREQ STD ADJUST aperture and screw into the plate assembly.

(8) Replace the top cover. Replace and secure the bezel.

Removal

42 (1) Remove the two screws adjacent to the FREQ STD ADJUST aperture in the rear panel.

(2) Pull the PCB and plate assembly upwards until the board is disconnected from the motherboard.

Ovened Frequency Standards 11-1710 and 11-1711 (Options 04A and 04B)

43 The kit comprises:

Item	Qty	Racal-Dana Part Number
Oscillator assembly	1	9444 for 11-1710 9423 for 11-1711
Crinkle washer, M3	2	24-2801
Screw, M3 x 6	2	24-7721

Installation

44 (1) Disconnect the AC power cord at the rear panel.

(2) Remove the two screws which secure the bezel to the rear panel: remove the bezel.

(3) Remove the top cover by sliding it towards the rear of the instrument.

(4) If an ovened frequency standard is fitted, remove this as in para. 41. If the basic frequency standard is in use, remove link LK1 and the frequency controls blanking plate from the rear panel.

(5) Connect the frequency standard into the motherboard at PL14, ensuring that the socket fits over the portion of PL14 indicated (see illustration in para. 41).

(6) Secure the oscillator assembly to the rear panel of the instrument, using the M3 screws and washers. The screws pass through the holes adjacent to the FREQ STD ADJUST aperture and screw into the oscillator assembly.

(7) Replace the top cover. Replace and secure the bezel.

NOTE: When either of the ovened frequency standard options is fitted, the ref. input and output option should also be fitted.

Removal

45 (1) Remove the two screws adjacent to the FREQ STD ADJUST aperture in the rear panel.

(2) Lift the oscillator assembly out of the chassis and disconnect the flying lead from the motherboard at PL14.

Reference Frequency Multiplier Option 11-1645 (Option 10)

46 The kit comprises:

Item	Qty	Racal-Dana Part Number
Frequency multiplier	1	19-1164
Crinkle washer, M3	2	24-2801
Screw, M3 x 6	2	24-7721

47 (1) Disconnect the AC power cord at the rear panel.

(2) Remove the two screws which secure the bezel to the rear panel: remove the bezel.

(3) Remove the top cover by sliding it towards the rear of the instrument.

(4) Remove the frequency standard, if it is an ovened type.

(5) Remove the shorting link from between pins 8 and 9 on PL16.

NOTE: This link should be stored in a safe place. It must be replaced if Option 10 is removed from the instrument.

(6) Connect the frequency multiplier PCB to the motherboard at PL16 and PL17, with the threaded spacers towards the right-hand side frame.

(7) Secure the PCB to the side frame, using the M3 screws and washers.

(8) Replace and secure the frequency standard if it was removed in (5).

(9) Replace the top cover. Replace and secure the bezel.

NOTE: Where this option is fitted, the ref. input and output option must also be fitted.

Reference Input/Output Option 11-9000 (Option 02)

48 (1) Disconnect the AC power cord at the rear panel.

(2) Remove the two screws securing the board to the rear panel, and remove the bezel.

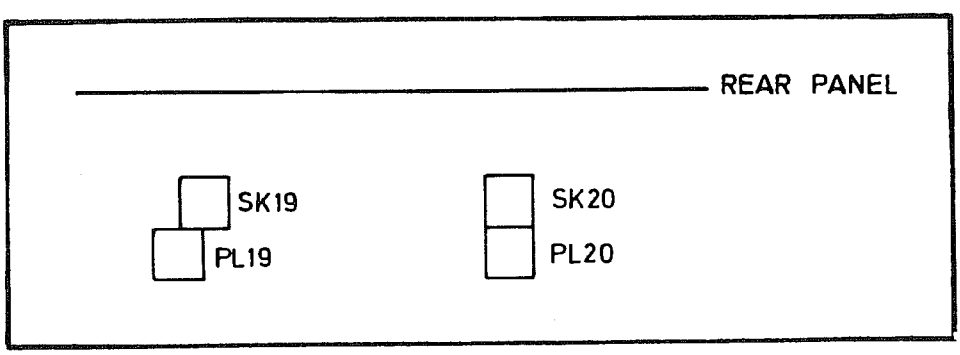
(3) Remove the top cover by sliding it towards the rear of the instrument. If the temperature compensated crystal oscillator (TCXO) is fitted, remove the screws holding this to the rear panel.

(4) Remove the four screws securing the rear panel to the side members and ease the rear panel back from the chassis. Take care not to strain the connecting wires.

(5) Remove the two plastic plugs covering the EXT STD INPUT and 10 MHz STD OUTPUT connector holes.

(6) Remove the nuts from the BNC connectors. Pass the connectors through the rear panel and secure the BNCs with the nuts on the outside.

(7) Replace the rear panel, taking care to align the connectors PL20/SK20. Note that the connectors PL19/SK19 are staggered when fitted correctly, see below:



(8) Replace the screws holding the rear panel.

(9) Replace the top cover. Replace and secure the bezel.

GPIB Option 11-9001 (Option 55)

49 The kit comprises:

Item	Qty	Racal-Dana Part Number
GPIB board assembly	1	19-1146
Bracket	2	11-1728
Speednut	2	24-0146
Shakeproof washer, M3	2	24-2813
Screw, M3 x 6	2	24-7721
Washer, M4	2	24-2802
Screw, M3 x 6	2	24-7721
Screw, M4 x 8	4	24-7730

NOTE:
This option cannot be fitted to an instrument already fitted with the battery pack option.

50 (1) Disconnect the AC power cord at the rear panel.

(2) Remove the two screws which secure the bezel to the rear panel: remove the bezel.

(3) Remove the top cover by sliding it towards the rear of the instrument.

(4) Remove the blanking plate from the rear panel by pushing out the plastic rivets from the inside of the instrument.

(5) Slide a speednut onto each of the two brackets. Ensure that the flat non-threaded face of the speednut is uppermost.

(6) Secure one bracket to each sideframe of the instrument using the M4 screws and crinkle washers supplied. Ignore the two holes near the rear of the instrument in the RH sideframe.

(7) Hold the GPIB board, component side down, with the GPIB connector towards the rear panel. Connect the ribbon-cable to the motherboard at SK4.

(8) Tilt the GPIB board, and lower it into the instrument, easing the GPIB connector into the shaped cut-out in the rear panel of the instrument.

(9) Line-up the holes in the GPIB board with the speednuts (move the speednuts slightly if necessary). Secure the board with the two self-tapping screws.

(10) Secure the bracket which carries the GPIB connector to the rear panel, using the two M3 screws and shakeproof washers.

NOTE:
The screws and washers provide the ground connection between the GPIB connector and the instrument chassis. Tighten the screws firmly to ensure that a good connection is obtained.

(11) Replace the top cover. Replace and secure the bezel.

Battery Pack Option 11-1625 (Option 07)

51 The kit comprises:

Item	Qty	Racal-Dana Part Number
PCB assembly	1	11-1722
Mounting bracket	1	11-1599
Battery pack	1	11-1723
Cover plate	1	13-2040
Crinkle washers, M3	2	24-2801
Screws, M3	2	24-7721
Crinkle washers, M4	6	24-2802
Plain washers, M4	2	24-2705
Screws, M4	6	24-7730
Spare fuse, 3AT	1	23-0069
Plastic rivet	1	24-0252

NOTE:
This option cannot be fitted to an instrument already fitted with the GPIB interface option without first removing that option.

52 (1) Disconnect the AC power cord at the rear panel.

(2) Remove the two screws which secure the bezel to the rear panel: remove the bezel.

(3) Remove the top cover by sliding it towards the rear of the instrument.

(4) Remove the blanking plate from the rear panel by pushing out the plastic rivets from the inside of the instrument.

(5) If a PCB-mounted frequency standard is fitted, remove the two screws adjacent to the FREQ STD ADJUST aperture.

(6) Remove the four screws which secure the rear panel to the side frames.

(7) Ease the rear panel away from the instrument until it disconnects from the motherboard at PL19 and PL20.

(8) Hold the PCB assembly with the switches towards the rear of the instrument and the PCB connector pointing downwards.

(9) Lower the assembly into the chassis and connect the PCB to the motherboard at PL21, taking care that it mates correctly.

(10) Replace and secure the rear panel.

(11) If a PCB-mounted frequency standard is fitted, secure it to the rear panel with the screws removed in (5).

(12) Position the cover plate over the switches protruding through the rear panel. Secure the cover plate and the rear panel to the PCB assembly, using the M3 screws and washers.

(13) Secure the mounting bracket to the right-hand side frame, using two M4 screws and washers. The horizontal flange should be towards the top of the instrument.

(14) Position the battery pack within the chassis, with the supporting lugs resting on the mounting bracket. Secure the battery pack to the left-hand side frame, using two M4 screws and washers.

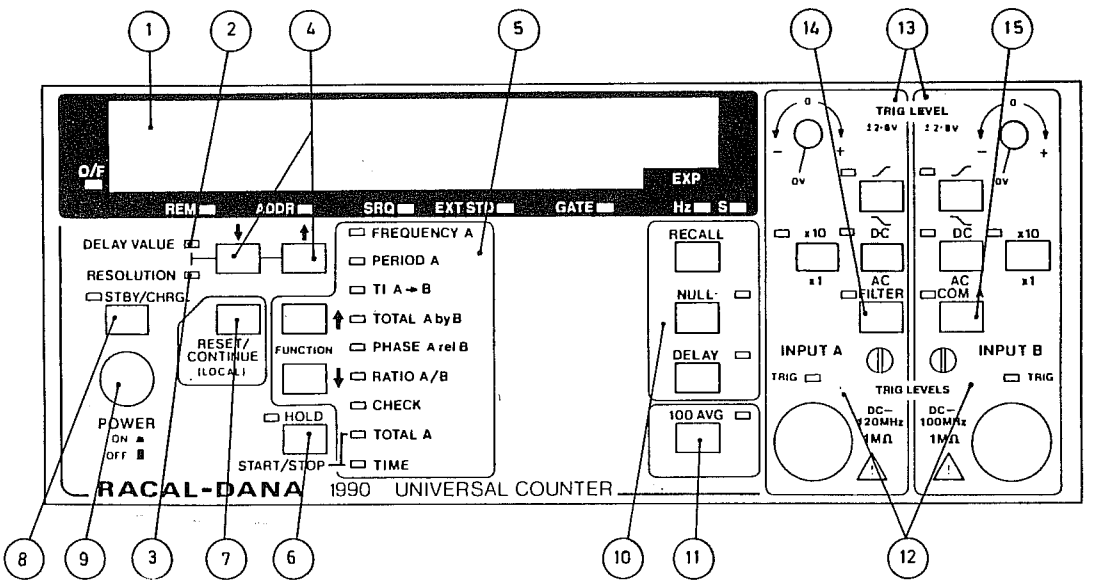
(15) Secure the supporting lugs to the mounting bracket, using M4 screws and washers.

(16) Connect the flying lead on the battery pack to the connector on the PCB assembly.

(17) Replace the top cover. Replace and secure the bezel.

INTRODUCTION

1 The instrument should be prepared for use in accordance with the instructions given in Section 3. If the instrument is being used for the first time, or at a new location, pay particular attention to the setting of the AC voltage selector.



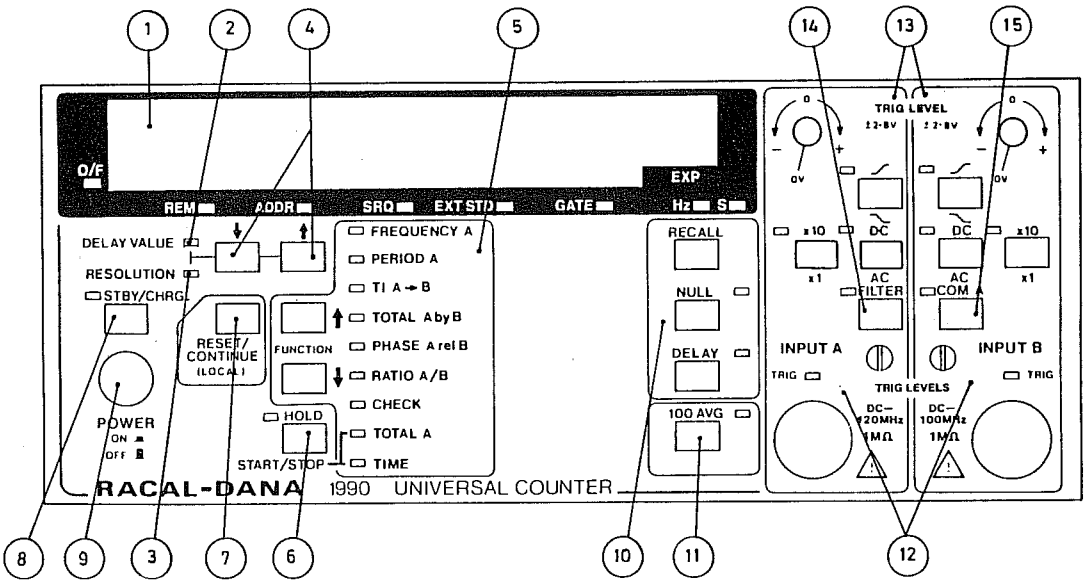
DESCRIPTION OF CONTROLS, INDICATORS AND CONNECTORS

Front Panel Items

2

Reference	Item	Description
1	Display	A 7-segment, LED, digital display, used to display: (1) The result of a measurement. (2) A number awaiting entry into an internal store. (3) A number recalled from an internal store. (4) Error indications.

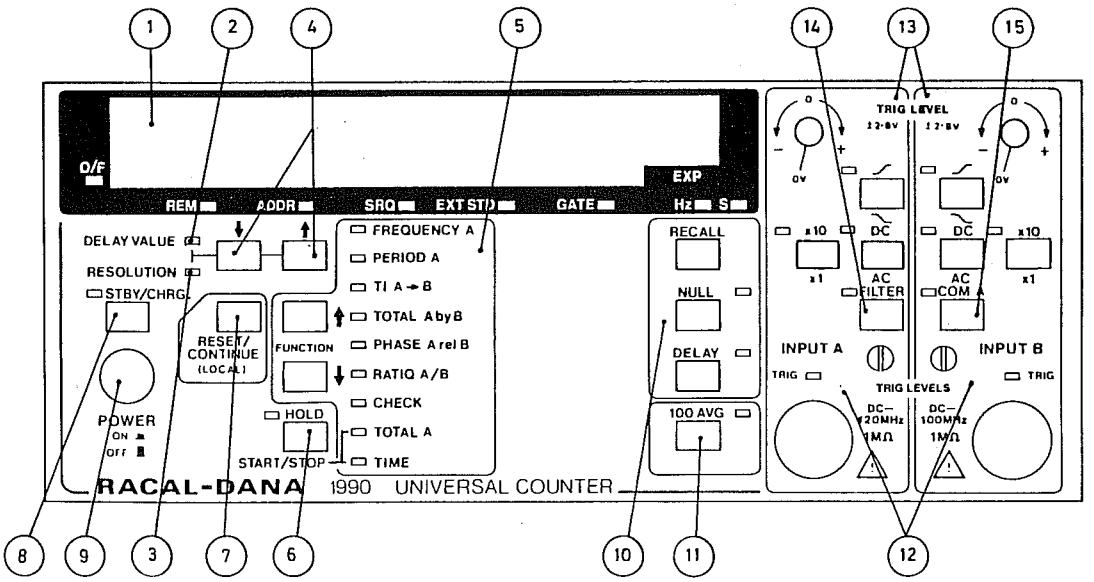
Reference	Item	Description
		The display format is in engineering format, with an 8-digit mantissa and a 1-digit exponent. The exponent is normally a multiple of three. The exponent digit is blanked, and should be assumed to be zero, for: (1) Display of phase mode measurement results. (2) Totalize measurement results having less than nine digits.
	O/F Indicator	Lights when the measurement result has overflowed the eighth digit of the display.
	REM Indicator	Lights when the instrument is operating under remote control.
	ADDR Indicator	Lights when the instrument is acting as a listener or as a talker.
	SRQ Indicator	Lights when the instrument generates a service request.
	EXT STD Indicator	Lights when the instrument is operating from an external frequency standard.
	GATE Indicator	Lights while a measurement cycle is in progress.
	Display Units Indicators	The Hz indicator lights for a frequency display. The S indicator lights for a time display. Neither indicator lights for a display of phase angle, ratio, total, or a number.
2	DELAY VALUE Control Indicator	Lights when a delay value is being displayed. The displayed delay value can be stepped up or down using the ↑ and ↓ keys.



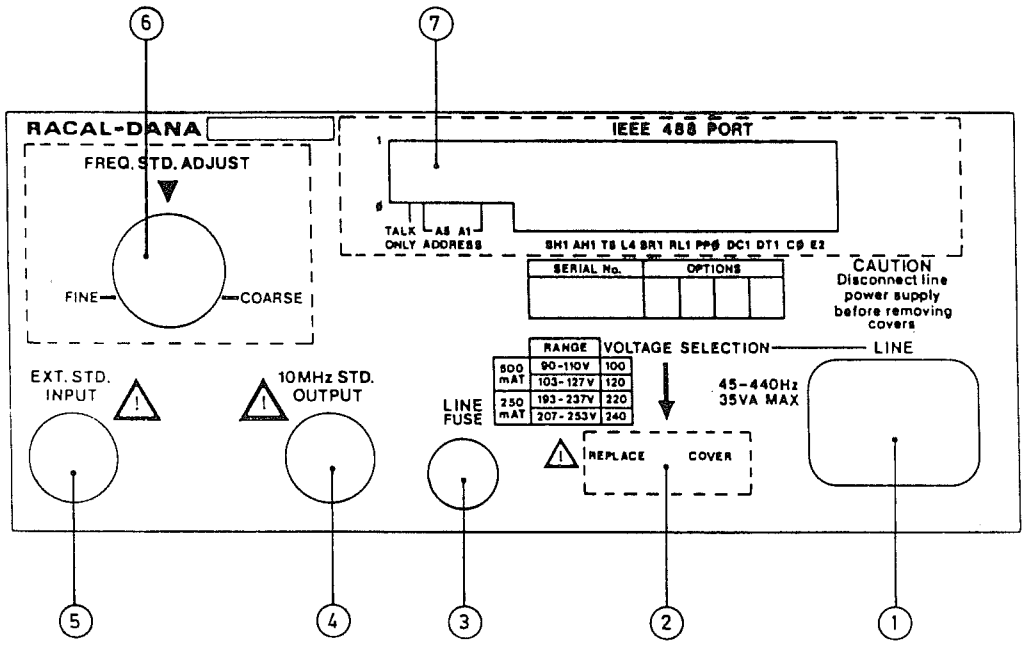
Reference	Item	Description
3	RESOLUTION Control Indicator	Lights to show that the resolution of the display, and, therefore, the measurement period (gate time) can be changed by means of the ↑ or ↓ control keys.
4	Step-Up ↑ and Step-Down ↓ Keys	Used to step the display resolution or the displayed delay value up or down.
5	Function Selector	The functions can be selected in turn using the FUNCTION ↑ and ↓ keys. The function selection 'wraps round' at both ends.
6	HOLD (Start/Stop) Key	Successive operations select or de-select the Hold (single-shot measurement) mode. The indicator lights when the instrument is in the Hold mode. Readings are triggered using the RESET key. When the instrument is in the Total A or Time modes, successive operations of the key start and stop the measurement cycle.

Reference	Item	Description
7	RESET/CONTINUE (LOCAL) Key	This key has three functions. [RESET] Clears the display and triggers a new measurement cycle when the instrument is in the measurement mode. [CONTINUE] Returns the instrument to the measurement mode and triggers a measurement cycle, following the display of a number recalled from store. [LOCAL] Returns the instrument to local control from remote GPIB control provided local lockout is not set.
8	STBY/CHRG Key	Successive operations switch the instrument into and out of the standby state. The indicator lights when the instrument is in the standby state. If the battery pack option is installed the indicator flashes when the battery approaches the discharged state. The battery is charged at the full rate when the instrument is in standby and external power is applied.
9	POWER Switch	Controls the AC or DC power to the instrument.
10	RECALL Key	Used in conjunction with NULL, DELAY and RESET keys. [RECALL] [NULL] displays the value in the Null store. [RECALL] [DELAY] displays the delay value and lights the DELAY VALUE indicator. The delay value can be changed using the Delay value ↑ and ↓ keys. [RECALL] [RESET] displays the GPIB address when this option is fitted.

Reference	Item	Description
	NULL Key and indicator	Key enables and disables the NULL function. At the time that the NULL function is enabled, the currently-displayed value is stored in the Null register. The indicator lights when NULL is selected.
	DELAY Key and indicator	Key enables and disables the DELAY function. The delay used is that currently in the delay value store. The indicator lights when DELAY is selected.
11	100 AVG Key and indicator	Key enables and disables the 100 AVG function. The indicator lights when 100 AVG is selected.
12	Measurement Channel Controls	The A and B channels have almost identical controls.
	TRIG LEVEL Controls	Used to set the trigger level, which can be continuously adjusted over the range -2.8 V to +2.8 V min. A switched 0 V position is also available, giving maximum sensitivity for frequency measurements.
	TRIG LEVEL Outputs	The trigger levels in use on the A and B channels are available at two terminals. The voltage range is typically ± 2.8 V , regardless of whether or not the X10 attenuator is selected.
	AC/DC Key	Used to select AC or DC coupling of the input signal. The indicator lights when DC coupling is selected.
	Trigger Slope Key	Used to select the positive-going, ⌐ or negative-going, ¬ , edge of the input waveform for triggering. The indicator lights when the positive-going edge is selected.
	X10/X1 Key	Used to select attenuation of the input signal. With X10 selected the input is attenuated by a factor of 10. The indicator lights when X10 is selected.



Reference	Item	Description
13	TRIG Indicators	Channels A and B are provided with trigger indicators. (1) Indicator permanently lit. Trigger level too low or signal input held in high state. (2) Indicator flashing. Channel being triggered. (3) Indicator permanently off. Trigger level too high or signal input held in low state.
14	FILTER Key	Successive operations enable and disable the channel A input filter. The indicator lights when the filter is enabled.
15	COM A Key	Used to connect the channel A input to channels A and B in parallel (common configuration). The indicator lights when the common configuration is selected.
	Input Connectors	All inputs are BNC connectors.

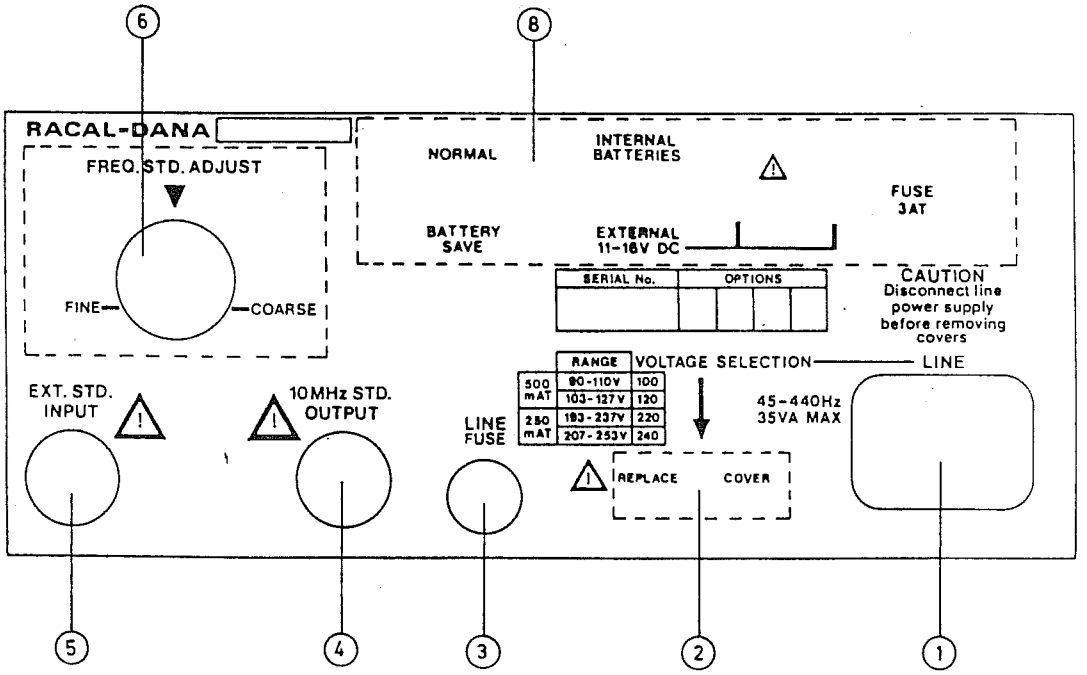


Rear Panel Items

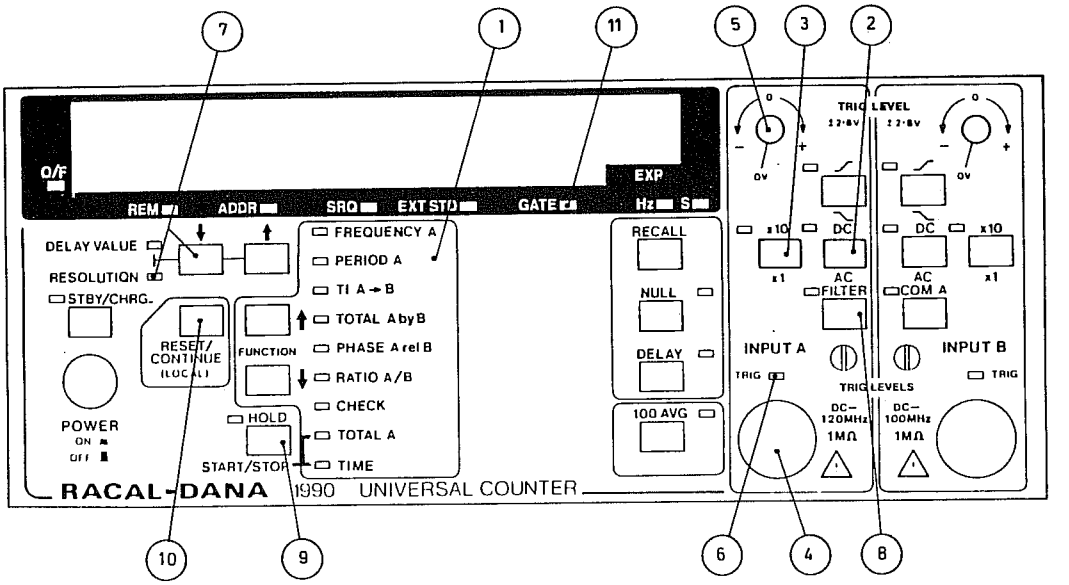
3

Reference	Item	Description
1	AC Power Input Plug	A standard connector for the AC power supply. An RFI filter is incorporated.
2	Line Voltage Selector	Voltage selection is changed by externally repositioning a printed circuit board. The voltage selected can be seen through a window in its retaining clamp.
3	Line Fuse	A $\frac{1}{4}$ in x $1\frac{1}{4}$ in, anti-surge, glass cartridge fuse. The required fuse ratings for different line voltage ranges are shown on the panel and in Section 3 of this manual.
4	10 MHz STD OUTPUT option 02 only	A BNC connector, providing a 10MHz output signal locked to the frequency standard in use.

Reference	Item	Description
5	EXT STD INPUT option 02 only	A BNC connector for connecting an external frequency standard. The instrument will operate from the external frequency standard whenever a signal of suitable frequency and amplitude is applied. The frequency required is 10 MHz unless the reference frequency multiplier option is fitted. With this option, frequencies of 1 MHz, 2 MHz, 5 MHz and 10 MHz are acceptable.
6	FREQ. STD. ADJUST	This aperture provides access to allow adjustment of the optional internal frequency standards.
7	GPIB Option	
	GPIB Address Switches	Switches A1 to A5 define the listen and talk addresses for GPIB operation in the addressed mode. The talk-only switch must be in the 'Ø' position. With the talk-only switch in the '1' position the instrument is set to the talk-only condition. The positions of switches A1 to A5 are then irrelevant.
	GPIB Connector	An IEEE-488-1978 standard connector used to connect the instrument to the GPIB. An adapter, Racal-Dana part number 23-3254, to convert the connector to the IEC 625-1 standard is available as an accessory.



Reference	Item	Description
8	Battery-Pack Option	
	DC Power Input Plug	Permits the instrument power to be derived from an external DC supply.
	Battery NORMAL/SAVE Switch	Used to select the Battery-Save facility.
	INTERNAL/EXTERNAL DC Supply Switch	Used to select operation from the internal battery or an external DC supply
	DC Supply Fuse	A $\frac{1}{4}$ in x $1\frac{1}{4}$ in glass cartridge fuse of the anti-surge type. The required rating is 3 AT.



FREQUENCY MEASUREMENT

4 (1) Switch the power on.

(2) Select the FREQ A measurement mode, using the function selector ① .

(3) Set the AC/DC coupling ② and attenuator ③ as required.

(4) Connect the signal to be measured to the channel A input ④ .

CAUTION: SIGNAL LEVEL
ENSURE THAT THE INPUT SIGNAL DOES NOT EXCEED THE DAMAGE LEVELS SPECIFIED IN SECTION 1 OF THIS MANUAL.

(5) Set the manual trigger level to the required value ⑤. Check that the channel A TRIG indicator ⑥ flashes.

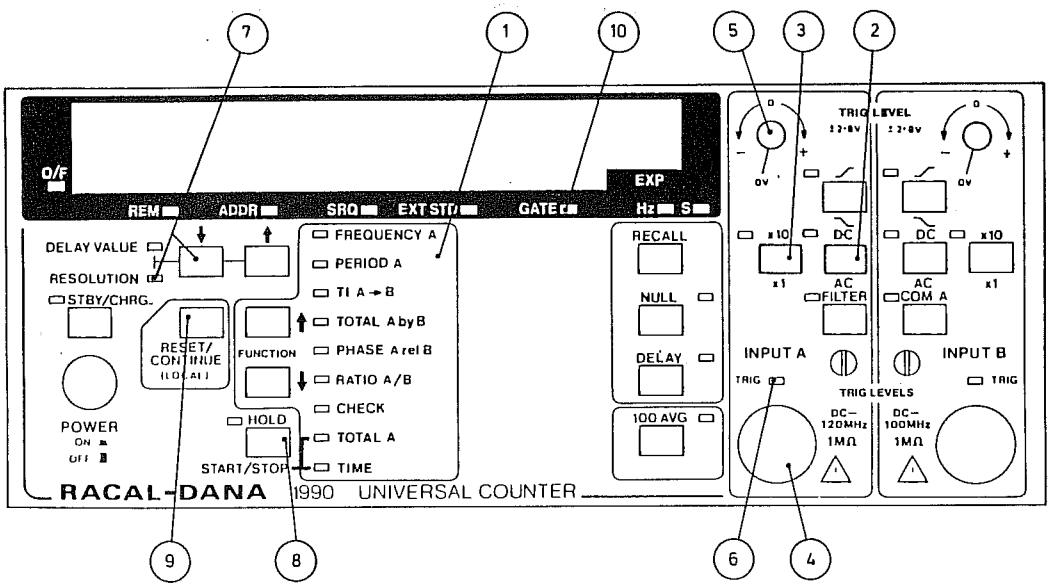
NOTE: Put the trigger control ⑤ to 0 V for maximum sensitivity. Any other position sets a trigger level between ±2.8 V.

(6) Select the required display resolution ⑦ .

(7) If a frequency below 50 kHz is to be measured in the presence of noise, enable the filter ⑧ .

(8) If operation in the hold mode is required, select HOLD ⑨ and press the RESET key ⑩ .

(9) Check that the GATE indicator ⑪ flashes on during the measurement period.



PERIOD MEASUREMENT

5 (1) Switch the power on.

(2) Select the PERIOD A measurement mode, using the function selector (1) .

(3) Set the AC/DC coupling (2) and attenuator (3) for channel A, as required.

(4) Connect the signal to be measured to the channel A input (4) .

CAUTION: SIGNAL LEVEL
ENSURE THAT THE INPUT SIGNAL LEVEL DOES NOT EXCEED THE DAMAGE LEVELS SPECIFIED IN SECTION 1 OF THIS MANUAL.

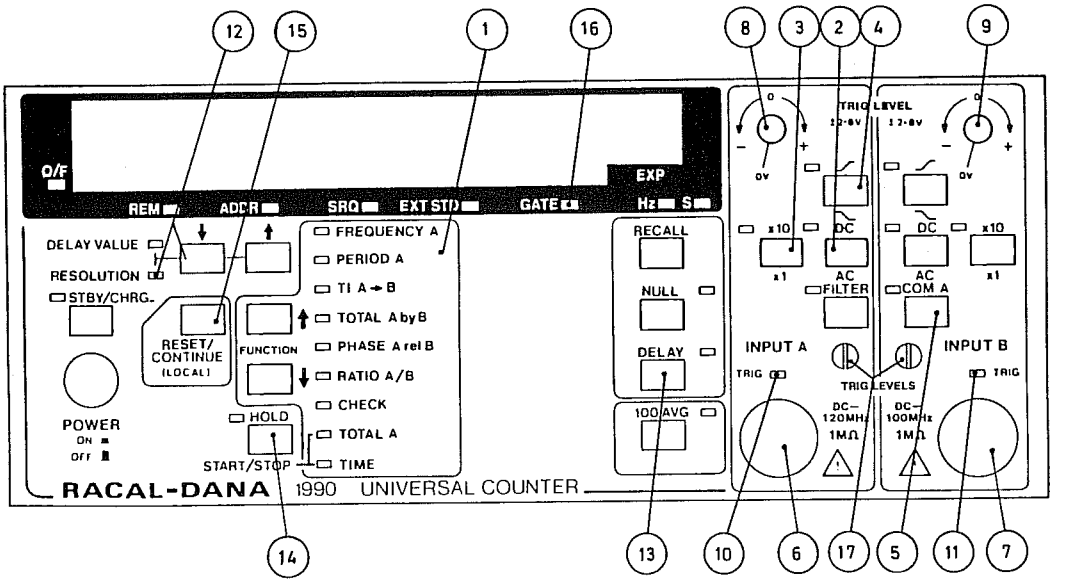
(5) Set the manual trigger level to the required value (5) . Check that the channel A TRIG indicator (6) flashes.

NOTE: Put the trigger control (5) to 0 V for maximum sensitivity. Any other position sets a trigger level between ±2.8 V.

(6) Select the required display resolution (7) .

(7) If hold mode operation is required, select HOLD (8) and press the RESET key (9) .

(8) Check that the GATE indicator (10) flashes on during the measurement period.



TIME INTERVAL MEASUREMENT

6 (1) Switch the power on.

(2) Select the T.I. A → B measurement mode, using the function selector (1) .

(3) Set the AC/DC coupling (2) , attenuator (3) , and slope (4) , as required. If the start and stop signals are from the same source, select COM A (5) .

(4) Connect the start signal to the channel A input (6) . If a separate stop-signal source is used, connect the stop signal to the channel B input (7) and set the associated input controls.

CAUTION: SIGNAL LEVEL
ENSURE THAT THE INPUT SIGNALS DO NOT EXCEED THE DAMAGE LEVELS SPECIFIED IN SECTION 1 OF THIS MANUAL.

(5) Set the manual trigger levels to the required values (8) (9). Check that the TRIG indicators (10) (11) flash.

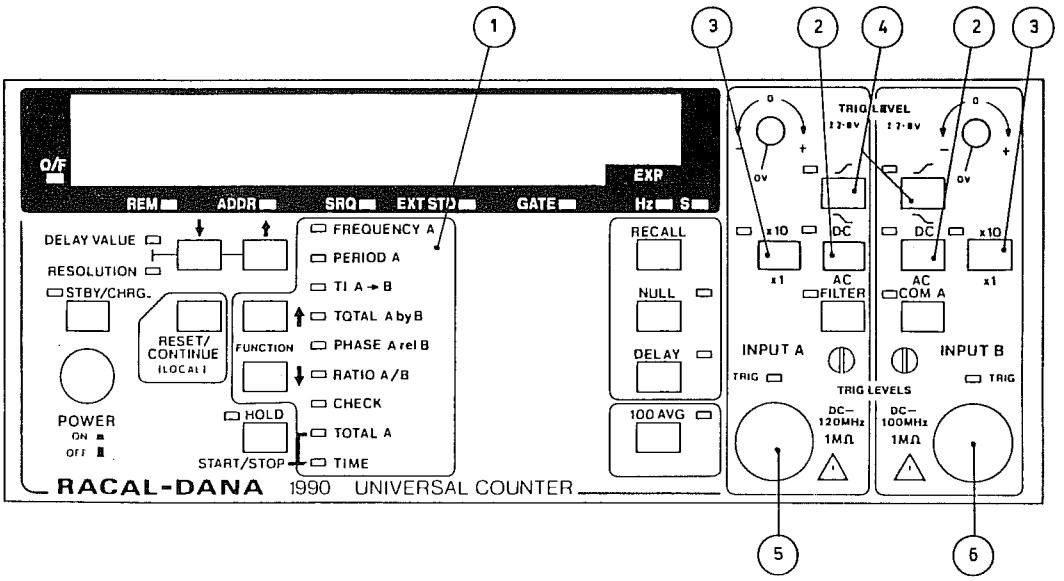
NOTE: If required, monitor the trigger output terminals (17) and set the trigger to a specific voltage level.

(6) Select the required display resolution (12) .

(7) If a delay to the stop circuit is required, set the required delay value and enable the delay (13) .

(8) If hold mode operation is required, select HOLD (14) and press the RESET key (15) .

(9) Check that the GATE indicator (16) flashes on during the measurment period.



TOTALIZE MEASUREMENT

Total A by B (Electrical)

7 A procedure for Total A (Manual) totalize is given in para. 8.

(1) Switch the power on.

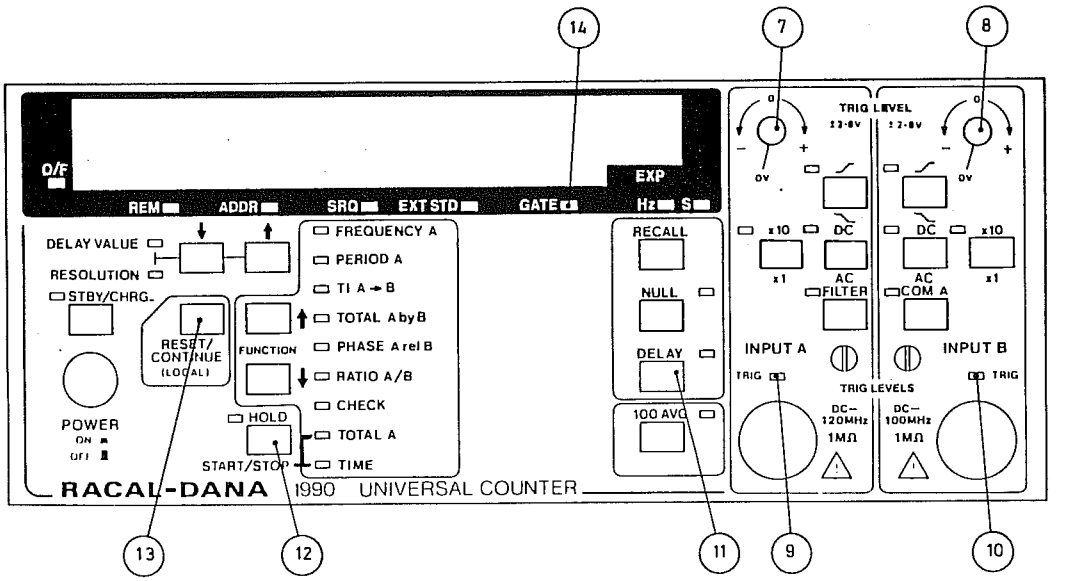
(2) Select the TOTAL A by B measurement mode using the function selector (1) .

(3) Set the AC/DC coupling (2) , attenuator (3) and slope (4) as required for both channels.

NOTE:
The channel A slope switch selects the slope of the events which are counted. The measurement period starts on the slope of the B channel signal selected by the channel B slope switch, and stops on the opposite slope.

(4) Connect the signal to be totalized to the channel A input (5) and the control signal to the channel B (6) input.

CAUTION: SIGNAL LEVELS
ENSURE THAT THE SIGNAL LEVELS DO NOT EXCEED THE DAMAGE LEVELS SPECIFIED IN SECTION 1 OF THIS MANUAL.

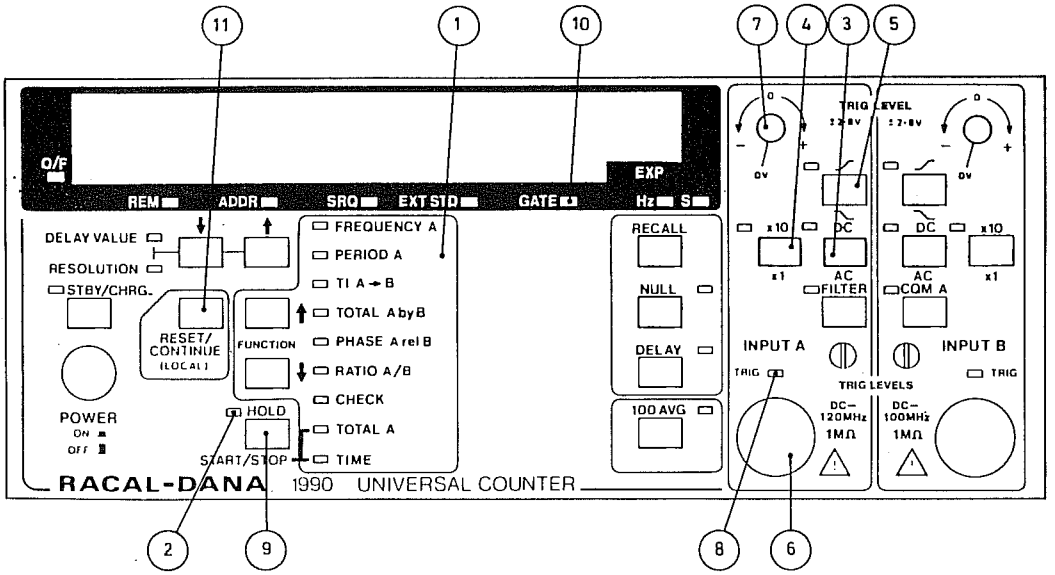


(5) Set the manual trigger levels to the required values (7) (8) Check that the TRIG indicators (9) (10) flash.

(6) If a delay to the stop circuit is to be used, set the required delay value and enable the delay (11).

(7) If hold mode operation is required, select HOLD (12) and RESET (13).

(8) Check that the GATE indicator (14) flashes on during the measurement period.



Total A (Manual)

8 (1) Switch the power on.

(2) Select the TOTAL A measurement mode, using the function selector (1) . The HOLD indicator (2) will light.

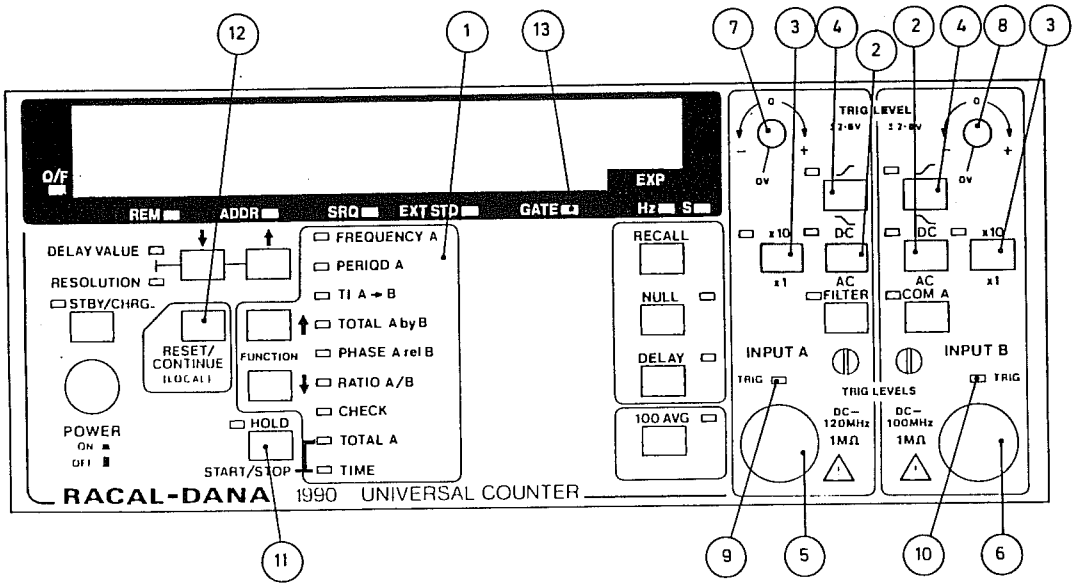
(3) Set the AC/DC coupling (3) , attenuator (4) and slope (5) of channel A as required.

(4) Connect the signal to be totalized to the channel A input (6).

CAUTION: SIGNAL LEVEL
ENSURE THAT THE INPUT SIGNAL DOES NOT EXCEED THE DAMAGE LEVELS SPECIFIED IN SECTION 1 OF THIS MANUAL.

(5) Set the manual trigger level (7) to the required value. Check that the TRIG indicator (8) flashes.

(6) Start and stop a measurement using the HOLD key (9) . The HOLD indicator (2) will be turned off and the GATE indicator (10) will light during the measurement period. The displayed result is cumulative over successive measurement cycles. If required, clear the display after a measurement cycle by pressing the RESET key (11) .



PHASE MEASUREMENT

9 (1) Switch the power on.

(2) Select the PHASE A rel B measurement mode, using the function selector (1) .

(3) Set the AC/DC coupling (2) , attenuator (3) and slope (4) as required.

(4) Connect the signals to be compared to the channel A (5) and B (6) inputs (the larger and cleaner signal to channel A for maximum accuracy).

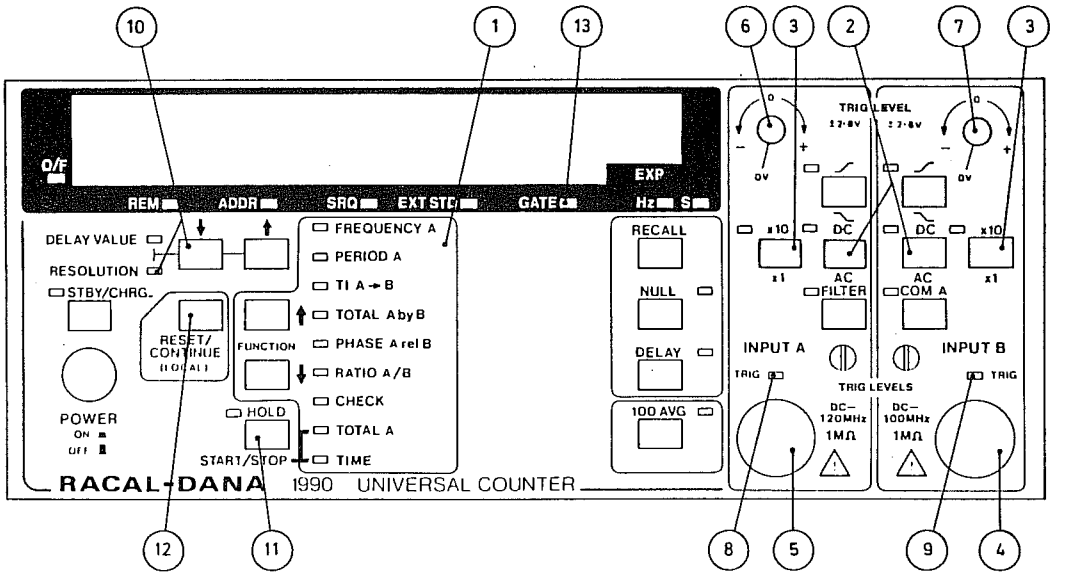
CAUTION SIGNAL LEVELS
ENSURE THAT THE INPUT SIGNALS DO NOT EXCEED THE DAMAGE LEVELS SPECIFIED IN SECTION 1 OF THIS MANUAL.

(5) Set the manual trigger levels to the required values (7)(8) . Check that the TRIG indicators (9) (10) flash.

(6) If hold mode operation is required, select HOLD (11) and press the RESET key (12) .

(7) Check that the GATE indicator (13) flashes on during the measurement cycle.

NOTE:
The phase measurement is always positive, and is the angle by which the signal applied to channel A leads that applied to channel B.



RATIO MEASUREMENT

10 (1) Switch the power on.

(2) Select the RATIO A/B measurement mode, using the function selector (1) .

(3) Set the AC/DC coupling (2) and attenuator (3) as required.

(4) Connect one of the signals to channel B (4) and the other to channel A (5) . The lower frequency signal should be connected to channel B.

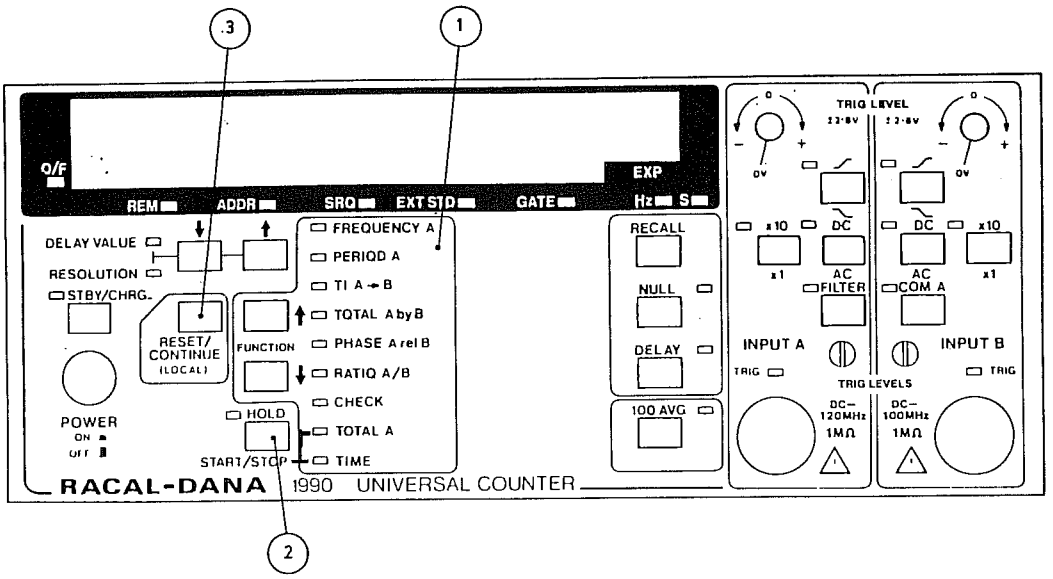
CAUTION: SIGNAL LEVEL
ENSURE THAT THE INPUT SIGNALS DO NOT EXCEED THE DAMAGE LEVELS SPECIFIED IN SECTION 1 OF THIS MANUAL.

(5) Set the manual trigger levels to the required values (6) (7) . Check that the TRIG indicators (8) (9) flash.

(6) Select the required display resolution (10) .

(7) If hold mode operation is required, select HOLD (11) and press the RESET key (12) .

(8) Check that the GATE indicator (13) flashes on during the measurement period.



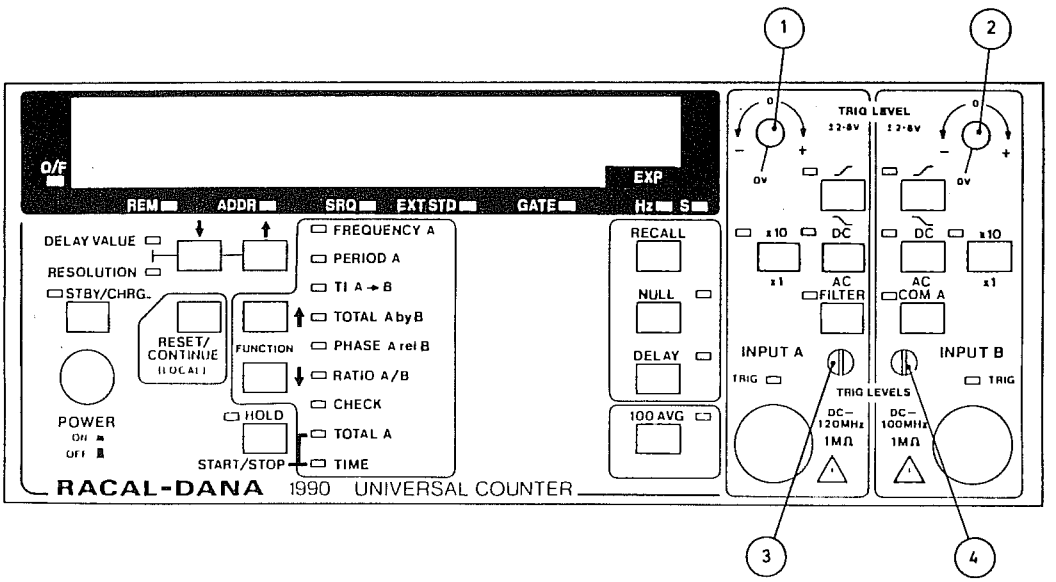
TIME MEASUREMENT

11 (1) Switch the power on.

(2) Select the TIME measurement mode using the function selector (1) .

(3) Start and stop the time measurement using the HOLD (start/stop) key (2) .

12 The HOLD indicator is turned off and the GATE indicator lit during the measurement period. The displayed result is cumulative over successive measurement cycles. If required, the display can be cleared, after a measurement cycle, by pressing RESET (3) .

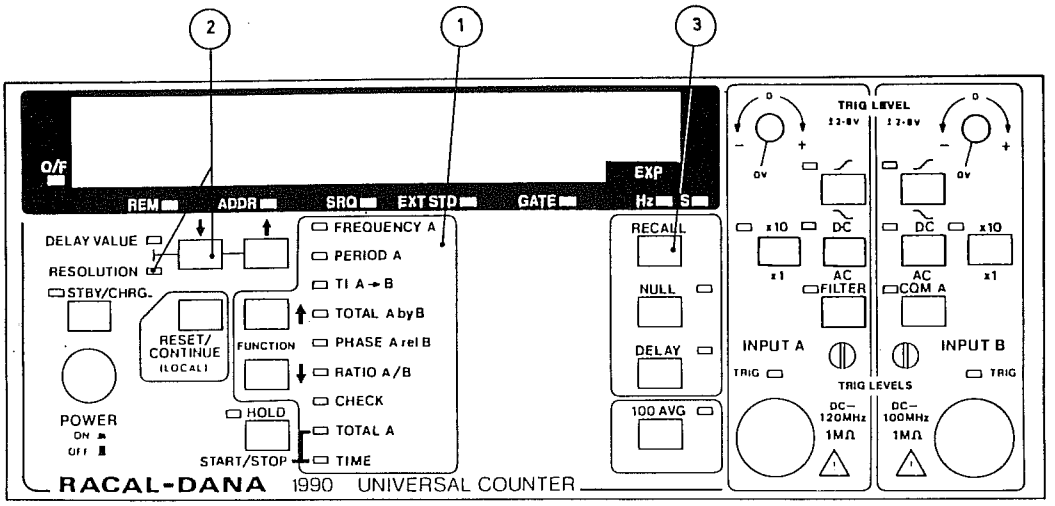


SETTING AND MEASURING THE TRIGGER LEVEL

13 (1) The trigger level is set using the rotary controls for channel A (1) and channel B (2) . Each control can be set independently for positive or negative levels typically between +2.8 V and -2.8 V with centre 0 V. Rotating the control clockwise gives a positive trigger level and anti-clockwise gives a negative trigger level.

(2) For maximum sensitivity on small signals a switched 0 V position is available by turning the appropriate control (1) or (2) fully anti-clockwise until the control clicks.

(3) The trigger voltage set can be measured at the output terminals (3) (4) , using a DVM, oscilloscope or other high input impedance instrument.



INSTRUMENT CHECKS

14 (1) Switch power on.

(2) Select the CHECK mode, using the function selector (1) . Check that 10 MHz is displayed. Resolution can be changed using the RESOLUTION key (2) .

(3) To check the front panel LEDs press RECALL (3) . All LEDs, with the exception of REM, ADDR, SRQ, GATE, TRIG A, TRIG B and STBY/CHRG, will flash on and off every two seconds. If the GPIB option is fitted, the REM, ADDR and SRQ will flash in time with the other LEDs.

DISPLAY RESOLUTION

15 For all measurement functions other than TOTAL A by B, TOTAL A and PHASE A rel B, the resolution refers to the number of zeros displayed when no signal is applied at the input. The resolution can be set to display 3 to 8 digits. A 10% overrange of the display is permitted without a change of range. Because of this, an additional digit with a value of 1 may appear at the more significant end of the display when measurements are made. If the 10% display overrange is exceeded, with eight digits selected, the overflow LED will light. An overflow can also occur when NULL or 100 AVG is enabled. The overflow digit can be displayed by decreasing the resolution.

16 With some measurement functions, the number of digits appearing may be less than the selected resolution to ensure that they are rounded to meaningful values.

17 When RATIO measurements are made, no more than eight digits are displayed, regardless of the resolution selected.

18 For the TOTAL A by B and TOTAL A measurement functions the display shows the true total of events counted from 1 to 99999999. For higher totals the exponent is used.

19 For the PHASE A rel B measurement, up to four digits may be displayed for frequencies up to 100 kHz and up to three digits for higher frequencies. Leading zeros are suppressed. For frequencies above 100 kHz the resolution of the display is reduced, and place-holding (half size) zeros are displayed as the least-significant digits.

Setting the Display Resolution

20 Whenever the resolution control indicator is lit, the resolution can be changed using the step-up and step-down keys.

GATE TIME

21 For the frequency, period and ratio measurement functions, the gate time is related to the resolution selected, as shown in Table 4.1.

TABLE 4.1

Resolution and Gate Time

Resolution	Gate Time
8	10 s
7	1 s
6	100 ms (see NOTE 2)
5	10 ms
4	1 ms
3	1 ms (see NOTE 3)

NOTE 1:
The gate times shown are nominal. Due to the use of the recipromatic counting technique the gate time may be extended by up to one period of the input signal on FREQ A, PERIOD A and RATIO A/B.

NOTE 2:
A resolution of 6 is selected when the instrument is first switched on.

NOTE 3:
With a resolution of 3 selected, measurements are averaged.

22 For the PHASE A rel B measurement function the gate time depends upon the signal frequency. The gate time is approximately 50 ms for frequencies above 200 Hz, but will be increased at lower frequencies.

NULL FEATURE

23 The null feature allows a displayed value to be entered into the internal NULL store. When the null feature is enabled (NULL indicator lit) the display indicates

(measured value minus the value held in the NULL store).

24 The null feature is avilable with all functions except phase and check.

25 (1) Use the procedures given in paragraphs 4 to 12 to set up the instrument to display the measurement required. If nulling from a value already in the NULL store, press

[RECALL] [NULL] .

The value in the NULL store will be displayed.

(2) To enable NULL, press

[NULL] .

The NULL indicator will light. The displayed value will be entered into the NULL store. When a new measurement is made the display indicates the difference between the measured value and the value in the NULL store.

(3) To disable the null facility, press

[NULL] .

The NULL indicator will go out and the display will indicate the measured value. The value in the NULL store is unchanged.

26 The value held in the NULL store can be displayed at any time by pressing

[RECALL] [NULL] .

To return the instrument to the status existing before the NULL store contents were displayed press

[CONTINUE] .

STOP CIRCUIT DELAY (HOLD OFF)

Use of the Delay

27 The stop circuit can be delayed when the T.I. A → B or the TOTAL A by B measurement function is selected. The required delay is entered into an internal store by the operator. The delay function can then be enabled and disabled as required. The delay is set to 10 ms when the instrument is first switched on.

28 The delay can be used to prevent the stop circuit being triggered prematurely by spurious signals, such as those resulting from contact bounce. The principle is shown in Fig 4.1.

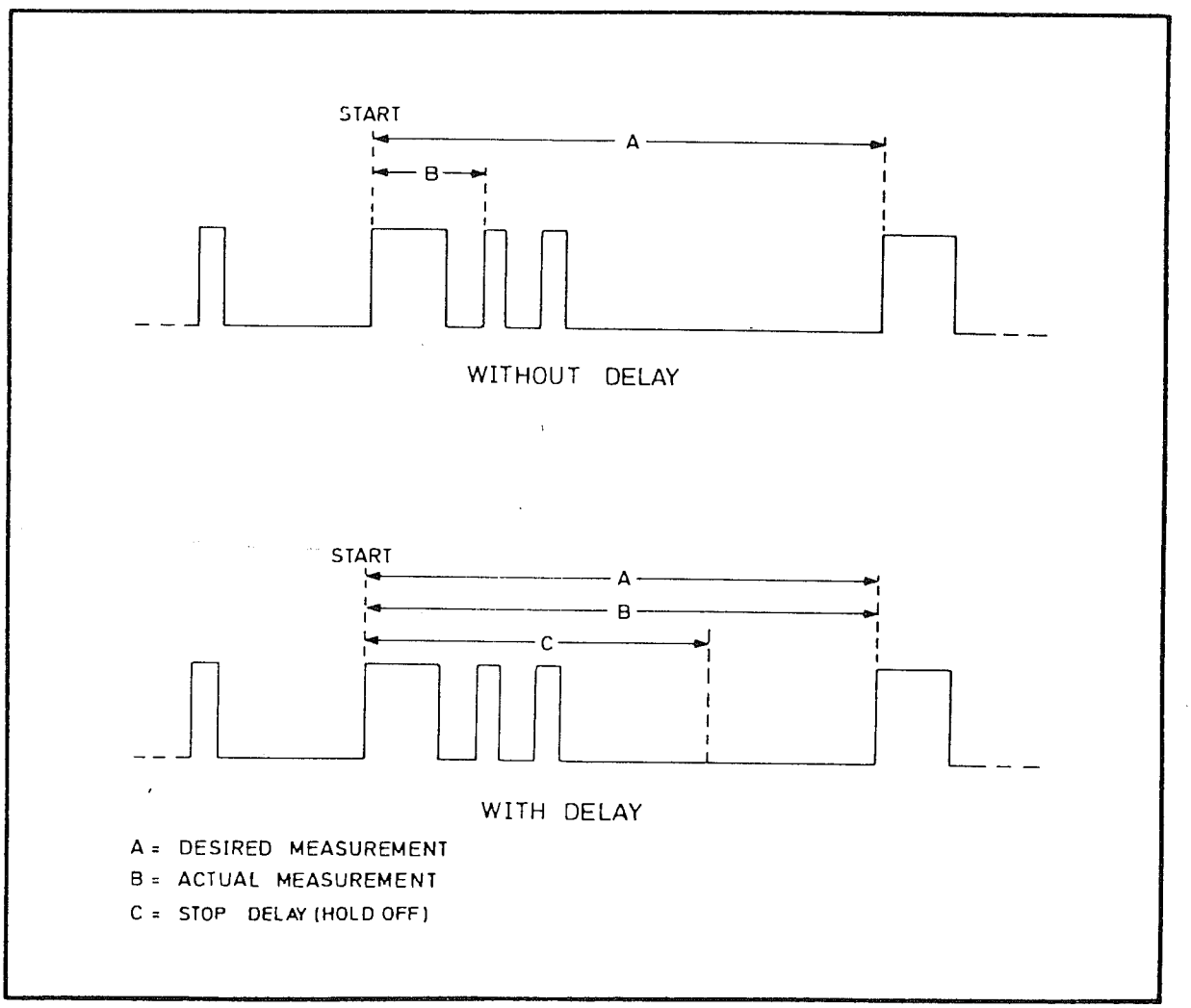


Fig 4.1 Use of Stop Circuit Delay

Displaying the Delay

29 The value of delay held in the store can be displayed by pressing

[RECALL] [DELAY] .

Changing the Delay

30 The delay value stored is changed using the DELAY VALUE ↑ or ↓ keys. Pressing RESET/CONTINUE or DELAY stores the new delay value and returns the instrument to measurement mode. If DELAY has been pressed, the newly entered delay value is also enabled.

31 The permitted range of delay is from 200 µs to 800 ms. The value in the delay store is retained when the instrument is switched to standby.

Enabling and Disabling the Delay

32 The stop delay is enabled and disabled by means of the DELAY key. The DELAY indicator lights when the delay is enabled.

AVERAGE OF 100 READINGS

33 This feature allows one extra digit of resolution to be obtained by taking 100 readings into store and displaying the software average value. The average of 100 readings can be used with the Time Interval, Phase Measurement, Frequency A, Period A and Ratio A/B.

34 To enable the averaging facility press the 100 AVG key. The 100 AVG indicator will light.

35 With the appropriate signals connected the instrument will take 100 measurements, during which time the gate indicator will flash 100 times. The average value is then displayed. For reliable operation the signal must be constant during the measurement period and asynchronous (not related) to the counters frequency standard.

36 A new sequence can be started at any time by pressing

[RESET / CONTINUE] .

37 To disable the averaging feature press 100 AVG . The 100 AVG indicator will go out.

SPECIAL FUNCTIONS

Frequency B

38 This function can be activated in FREQUENCY A mode only, by pressing:

DELAY

and holding the key down for three seconds. The DELAY indicator will then light and the counter will measure frequency B to the resolution selected.

39 To disable Frequency B press:

DELAY or RESET / CONTINUE .

The DELAY indicator will go out. Note that normal delay mode is not available in Frequency.

LED Check

40 When in CHECK mode this function is activated by pressing:

RECALL .

The LED Check causes the display and single LEDs to be alternately on and then off at a 3-second rate. All LEDs are checked, including the GPIB LEDs (if GPIB is fitted), except the STBY/CHRG, GATE and TRIG LEDs. To revert to the CHECK function press

RESET / CONTINUE .

ERROR CODES

41 The instrument is able to detect a number of error states, which are indicated on the display. The meanings of the error codes are shown in Table 4.2

TABLE 4.2

Error Codes

Display	Error
Er 01	Phase measurement attempted on signals of different frequencies.
Er 02	Measurement result too large or too small for the display.
Er 03	Overflow of internal counters.
Er 04	Number entry error (GPIB only).
Er 05	GPIB programming error (GPIB only).
Er 06	Phase inputs greater than 5 MHz.
Er 50	Basic check function error.

Clearing the Error Codes

42 Error code Er 01 is cleared by:

(1) Making a phase measurement on signals of equal frequency.

(2) Selecting another measurement function.

Error codes Er 02 and Er 03 are cleared by:

(1) Obtaining a measurement result that is within range.

(2) Selecting another measurement function

Error code Er 06 is cleared by:

(1) Reducing the input frequency to less than 5 MHz.

(2) Selecting another measurement function.

USING THE BATTERY PACK OPTION

Power Supply Changeover

43 When the battery pack option is installed, the instrument can be powered from the internal battery, an external DC supply of 11V to 16V, or an external AC supply. If the instrument is operating from either the DC supply or the battery, it will automatically change to operation from the AC supply when this is connected. The battery will not take over from either the AC or the DC supply if the supply fails. An external DC supply will not take over from the AC supply if the AC supply fails.

Battery-Low Indication

44 When the instrument is operating from the internal battery, or from an external DC supply, the STBY/CHRG indicator will start to flash as the supply voltage approaches the minimum permissible level. This occurs regardless of whether the instrument is in the standby mode or not. When operating from the battery, the instrument can be used in the measurement mode for approximately 15 minutes after the indicator commences flashing.

45 When the voltage of the battery or the external DC supply reaches the minimum permissible level, the instrument shuts down completely.

Operating Instructions

46 Instructions for preparing the instrument to make measurements are given in the following paragraphs. No other change in the operating procedure is required.

Operation From the Battery

47 (1) Set the INT/EXT switch on the rear panel to INTERNAL BATTERIES.

(2) Set the BATTERY SAVE/NORMAL switch to NORMAL.

(3) Switch the instrument on.

(4) Check that the instrument goes through the normal switch-on sequence. If the STBY indicator is flashing, or if there is no display, charge the battery.

48 If the battery-save facility is to be used, set the BATTERY SAVE/NORMAL switch to BATTERY SAVE. The instrument will remain in the measurement mode for approximately one minute and will then switch to standby. It can be returned to the measurement mode for a further period of one minute by pressing the STBY/CHRG key.

Operation From an External DC Supply

49 (1) Ensure that the instrument is switched off.

(2) Connect the DC supply to the DC power-input plug on the rear panel. The mating connector is a 2.1 mm coaxial socket.

CAUTION: SUPPLY POLARITY
THE POSITIVE SIDE OF THE SUPPLY MUST BE CONNECTED TO THE CENTER CONDUCTOR.

(3) Set the INT/EXT switch on the rear panel to EXTERNAL 11-16V.

(4) Switch the instrument on. Check that the instrument goes through the normal switch-on sequence.

Battery Charging

50 The battery is trickle-charged whenever the instrument is operated from an A.C. supply and INT/EXT switch set to INT position. To charge the battery at the full rate, connect the instrument to an external AC or DC supply and switch to the standby mode.

SECTION 5 OPERATING VIA THE GPIB

INTRODUCTION

1 The instrument must be prepared for use in accordance with the instructions given in Section 3. If the instrument is being used for the first time, or at a new location, pay particular attention to the setting of the AC line voltage selector.

GPIB OPERATING MODES

2 The instrument can be operated via the GPIB in either the addressed mode or the talk-only mode.

TALK-ONLY MODE

3 The talk-only mode may be used in systems which do not include a controller. Such a system permits remote reading of the instrument's measurement data, but the instrument is operated by means of the front-panel controls as described in Section 4.

4 The rate at which measurements are made is determined by the instrument. The output buffer is updated at the end of each measurement cycle, overwriting the previous measurement data if this has not been transferred to the listener.

5 The transfer of data from the instrument to the listener is triggered by the listener. The instrument's output buffer is cleared when the data transfer is complete. Problems arising from the differences between the measurement rate and data transfer trigger rate are resolved according to the following protocol:

(1) If data transfer is in progress at the end of a measurement cycle, the updating of the output buffer is delayed. The data transferred will relate to the previous measurement cycle.

(2) If the data transfer trigger occurs during a measurement cycle and the output buffer is empty, data transfer will be delayed until the buffer is updated. The data transferred will then relate to the latest measurement cycle.

(3) If a measurement cycle is completed before the results of the previous cycle have been transferred to the listener, the buffer will be updated. The data for the previous cycle will be overwritten and lost.

6 The rate at which measurements are made can be controlled in the following ways:

(1) The gate time of the instrument (duration of the measurement cycle) can be controlled by choosing an appropriate display resolution.

(2) The instrument can be operated in the hold mode. Single measurement cycles can be triggered, when required, by means of the RESET key.

7 The format of the data output is described in Table 5.1.

ADDRESSED MODE

8 In addressed-mode operation, all the instrument's functions, except the power ON/OFF, standby switching and trigger levels, can be controlled by means of device-dependent commands, sent via the bus, when the instrument is addressed to listen. The measurements made, and data regarding the instrument's status, can be read via the bus when the instrument is addressed to talk. If the instrument is addressed to talk when the output buffer is empty, no data transfer can take place and bus activity will cease. Data transfer will commence when the output buffer is updated at the end of the next measurement cycle.

DATA OUTPUT FORMAT

9 The same output message format is used for the transmission of measured values and numbers recalled from the instrument's internal stores. The message consists of a string of 21 ASCII characters for each value transmitted. These are to be interpreted as shown in Table 5.1. The units should be assumed to be Hz, seconds, degrees or a ratio, depending upon the commands previously given to the instrument.

DEFERRED COMMANDS AND IMMEDIATE COMMANDS

10 Some commands (known as Deferred Commands) are accepted until a terminating character or message is received, see Table 5.5. The whole string will then be obeyed. Other commands (known as Immediate Commands) are obeyed as soon as they are received. These are indicated, in Table 5.18, by an asterisk.

EXAMPLE: OUTPUT 716; FA ANS SRS5 S81 CR LF

Because SRS is an immediate command, Frequency A, A Channel Negative Slope, and 5 Digit Resolution will all be set following receipt of SRS5.

TABLE 5.1

Output Message Format

Byte No	Interpretation	Permitted ASCII Characters
1	Function letter	See Table 5.2
2	Function letter	
3	Sign of measurement	+ or -
4	Most significant digit	0 to 9
5	Digit	0 to 9 or .
6	Digit	0 to 9 or .
7	Digit	0 to 9 or .
8	Digit	0 to 9 or .
9	Digit	0 to 9 or .
10	Digit	0 to 9 or .
11	Digit	0 to 9 or .
12	Digit	0 to 9 or .
13	Digit	0 to 9 or .
14	Digit	0 to 9 or .
15	Least significant digit	0 to 9 or .
16	Exponent indicator	E
17	Sign of exponent	+ or -
18	More significant digit	0 to 9
19	Less significant digit	0 to 9
20	Carriage return	CR
21	Line Feed	LF

NOTE 1:
Bytes 4 to 15 will always include 11 digits and a decimal point. Zeros will be added, where necessary, in the more significant digit positions.

NOTE 2:
The exponent indicated by bytes 18 and 19 will always be a multiple of three.

TABLE 5.2

Function Letters

Function	Function Letters
Frequency A	FA
Period A	PA
Time interval	TI
Total A by B	TA
Phase	PH
Ratio A/B	RA
Check	CK
Total A	TM
Time	TC
Recalled Data	**Function Letters**
Unit type	UT
Resolution	RS
Null store	NL
Delay time	DT
Special function	SF
Master software issue number	MS
GPIB software issue number	GS

NOTE:
Spaces are substituted for the function letters when special function 81 is active.

SERVICE REQUEST

11 The instrument can be set, by means of device-dependent commands, to generate the service request message (SRQ) when:

(1) A measurement cycle is completed
(2) A change of frequency standard occurs
(3) An error state is detected
(4) Any combination of (1), (2) and (3).

12 The generation of the SRQ may also be inhibited. The necessary commands are given in Table 5.17. Option (3) of Paragraph 10 is selected when the instrument is first switched on.

STATUS BYTE

13 The format of the status byte, generated in response to a serial poll, is given in Table 5.3.

TABLE 5.3

Status Byte Format

DIO Line	Function
1	LSB }
2	} Number of error detected (binary)
3	MSB } (See NOTE 1)
4	'1' = frequency standard changed
5	'1' = reading ready (See NOTE 2)
6	'1' = error detected
7	'1' = service requested
8	'1' = gate open

NOTE 1:
The error code numbers which can occur are:

1 Phase measurement attempted on waveforms of differing frequency.
2 Result out of range of the display
3 Overflow of internal counters
4 Error in numerical entry
5 Syntax error in GPIB command
6 Phase measurement attempted on signal above 10 MHz.

No measurement data string is available if error code 1, 2 or 3 is generated.

NOTE 2:
Regardless of the SRQ mode in use, the SRQ message that a reading is ready is not generated following a data-recall operation.

NOTE 3:
The errors are cleared as follows:

Error 1: Correct the difference in input frequencies or change the measurement mode in use.

Error 2: The error is cleared when an in-range measurement is completed.

Error 3: The error is cleared when an in-range measurement is completed.

Error 4: The error is cleared when a valid numerical entry is made.

Error 5: The command string will be correctly executed up to the point at which the error occurs. The remainder of the string will be hand-shaken, but not executed. The error is cleared when the next valid command is received.

Error 6: Correct the input frequency or change the measurement mode in use.

14 The instrument will respond to all valid device-dependent commands which are received after it has been addressed to listen. Device-dependent commands are recognized as such because they are transmitted with the attention (ATN) message false.

15 The instrument also responds to a number of multi-line interface messages. These are recognized because they are transmitted with the ATN message true. Refer to Table 5.4, which gives the instrument's response to different bus messages. The following paragraphs detail the instrument's response to these messages. Any multi-line message not specifically mentioned is hand-shaken, but is otherwise ignored.

Address Messages

16 The instrument responds to address messages defined by the setting of the address switches, A1 to A5, on the rear panel.

17 On receipt of its listen address, the instrument becomes a listener. If it has previously been addressed to talk it ceases to act as a talker. If in the local control state when the address is received, the instrument goes to the remote control state provided that the REN message is true.

18 On receipt of its talk address, the instrument becomes a talker. If it has previously been addressed to listen it ceases to act as a listener. If in the local control state when the address is received, it will remain under local control.

19 If the instrument has been addressed to talk, and then receives the talk address of another device, it ceases to act as a talker.

Local Lockout

20 The instrument will respond to the local lockout (LLO) message regardless of its addressed state. The return-to-local function of the LOCAL key on the front panel is disabled (the RESET/CONTINUE function remains enabled when in local control).

21 Local lockout is cleared by sending the remote enable (REN) message false. This returns all devices on the bus to the local control state.

Device Clear and Selected Device Clear

22 The instrument only responds to the device clear (DCL) message and the selected device clear (SDC) message when it is in the remote control state. It will only respond to the SDC message if it is a listener, but will respond to the DCL message regardless of its addressed state.

23 The instrument responds to either message by reverting to the functions and settings of the power-up state. No change is made to the condition of the GPIB interface.

TABLE 5.4

Response to Bus Messages

Message	Addressed State	Instrument Response
Address	Any	For listen address: Becomes a listener and goes to the remote control state. If previously addressed to talk, ceases to act as a talker. For talk address: Becomes a talker. If previously addressed to listen, ceases to be a listener. For talk address of another device: If previously addressed to talk, ceases to be a talker.
Local Lockout (LLO)	Any	LOCAL key disabled. (Cleared by sending the REN message false).
Device Clear (DCL) Selected Device Clear (SDC)	Any, but must be in remote control. Listen and in remote control	Reverts to power-up state.
Serial Poll Enable (SPE)	Any	Enters the serial poll mode state (SPMS). If addressed to talk while in this state, sends the status byte.
Serial Poll Disable (SPD)	Any	Enters the serial poll idle state (SPIS). If addressed to talk while in this state, sends data in the output message format.
Group Execute Trigger (GET)	Listen, and no measurement cycle in progress	Takes a measurement.
Go to Local (GTL)	Listen	Reverts to local control.
Untalk (UNT) Unlisten (UNL)	Talk Listen	Ceases to be a talker. Ceases to be a listener. The ADDR indicator is turned off.

Serial Poll Enable and Serial Poll Disable

24 The instrument responds to both the serial poll enable (SPE) message and the serial poll disable (SPD) message regardless of its addressed state.

25 The instrument responds to the SPE message by entering the serial poll mode state (SPMS). If the instrument is addressed to talk while in this state, it will put its status byte onto the bus instead of its normal data output string.

26 The instrument responds to the SPD message by leaving the SPMS and entering the serial poll idle state (SPIS). If the instrument is addressed to talk while in this state, it will put its data output string onto the bus provided data is available in the output buffer.

Group Execute Trigger

27 The instrument responds to the group execute trigger (GET) message provided that it is a listener and no measurement cycle is in progress. Except for the inability to retrigger during a measurement cycle, the response to the GET message is the same as to the device-dependent command T2.

Go to Local

28 The instrument responds to the go to local (GTL) message provided that it is a listener. The instrument reverts to the local control state, but remains addressed to listen. It will return to remote control on receipt of the first byte of a device-dependent command.

Untalk and Unlisten

29 If addressed to talk, the instrument will go to the talker idle state (TIDS) on receipt of the untalk message. If addressed to listen, it will go to the listener idle state (LIDS) on receipt of the unlisten message. The ADDR indicator will be turned off.

INPUT COMMAND CODES

30 When the instrument is addressed to listen it can be controlled by means of device-dependent commands given in the following tables:

31 If more than one command is to be sent, no delimiters are required. If necessary, commas, spaces and semicolons may be included in command strings as an aid to clarity without affecting the operation of the instrument. Each command string must be followed by an end-of-string terminating group. The permitted terminating groups are shown in Table 5.5.

TABLE 5.5

Permitted Terminators

1	2	3	4	5	6
LF	LF EOI true	CR EOI true	CR LF	CR LF EOI true	Last Character EOI true

TABLE 5.6

Instrument Preset Code

Function	Code
Set instrument functions and settings to the power-up state	IP

TABLE 5.7

Measurement Function Codes

Function	Code
Frequency A	FA
Period A	PA
Time interval	TI
Total A by B	TA
Phase of A relative to B	PH
Ratio A/B	RA
Check	CK
Total A	TM
Time	TC

TABLE 5.8

Input Control Codes

Function	Code	
	A Channel	B Channel
AC coupling selected	AAC	BAC
DC coupling selected	ADC	BDC
Positive slope trigger selected	APS	BPS
Negative slope trigger selected	ANS	BNS
X10 attenuator disabled	AAD	BAD
X10 attenuator enabled	AAE	BAE
A channel filtering enabled	AFE	
A channel filtering disabled	AFD	
A and B channels separate		BCS
A and B channels common		BCC

TABLE 5.9

Measurement Control Codes

Function	Code
Select continuous measurement mode	TØ (see NOTE 1)
Select one-shot measurement mode	T1 (see NOTE 2)
Take one measurement or start total A or time measurement	T2 (see NOTE 3)
Stop total A or time measurement	T3 (see NOTE 3)
Read present value without stopping totalize measurement	RF (see NOTE 4)
Null disabled	ND
Null enabled	NE
Delay disabled	DD
Delay enabled	DE
100 Average disabled	NA
100 Average enabled	AE
Reset (Stop measurement cycle and clear output buffer)	RE

NOTE 1:
When making continuous measurements the output buffer is updated at the end of each gate period. If the buffer is being read via the GPIB when the gate period ends, updating is delayed until reading is complete.

NOTE 2:
When one-shot measurements are being made, the output buffer is cleared each time command T2 is received. The measurement made must, therefore, be read before a further measurement cycle is triggered.

NOTE 3:
When making totalize measurements, commands T2 and T3 are used with TM. In this mode the readings made in successive totalize periods are cumulative. The RE command is used to reset the count to zero when required.

NOTE 4:
The RF command (reading on the fly) must be sent each time a reading is required. The reading is obtained when the instrument is made a talker.

TABLE 5.10

Store and Recall Codes

Function	Code
Recall unit type	RUT
Store display resolution number	SRS
Recall display resolution number	RRS
Store null value	SN (see NOTE 1)
Recall null value	RN (see NOTE 1)
Store delay value	SDT
Recall delay value	RDT
Recall special function register	RSF
Recall master software issue number	RMS
Recall GPIB software issue number	RGS

NOTE 1:
Numbers to be stored should follow the store command. The format to be used for numerical entry is given in Table 5.11. The limiting values for numerical entries are given in Table 5.12.

NOTE 2:
The instrument returns to the measurement mode automatically at the completion of a store or recall operation.

NOTE 3:
No SRQ message is generated for recalled data.

TABLE 5.11

Numerical Input Format

Byte	Interpretation	Permitted ASCII Characters
1	Sign of mantissa	+ or -
2	Most significant digit	0 to 9 or .
3	Digit	0 to 9 or .
4	Digit	0 to 9 or .
5	Digit	0 to 9 or .
6	Digit	0 to 9 or .
7	Digit	0 to 9 or .
8	Digit	0 to 9 or .
9	Digit	0 to 9 or .
10	Digit	0 to 9 or .
11	Least significant digit	0 to 9 or .
12	Exponent indicator	E or e
13	Sign of exponent	Space, + or -
14	More significant digit	0 to 9
15	Less significant digit	0 to 9

NOTE 1:
Spaces, nulls or zeros occurring immediately before byte 1 will be ignored.

NOTE 2:
Byte 1 may be omitted. A positive mantissa will then be assumed.

NOTE 3:
Bytes 2 to 11 may contain up to nine digits and a decimal point. If more than nine digits are entered without a decimal point, excess digits will be truncated. The excess digits will, however, increase the power of ten stored.

If fewer than nine digits are required the unused bytes may be omitted.

NOTE 4:
Spaces or nulls entered between bytes 11 and 12 will be ignored.

NOTE 5:
The exponent group, bytes 12 to 15, may be omitted.

NOTE 6:
Byte 13 may be omitted or transmitted as a space. In either case a positive exponent will be assumed.

NOTE 7:
Byte 15 may be omitted for a single-digit exponent.

NOTE 8:
Units are assumed to be seconds for delay time.

TABLE 5.12

Numerical Input Ranges

Function	Command Code	Numerical Limits	
		Low	High
Resolution	SRS	3	8
Null store	SN	$\geqslant 1 \times 10^{-9}$	$<1 \times 10^{10}$
		$>-1 \times 10^{10}$	$\leqslant -1 \times 10^{-9}$
Delay time	SDT	200×10^{-6}	0.8

NOTE 1:
Numbers entered will be rounded up before storage, as follows:

(1) Delay time, 1 ms to 800 ms, multiples of 1 ms, or a fixed delay of 200 µs.

NOTE 2:
Resolution entries will be rounded down to the next integer. The related gate times are shown in Table 5.13.

NOTE 3:
The exponential numbers format is shown in Table 5.11.

TABLE 5.13

Resolution Selection

Number of digits in Freq., Period, Time and Check.	Gate Time	Resolution number
8	10 s	8
7	1 s	7
6	100 ms	6
5	10 ms	5
4	1 ms	4
3	1 ms	3

TABLE 5.14

Special Function Codes

Function	Code
Enter special function nn in special function register	Snn

NOTE 1:
The list of special functions is given in Table 5.15.

NOTE 2:
A special function number entered in the register while the special functions are enabled will be enabled immediately.

TABLE 5.15

Special Functions

Function Number	Function Description
20	Normal operation
21	Frequency B
70	Basic 10 MHz check
71	LED check
80	Leading letters in output string
81	No leading letters in output string

Special Function Register

32 The special functions are stored in a register organised by decades. Only decades 2, 7 and 8 are used in this instrument. The first digit of a special function number indicates its position in the register and the second digit is stored in that location. If recalled, the special function register will be transmitted as a string of 21 ASCII characters. These are interpreted in Table 5.16.

TABLE 5.16

Output Message Format

Byte	Output Characters	Notes
1	'S' or space	Spaces transmitted if
2	'F' or space	SF 81 is programmed
3	'+'	
4, 5	0	
6	0 or 1	0 = SF20 selected 1 = SF21 selected
7-10	0	
11	0 or 1	0 = SF70 selected 1 = SF71 selected
12	0 or 1	0 = SF80 selected 1 = SF81 selected
13-15	0	
16	'E'	
17	'+'	
18, 19	0	
20	CR	
21	LF	

TABLE 5.17

Service Request Codes

Function	Code
Inhibit generation of SRQ	QØ
SRQ generated when error is detected	Q1
SRQ generated for measurement ready	Q2
SRQ generated for measurement ready or error detected	Q3
SRQ generated for frequency standard changeover	Q4
SRQ generated for frequency standard changeover or error detected	Q5
SRQ generated for measurement ready or frequency standard changeover	Q6
SRQ generated for measurement ready, error detected or frequency standard changeover	Q7

NOTE:
SRQ is not generated by data recalled from store.

TABLE 5.18

Alphabetic List of Command Codes

Code		Code	
AAC	A channel, AC coupling	ND	Null disabled *
AAD	A channel X10 attenuator disabled	NE	Null enabled *
AAE	A channel X10 attenuator enabled	PA	Period A
ADC	A channel, DC coupling	PH	Phase A relative to B
AE	100 Average enabled	Qn	SRQ mode *
AFD	A channel filtering disabled	RA	Ratio A/B
AFE	A channel filtering enabled	RDT	Recall delay time
ANS	A channel, -ve slope	RE	Reset measurement
APS	A channel, +ve slope	RF	Read total so far
BAC	B channel, AC coupling	RGS	Recall GPIB software issue
BAD	B channel X10 attenuator disabled	RMS	Recall master software issue number *
BAE	B channel X10 attenuator enabled	RN	Recall null value *
BCC	A and B channels common	RRS	Recall resolution *
BCS	A and B channel separate	RSF	Recall special function *
BDC	B channel, DC coupling	RUT	Recall unit type *
BNS	B channel, -ve slope	Snn	Special Function number *
BPS	B channel, +ve slope	SDT	Store delay time
CK	Check	SN	Store null value *
DD	Delay disabled	SRS	Store resolution *
DE	Delay enabled	TA	Total A by B
FA	Frequency A	TC	Time
IP	Instrument preset *	TI	Time interval
NA	100 Average function disabled	Tn	Measurement mode or Start/Stop reading

NOTE:
n represents a single digit.
* = Immediate Command, see Deferred Commands and Immediate Commands on Page 5-2.