

# Maintenance manual

9901

## Universal Counter-Timer



WOH 6201

Universal Counter Timer 9901

## 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.

## 'POZIDRIV' SCREWDRIVERS

Metric thread cross-head screws fitted to Racal equipment are of the 'Pozidriv' type. Phillips type and 'Pozidriv' type screwdrivers are not interchangeable, and the use of the wrong screwdriver will cause damage. POZIDRIV is a registered trade mark of G.K.N. Screws and Fasteners Limited. The 'Pozidriv' screwdrivers are manufactured by Stanley Tools Limited.

## CONTENTS

	<u>Page</u>
FRONTISPIECE	
SECTION 1 TECHNICAL SPECIFICATION AND SUPPLEMENTARY DATA	
SECTION 2 DESCRIPTION OPERATION AND MAINTENANCE	
CHAPTER 1 GENERAL INSTRUCTIONS	1-1
CHAPTER 2 OPERATING INSTRUCTIONS	
Power Supply	2-1
Frequency Measurement	2-2
Period Measurement	2-3
Time Interval (TI and TI Average)	2-4
Ratio	2-5
Totalize	2-6
Description of Controls	2-9
Indicators	2-9
Rear Panel Items	2-9
CHAPTER 3 PRINCIPLES OF OPERATION	
The CDI Chip	3-1
Basic Frequency Meter	3-1
General Circuit Functions	3-2
Dynamic Display System	3-2
Self Check	3-3
Average Period Measurement	3-3
Time Interval (Single and Double Line)	3-4
Time Interval Average	3-5
Ratio	3-6
Totalize	3-7
Control Sequence	3-8
Display and Data Output System	3-9
Resistor Arrays	
CHAPTER 4 TECHNICAL DESCRIPTION	
Introduction	4-1
Function and Range Switching	4-1
Control Codes	4-1
Frequency Auto Mode	4-1

## CONTENTS (Continued)

	<u>Page</u>
Data Latch/Unlatch, Normal/Hold and Reset	4-3
Channel 'A' Input	4-3
AC Amplifier	4-3
DC Amplifiers	4-4
'B' Channel DC Amplifier	4-4
Bounce Protection	4-4
'A' Channel DC Amplifier	4-5
Check Mode	4-5
Slope Selection	4-5
Manual Start/Stop	4-6
Data Output and Display System	4-6
Multiplex Readout and Display	4-6
Decimal Point and Overflow Decode	4-6
Gate Indicator LP2	4-7
Display Time and Reset Generator	4-7
Display Time Circuit	4-7
Reset Pulse	4-7
Manual Reset	4-8
External Reset	4-8
Segment Check	4-8
Frequency Standard	4-8
Standard Oscillator Assembly 19-0834	4-8
Optional Oscillator	4-8
Frequency Doubler	4-9
1 MHz Reference Output	4-9
External Standard Input	4-9
Power Supply	4-9
+5V Stabilization	4-9
-5V Stabilization	4-9
On/Off Switching	4-10
CDI Chip 2V Supply	4-10

## CHAPTER 5

### MAINTENANCE

Test Equipment Required	5-1
Removal of Covers	5-2
Transformer Voltage Selection	5-2
Voltage Selection Diagram	5-3
Fuses	5-4
Power Lead	5-4
Power Supply Check	5-4

## CONTENTS (Continued)

	<u>Page</u>
Performance Tests and Calibration	5-5
Segment, Decimal Point and Self Check	5-5
Sensitivity Checks: Input 'A'	5-6
Time Interval Single Line Check	5-7
Time Interval Double Line Check	5-8
Time Interval Average Check	5-9
Ratio Check	5-9
Totalize Check	5-10
Frequency Standard Calibration	5-11
Dismantling	5-12
Removal of Display PCB	5-12
Removal of Main PCB	5-13
Replacement of Main PCB	5-13
Fitting Optional Frequency Standard Unit	5-14

## IN TEXT ILLUSTRATIONS

<u>Fig. No.</u>		<u>Page</u>
A1	Data Sequence Diagram	Tech. Spec. (9)
3.1	Basic Frequency Meter	3-1
3.2	Period Measurement	3-3
3.3	Time Interval Measurement	3-4
3.4	Time Interval Average Measurement	3-5
3.5	Ratio Measurement	3-6
3.6	Totalizing	3-7
3.7	Control Sequence Diagram	3-8
3.8	Multiplex Display System	3-9
3.9	D. I. L. Resistor Array	3-10
5.1	Voltage Selection Diagram	5-3

## LIST OF TABLES

<u>Table No.</u>		<u>Page</u>
1	Data Output Socket	Tech. Spec. (7)
2	Function Information	) Tech. Spec. (8)
3	Time Base Selection	) 4-2
4	Function Information	4-2
5	Time Base Selection	4-2

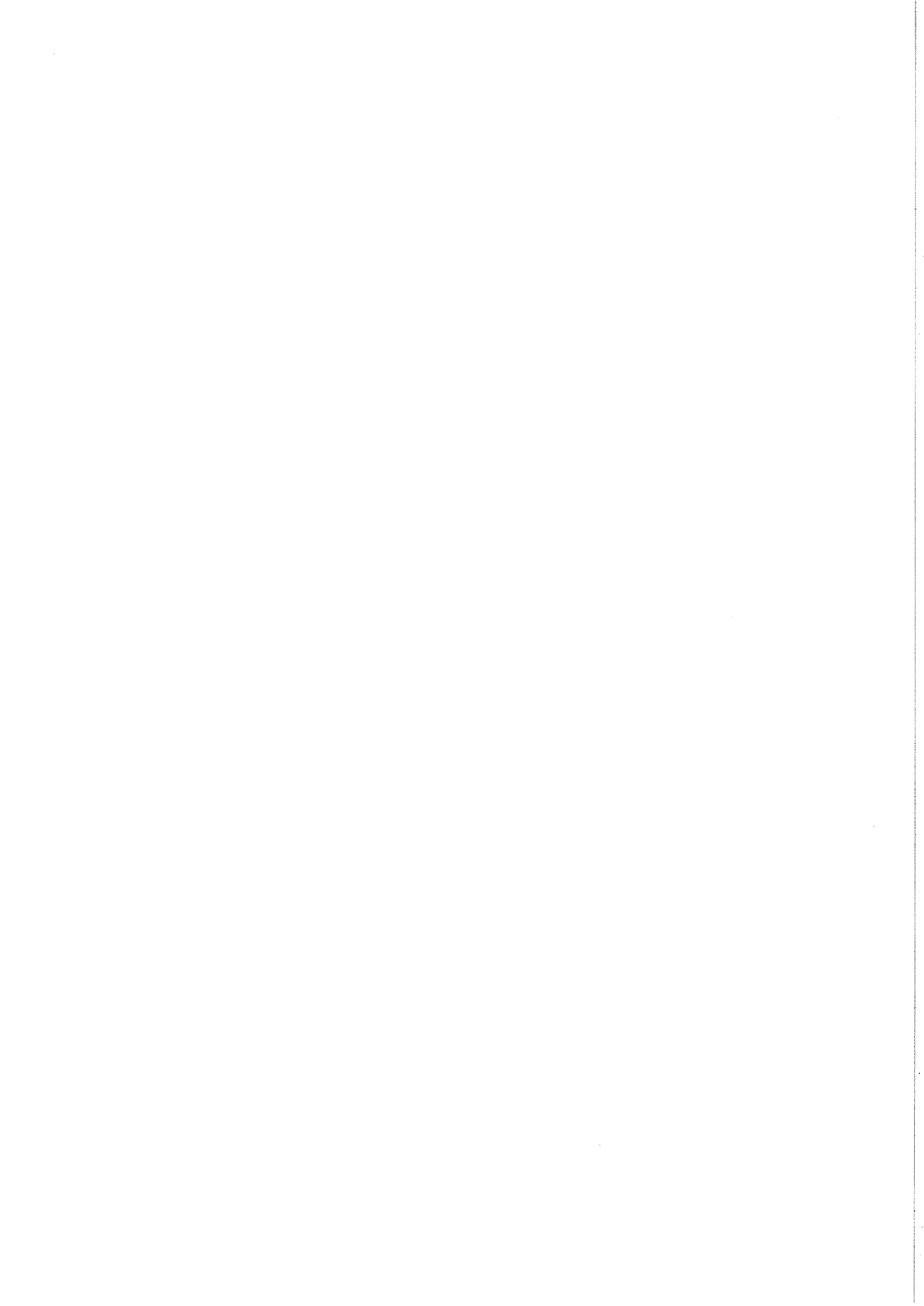
## LIST OF TABLES (Continued)

<u>Table No.</u>		<u>Page</u>
6	Test Equipment Required	5-1
7	Self Check Readout	5-5
8	Input 'A' Sensitivity Check	5-6
9	Time Interval Single Line Check	5-8
SECTION 3	<u>PARTS LISTS, COMPONENT LAYOUTS AND CIRCUIT DIAGRAMS</u>	
	Component Layout: Display Assembly Parts List 1: Display Assembly	Fig. 1
	Circuit and Layout: Oscillator PCB Assembly Parts List 2: Oscillator PCB Assembly	Fig. 2
	Parts List 3: Chassis, Front and Rear Panel Assemblies	
	Parts List 4a and 4b: Main PCB Assembly Component Layout: Main PCB Assembly	Fig. 3
	Overall Circuit: 9901	Fig. 4
SECTION 4	APPENDICES AND CHANGE INFORMATION	
	APPENDIX 1: SERIAL TO PARALLEL INTERFACE UNIT	



SE\_\_\_\_\_ TION 1

TECHNICAL \_\_\_\_\_ SPECIFICATION



## CONTENTS (Continued)

	<u>Page</u>
Performance Tests and Calibration	5-5
Segment, Decimal Point and Self Check	5-5
Sensitivity Checks: Input 'A'	5-6
Time Interval Single Line Check	5-7
Time Interval Double Line Check	5-8
Time Interval Average Check	5-9
Ratio Check	5-9
Totalize Check	5-10
Frequency Standard Calibration	5-11
Dismantling	5-12
Removal of Display PCB	5-12
Removal of Main PCB	5-13
Replacement of Main PCB	5-13
Fitting Optional Frequency Standard Unit	5-14

## IN TEXT ILLUSTRATIONS

<u>Fig. No.</u>		<u>Page</u>
A1	Data Sequence Diagram	Tech. Spec. (9)
3.1	Basic Frequency Meter	3-1
3.2	Period Measurement	3-3
3.3	Time Interval Measurement	3-4
3.4	Time Interval Average Measurement	3-5
3.5	Ratio Measurement	3-6
3.6	Totalizing	3-7
3.7	Control Sequence Diagram	3-8
3.8	Multiplex Display System	3-9
3.9	D. I. L. Resistor Array	3-10
5.1	Voltage Selection Diagram	5-3

## LIST OF TABLES

<u>Table No.</u>		<u>Page</u>
1	Data Output Socket	Tech. Spec. (7)
2	Function Information	) Tech. Spec. (8)
3	Time Base Selection	)
4	Function Information	4-2
5	Time Base Selection	4-2

LIST OF TABLES (Continued)

<u>Table No.</u>		<u>Page</u>
6	Test Equipment Required	5-1
7	Self Check Readout	5-5
8	Input 'A' Sensitivity Check	5-6
9	Time Interval Single Line Check	5-8

SECTION 3      PARTS LISTS, COMPONENT LAYOUTS AND CIRCUIT DIAGRAMS

Component Layout: Display Assembly      Fig. 1  
Parts List 1: Display Assembly

Circuit and Layout: Oscillator PCB Assembly      Fig. 2  
Parts List 2: Oscillator PCB Assembly

Parts List 3: Chassis, Front and Rear  
Panel Assemblies

Parts List 4a and 4b: Main PCB Assembly  
Component Layout: Main PCB Assembly      Fig. 3

Overall Circuit: 9901      Fig. 4

SECTION 4      APPENDICES AND CHANGE INFORMATION

APPENDIX 1: SERIAL TO PARALLEL INTERFACE UNIT

## TECHNICAL SPECIFICATION

1. GENERAL Model 9901 is a 6 digit 50 MHz Autoranging Universal Counter Timer.
  
2. MEASURING FUNCTIONS  
Modes of Operation: Frequency (Manual), Frequency (Autoranging), Single and Multiple Period, Single and Multiple Ratio, Single and Double Line Time Interval, Single and Double Line Time Interval Averaging; Totalizing.
  
3. DISPLAY  
Format: Six digit in-line, LED seven segment display. Decimal point automatically positioned.  
Latch: The display is latched for Frequency, Period and Ratio measurement and automatically unlatched in all other modes.  
Overflow Indicator: LED illuminated when overflow occurs.  
Gate indicator: LED illuminated when gate is open.  
Display Time: Gate time plus 0.25s in Frequency, Period and Ratio modes. 2.0s in other modes. A switched hold position is provided.  
Measurement Check: Counter reads 1 MHz.  
Segment Check: Sets display LED's to 8 when Check and Reset selected.  
Reset: Manual by push-button, or automatic.
  
4. CHANNEL A INPUT - A.C. COUPLED  
Frequency Range: 10 Hz to 50 MHz.  
Sensitivity: 10 mV r.m.s.  
Maximum Input Level: 250V r.m.s. up to 10 kHz.  
50V r.m.s. up to 100 kHz.  
10V r.m.s. above 100 kHz.  
400V d.c.

Input Impedance: 1 M $\Omega$  in parallel with 25pF.

5. CHANNELS A & B - D.C. COUPLED

Frequency Range: D.C. to 10 MHz.

Sensitivity:  $\pm 0.25V$  about +1V nominal or contact closure to earth.

Maximum Input Level:  $\pm 35V$ .

Pulse Duration: 50 ns minimum at trigger points.

Input Impedance: Approximately 10 k $\Omega$

6. FREQUENCY MEASUREMENT

Input: Channel A.

Frequency Range: D.C. to 50 MHz (direct).

Coupling: A.C. or D.C.

Gate Times: Manual: 1 ms to 100s in decade steps.

Automatic: Gate times up to 1s are selected automatically to avoid overspill. Designed hysteresis avoids undesirable range changing at small frequency deviations.

7. SINGLE & MULTIPLE PERIOD MEASUREMENT

Input Channel: Channel A.

Range: 1  $\mu$ s to 1s.

Clock Unit: 1  $\mu$ s.

Coupling: A.C. or D.C.

Periods Averaged: 1 to 10<sup>5</sup> in decade multiples

Accuracy:  $\pm 0.3\%$   $\pm$  Freq. standard  
 $\frac{\text{Number of periods averaged}}{\text{stability}}$   
(at 50 mV r.m.s. a.c. input with 40 dB S/N ratio).

Bandwidth: Automatically reduced to 10 MHz (3 dB) when Period selected.

8. TIME INTERVAL SINGLE & DOUBLE LINE

Input Channel:	Single Line: Channel B. Double Line: Start Channel B Stop Channel A.
Time Range:	100 ns to $10^4$ s (2.8 hours approximately).
Clock Units:	100 ns to 10 ms.
Coupling:	D.C.
Start/Stop Signals:	Electrical or contact.
Manual Start/Stop:	By single push button on front panel.
Trigger Slope Selection:	Electrical. Positive or negative slopes can be selected on both Start and Stop signals. Contact. Opening or closure can be selected on both Start and Stop signals.
Bounce Protection:	A 10 ms dead time is automatically included when contact operation is selected.

9. TIME INTERVAL AVERAGING SINGLE & DOUBLE LINE

Input Channel:	Single Line: Channel B. Double Line: Start Channel B Stop Channel A.
Time Range:	150 ns to 0.1s.
Dead Time between Intervals:	100 ns minimum.
Clock Unit:	100 ns.
Time Intervals Averaged:	1 to $10^5$ in decade multiples.
Accuracy:	$\pm$ Frequency standard accuracy $\pm$ system error $\pm$ averaging error.  System error: 10 ns per input channel. This is the difference in delays between start and stop signals and can be minimised by matching externally.

Accuracy: (Cont'd.)

$$\text{Averaging Error: } \frac{\text{Trigger error} + 100 \text{ ns}}{\sqrt{\text{Intervals Averaged}}}$$

$$\text{Trigger Error: } \frac{5}{\text{Signal slope at trigger point (V/}\mu\text{s)}} \text{ (ns)}$$

10. RATIO

Higher Frequency Input: Channel A.

Higher Frequency Range: D.C. to 50 MHz.

Lower Frequency Input: Channel B.

Lower Frequency Range: D.C. to 10 MHz.

Reads:  $\frac{\text{Frequency A} \times n}{\text{Frequency B}}$

Multiplier n: 1 to  $10^5$  in decade multiples.

11. TOTALIZING

Input Channel: Channel A (D.C. to 10 MHz).

Maximum Rate:  $10^7$  events per second.

Pulse Width: 50 ns minimum at trigger points.

Prescaling: Events can be prescaled in decade multiples (n) from 1 to  $10^5$ .

Reads:  $\frac{\text{Number of input events}}{n}$

Manual Start/Stop: Single push button on front panel.

Electrical Start/Stop: By electrical signal applied to Channel B. Specification as for Time Interval, single line working.

12. FREQUENCY STANDARD

See also Option 04

Frequency: 5 MHz.

Temperature Stability:  $\pm 8$  parts in  $10^6$  over temperature range  $0^\circ\text{C}$  to  $+55^\circ\text{C}$ .  
 $\pm 3$  parts in  $10^6$  over temperature range  $+20^\circ\text{C}$  to  $+40^\circ\text{C}$ .



Average Ageing Rate:  $\pm 1$  part in  $10^6$  per month three months after delivery but less than  $\pm 1$  part in  $10^5$  in the first year.

Frequency Standard Output: 1 MHz t.t.l. compatible rectangular wave.

13. EXTERNAL STANDARD

Frequency: 1 MHz.

Input Socket: Applied to channel B input socket and provides external standard for Frequency and Period measurement only.

14. EXTERNAL SIGNALS

Data Outputs: Eight digits with overflow and decimal points in serial BCD form at standard t.t.l. levels. Refer to Table 1 on page (7).

Other Outputs: Function and timebase data. Schmitt trigger outputs from both channels.

Inputs: Reset and print hold.

15. POWER REQUIREMENTS

Supply: 94V to 265V r.m.s., 45 to 450 Hz a.c.

Voltage Ranges (a.c.): Eight ranges selected by transformer connection and link:

94V to 106V	200V to 225V
106V to 119V	212V to 239V
118V to 132V	223V to 251V
188V to 212V	235V to 265V

Consumption: 20 VA approximately.

16. ENVIRONMENTAL & SAFETY SPECIFICATIONS

Operating Temperature Range:  $0^{\circ}\text{C}$  to  $+55^{\circ}\text{C}$ .

Storage Temperature Range:  $-40^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ .

Humidity: 95% r.h. at  $+40^{\circ}\text{C}$ .

Mechanical: In accordance with IEC 68.

Safety: Meets IEC 348 (BS4743)

17. MECHANICAL

Dimensions:                      Height 110 mm  
   Width 284 mm  
   Depth 268.5 mm

Weight:                              2.7 kg.

18. ACCESSORIES & OPTIONS

Option 04A Frequency Standard 9442

Frequency:                        5 MHz.

Ageing Rate:                       $\pm 3$  parts in  $10^9$  per day after 3 months continuous operation.

Warm-Up Time:                    Better than  $\pm 2$  part in  $10^7$  within 6 minutes.

Temperature Stability:            Better than  $\pm 3$  parts in  $10^9$  per  $^{\circ}\text{C}$  over the range  $-10^{\circ}\text{C}$  to  $+45^{\circ}\text{C}$ .

Accessories Available

Accessories are available to give data output in parallel format (for printers etc.) or IEC/ASCII bus compatible format.

## SUPPLEMENTARY DATA

### DATA OUTPUT CONNECTIONS

A1 Data and command information is provided on a 28-way edge connector accessible via a removable cover on the rear panel. The facilities and pin connections are listed in Table 1 below. The logic for time base and function data is given in Tables 2 and 3.

TABLE 1  
Data Output Socket

Pin	Facility	Pin	Facility
1	-5.0V	A	0V
2	+5V	B	$\overline{\text{Overflow}}$ (static indication)
3	Key Way	C	Key Way
4	$\overline{4}$ (BCD)	D	$\overline{1}$ (BCD)
5	$\overline{8}$ (BCD)	E	$\overline{2}$ (BCD)
6	$\overline{\text{External Hold Input}}$	F	10 kHz Sync.
7	$\overline{\text{External Reset Input}}$	H	Main Gate
8	Auto	J	Not Used
9	$\overline{c}$ } Function	K	$\overline{z}$ } Time Base
10	$\overline{b}$ } Information	L	$\overline{y}$ } Information
11	$\overline{a}$ } (See Table 2)	M	$\overline{x}$ } (See Table 3)
12	$\overline{R_0}$	N	Not Used
13	$\overline{\text{Hold/Reset}}$	P	Schmitt 'B' } See
14	Not Used	R	Schmitt 'A' } NOTE 1

- NOTES:**
1. Schmitt 'A' and Schmitt 'B' outputs on pins R and P show the states of d.c. channel Schmitt triggers.
  2. External Hold Input  
To extend the cycle time the external hold signal (logic '0') must be applied during the gate or hold time. To initiate a new measurement cycle the external hold must go 'high' for not less than 200  $\mu$ s.
  3. External Reset Input  
To apply external reset the level at pin 7 must go to logic '0' for not less than 5 ms. On reverting to '1' level the display resets to 'all zeros' and a new measurement commences.

## FUNCTION AND TIMEBASE LOGIC CODES

### Function Data

A2 Function information format: 3 lines coded as follows. The table gives the logic available at the edge connector. The inverse levels are applied to the CDI Chip in the instrument.

TABLE 2  
Function Information

Function	Code		
	$\bar{a}$	$\bar{b}$	$\bar{c}$
Frequency	1	1	1
Average Period	0	1	1
Totalize $\frac{A}{n}$	0	1	0
Ratio $n \frac{A}{B}$	1	1	0
T.I. (single line or double line not averaged)	0	0	1
T.I. (single line or double line averaged)	1	0	1

### Time Base Selection Data Output

A3 Time Base information: 3 lines coded as follows.

TABLE 3  
Time Base Selection

$\bar{x}$	Code $\bar{y}$	$\bar{z}$	Frequency Gate Time	Multiplier 'n'	Time Interval Clock
1	1	1	1 ms	1	0.1 $\mu$ s
0	1	1	10 ms	$10^2$	1 $\mu$ s
1	0	1	100 ms	$10^3$	10 $\mu$ s
0	0	1	1 sec	$10^4$	100 $\mu$ s
1	1	0	10 sec	$10^5$	1 ms
0	1	0	100 sec	$10^5$	10 ms

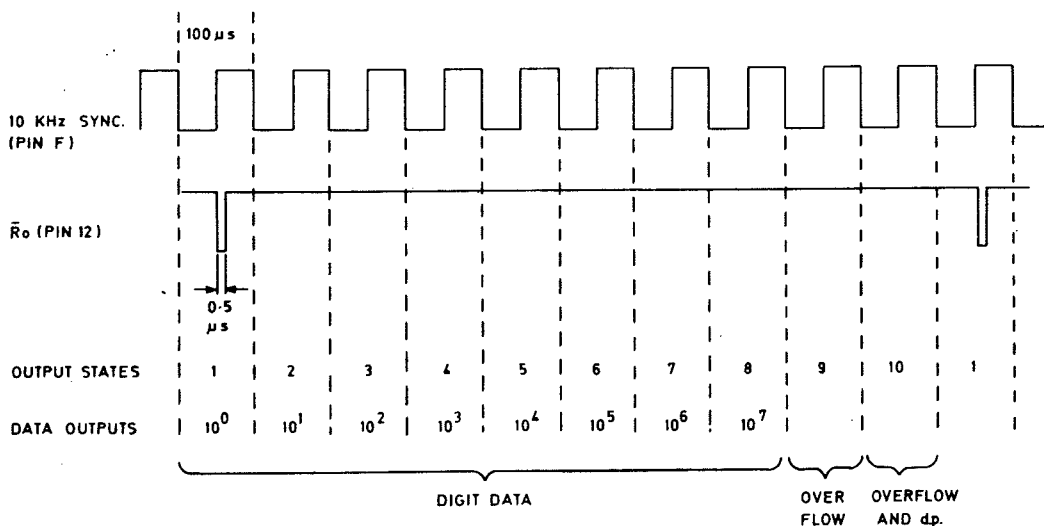
## DATA FORMAT PRINCIPLES

### DATA OUTPUT FORMAT

A4. In standard format the b.c.d. output data is available at the 28-way edge connector in a bit parallel byte serial form. The data is sequenced by a 10 kHz synchronising signal. The data presentation is delayed 0.5  $\mu$ s from the negative edge of the synchronising signal. An additional synchronising pulse ( $\bar{R}_0$ ) determines the first state ( $10^0$  digit). Accessories are available to give data output in parallel format (for printers etc.) or IEC/ASCII bus compatible format. (Options)

The ten data output states are as follows: the timing is shown below.

<u>States</u>	<u>Facility</u>
1 to 8	Digit (display information).
9	Overflow for $10^3$ , $10^4$ , $10^6$ and $10^7$ digits on pins D, E, 4 and 5 respectively.
10	Decimal point position in kHz units, plus overflow information for $10^5$ digit, via pin 5.



Data Sequence Diagram

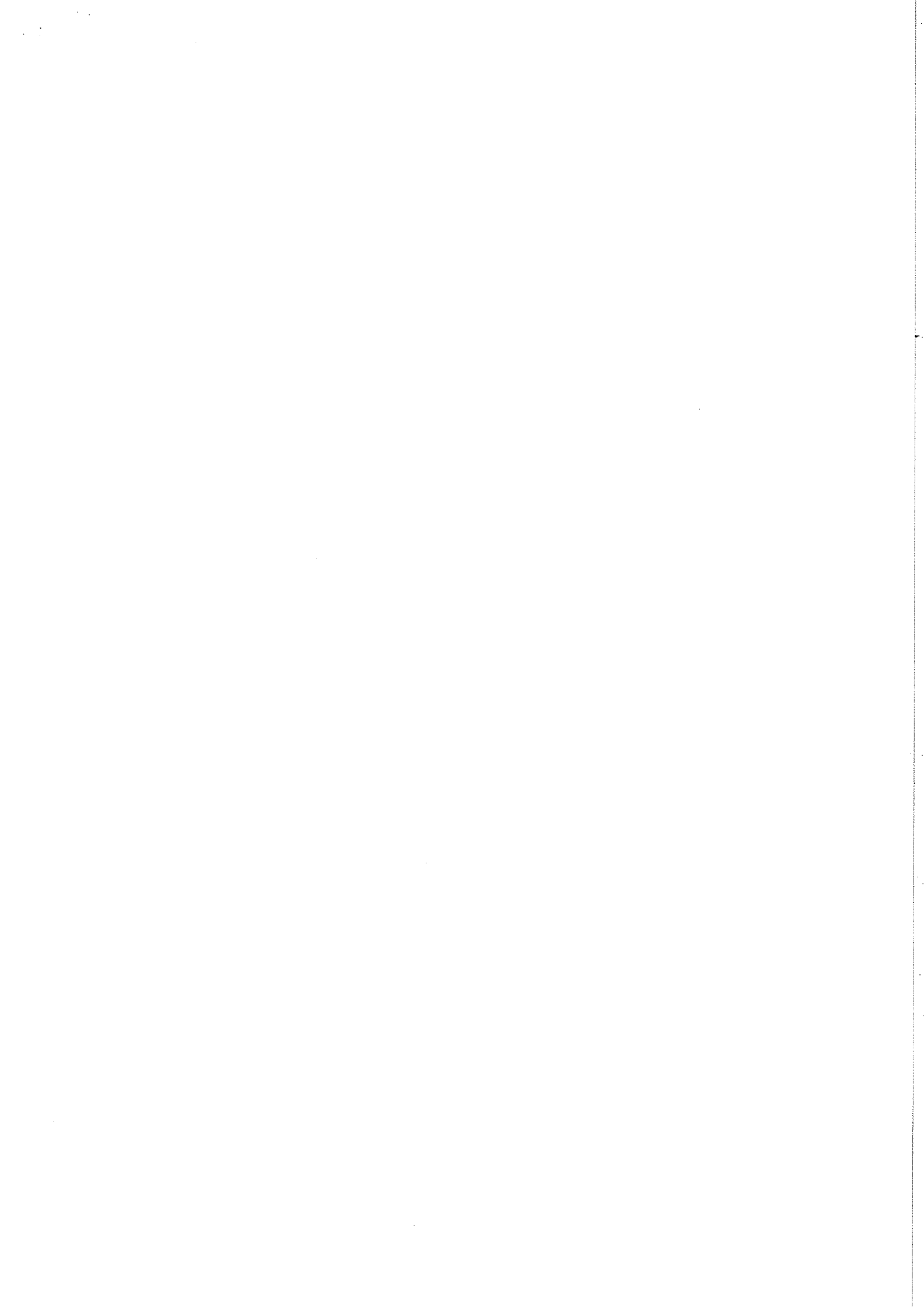
Fig A.1



SECTION 2

DE DESCRIPTION

OPERATION & MAINTENANCE





## CHAPTER 1

### GENERAL DESCRIPTION

#### INTRODUCTION

1.1 The 9901 is a six-digit auto ranging universal counter timer, powered from a.c. mains and providing a comprehensive range of facilities. The heart of the instrument is a large scale integration element (IC2) which performs all the measuring functions of a 50 MHz universal counter timer. This integrated circuit will commonly be referred to as the 'CDI Chip'.

#### OPERATING FACILITIES

- 1.2 (a) Frequency measurement ranges: AC coupled: 10 Hz to 50 MHz.  
DC coupled: DC to 10 MHz.  
In AUTO mode the instrument automatically selects the gate time (.01, 0.1 or 1s) which gives optimum resolution on the display.
- (b) Period measurement, 1 to  $10^5$  periods in decade steps, a.c. or d.c. coupled.
- (c) Ratio measurement.
- (d) Time Interval, single or double line, with manual or electrical start/stop signals, trigger slope selection and choice of pulse or contact timing control.
- (e) Time Interval average, single or double line, with trigger slope selection and choice of pulse or contact timing control.
- (f) Totalize, with electronic or manual start/stop.

In addition, other control facilities provide AC/DC input selection, manual hold and reset, and self check.

#### POWER SUPPLY

1.3 The instrument operates from a.c. supplies between 94V and 265V, 45 to 450 Hz. A tapping and link on the internal mains transformer must be correctly set according to the user's supply voltage, as described in Chapter 5. A label fixed to the rear panel should indicate the selected range. Spare labels are supplied with the instrument for voltage ranges other than 223V to 251V.

## CHECK FACILITIES

### 1 MHz Readout

- 1.4 When the OPERATE/CHECK switch is set to CHECK the 1 MHz internal reference signal is fed through the instrument to provide an operational check on 'Frequency' and 'Period' modes.

### Segment Check

- 1.5 With CHECK selected the instrument will display 'all eights' when the RESET button is pressed, thus checking all segments in the display LED's.

## DATA OUTPUT AND CONTROL

- 1.6 The instrument uses a parallel-to-serial data output system. The data is available at a 28-way connector accessible at the rear panel. Details are given in Table 1 in the Technical Specification. Accessories are available to convert the data output to parallel format. Provision is made, via the data output connector, for the application of external hold and reset control signals to the counter in the CDI Chip.

## FREQUENCY STANDARD

- 1.7 A discrete component 5 MHz oscillator is fitted in the basic versions of the instrument, but at customer's option a high stability fast-warm-up oscillator unit from the Racal range may be fitted. The optional unit should be serviced only by Racal Instruments or authorized agent. An aperture in the rear panel provides access for oscillator calibration.
- 1.8 An external standard, which will automatically over-ride the internal standard, can be applied via the front panel 'B' input socket for use on Frequency and Period mode. A 1 MHz reference, derived from the standard in use, is available via a rear panel BNC socket.

## CARRYING HANDLE

- 1.9 The instrument is fitted with a combined carrying handle and bench stand. To adjust the stand, press in the two handle bosses simultaneously while setting the stand to the desired position.

## MAINTENANCE

- 1.10 The customer is recommended to take advantage of the servicing facilities offered by Racal Instruments Ltd., and agents.

CHAPTER 2  
OPERATING INSTRUCTIONS

POWER SUPPLY

2.1 Before operating a new instrument, or at a new location, check that the mains voltage selection is correct (check rear panel label) and that the fuse has the specified rating.

FREQUENCY MEASUREMENT

2.2 In this mode the unknown frequency is gated to the counter decades for the gating period selected by the chosen Range push-button (n). For frequencies below 10 kHz the use of period mode will give greater resolution.

- (1) Set the POWER switch to ON.
- (2) Set the following controls:-
  - (a) Function switch to FREQUENCY - 'A' MAN.
  - (b) AC/DC switch to AC or DC, as required.
  - (c) If using AC mode set the SENSITIVITY control initially to the maximum clockwise position.
  - (d) CHECK/OPERATE switch to OPERATE.
  - (e) HOLD/NORMAL switch to NORMAL.
  - (f) Pulse/Contact switch to Pulse ( $\square$ ).
- (3) Connect the unknown signal to the 'A' input socket.
- (4) If counting is not satisfactory adjust the SENSITIVITY control anti-clockwise towards the 10 mV setting until a stable reading is obtained.
- (5) Select the 'n' push-button which fills the display, or switch to AUTO for optimum resolution. The frequency readout is in kHz.
- (6) If operating on HOLD, press and release the RESET button to obtain a new reading.

PERIOD MEASUREMENT

2.3 This mode is recommended for measuring low frequencies in the range 1 Hz to 10 kHz with improved resolution. The incoming unknown signal is taken to the time-base decade dividers, the output of which (selected by the Range push-buttons) is used to gate the internal frequency standard to the counter decades. The display indicates the actual value of the period of the incoming signal in microseconds. Greater accuracy is obtained by selecting a longer gate time, thus taking the measurement over a greater number of periods.





## Period Operation

- 2.4 (1) Set the POWER switch to ON.
- (2) Set the following controls:-
  - (a) Function switch to PERIOD 'A'.
  - (b) AC/DC switch to AC or DC, as required.
  - (c) If using AC mode, set the SENSITIVITY control initially to maximum clockwise.
  - (d) PULSE/CONTACT switch to PULSE ( $\square$ ).
  - (e) CHECK/OPERATE switch to OPERATE.
  - (f) HOLD/NORMAL switch to NORMAL.
- (3) Connect the unknown signal to the 'A' input socket.
- (4) Select the number of periods to be timed, by depressing the relevant Range ('n') push-button. A greater number of periods gives increased resolution, but longer measuring time.
- (5) Adjust the SENSITIVITY control anticlockwise to obtain steady counting. This control is useful in filtering out h.f. interference on low frequency measurements.
- (6) If operating on HOLD press and release the RESET button to obtain a new reading.

## TIME INTERVAL (T.I. and T.I. Average)

- 2.5 In this mode the instrument is effectively serving as a stop watch by counting clock pulses derived from the frequency standard. The time interval may be controlled by successive events on a single line (such as pulse widths) in which case Input 'B' is used with the B-B/B-A switch set to B-B.
- 2.6 For timing events on separate lines the B-B/B-A switch must be set to B-A. The 'start' signal applied to the 'B' Input and the 'stop' signal to the 'A' input. Trigger slopes can be selected by the START/STOP slope switches.
- 2.7 The T.I. mode is most suited to the measurement of single intervals such as pulse widths. A range of widths from 100 ns to several hours may be measured by selecting the appropriate clock unit. The maximum clock rate is 100 ns, therefore resolution on short duration pulses is likely to be unsatisfactory, but can be improved by the use of T.I. Average mode, which increases resolution by the averaging of the inherent  $\pm 1$  count 'gate uncertainty' factor over a number of time intervals (1 to  $10^5$ ). It should be noted, when time averaging, that the repetition rate of the pulses under measurement must not be synchronous with the frequency standard in use.


### Time Interval Operation

- 2.8
- (1) Set the POWER switch to ON.
  - (2) Set the following controls:-
    - (a) Function: depress the T.I. or T.I. Avg. button, as required.
    - (b) Pulse/Contact switch: as required.
    - (c) B-B/B-A switch: for single line select B-B. For double line select B-A and AC/DC switch to DC.
    - (d) \*START and STOP slope switches: select required triggering polarities (not required for manual timing).
    - (e) HOLD/NORMAL switch: select NORMAL.
  - (3) Connect the input(s) for electronic timing. For single line timing connect the external signals to Input 'B'. For double line connect the 'start' line to 'B' and the 'stop' line to 'A'.
  - (4) Press the Range (n) button which provides the appropriate readout. The guide lines from the T.I. buttons indicate the time units of the display.
  - (5) For manual timing press the START/STOP push-button, as required.
  - (6) If operating on HOLD press and release the RESET button to initiate a new (non-manual) timing process.
- \*NOTE: On Time Interval Average (single line) the  to  and  to  measurement is effectively equivalent to Period mode. Therefore the user is recommended to use Period for this particular type of measurement as the accuracy is greater and the measurement time reduced.

## RATIO $n \frac{A}{B}$

2.9 In this mode, two unknown signals are fed to inputs 'A' and 'B'. Generally the higher frequency is fed via input socket 'A' to the counter decades and the lower frequency is fed through input socket 'B' to the time-base decades, but this input arrangement may be reversed, as for example, when the lower frequency has a smaller amplitude (e.g. 10 mV) and the higher frequency a considerably larger amplitude. The display indicates the ratio  $n \frac{A}{B}$  and the reading must be divided by the factor 'n' to obtain the ratio  $\frac{A}{B}$ .

### Ratio Operation

- 2.10 (1) Set the POWER switch to ON.
- (2) Set the following controls:-
  - (a) The FUNCTION switch to RATIO  $n \frac{A}{B}$ .
  - (b) The AC/DC switch to AC or DC as appropriate.
  - (c) The Pulse/Contact switch to Pulse ().
  - (d) CHECK/OPERATE switch to OPERATE.
  - (e) HOLD/NORMAL switch to NORMAL.
- (3) Connect the input signals to sockets 'A' and 'B'. (see para. 2.9).
- (4) Press the Range (n) button which gives a full display without overspill.
- (5) If on AC adjust the SENSITIVITY control as necessary.
- (6) If on HOLD press the RESET button for a new reading.
- (7) To obtain the true ratio the displayed reading must be divided by the factor 'n' indicated above the selected Range button.

## TOTALIZE $\frac{A}{n}$

2.11 In this mode, signals on input socket 'A' are prescaled and taken to the counter decades. The count can be controlled manually by the START/STOP button, or electrically by timing signals connected to socket 'B'. This mode permits a number of events occurring with random timing to be counted over a chosen period.

2.12 (1) Set the POWER switch to ON and other controls as follows:-

- (a) The Function switch to TOTAL  $\frac{A}{n}$ .
  - (b) The AC/DC switch to DC.
  - (c) The B-B/B-A switch to B-B.
  - (d) The CHECK/OPERATE switch to OPERATE.
  - (e) The Pulse/Contact switch as required.
  - (f) The HOLD/NORMAL switch to NORMAL.
  - (g) The START and STOP slope switches to select the required trigger edge polarities.
- (2) Connect the signal to be totalized to socket 'A' and the electrical timing signals (if used) to socket 'B'.
- (3) Press the Range push-button which will provide suitable units for the count. For example, if the  $10^3$  button is depressed the display will be in units of 1000.
- (4) If operating on HOLD, press and release the RESET button before taking a reading.
- (5) If manual control is being used press START/STOP button to commence counting and again to terminate counting. The display will be held for about four seconds before automatically clearing.
- (6) In order to obtain the true total the displayed reading must be multiplied by the scaling factor 'n' indicated above the selected Range button.

## DESCRIPTION OF CONTROLS

### Function Push-Button Switch Bank:

This bank of seven push button switches, located near the centre of the front panel, select the following measurement modes:-

(i) T.I.

Provides time interval measurement between two successive events. The events may be on one line (B-B) or separate lines (B-A), with start and stop slopes of the same or opposite polarity.

(ii) T.I. Avg.

This mode is suitable for the measurement of short repetitive events, with start/stop controls as in T.I. By averaging over a number of events the resolution is increased.

(iii) FREQ. 'A'

Provides frequency measurement of the 'A' channel input with readout in kHz.

### AUTO and MANUAL Modes

With the MAN (manual) switch depressed, the required gate time can be selected from the Range ('n') buttons. With the AUTO switch depressed, the instrument will automatically select the gate time (.01, 0.1 or 1 second) which gives optimum resolution on the display.

(iv) PERIOD 'A'

Provides period measurement on 'A' channel signal with readout in microseconds.

(v) RATIO  $n \frac{A}{B}$

Refer to para.2.9.

(vi) TOTAL  $\frac{A}{n}$

Provides accumulated total of events applied to Channel 'A', with prescaling by the factor 'n' according to the switch selected in the Range switch bank.



#### Time Base Range Push-Buttons:

This bank of six 'n' switches offers a choice of gate times. The multiplier 'n' associated with each switch may also be defined as follows:-

- (a) The number of periods averaged on 'period average' measurement.
- (b) The 'A' input prescale factor on 'totalize'.
- (c) The 'B' input prescale factor on 'ratio'.
- (d) The number of intervals averaged on 'time interval average'.
- (e) The switch bank also is used to select the clock unit on 'time interval'.

#### START Slope Switch:

A slide switch which selects either positive-going or negative-going trigger edge for start of time interval, time interval average, and totalize measurements. Applies to the 'B' channel only.

#### STOP Slope Switch:

Selects the required 'stop' trigger edge polarity on time interval, time interval average, and totalize.

#### Line Selection:

Position B-B select single line 'start/stop' for time interval measurement (Channel 'B'). Position B-A selects 'start' Channel 'B' and 'stop' Channel 'A' on time interval measurements.

#### AC/DC Switch:

This switch selects either a.c. or d.c. coupling in the 'A' channel amplifier.

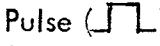



#### Operation on DC Mode

The use of d.c. mode is recommended in the following circumstances:-

- (a) For signals having a slow rate of rise and fall (e.g. sinusoidal signals of frequency lower than 10 Hz).
- (b) For signals of rectangular waveform which have a mark/space ratio other than 1:1, provided the frequency is less than 10 MHz.

Pulse/Contact Switch:

This switch selects the input timing mode for the 'A' and 'B' channel d.c. amplifiers.

- (a) Pulse () position. The position is for operating with electronically derived signals.
- (b) Contact () position. This position is used for measurement where the timing signals are obtained from contacts. The Start/Stop switches must be set so that  is used for contact closing and  for contact opening. A capacitor is introduced internally to reduce the effects of contact bounce.

OPERATE/CHECK Switch:

OPERATE is normal setting. CHECK provides a 1 MHz readout of the internal reference frequency for self-check of counting and display circuits.

Segment Check

To check all LED segments in the display, press the RESET button while in CHECK mode. This will produce an "all 8" display.

START/STOP Push-Button:

Provides manual start/stop on Time Interval and Totalize modes.

NORMAL/HOLD Switch:

In the NORMAL position the instrument provides continuous updating of the display. In the HOLD position the display is held but a single shot update can be obtained by depressing the adjacent RESET button.

RESET Push-Button:

When the RESET button is depressed and released the instrument will clear down to zero and initiate a new measurement. The RESET button is also used in the segment check.

POWER ON/OFF Switch:

Switches off the internal d.c. supplies.

## INDICATORS

### OVERFLOW:

The OVERFLOW indicator will illuminate when the count exceeds the capacity of the display.

### GATE:

The GATE indicator illuminates when the counter gate is 'open'. Thus the illumination period is related to gate time selected.

## REAR PANEL ITEMS

### 1 MHz O/P Socket:

A 1 MHz reference signal derived from the frequency standard in use is available at this BNC socket.

### Data Output Connector:

The facilities provided by the 28-way edge connector are listed in Table 1 in the Technical Specification (supplement) at the front of the book.

### Power Plug:

A three-core power lead is supplied with the instrument.

### Power Fuse:

Fuse ratings are annotated on the rear panel.

### Osc. Adjust:

This aperture provides access to the calibration adjustment in the 5 MHz oscillator. In a few early models the standard oscillator is mounted on the main p.c.b.



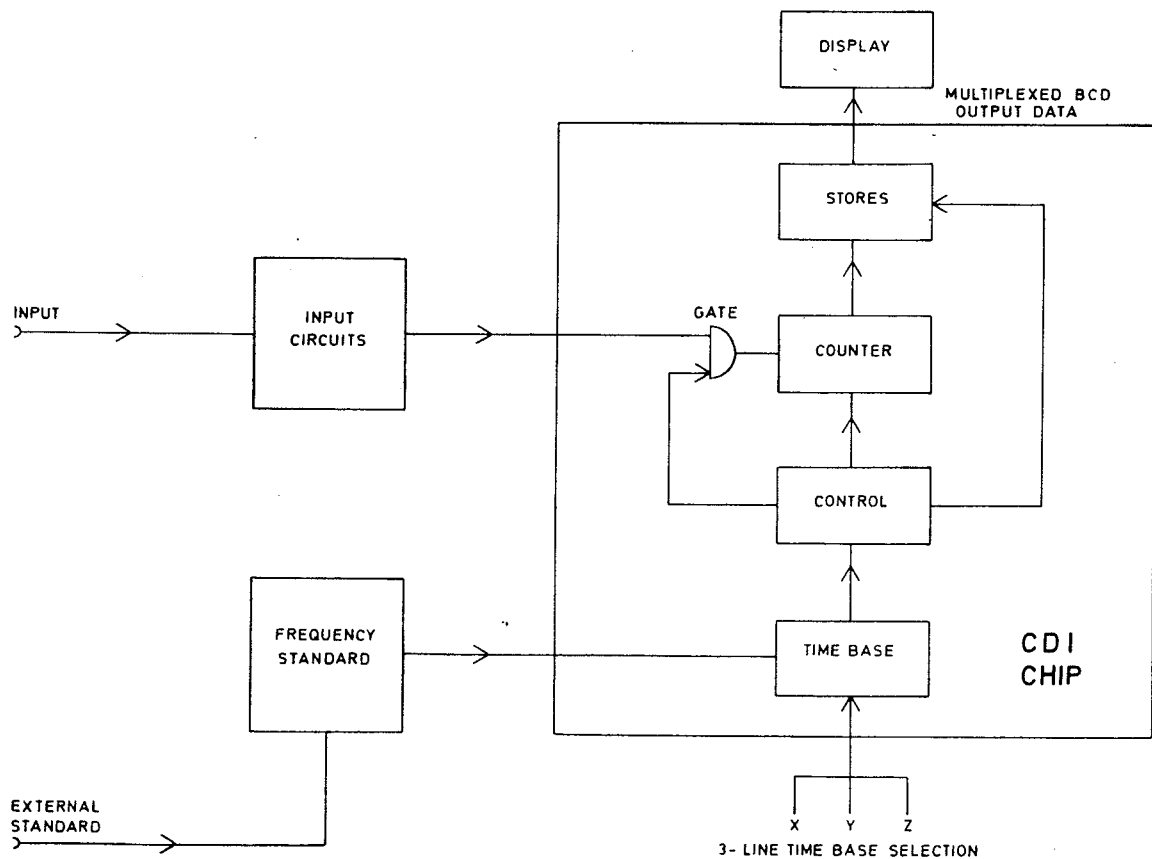
## CHAPTER 3

### PRINCIPLES OF OPERATION

#### THE CDI CHIP

3.1 A basic digital frequency meter comprises a chain of decade counters feeding b.c.d. data into latched stores. Counting is controlled via a main gate which is opened for a period determined by the timebase. Provision is made for resetting the counter and releasing the data for display. In the 9901 these functions are carried out in the integrated circuit IC2, which achieves large scale integration, using the collector-diffusion-isolation principle. For convenience, IC2 will often be referred to in the hand-book as the 'CDI Chip'.

3.2 In addition to frequency measurement, the CDI Chip performs numerous other functions such as Autorange operation and the correct routing of signals for start/stop, time base drive and external standard input, etc.



Basic Frequency Meter

Fig. 3.1

## GENERAL CIRCUIT FUNCTIONS

- 3.3 Outside the CDI Chip, other circuit functions are carried out, such as:-
- (a) Input amplification and signal shaping. Sensitivity control and input (channel) selection. Check signal routing.
  - (b) A six-digit display system in bit-parallel byte serial (multiplex) form, with data readout available for external use.
  - (c) Clock (reference) frequency generation using a discrete 5 MHz oscillator circuit, or an optional high-stability temperature controlled oscillator. The reference frequency is doubled to 10 MHz for use in the CDI Chip.
  - (d) Trigger slope selection, bounce protection, display time, decimal point selection and external reset are provided by means of discrete circuits.
  - (e) The power system operates from a.c. mains feeding +5V and -5V rectifiers and stabilizing circuits and +2V supply to the CDI Chip.

### Dynamic Display System

3.4 The seven-digit display uses light-emitting diodes as numerical indicators. These indicators are driven by b.c.d. data from the CDI Chip, via a seven-segment decoder. Each displayed numeral is formed by illuminating an appropriate number of short straight segments. The numeral '8', for example, is formed from 7 segments, whereas the numeral '6' will require only 5 segments.

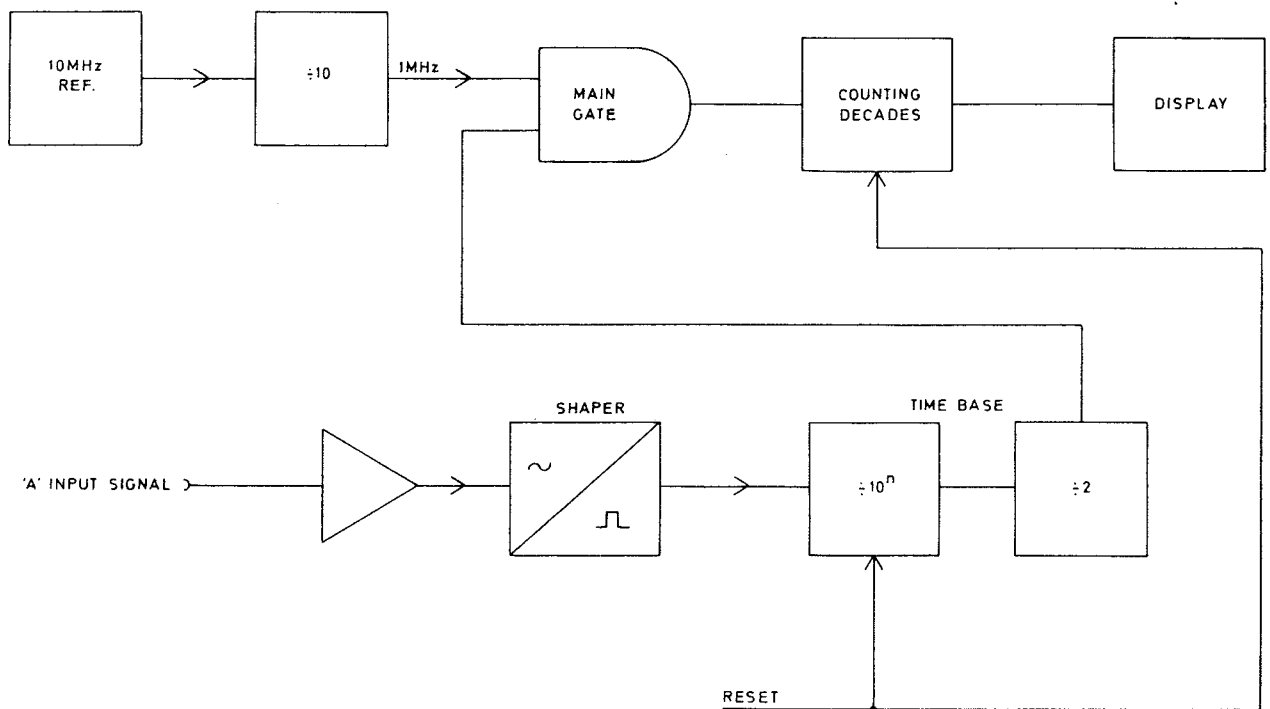
### SELF CHECK

3.5 In the Self Check mode the standard frequency of 1 MHz takes the place of the unknown frequency, thus providing a check on the measurement system in the different modes.

## AVERAGE PERIOD MEASUREMENT

3.6 The period of a waveform is measured by counting the number of clock pulses which occur during one or more cycles of that waveform. Greater accuracy is obtained by measuring over as many cycles as possible. As shown in Figure 3.2, the signal of unknown frequency is applied to the 'A' Input and after amplification and shaping is applied to the time base decades. In the time base the unknown signal generates a selection of gate waveforms, one of which is selected by depressing the appropriate Range ('n') push-button. The chosen gating waveform is applied to the main gate to control the number of periods during which the measurement is taken.

3.7 Clock pulses from the frequency standard are fed to the signal input of the main gate and are counted during the time interval controlled by the selected time base output. The main gate then closes and the display shows the total of clock pulses counted, with decimal point positioned to indicate the average period of the signal.



Period Measurement

Fig. 3.2

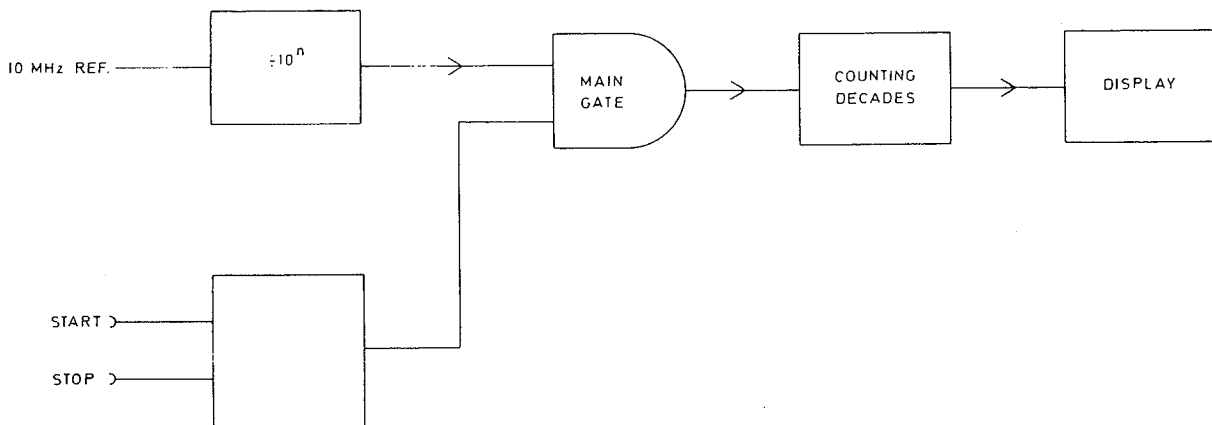
### TIME INTERVAL-B (SINGLE LINE)

3.8 In this mode the instrument is effectively serving as a stop-watch. Start and Stop signals are supplied from an input on the 'B' channel or by operating the manual START and STOP buttons. The time interval is measured by counting clock units derived from the frequency standard.

3.9 The 0.1 microsecond output from a 10 MHz frequency reference is applied to the time base decades and a suitable clock unit is selected by depressing an appropriate Range push-button. These clock pulses are then coupled to the signal input of the main gate and are totalled in the counter decades during the interval between the Start and Stop signals. At the end of the count the total of time units is displayed. The time value of the chosen unit is marked beside the Range button ('n').

### TIME INTERVAL B-A (DOUBLE LINE)

3.10 The operating principle is the same as for single line, except that the start and stop signals are on separate inputs. The display will read the true time interval between events on the separate 'A' and 'B' channels.



Time Interval Measurement

Fig. 3.3

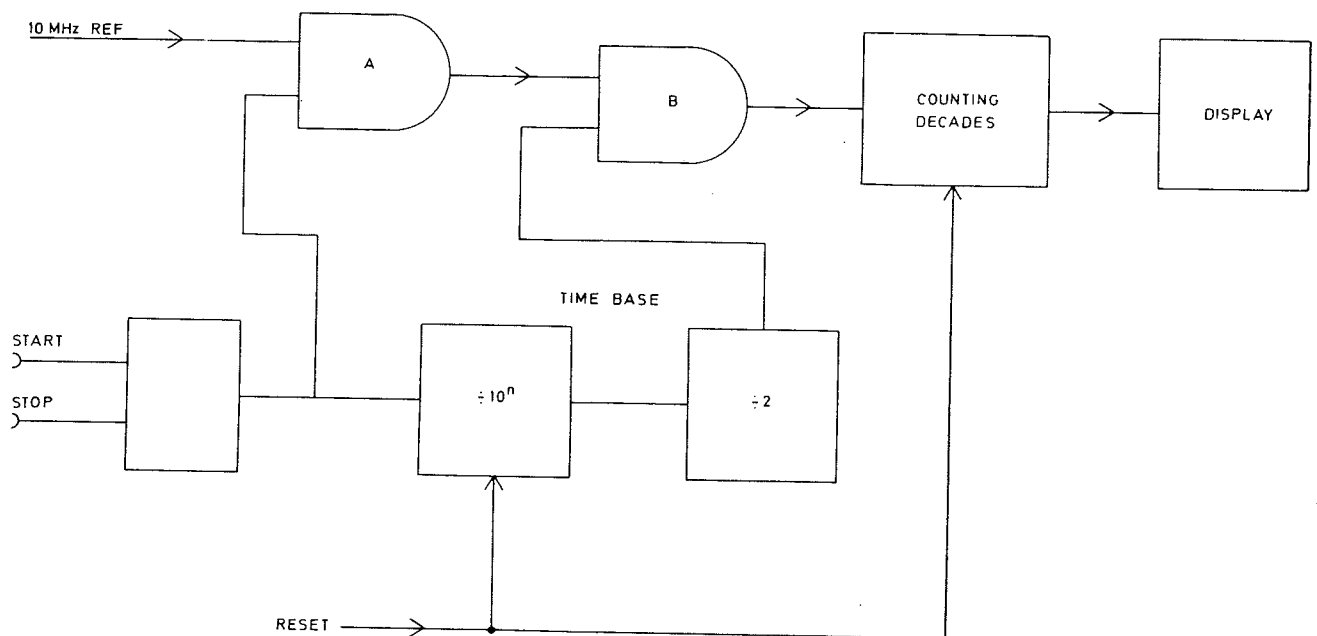


## TIME INTERVAL AVERAGE

3.11 The reference frequency is 10 MHz, thus the shortest available clock unit is 100 ns, which places a limit on the resolution available for such measurements such as narrow pulse widths. Greater resolution is achieved by the 'averaging' technique, which functions as follows:-

3.12 Referring to Figure 3.4 the clock input to the counter has to pass through two gates in series (gates 'A' and 'B' in the diagram). The successive Start and Stop pulses open and close Gate 'A' allowing 10 MHz clock pulses to pass to Gate 'B' during each 'gate open' period. Gate 'B' is held open by the time base for the selected time ( $10^n$ ) and the clock pulses are totalled in the counter. At the end of the selected time base period Gate 'B' closes and the count is displayed as the average time interval.

NOTE: To obtain the improved resolution from time interval averaging, the recurrence frequency of the timing input signal must not be harmonically related to the frequency standard of the counter.

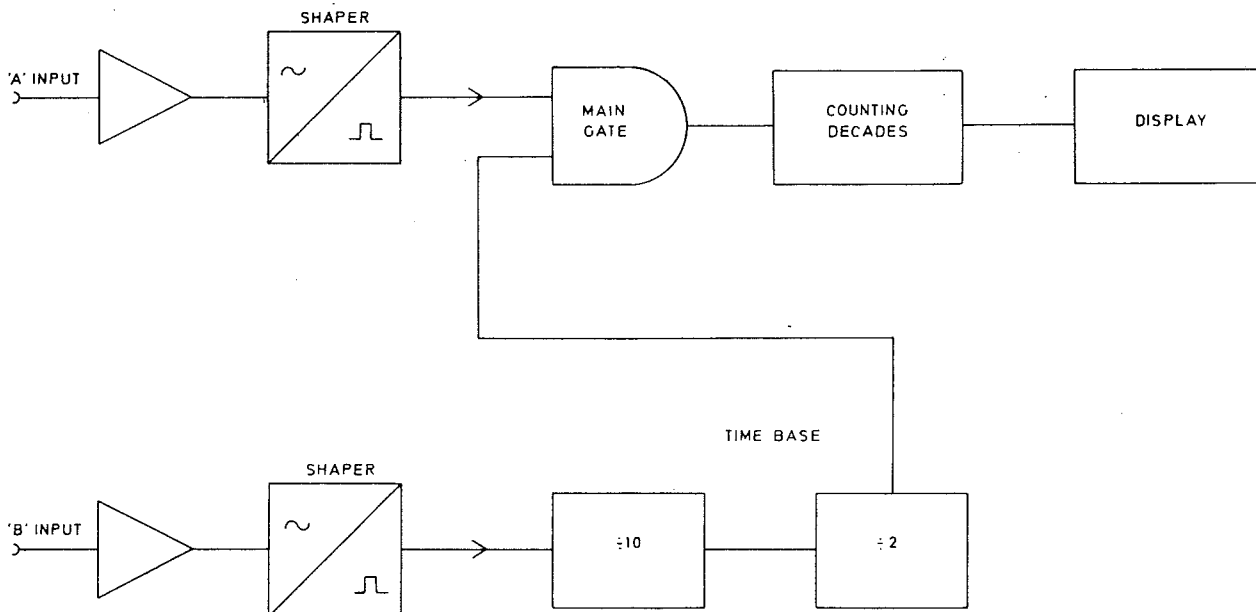


Time Interval Average Measurement

Fig. 3.4

## RATIO

3.13 The principle of operation is very similar to frequency measurement, except that the time base output is not derived from the frequency standard. Instead, the lower of the frequencies to be compared is applied to the 'B' Input and divided in the time base. The higher frequency is applied to the 'A' Input and fed via the main gate to the counter. A waveform from the time base decades (derived from the 'B' Input) is selected to gate the 'A' channel signal by depressing an appropriate Range ('n') push-button. Since the time base output is a divided version of the 'B' signal, the readout gives a count which corresponds to the ratio of the two input frequencies, multiplied by the factor 'n'. The particular 'n' factor used is that shown adjacent to the selected push-button.



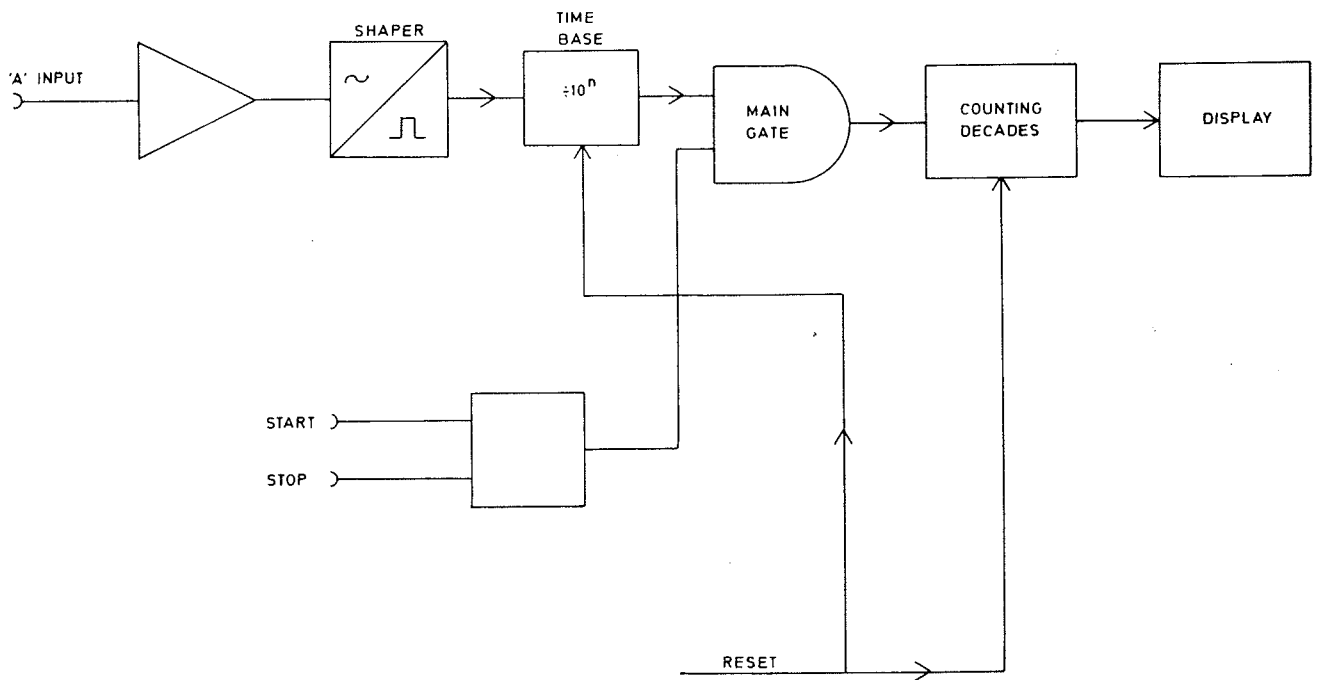
Ratio Measurement

Fig. 3.5

## TOTALIZE

3.14 The events to be counted are applied to the 'A' Input and, after amplification and shaping, are coupled to the input of the time base decades. An output is selected from an appropriate time base decade by depressing the relevant 'n' push-button. This scaled output is coupled to the signal input of the main gate.

3.15 A command level from the START push-button opens the main gate and allows counting to commence; the gate is closed by a command from the STOP push-button. Automatic Start/Stop can be arranged by applying suitable control pulses to the 'B' Input socket.

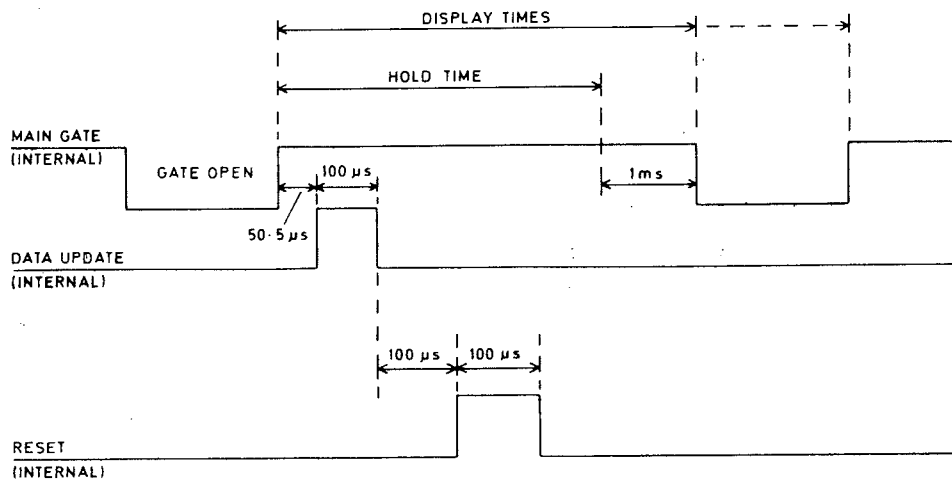


Totalizing

Fig. 3.6

## CONTROL SEQUENCE

3.16 Figure 3.7 shows the control sequence diagrammatically (not to scale). The longer display time shown in the diagram applies to the latched modes (Frequency, Period and Ratio).



Control Sequence Diagram

Fig. 3.7

### External Hold

3.17 If, when used with external circuitry, it is required to extend the cycle time, the external hold signal (logic '0') at pin 6 of the data connector, must be applied before the end of the gate or hold time. To allow a new measurement cycle to commence, the external hold input must go 'high' for not less than 200 μs.

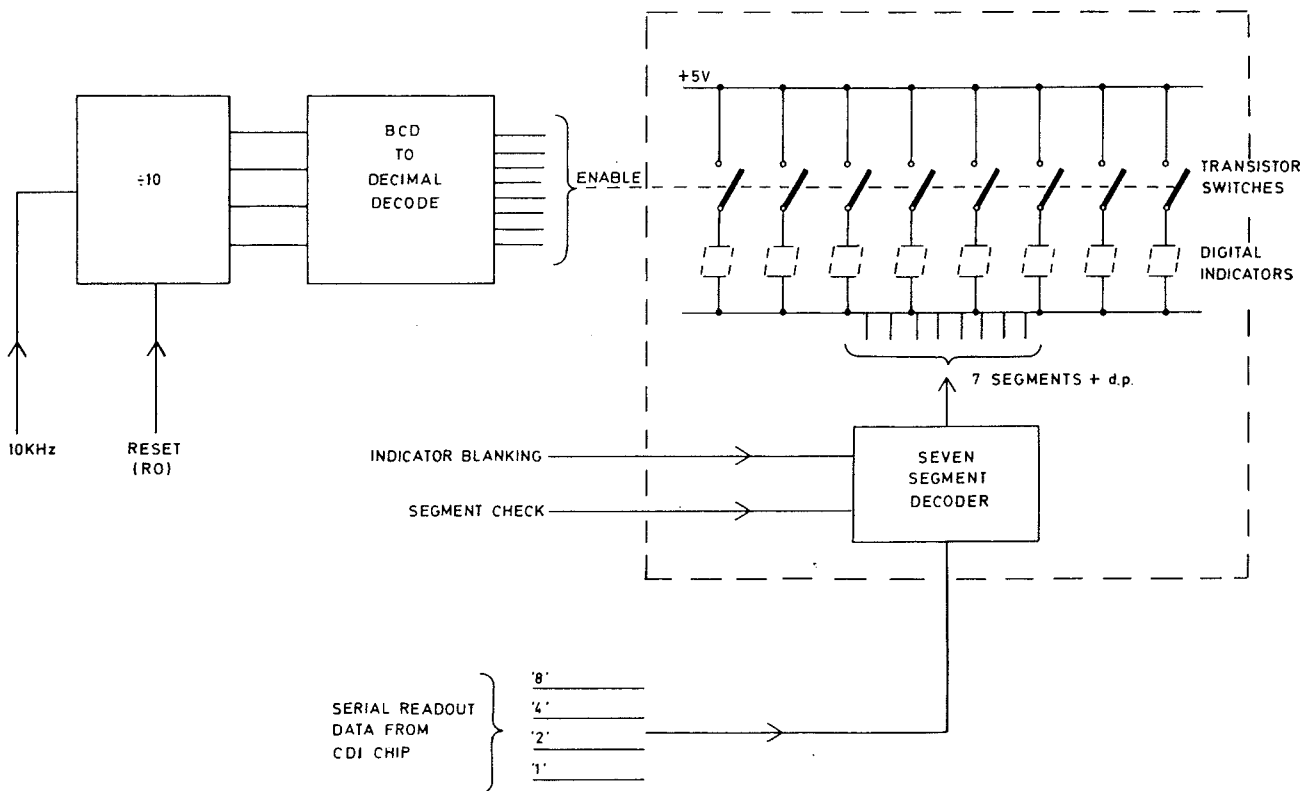
### External Reset

3.18 External reset is achieved by the application of logic '0' to pin 7 of the connector for a period of not less than 5 ms; on reverting to '1' level this will reset the display to 'all zeros' and initiate a new measurement cycle.

## DISPLAY AND DATA OUTPUT SYSTEM

### Multiplex Readout

- 3.19 The readout data is fed from the CDI Chip to the display decode via a single four-wire b.c.d. connection. To permit this simple interconnection a parallel-to-serial (multiplex) system is used. The principles are shown in Figure 3.8, although it should be noted that part of the system is in the CDI Chip.
- 3.20 In the CDI Chip the data stores feed in parallel into a common b.c.d. four-line output. The store outputs are enabled in turn for approximately 100  $\mu$ s by a 10 kHz reference signal, derived from the frequency standard.
- 3.21 The b.c.d. data is fed to a 7-segment decoder (IC17) which offers the decoded data to the bank of LED digital indicators. The 10 kHz reference signal is fed to a BCD/Decimal decoder which 'enables' each display LED in turn for 100  $\mu$ s. A reset pulse (Ro) which is generated in the 10<sup>0</sup> state of the counter, ensures that the display enable is synchronised with the data store readout. A diagram showing the data output format is given on page 9 of the Technical Specification.



Multiplex Display System

Fig. 3.8

3.22 In the LED indicators each displayed numeral is formed by illuminating an appropriate number of short straight segments. The numeral '8', for example, is formed from 7 segments, whereas the numeral '6' will require only 5 segments. The segments can be checked by selecting CHECK and pressing the RESET button. This calls up an 'all eights' display.

### Decimal Point

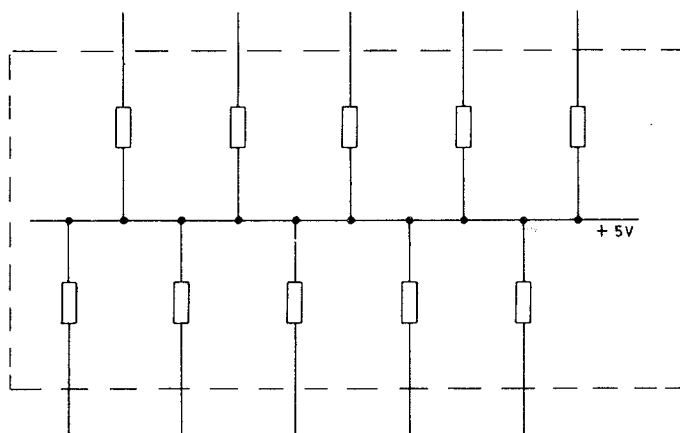
3.23 Decimal point (d.p.) information is obtained by encoding the four line b.c.d. output data from the CDI Chip with the display enable signal. This encode turns on a d.p. drive transistor at the correct instant to illuminate the appropriate decimal point.

### Control Information

3.24 Function selection in the instrument is performed by a 3-line binary coded system identified as lines a, b and c. The time base ('n') units are also selected by a 3-line system identified as lines x, y and z. The inverse of the logic used in the CDI Chip is available at the rear panel data output connector. The logic decode is given in Table 2 and Table 3 in the Technical Specification at the front of the book.

### Resistor Arrays

3.25 Many of the integrated circuits are 'open collector' types. For these IC's discrete 'pull-up' resistors are provided in the circuit. These resistors may be mounted in sealed dual-in-line (d.i.l.) packages, for example R83 (Fig. 4) which has seven  $56\Omega$  resistors with a common connection to +5V. Such arrays cannot be serviced and must be changed in the event of a faulty resistor. Figure 3.9 shows a typical array schematically.



D.I.L. Resistor Array

Fig. 3.9

## CHAPTER 4

### TECHNICAL DESCRIPTION

#### INTRODUCTION

4.1 Apart from some switches and certain items of the power supply, the circuit for the instrument is mounted on one main p.c.b. assembly. The optional fast warm-up oscillator is available as a separate unit.

#### LOGIC CIRCUIT SYMBOLS

4.2 Extensive use is made of integrated circuits (IC's) and these are identified by a number and suffix letter. In the circuit description a particular IC pin will be identified by a reference such as 'IC10a/3', which indicates pin 3 on that particular gate. The logic symbols used in the circuits are those found in most manufacturers IC data sheets to which reference should be made if detailed information is required. The CDI Chip, IC2 is, however, available only through the Service Department of Racal Instruments Ltd.

#### OPERATING CONTROLS

4.3 It is assumed that the reader understands the operational function of each control, as described in Chapter 2.

#### FUNCTION AND RANGE SWITCHING

##### Switch Selection

4.4 In the circuit diagram, Fig. 4 at the back of the book, the Function and Range push-button banks S1 and S2 are at the lower left corner. It should be noted that the PERIOD and 'n' (1) switches are shown as selected and all other push-buttons are at 'off'. Switching functions are directed by logic signals, the +5V supply and 'pull-up' resistors being provided in the d.i.l. resistor array R63 and discrete resistors R53-R55.

##### Control Codes

4.5 Operational modes within the CDI Chip (other than AUTO) are selected by the switch bank S1 and the  $\bar{a}$ ,  $\bar{b}$  and  $\bar{c}$  lines, which are connected via inverters IC1a, c and e to IC2. Table 4, below, gives the logic coding at the switch connections. Time base (range) selection is made via switch bank S2 and lines  $\bar{x}$ ,  $\bar{y}$  and  $\bar{z}$ , which control the gate times in IC2 via the inverters IC1b, d and f. Table 5 gives the logic coding at the switch connections.

##### Frequency Auto Mode

4.6 The autoranging facility operates on Frequency mode and automatically selects the

gate time (.01, 0.1 or 1 second) which gives optimum resolution. When pin 4 on the CDI Chip is allowed to float it automatically selects AUTO operation and also latches the display.

4.7 Depressing the **FREQ AUTO** button produces the following action:-

- (1) Pin 4 on IC2 has a tri-state capability and when this pin is allowed to float free the Chip automatically changes to AUTO operation. By pressing the **FREQ AUTO** button the open collector resistor (R53) of IC13e is disconnected, allowing IC2/4 to float.

TABLE 4

Function Information

Function	Code		
	$\bar{a}$	$\bar{b}$	$\bar{c}$
Frequency	1	1	1
Average Period	0	1	1
Totalize $\frac{A}{n}$ : Start/Stop 'B'	0	1	0
Ratio $n \frac{A}{B}$	1	1	0
T.I.(single or double line not averaged)	0	0	1
T.I.(single or double line averaged)	1	0	1

TABLE 5

Time Base Selection

$\bar{x}$	Code		Frequency Gate Time	Multiplier 'n'	Time Interval Clock
$\bar{y}$	$\bar{z}$				
1	1	1	1 ms	1	0.1 $\mu$ s
0	1	1	10 ms	10	1 $\mu$ s
1	0	1	100 ms	$10^2$	10 $\mu$ s
0	0	1	1 sec	$10^3$	100 $\mu$ s
1	1	0	10 sec	$10^4$	1 ms
0	1	0	100 sec	$10^5$	10 ms



### Data Latch/Unlatch

4.8 This is determined by the logic level applied to IC2/4, as follows:-

Latch ..... logic '1'

Unlatch ..... logic '0'

4.9 In Totalize and in both Time Interval modes the data stores in IC2 are unlatched by a logic '0' at IC2/4. This is arranged by Function switch S1 which applies an earth to R55 when the FREQ., PERIOD and RATIO buttons are not selected, this '0' is then fed through inverters IC13c and IC13b to IC2/4.

### Normal/Hold and Reset

4.10 The NORMAL/HOLD switch 1S7 is mounted on the Display Assembly and shown on the right hand side of the circuit diagram (Fig. 4). In the NORMAL position the display is continuously updated, the automatic reset being produced within the CDI Chip.

4.11 The HOLD connection to the CDI Chip is at IC2/13, the logic requirements at this point are:-

	( Hold..... '1'
IC2/13	( Free Run..... '0'
	( Reset..... Transition '1' to '0'

The Hold and manual Reset signals are applied via the display time generator and associated circuit described in paras. 4.39 and 4.40.

## 'A' CHANNEL INPUT

### Introduction

4.12 The 'A' channel has alternative amplifier paths, selected by the AC/DC switch 1S1. The two amplifier paths have a common output stage (Q8) which feeds into the counter of the CDI Chip at IC2/22.

### 'A' Channel AC Amplifier

4.13 Signals in the range 10 Hz to 50 MHz which are applied to the 'A' input socket are fed via the AC/DC switch (AC position) and capacitor IC1 to the SENSITIVITY potentiometer 1R1. From 1R1 the signal is fed via a coaxial lead to the a.c. amplifier on the main p.c.b.

4.14 The a.c. amplifier has a high impedance FET input (Q1) with overload protection by the clipping resistor R1 together with the gate-drain junction and diode D1. The output from the source of Q1 drives a wideband amplifier IC21, which feeds via C8 into emitter follower Q3. Transistor Q2 is turned off in all modes except PERIOD. In PERIOD mode the removal of the earth via switch S1 turns on Q2, to restrict the bandwidth by the introduction of capacitor C9.

4.15 Transistor Q3 drives the Schmitt Trigger shaper Q4/Q5. Potentiometer R11 sets the bias on Q3 to ensure that the mean signal level is correctly set relative to the two triggering levels of the Schmitt circuit, thus ensuring maximum sensitivity. From Q5 the shaped signal is fed via Q7 and Q8 to the counter at IC2/22.

4.16 When the AC/DC switch is set to DC, and also when CHECK is selected, the AC amplifier is disabled (except the output stage Q8) by a '1' applied to the base of Q6 via the inverter IC14d.

#### D.C. AMPLIFIERS

4.17 The 'A' and 'B' channel d.c. amplifiers are basically identical. The description of the 'B' amplifier and contact bounce protection, given below, applies to both circuits.

##### 'B' Channel D.C. Amplifier

4.18 The 'B' input is fed in via pin 12 on the main p.c.b. and emitter-follower Q11 to the input of IC22d which is a dual line receiver adapted, by feedback, to operate as a Schmitt trigger shaper.

4.19 The shaped output from IC22c/9 is fed via the slope selection gate IC19b and inverters IC14b and IC14c to the output stage Q12 which feeds the signal to the Start input of the CDI Chip at IC2/20. Simultaneously, the output from IC22c/9 is fed via IC19a, IC18b, IC18c and Q10 to the Stop input at IC2/21. On single line operation IC2 interprets the positive edge of the first pulse received as the start, and the positive edge of the second pulse as the stop. For single line (B-B) operation the 'B' channel Stop path is enabled at IC18b/3 by a '1', applied via inverter IC14a from an earth at switch 1S2. For double line (B-A) operation IC18b is disabled by a '0' from inverter IC14a.

4.20 The emitters of Q10 and Q12 are connected to 0V via transistor Q13 which is normally conducting, except when manual start/stop is used (see para. 4.29). The states of the Schmitt triggers at IC22b/4 and IC22c/9 are fed to the data output connector at pins R and P for external information.

##### Bounce Protection

4.21 Fixed bounced protection is provided when the Pulse/Contact switch is at 'Contact'. Referring to the 'B' amplifier, for example, if the external timing contact is open,

Q11 will be non-conducting due to the +5V applied via the Pulse/Contact switch 1S6, R45 and D18 to the base of Q11.

4.22 When the external timing contact closes to earth, it discharges C21 via D18 and R42, thus pulling down the base and turning on Q11. This sends a signal to the Start and Stop inputs of the CDI Chip.

4.23 Contact bounce pulses are prevented from causing a spurious 'stop' because they are of too short a duration to re-charge C21, thus Q11 is unaffected until the timing contact re-opens, C21 is then able to re-charge and Q11 turns off, thus the bounce protection period is determined by the value of C21.

#### 'A' Channel D.C. Amplifier

4.24 The 'A' amplifier and its bounce protection circuit function in the same manner as the 'B' amplifier described above. The input signal is supplied when the AC/DC switch 1S1 is set to DC. There is also an additional gating stage in the output (IC18a) which inhibits the 'A' d.c. amplifier output when the B-B/B-A switch 1S2 is set to B-B for single line Time Interval mode.

#### CHECK Mode

4.25 In CHECK the 'A' channel a.c. amplifier is inhibited and the 1 MHz reference is fed to the counter in the CDI Chip. The 1 MHz reference from IC2/6 is fed to IC15c which is enabled by a '1' on IC15c/9 when switch 1S5 is set to CHECK. (The pull-up resistor is R95 on the right hand side of the circuit diagram). From IC15c the 1 MHz is fed via IC15b and C14 to the output stage Q8, thence to the counter via IC2/22.

4.26 To inhibit the 'A' amplifier in CHECK mode a '0' is provided by switch 1S5 which is inverted in IC14d and turns on Q6, which shunts the amplifier. The same inhibit is applied when the AC/DC switch is at DC.

#### SLOPE SELECTION

4.27 The polarities of the Start/Stop triggering edges are selected by switches 1S3 (STOP slope) and 1S4 (START slope) in conjunction with the Exclusive-OR gates IC19a, 19b and 19d. An Exclusive-OR gate gives a '1' output when the input pins have opposite logic signals. By means of the slope selection switches alternative logic levels can be applied to these gates, which can thus determine which edge of the input pulse shall perform the start or stop function.

4.28 The selected triggering edge is differentiated by R40/C19 in the stop line and R50/C22 in the start line to provide the appropriate triggering pulse. The slope gates have the following functions:-

<u>Gate</u>	<u>Function</u>
IC19a	'B' channel stop (single line timing and totalizing)
IC19b	'B' channel start (single and double line timing, and totalizing).
IC19d	'A' channel stop in Time Interval double line.

### MANUAL START/STOP

4.29 The emitters of the Start and Stop transistors Q12 and Q10 are connected to 0V via the snap-action transistor switch Q16/Q13 and R56. This circuit provides a pulse when manual start/stop is used, which eliminates contact bounce effects. Under normal conditions capacitor C23 is charged up, and Q16 and Q13 are turned on. When the START/STOP button S50 is pressed, it rapidly discharges C23 and turns off Q16 and Q13. Turning off Q16 and Q13 effectively turns off Q12 and Q10, producing the appropriate pulses for start and stop at the inputs to the CDI Chip. Because Q16 and Q13 cannot turn on again until C23 has charged up the contact bounce pulses are suppressed.

### DATA OUTPUT AND DISPLAY SYSTEM

NOTE: Refer to the Supplementary Data in the Technical Specification at the front of the book for a summary and diagram of the data output format.

#### Multiplex Readout and Display

4.30 The Display Assembly contains a 6-digit readout system using light-emitting diode (LED) numerical indicators. The display data is fed from IC2 on pins 15 to 18, this 4-way output being fed from a parallel-to-serial (multiplex) system within the CDI Chip, to the 7-segment decoder IC17.

4.31 In the multiplex system the b.c.d. outputs from the data stores are fed in sequence on to the 4-way output. This is determined by a 10 kHz synchronising signal (derived from the frequency standard) which interrogates each decade store in turn for a period of 100  $\mu$ s. The same 10 kHz signal is used (via IC10) to 'enable' the appropriate LED in the Display.

4.32 The system is set by the (Ro) signal which occurs in the  $10^0$  state of the data output at IC2/14. This sets IC10 to the '0' state, and via IC16/1, turns on Q19. This enables the  $10^0$  digital indicator D.1.2 which displays the digit determined by the 7-segment decoder IC17. The other display LED's are then enabled in sequence for a period of 100  $\mu$ s each.

#### Decimal Point and Overflow Decode

4.33 The d.p. and overflow data is fed out from the CDI Chip during the ninth state of

the counter and is stored in the latch package IC7. Decimal point information in IC7 is applied via pins 1, 8 and 11 to the Exclusive OR gates IC11a, b and d where it is compared with the b.c.d. drive to the digit enable circuit. When the three Exclusive-OR gates have the correct logic inputs a signal will pass via the inverters IC11a-b-c to turn on Q25 at the appropriate time to achieve the correct decimal point position. When the  $10^5$  decade in the counter overflows, a 'carry' level is fed to IC7 during the ninth state. This appears at IC7/15 as a 'low' which turns on the indicator LP1. The same signal is supplied to the rear data output connector at pin B. The latched store IC7 is triggered during the ninth state by a '0' at IC16/11 which is inverted in IC11c and fed to IC7/13. Later Display Assemblies are fitted with links LK1 and LK2. See Notes on Parts List 1 and Fig. 4.

#### Gate Indicator

4.34 The LED LP2 illuminates in synchronism with the counter main gate when measurement is in progress. The main gate waveform at IC2/19, which goes 'low' when the gate is open, is inverted in IC6c and thus turns on Q28 to illuminate LP2 during the 'gate open' periods. The action of D7 and C44 is to stretch the gate lamp drive signal.

### DISPLAY TIME AND RESET GENERATOR

#### Introduction

4.35 This circuit is centred on IC9a, IC9b and transistors Q29, Q30 and Q31. It produces a display time of approximately 400 ms which is extended to approximately 2 seconds in Time Interval, Time Interval Average and Totalize. At the end of the display time a negative-going transition resets the counter in IC2/13.

#### Display Time Circuit

4.36 The main gate signal at IC2/19 is fed to the control bistable at IC9b/11. At the end of the main gate period IC9b/11 goes high, sending IC9b/8 low. This removes the clamp from the display time capacitor C46 and allows it to charge up via R96, R93, Q29 (see next para.) and switch 1S7 (NORMAL position).

4.37 Q29 is turned off by a '1' supplied to the base via inverter IC13c from an earth on R55 when the **FREQ.**, **PERIOD** and **RATIO** switches are not selected. This adds R92 to the charging circuit which increases the display time to about 2 seconds.

4.38 Capacitor C46 charges until the voltage at Q30 emitter rises above that at the base (fixed by R101/R102) at which point Q30 begins to conduct and a regenerative action develops which allows C46 to discharge very rapidly through R100 and Q30/Q31. The time taken for this discharge determines the width of the reset pulse, which should be not less than 100 ns.

#### Reset Pulse and Hold State

4.39 When the regenerative switch Q30/Q31 fires, the voltage at Q31 collector falls sharply. This negative-going pulse is fed to IC9b/13 and clears the control bistable. The transition at IC9b/8 is fed via IC6b to reset the counter by a '1' to '0' transition

at IC2/13. This reset signal is differentiated in C43/R85 and turns off Q27. The 'high' at Q27 collector is inverted in IC12e and the resultant '0' at IC17/4 briefly blanks the display while the instrument is preparing for a new measurement. When switch 1S7 is set to HOLD the +5V supply is disconnected and capacitor C46 cannot charge up, thus preventing any reset action.

#### Manual Reset

4.40 This is generated in IC9a. Pressing the manual RESET button (S52) puts a '0' on IC9a/1. The resulting '0' at IC9a/5 is inverted in IC6b to put a 'hold' on the counter via IC2/13. Release of the manual RESET allows the 10 kHz clock signal at IC9a/3 to drive the 'Q' output (IC9a/5) to the '1' state, which resets the counter via IC2/13. At the same time the transition of IC9a/6 from '0' to '1' is differentiated by R68/R90/C45 and applied to IC2/4 via IC6a and IC13e to momentarily unlatch the data stores and clear the previous reading.

#### External Reset

4.41 An external reset signal with a minimum duration of 5 ms can be applied via pin 7 of the rear data connector. This reset is applied to IC9a/1 and operates in the same way as manual reset (see previous para.).

#### Segment Check

4.42 This is obtained by selecting CHECK and holding down the manual reset button. In Check position the switch 1S5 (via R95) applies a '1' to enable IC15a. Depressing the manual reset switch S52 applies a '1' (via IC13a/2) to IC15a/1. This feeds a '0' to the segment decoder IC17/3 which produces an 'all eights' display while the reset button is held down.

### FREQUENCY STANDARD

#### Standard Oscillator Assembly 19-0834

4.43 In the standard instrument the reference frequency is generated in a 5 MHz discrete component assembly attached to the rear panel with access to the trimming capacitor (C4), via a rear panel aperture. The circuit is shown in the main p.c.b. circuit (Fig. 4) and also in Fig. 2. In early models the 5 MHz oscillator was mounted on the main p.c.b. and the output connected via link LK1. This early circuit (Q17, XL1, C35 etc.) is shown in Fig. 4. The circuit is identical to the 19-0834 in Fig. 2, but the component references are different.

#### Optional Oscillator

4.44 The fast warm up oscillator Type 9442 is mounted on a B7G base and connected as shown in the circuit diagram (Fig. 4). This is a precision item. If a fault develops, users are advised to return the oscillator unit to Racal Instruments Ltd. or approved agent, for servicing. No parts list or circuit information is provided in this handbook.

### Frequency Doubler

4.45 The 5 MHz reference from the oscillator is fed via C32 to a shaper formed by IC3d with L2 and diodes D5/D6. The square wave signal is then fed via IC3a to the monostables IC4a and IC4b. A positive monostable pulse is produced from each edge of the input and fed from IC4a/4 and IC4b/12 respectively to the Nand gate IC3c, thus producing a 10 MHz input to the CDI Chip at IC2 pin 5. In earlier models (refer to handbook Issue 1) the shaped signal is fed via an inverter IC4a to the two branches of a digital doubler with output at IC3a/3. By a process which delays the signal in one path by a series of inverters, then by an Exclusive-OR arrangement, the two signal paths produce a doubling effect.

### 1 MHz Reference Output

4.46 The 1 MHz reference is fed from IC2/6 via the buffer IC15d to the 1 MHz BNC output socket on the rear panel.

### External Standard Input

4.47 A 1 MHz reference can be fed in via the 'B' input socket as this socket is not used in Frequency and Period modes. The input path is via the 'B' channel amplifier and the Start gates IC19b etc to Q12 and thence to the input of the CDI Chip at IC2/20.

## POWER SUPPLY

4.48 The a.c. supply is fed in via a 3-pin fixed plug on the rear panel, thence via the anti-surge fuse FS50 to the transformer T50. The transformer tapings are arranged to suit the local supply voltage as shown in the diagram on page 5-3. The output at secondary winding 'A' is rectified to provide +5V by the potted bridge rectifier D50, which is mounted on the rear panel for adequate heat dissipation. The -5V supply is provided by the discrete diode bridge D11-D14. Smoothing and reservoir capacitors are C49, C51, C53 and C54. Capacitor C50 ensures that any ripple in the +5V line will not affect the -5V stabilizing comparator IC5b, and C52 and C60 stabilize the system.

### +5V Stabilization

4.49 The reference is provided from the +5V rail by zener diode D10 which is connected to the comparator IC5a/2. The other input to the comparator (IC5a/1) is from the 0V rail. The comparator function is to ensure that the 0V rail is maintained 5.1V below the voltage of the +5V rail. Any change from this state will cause IC5a to apply a signal to Q33 which will regulate the current in Q50 to restore the correct condition.

### -5V Stabilization

4.50 The -5V stabilizing comparator is IC5b, in which both inputs should be at 0V when conditions are correct. IC5b/7 is connected to the 0V rail and IC5b/6 to the mid-point of a potential divider (R104, R105 and R106) which is connected between the stabilized +5V rail and the -5V rail. If the level at IC5b/6 departs from 0V then a correcting signal

from IC5b/10 will regulate the current in Q32 to correct the error.

#### On/Off Switching

4.51 The single pole Power on/off switch S51 operates in the negative supply from the rectifiers D11-D14. It also switches off the +5V supply by disconnecting the reference zener diode D10 in the 'off' position.

#### CDI Chip 2V Supply

4.52 A stabilized +2V supply is derived from the +5V rail via the regulator Q14 which is controlled by Q15 from a reference voltage provided by the CDI chip at IC2/11.



CHAPTER 5

MAINTENANCE

TABLE 6: TEST EQUIPMENT REQUIRED

Item No.	Preferred Item	Remarks
1	Digital Multimeter Racal 9077	Provides 10 mV resolution on 50V range. DC Input resistance 10 M $\Omega$
2	Oscilloscope BWD 525	Bandwidth d.c. to 50 MHz Sensitivity 50 mV/cm
3	Frequency Standard	1 MHz; accuracy $\pm 1$ part in $10^8$ Output 1V r.m.s. nominal
4	Signal Generator  Racal 9061 ) 9062 ) combi- 9063 ) nation	Required frequency range 10 Hz to 60 MHz Output from 5 mV r.m.s. to 1V r.m.s., into 50 $\Omega$ NOTE: LF Signal Generator must have signal-to-noise ratio better than 40 dB.
5	Millivoltmeter Racal 9301	Required frequency range: 10 kHz to 60 MHz Measurement: 1 mV to 3V
6	Coaxial leads, 50 $\Omega$	BNC to BNC. Length 3 ft (1 metre) approximately.
7	Terminating Pad, BNC, 50 $\Omega$ (quantity 1)	
8	Terminating connector, BNC. 50 $\Omega$ (T Piece, quantity 3)	
9	Power Supply 240V $\pm$ 2%, 50 Hz Single phase, line neutral and earth.	
10	Pulse Generator (For Time Interval Check)	1 kHz to 1 MHz p.r.f. Pulse width 100 ns to 0.1 ms. Amplitude 50 mV to +3V.

## REMOVAL OF COVERS

WARNING: DANGEROUS AC VOLTAGES ARE EXPOSED WHEN COVERS ARE REMOVED WITH AC SUPPLY CONNECTED.

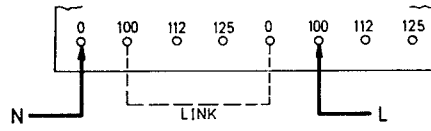
- 5.1
- (1) Set the POWER switch to 'off', switch off the a.c. supply at the supply point and unplug the power lead.
  - (2) Remove the rubber plugs (located near to the rear end) from both side panels of the instrument and slacken, by about two turns, the screws revealed.
  - (3) Grip the rear panel assembly and ease it back from the main case to the maximum extent available (about 5 mm).
  - (4) The rear edge of either cover can now be lifted and the cover withdrawn outwards and rearwards.
  - (5) To replace the covers reverse the above procedure.

## TRANSFORMER VOLTAGE SELECTION

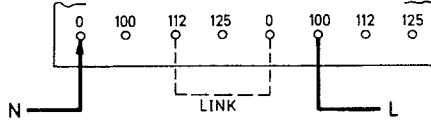
5.2 The instrument will normally be dispatched with the transformer primary tapping set to the 223-251V supply range. To check the selection proceed as follows.

- (1) Unplug the power cable from the supply and remove the top cover (see para. 5.1).
- (2) Refer to the diagrams on the next page and:-
  - (a) Note the diagram which corresponds to the local a.c. supply voltage.
  - (b) Connect the correct link(s) and make the required line lead connection (L) as indicated in the appropriate diagram.
- (3) Verify that the label on the rear panel indicates correctly the selected voltage range. Alternative labels are provided with the instrument for ranges other than 223V to 251V.
- (4) Replace the top cover.

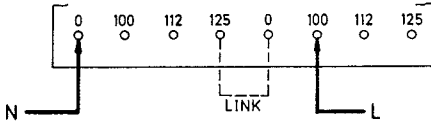
188-212V



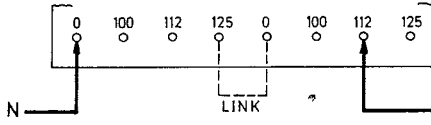
200-225V



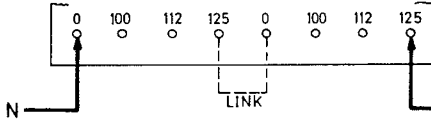
212-239V



223-251V

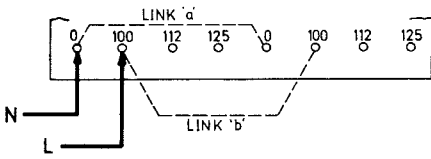


235-265V

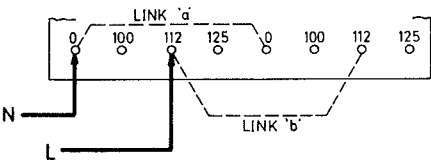


188V TO 265V

94-106V

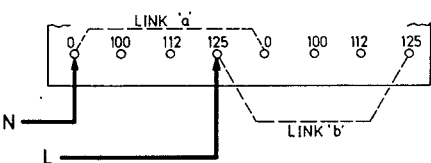


106-119V



94V TO 132V

118-132V



Mains Transformer  
Voltage Selection Diagrams

## FUSES

- 5.3 (1) Check that the power fuse on the rear panel is correctly rated for the supply voltage, as follows. The fuse is a glass cartridge type, 5 x 20 mm.

<u>Supply Range</u>	<u>Fuse Rating</u>	<u>Racal Part No.</u>
188V to 265V	100 mA anti-surge	23-0033
94V to 132V	200 mA anti-surge	23-0027

## POWER LEAD

- 5.4 Fit a suitable plug to the power lead in accordance with the standard colour code: -

Brown ..... Line  
Blue ..... Neutral  
Green/Yellow .... Earth (Ground)

## POWER SUPPLY CHECK

- 5.5 (1) Remove the covers and prepare the power supply as described in the preceding paragraphs. Check that the a.c. supply voltage is correct.
- (2) With power supply connected, switch POWER to ON.
- (3) Using the multimeter (Page 5.1, Table 6, item 1) check the d.c. voltages at the following points on the main p.c.b. Fig. 3 at the back of the book shows the component layout.

<u>Test Point</u>	<u>Measurement</u>	<u>Remarks</u>
TP7	+5.1V $\pm$ 0.1V )	Relative to chassis.
TP6	-5V $\pm$ 0.2V )	

**NOTE:** There are no adjustments in the power supply circuit. If the 5V supplies are outside the limits given above, the mains supply voltage and the transformer line lead connection and links (see page 5-3) should be carefully checked. If these are correct the zener reference diode D10 should be checked.

## PERFORMANCE TESTS AND CALIBRATION

**NOTE:** If the Racal Synthesized Signal Generator is used, with its frequency standard synchronised to that of the 9901, a readout accuracy of  $\pm 1$  count will be obtained.

### Segment, Decimal Point and Self Check

- 5.6
- (1) Connect the a.c. supply and set the POWER switch to ON.
  - (2) Set the CHECK/OPERATE switch to CHECK.
  - (3) Depress the FREQ. 'A' MAN button and verify that the GATE indicator illuminates.
  - (4) The instrument should now read 1000 kHz. Refer to Table 7 and check the display and decimal points (Freq. column) for each 'n' range button.
  - (5) Depress the PERIOD 'A' button and verify the readout and decimal points according to the Period column of Table 7.
  - (6) Briefly hold in the RESET button and check that the display reads 'all eights' (segment check).

TABLE 7  
SELF CHECK READOUT

Range 'n' Selected	Gate Time	Display ( $\pm 1$ count)	
		Frequency	Period
1	1 ms	001000.	000001.
10	10 ms	01000.0	00001.0
$10^2$	100 ms	1000.00	0001.00
$10^3$	1 sec	* 000.000	001.000
$10^4$	10 sec	* 00.0000	01.0000
$10^5$	100 sec	* 0.00000	1.00000

**NOTE:** With readouts marked (\*) the most significant digit will overspill and the OVERFLOW lamp will illuminate after the appropriate gate time.

- (7) Depress the **FREQ. AUTO** button and verify that display reads 1000.00. This checks that the **AUTO** facility has selected the optimum time base range ( $10^2$ ) for the 1 MHz signal.
- (8) Finally set the **CHECK/OPERATE** switch to **OPERATE**.

Sensitivity Checks: Input 'A'

5.7 Equipment Required

HF Signal Generator (Page 5-1, Table 6, item 4).

5.8 Frequency and Period Check

- (1) Set the controls as follows:-
  - (a) **HOLD/NORMAL** to **NORMAL**.
  - (b) **AC/DC** to **AC**.
  - (c) **FREQ. 'A' MAN**.
  - (d) **AC SENSITIVITY** control anticlockwise to 10 mV position.
  - (e) **Select Range** button  $n = 10$ .
- (2) Terminate the 'A' input socket in  $50\Omega$  and apply 55 MHz at a level of 10 mV r.m.s.
- (3) Verify a correct and stable count. If necessary adjust potentiometer R11 (on the main p.c.b.) clockwise to obtain steady counting. (Refer to Fig. 3 at back of book for component location).
- (4) Apply the signal frequencies listed in Table 8 below. Select an appropriate 'n' button and verify a stable count in each case.

TABLE 8  
'A' Input Sensitivity Check

Range Selection ('n')	Input Frequency	Signal Level (r.m.s.)	Tolerance
n = 1	55 MHz	)	See Note at top of page 5-5
n = 1	10 MHz	)	
n = $10^3$	1 MHz	) 10 mV	
n = $10^3$	1 kHz	)	

- (5) Apply a 1 kHz signal at 10 mV r.m.s.
- (6) Depress the PERIOD 'A' and  $n = 10^3$  Range buttons.
- (7) Verify a display of approximately 1000.00.
- (8) Depress the FREQ. 'A' button. Change the signal generator to 20 MHz at 1V r.m.s. approximately.
- (9) Turn the SENSITIVITY control clockwise and verify that counting ceases before the control reaches the fully clockwise position.
- (10) Reset the SENSITIVITY to the 10 mV position and disconnect the signal generator.

### Time Interval Single Line Check

#### 5.9 Equipment Required









Timing source such as a pulse generator.

#### 5.10 Procedure

- (1) Set the following controls:-
  - (a) HOLD/NORMAL to NORMAL.
  - (b) Pulse/Contact to Pulse .
  - (c) B-B/B-A switch to B-B.
  - (d) Depress the TI button.
- (2) Set the pulse generator to 1 kHz p.r.f. 1:1 mark/space ratio and amplitude 1V peak to peak. Connect to the 'B' input socket terminated in  $50\Omega$
- (3) Select the  $n = 10^2$  Range button. Set the START and STOP slope switches to the positions in Table 9 and verify the measurements in column (x) bearing in mind the calibration accuracy of the pulse generator.
- (4) Set the pulse generator to 4:1 mark/space ratio and verify the measurements in Table 9 column (y). This checks for correct switch connections, if for example, the display board has been replaced.

TABLE 9

Time Interval Single Line Check

Slope Switch Selection		Displayed Measurement with 1 kHz Input		
		(x) Mark/Space 1:1	(y) Mark/Space 4:1	
Start	Stop			
(a)			1 ms	1 ms
(b)			1 ms	1 ms
(c)			500 $\mu$ s	800 $\mu$ s
(d)			500 $\mu$ s	200 $\mu$ s

Time Interval Double Line Check

5.11 Equipment Required



Pulse Generator (Page 5-1, Table 6, item 10)  
Two BNC 'T' Pieces: one 50 $\Omega$  termination.

5.12 Procedure

- (1) Set the B-B/B-A switch to B-A and the AC/DC switch to DC.
- (2) Connect the pulse generator to both input sockets, using two BNC 'T' pieces with a single 50 $\Omega$  termination.
- (3) Refer to Table 9 and perform checks (c) and (d).



### Time Interval Average Check

- NOTES: 1. The repetition rate of the timing pulses used for this test must not be harmonically related to the frequency standard of the counter.
2. The minimum space (dead time) between intervals is 100 ns.
- 5.13 (1) Set up the 9901 controls as for Time Interval single line (para. 5.10).
- (2) Set the pulse generator to a pulse width of 200 ns, and a p.r.f. not harmonically related to 1 MHz. (See also NOTE 2 above).
- (3) Set the START slope switch to  and the STOP slope switch to .
- (4) Depress the  $10^3$  Range button and verify that the display reads the pulse duration as set on the pulse generator, bearing in mind the calibration accuracy of the pulse generator.

### Ratio Check

#### 5.14 Equipment Required

Signal Generator (Page 5-1, Table 6, item 4).  
Two BNC 'T' Pieces and one 50Ω termination.

#### 5.15 Procedure

- (1) Set the 9901 controls as follows:-
- (a) AC/DC switch to DC.
  - (b) Pulse/Contact switch to 'Pulse'.
  - (c) HOLD/NORMAL to NORMAL.
  - (d) Depress the RATIO button.
- (2) Set the signal generator to 5 MHz at 100 mV r.m.s.
- (3) Connect the signal generator output to the 'A' and 'B' input sockets, using two BNC 'T' pieces with a single 50Ω termination.
- (4) Depress the  $n = 1$  Range button and verify that the display reads 000001 + 1 count.
- (5) Depress the Range buttons ( $10$ ) to ( $10^5$ ) in turn and check that the ratio reading increases by a factor of ten at each step.
- (6) Disconnect the signal generator from the 'B' input.