PUBLICATION NO. 980647

1991 AND 1992
UNIVERSAL TIMER/COUNTER

RACAL-DANA

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RACAL

PUBLICATION DATE: AUGUST 1987

WARRANTY

Within one year of purchase, Racal-Dana will repair or replace your instrument, at our option, if in any way it is defective in material or workmanship. The instrument must be returned to the country of purchase, unless prior arrangement has been made, and Racal-Dana Instruments will pay all parts and labor charges. Just call Racal-Dana Customer Service at (714) 859-8999 in U.S.A., (0703) 843265 in England, (1) 3-955-8888 in France, 06102-2861/2 in Germany or (02) 5062767, 5052686, or 503444 in Italy for assistance. We will advise you of the proper shipping address for your prepaid shipment. Your instrument will be returned to you freight prepaid.

PROPRIETARY NOTICE

This document and the technical data herein disclosed, are proprietary to Racal-Dana Instruments, Inc., and shall not, without express written permission of Racal-Dana Instruments, Inc., be used, in whole or in part to solicit quotations from a competitive source or used for manufacture by anyone other than Racal-Dana Instruments, Inc. The information herein has been developed at private expense, and may only be used for operation and maintenance reference purposes or for purposes of engineering evaluation and incorporation into technical specifications and other documents which specify procurement of products from Racal-Dana Instruments, Inc.

FOR YOUR SAFETY

Before undertaking any maintenance procedure, whether it be a specific troubleshooting or maintenance procedure described herein or an exploratory procedure aimed at determining whether there has been a malfunction, read the applicable section of this manual and note carefully the **WARNING** and **CAUTION** notices contained therein.

The equipment described in this manual contains voltage hazardous to human life and safety and which is capable of inflicting personal injury. The cautionary and warning notes are included in this manual to alert operator and maintenance personnel to the electrical hazards and thus prevent personal injury and damage to equipment.

If this instrument is to be powered from the AC line (mains) through an autotransformer (such as a Variac or equivalent) ensure that the common connector is connected to the neutral (earthed pole) of the power supply.

Before operating the unit ensure that the protective conductor (green wire) is connected to the ground (earth) protective conductor of the power outlet. Do not defeat the protective feature of the third protective conductor in the power cord by using a two conductor extension cord or a three-prong/two-prong adaptor.

Maintenance and calibration procedures contained in this manual sometimes call for operation of the unit with power applied and protective covers removed. Read the procedures carefully and heed Warnings to avoid "live" circuit points to ensure your personal safety.

Before operating this instrument:

1. Ensure that the instrument is configured to operate on the voltage available at the power source. See Installation Section.

2. Ensure that the proper fuse is in place in the instrument for the power source on which the instrument is to be operated.

3. Ensure that all other devices connected to or in proximity to this instrument are properly grounded or connected to the protective third-wire earth ground.

If at any time the instrument:

- Fails to operate satisfactorily
- Shows visible damage
- Has been stored under unfavorable conditions
- Has sustained stress

It should not be used until its performance has been checked by qualified personnel.

Publication No. 980682

1991/2 Battery Pack Kit (Opt. 07)
Instruction Sheet

May 8, 1989

The assembly instructions provided, supersede those found on pages 2-10 through 2-12 of the 1991/2 instruction manual (Publication No. 980647).

11-1625, BATTERY PACK KIT (OPTION 07)

REF. DESIG.	RACAL-DANA P/N	DESCRIPTION	FSC	MFG. P/N
1	11-1722	PCB ASSY., CHASSIS	21793	11-1722
2	11-1599	BRACKET	21793	11-1599
3	11-1723	BATTERY CHASSIS ASSEMBLY	21793	11-1723
4	13-2040	BATTERY OPTION PLATE	21793	13-2040
5	24-2801	WASHER, CRINKLE, M3 (2 REQ'D)	---	---
6	24-7721	SCREW, PAN HD, M3 X 6 (2 REQ'D)	---	---
7	24-2802	WASHER, CRINKLE, M4 (6 REQ'D)	---	---
8	24-2705	WASHER, PLAIN, M4 (2 REQ'D)	---	---
9	24-7730	SCREW, PAN HD, M4 X 8 (6 REQ'D)	---	---
10	15-0496	OPTION LABEL	21793	15-0496
11	000121	RES, CARBON, 120 OHM, 1/4W, 5%	81349	RC07GF121J

ASSEMBLY INSTRUCTIONS

(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.

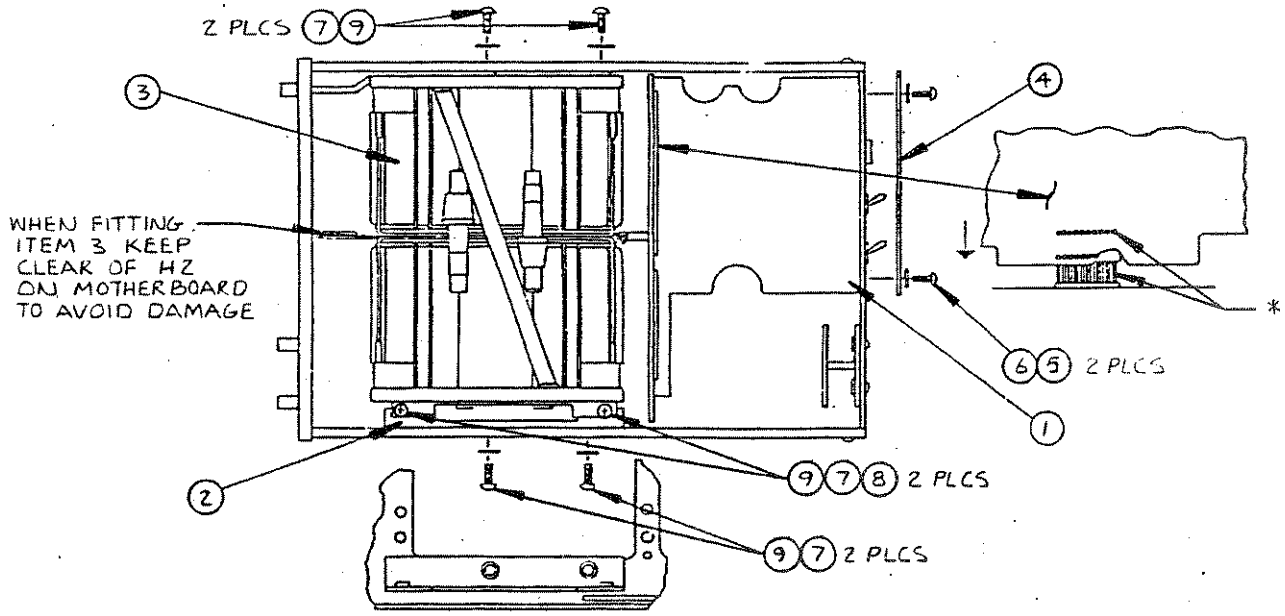
(14) Position the battery pack within the chassis, with the supporting lugs resting on the mounting bracket. Secure the battery pack to the left-hand side frame, using two M4 screws and washers.

(15) Secure the supporting lugs to the mounting bracket, using two 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.

(18) Fit option label to serial no. label on rear panel.



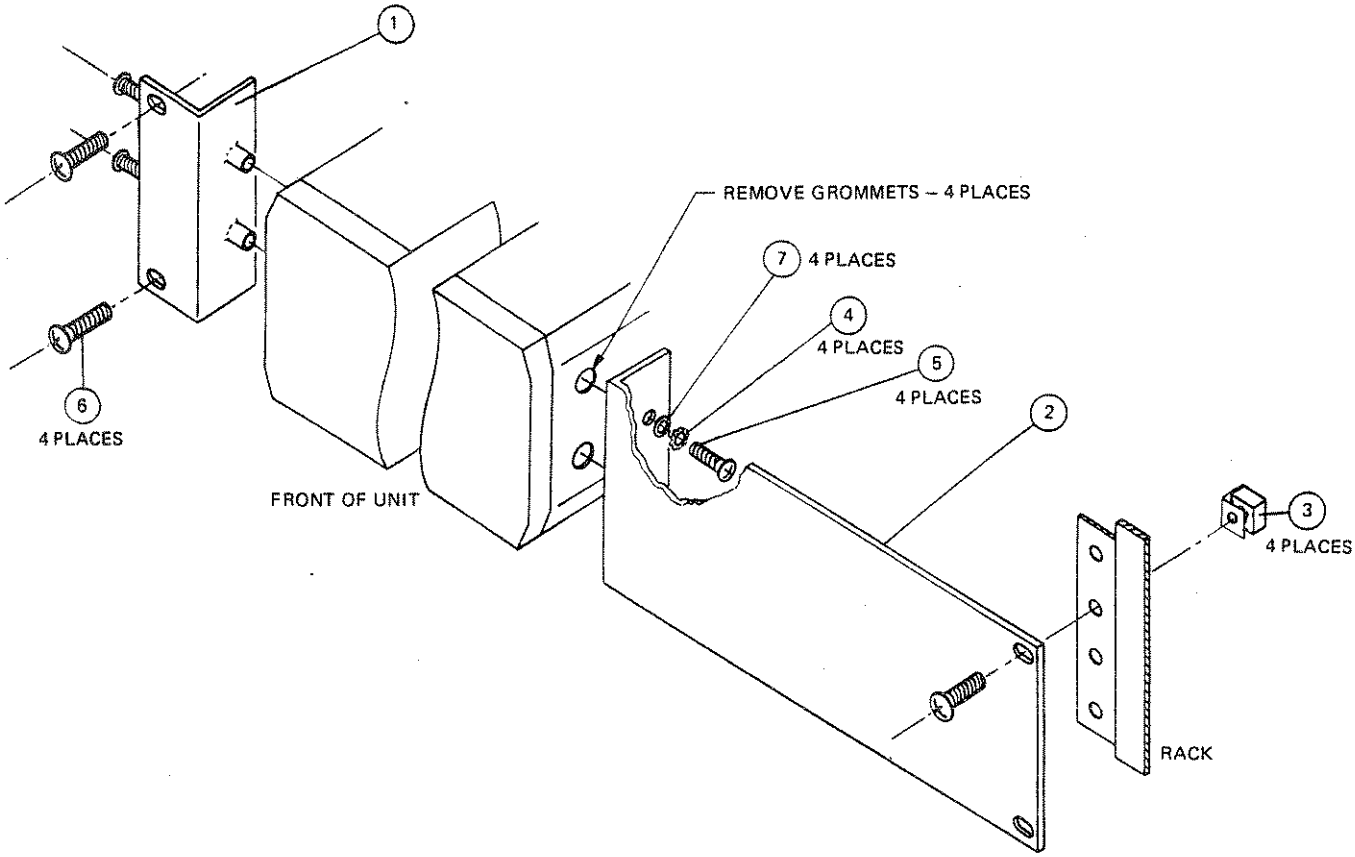
* . FOR SOCKETS <u>WITHOUT KEYWAYS</u> ALIGN PINS AND SOLDER PADS CAREFULLY.

1. Remove grommets - 4 places.

2. Attach rack mounting ear (1) and extension (2) to side of unit with screw (5) and crinkle washer (4) and flat washer (7) in 4 places.

3. Clip Tinnerman nuts (3) to rack in 4 places.

4. Attach unit to rack/nuts with screws (6) in 4 places.



CONTENTS OF KIT 404673)

ITEM NUMBER	RACAL-DANA P/N	DESCRIPTION (QTY.)	FSC	MANU P/N
1	455433	Rack Mounting Ear (1)	21793	455433
2	455439	Mounting Ear Extension (1)	21793	455439
3	610920	Nut, Retainer (4)	21793	610920
4	R-24-2802	Washer, Crinkle, M4 (4)	21793	R-24-2802
5	616346	Screw, PPH, M4 x 16 (4)	---	----
6	615091	Screw, PPH, 10-32 x .500 (4)	---	----
7	617104	Washer, Flat #8 Light Series (4)	---	----

AMENDMENT TO

MODEL 1991/2 INSTRUCTION MANUAL
PUBLICATION NO.
980647 and 980651

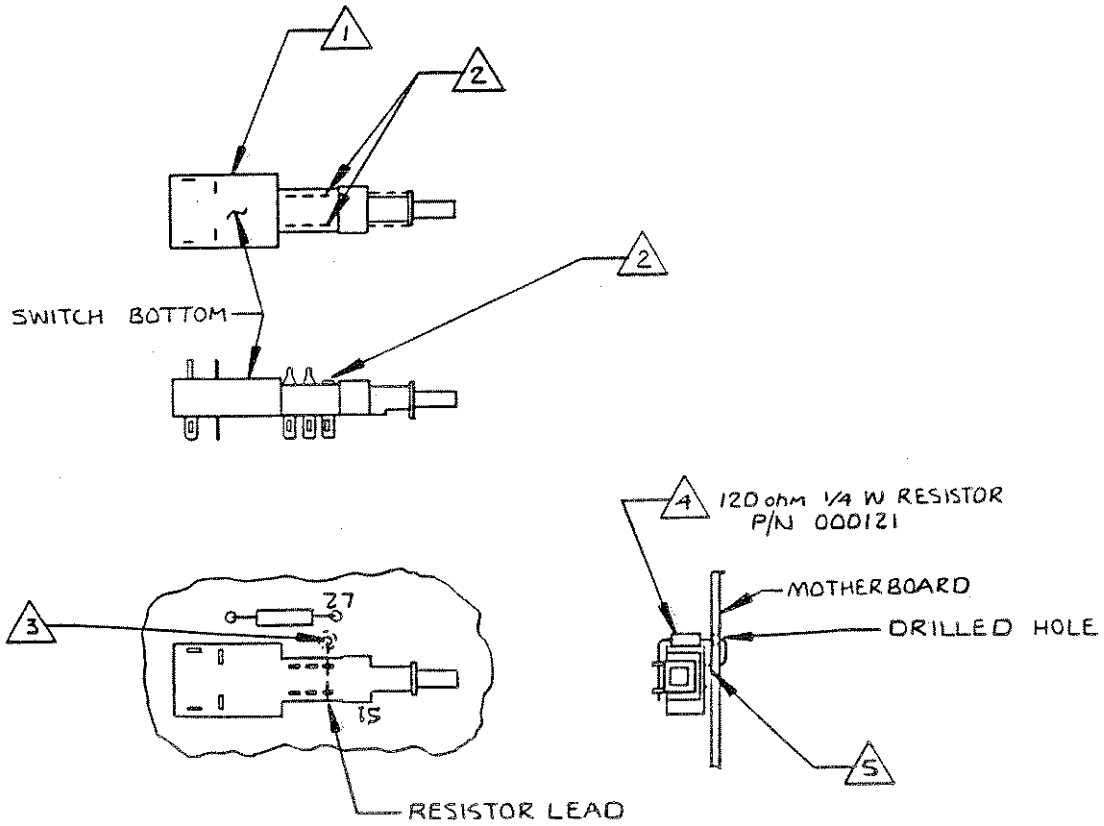
April 28, 1989

1. Pages 1-11 and 1-20, Change the part number for Option 60A Rack Mounting Kit from 11-1648 to 404673.

2. Page 2-5 Replace Section 2.8.1 Option 60A Rack Mounting Instructions with the information provided in this amendment.

THE FOLLOWING MOTHERBOARD MODIFICATIONS MUST BE PERFORMED WHEN INSTALLING BATTERY PACK OPTION ON 1991/1992:

1. REMOVE THE AC MAINS POWER SWITCH S1 FROM INSTRUMENT MOTHERBOARD.
2. CLIP 2 PINS ON BOTTOM SIDE OF SWITCH AS SHOWN. CLIP PINS TO WITHIN .040 OR AS FLUSH AS POSSIBLE.
3. DRILL .040 TO .060 DIA HOLE IN MOTHERBOARD APPROX. WHERE SHOWN.
4. RE-INSTALL SWITCH AS SHOWN. INSERT ONE END OF 120 ohm, 1/4 W RESISTOR INTO DRILLED HOLE AND SOLDER OTHER END TO SWITCH TERMINALS AS SHOWN.
5. SOLDER RESISTOR LEAD INTO CLOSEST UNUSED HOLE BENEATH THE SWITCH. (HOLE ONCE OCCUPIED BY CLIPPED LEAD). CLIPPED SWITCH LEAD MUST CLEAR SOLDERED RESISTOR LEAD BY AT LEAST 0.025".



MOTHERBOARD MODIFICATION DETAILS

Amendment to

Racal-Dana Model 1991/2 Instruction Manual

Publication No. 980647

May 16, 1988

1. This Amendment adds the drawings and Parts Lists for the Option 04A and 04T Oscillators.

2. Option 04A (Catalog Order No. 404392) is shown on drawing 404397 (Page B2).

3. Option 04T (Catalog Order No. 11-1713) is shown on drawing 19-1208 (Page B3).

4. Parts lists are as follows:

404397 - OVEN OSCILLATOR (OPTION 04A)

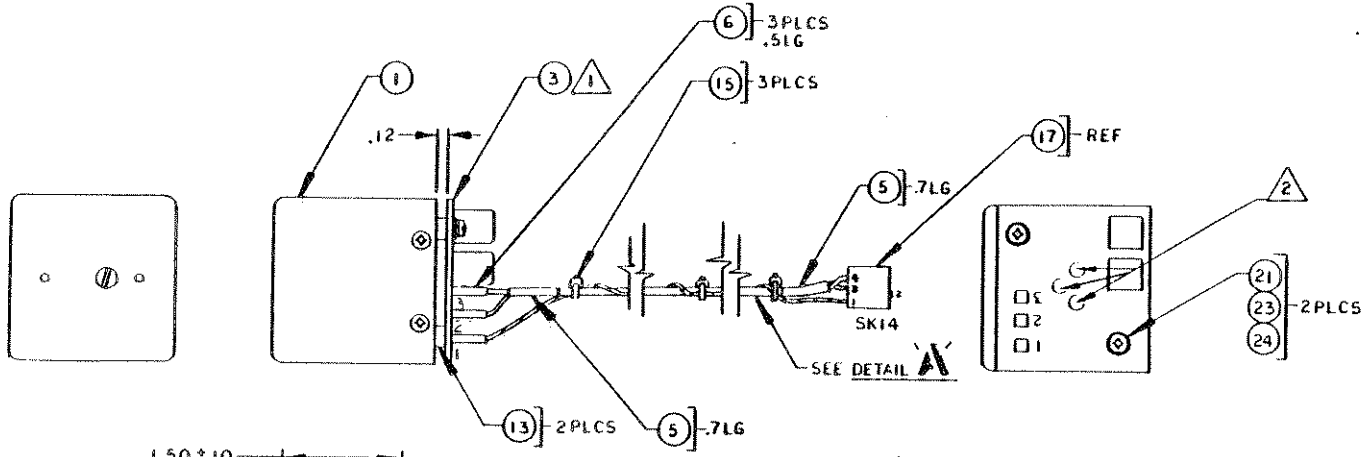
REF. DESIG.	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
SK14	611056	CONNECTOR, CABLE, 5-PIN	21793	611056
1	11-1710	OSCILLATOR	21793	11-1710
3	R-19-1238	PCB ASSY., DOUBLER	21793	R-19-1238
5	500009	TUBING, SHRINK, .125 ID, BLK	—	—
6	500064	TUBING, SHRINK, .01 ID	—	—
8	500174	CABLE, COAX, LOW THERMAL	—	—
10	524555	WIRE, TEFLON, STRANDED, 24 GA, GRN	—	—
11	524929	WIRE, TEFLON, STRANDED, 24 GA, WHT/RED	—	—
13	610304	SPACER, 1/4D X 1/2 LG (2 REQ'D)	—	—
15	610777	CABLE TIE (3 REQ'D)	53421	T18R
17	611052	KEY, POLARIZING, PLUG	00779	87077-1
18	611053	TERMINAL, CRIMP (3 REQ'D)	00779	530553-2
21	611074	SCREW, METRIC, M3 X 10 (2 REQ'D)	—	—
23	617102	WASHER, FLAT, #4, LIGHT SERIES (2 REQ'D)	—	—
24	617127	WASHER, LOCK, #4, LIGHT SERIES (2 REQ'D)	—	—

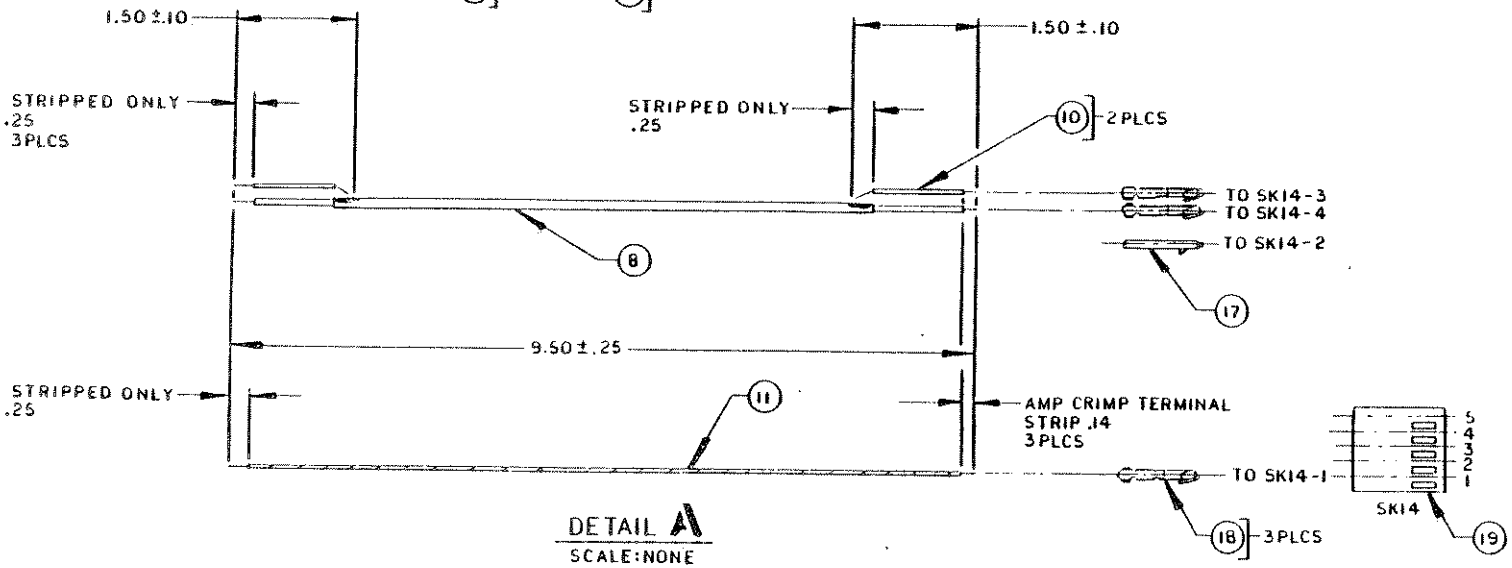
19-1208 - OVEN OSCILLATOR (OPTION 04T)

REF. DESIG.	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
C1	100133	CAP, CERAM, .1 UF, LOW PROFILE, 20%	32897	8131LP-100-25U-104M
OSC 1	921014	OSCILLATOR	NDKAM	NSA0134A
SK14	R-23-5166	CONNECTOR, 5-WAY	21793	R-23-5166
10	R-18-1147	PC BOARD (UNLOADED)	21793	R-18-1147

5. Add to List of Suppliers on Page 8-3.

NDKAM = NDK AMERICA INC., CUPERTINO, CA





DETAIL A
SCALE:NONE

2 SOLDER AT ASSY.

1 REMOVE & DISCARD CABLE SUPPLIED WITH ITEM 3 & REPLACE WITH ITEMS 5,6,8,10,11,15, & 17-19.

NOTES UNLESS OTHERWISE SPECIFIED

RACAL-DANA Instruments Inc.
4 GOODYEAR IRVINE CALIFORNIA 92714

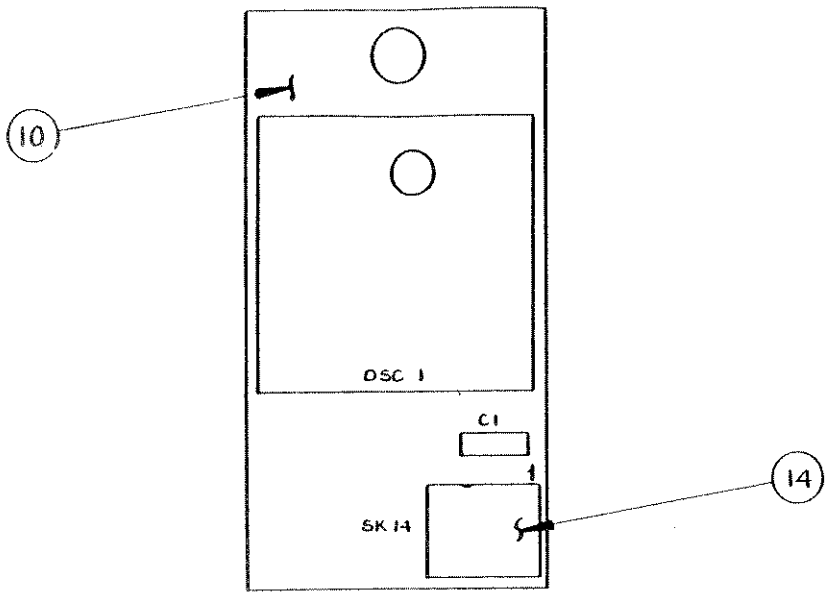
DOCUMENT TITLE
OVEN OSCILLATOR, 9444

SIZE	CODE IDENT NO.	DOCUMENT NO.	REV
C	21793	404397	A

SCALE — SHEET 1 OF 3

DOC NO. 404397

DRG No	USED ON 1991 , 1992 (11-1713)



RACAL-DANA INSTRUMENTS LTD	RACAL DRG No R-19-1208	REV A
TITLE PCB ASSY, 10 MHZ TCXO	DRAWING No SHEET 1 OF 2	

AMENDMENT

Racal-Dana Model 1991/2

Instruction Manual, Part Number 980651/980647

April 10, 1988

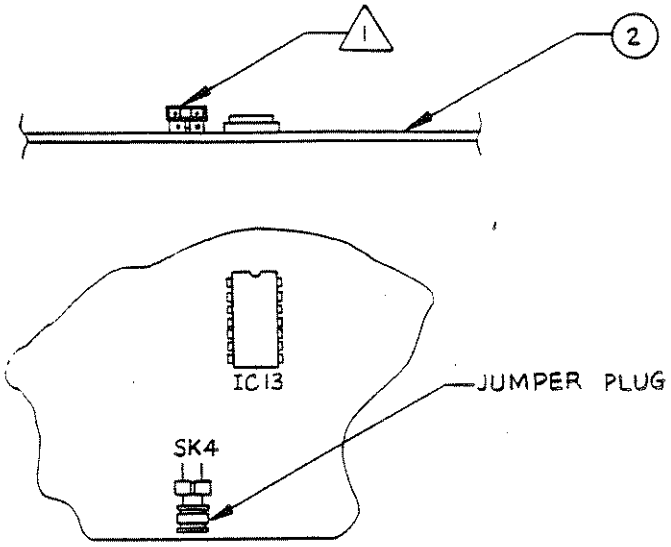
1. **Addition of GPIB Assembly**

   a. On page 7-1, add the following to the list of drawings:

      Figure 7.10A GPIB Assembly (404574)....7-22.

   b. On page 7-1, change the designation of Figure 7.10 to 7.10B. (Figure 7.10B is a subassembly of Figure 7.10A).

   c. On page 7-22, add Figure 7.10A, GPIB Assembly (404574) as shown below:



1 MAKE CERTAIN JUMPER PLUG IS INSTALLED IN UPPER TWO PINS OF SK4 AS SHOWN.

NOTES: UNLESS OTHERWISE SPECIFIED

   d. On page 7-22, change the designation of Figure 7.10 to 7.10B.

   e. On page 8-1, add the following to the listing of parts lists:
      GPIB Assembly (404574)....8-17

   f. On page 8-17, add the parts list for 404574-GPIB Assembly:

      Ref. Desig: {2} 1, Racal-Dana P/N: 401820, Description: PCB Assy, GPIB, FSC: 21793, Manu P/N: 401820

2. **Update of PCB Assembly, GPIB (401820) from Revision A to Revision B.**

   a. On page 7-22, delete item 50 from the drawing and add the following note:

      Trim lead length of SK4 connector so that lead protrusion on PCB circuit side does not exceed 0.072 inch.

   b. On page 8-17, delete item 50 (11-1603) from GPIB PCB Assy. parts list.

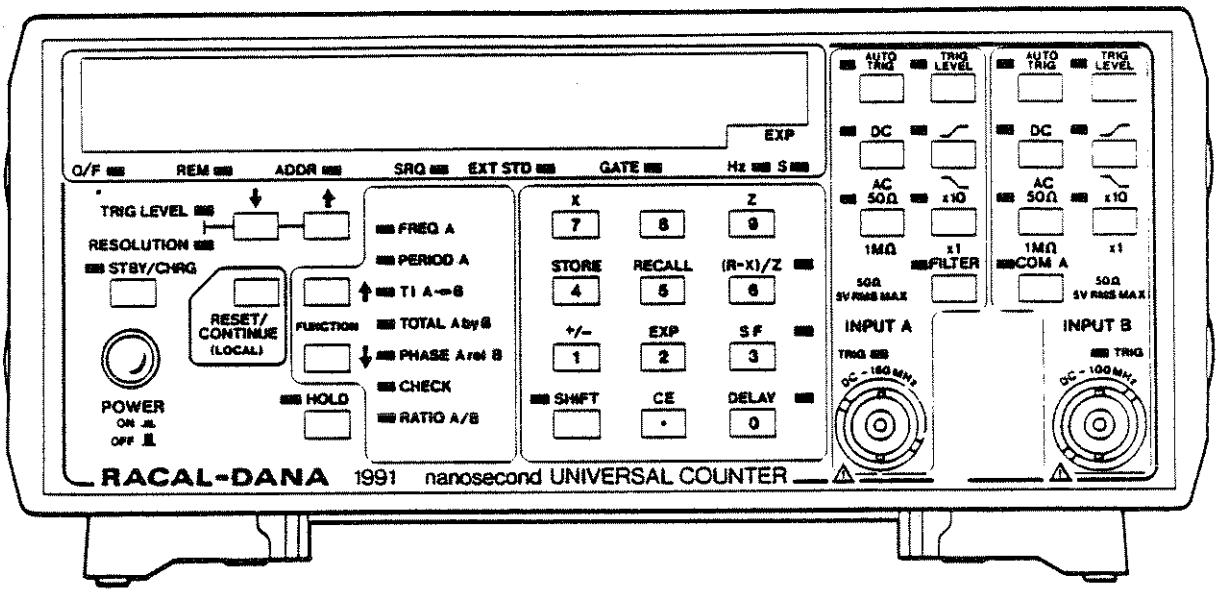


Figure 1.1 - Model 1991 Universal Timer/Counter

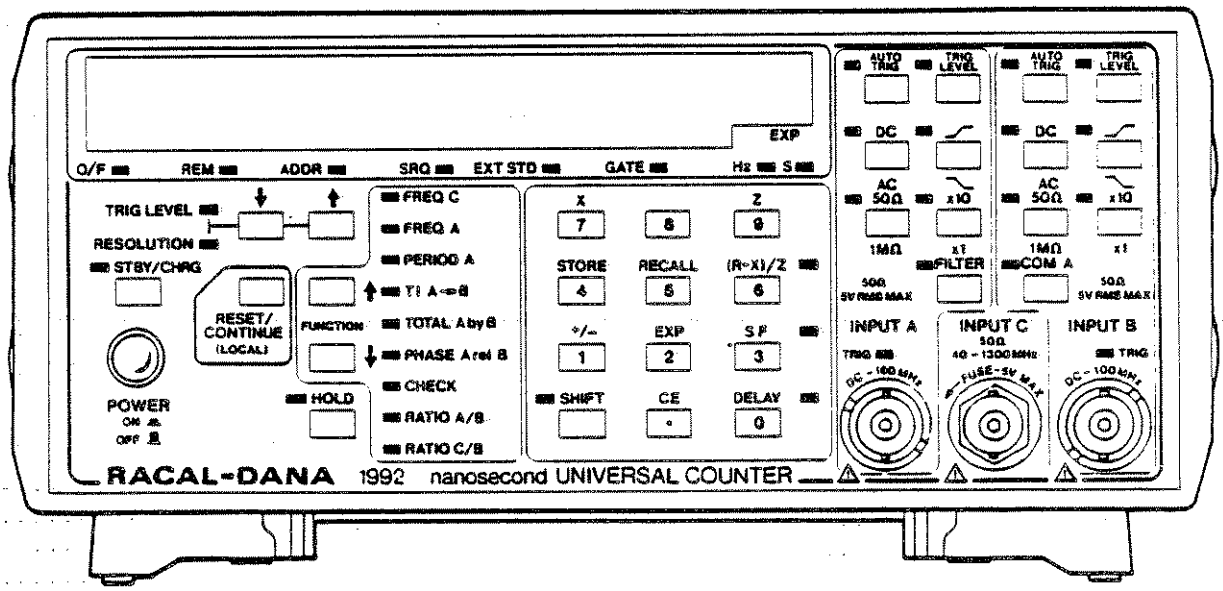


Figure 1.2 - Model 1992 Universal Timer/Counter

AMENDMENT TO

THE FOLLOWING RACAL-DANA INSTRUCTION MANUALS

1991/2 Publication No. 980647
1991/2 Publication No. 980651
1992-02M Publication No. 980636
1994 Publication No. 980601

June 27, 1989

Page 6-15

Special Function (SF) 76 should be: 74

SECTION 1 GENERAL INFORMATION

1.1 INTRODUCTION

1.1.1 This Instruction Manual provides information for installing, operating, and servicing of Racal-Dana's 1991 and 1992 Universal Timer Counters. Figures 1.1 and 1.2 are front views of the 1991 and 1992. The 1991 offers universal counter functions using Inputs A and B. The 1992 also provides frequency measurements to 1.3 GHz using Input C.

1.2 SUMMARY

1.2.1 This manual is organized into the following eight sections:

SECTION 1. General Information:

a. Published Specifications

b. Safety

c. Product Support

d. General Description

SECTION 2. Installation and Preparation for Use:

a. Unpacking and Initial Inspection

b. Reshipment

c. Power Connections

d. Storage and Temperature

e. Functional Check

f. Miscellaneous Setup Procedures

g. Option Installation Instructions

SECTION 3. Local Operation:

a. Panel Descriptions

b. Operating Procedures

c. Trigger Level

d. Display Resolution

e. Gate Time

f. Stop Circuit Delay (Hold Off)

g. Special Functions

h. Error Codes

i. Math Function

j. External Arming

SECTION 4. GPIB Operation:

a. GPIB Description

b. GPIB Address Assignment

c. GPIB Functional Check

d. Interface Message Repertoire and Response

e. GPIB Operating Modes

f. Output Message Format

g. Service Request

h. Status Byte

i. Input Commands

SECTION 5. General Theory of Operation:

a. Functional Blocks

b. Theory of Operation by Block

SECTION 6. Maintenance:

a. PVP/Calibration Inspection Intervals

b. Required Test Equipment

c. Dismantling and Reassembly

d. Special Functions for Diagnostic Purposes

e. Troubleshooting

f. Post-Repair Setup

g. Internal Frequency Standard - Routine Calibration

h. Overall Performance Verification Procedure

SECTION 7. Drawings:

a. Assembly Drawings

b. Schematic Drawings

SECTION 8. Parts List:

a. Replaceable Parts and Assemblies

1.3 SPECIFICATIONS

1.3.1 Table 1.1 lists the 1991/1992 specifications. The specifications indicate the performance standards to which the instrument conforms at the time of shipment.

Table 1.1 - 1991/1992 Specifications

INPUT CHARACTERISTICS (MODEL 1991)	
Inputs A and B	
Frequency Range:	
Input A:	DC to 160 MHz DC-coupled 10 Hz to 160 MHz AC-coupled
Input B:	DC to 100 MHz DC-coupled 10 Hz to 100 MHz AC-coupled
Sensitivity:	
Sine Wave:	25 mV rms DC to 100 MHz 50 mV rms to 160 MHz
Pulse:	75 mV p-p, 5 ns min. width
Dynamic Range: **(x1 attenuation)**	75 mV to 5V p-p to 50 MHz 75 mV to 2.5V p-p to 100 MHz 150 mV to 2.5V p-p to 160 MHz
Signal Operating Range:	
x1 attenuation:	± 5.1V
x10 attenuation:	± 51V
Input Impedance (nominal): **(x1 and x10 attenuation)**	
Separate Mode:	50 ohms or 1 Megohm //≤45 pF
Common Mode:	50 ohms or 1 Megohm //≤55 pF
Maximum Input (without damage):	
50 ohms:	5V (DC + AC rms)
1 Megohm: **(x1 attenuation)**	260V (DC + AC rms), DC to 2 kHz Decreasing to 5V rms, at 100 kHz and above
1 Megohm: **(x10 attenuation)**	260V (DC + AC rms), DC to 20 kHz Decreasing to 50V rms at 100 kHz and above
Coupling:	AC or DC
Low Pass Filter:	50 kHz nominal (Input A selectable)
Trigger Slope:	+ve or -ve
Attenuator:	x1 or x10. In Auto Trigger mode, attenuator selected automatically if necessary

Table 1.1 - 1991/1992 Specifications (Cont'd)

Trigger Level Range:	
Manual:	± 5.1V in 20 mV steps
x1 attenuation:	± 51V in 200 mV steps
x10 attenuation:	± 51V
Automatic:	
Trigger Level Accuracy:	
Manual and Automatic:	
x1 attenuation:	± 30 mV ±1% of trigger level reading
x10 attenuation:	± 300 mV ±1% of trigger level reading
Auto Trigger:	
Frequency Range:	DC and 50 Hz to 100 MHz (Typically 160 MHz)
Min. Amplitude (AC):	Typically 150 mV p-p*
x10 attenuator	Automatically selected if input signal exceeds ± 5.1V or 5.1V p-p*
Trigger Level Outputs:	
(Rear Panel)	
Range:	± 5.1V
Accuracy (Relative to true trigger level)	
x1 attenuation:	± 1% V output ±10 mV
x10 attenuation:	± 1% V output ± 100 mV
Impedance:	10 kohm nominal

MODEL 1992: Specification for input characteristics is identical to that for the 1991 except for the following addition:

Input C	
Frequency Range:	40 MHz to 1.3 GHz
Sensitivity:	
Sine Wave:	< 15 mV rms, 40 MHz to 1 GHz < 75 mV rms to 1.3 GHz
Dynamic Range:	15 mV rms to 5V rms to 1 GHz 75 mV rms to 5V rms to 1.3 GHz
Input Impedance:	50 ohms nominal AC-coupled
VSWR:	≤ 2:1 at 1 GHz
Maximum Input:	7V rms (fuse-protected) Fuse located in BNC connector
Damage Level:	2.5W

*See Definitions

Table 1.1 - 1991/1992 Specifications (Cont'd)

MEASUREMENT MODES	
Frequency A	
Range:	DC to 160 MHz
Digits Displayed:	3 to 9 digits plus overflow
LSD Displayed (Hz):	$F \times 10^{-D}$ (D = No. of digits, F = Frequency rounded up to next decade)*
Resolution* (Hz):	± LSD† ± (Trig. Error* x Frequency) /Gate Time
Accuracy* (Hz):	± Resolution ± (Timebase Error x Frequency)
Frequency C (Model 1992 only)	
Range:	40 MHz to 1.3 GHz
LSD*:	As for Frequency A
Resolution* and Accuracy*:	As for Frequency A
Time Interval	
Range:	
Separate Mode:	0 to 8×10^5s Typically -2 ns to $+8 \times 10^5$s
Common Mode:	5 ns to 8×10^5s
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:	1 ns min
Resolution* (sec):	± LSD ± 1 ns ± Trig Error*
Accuracy* (sec):	± Resolution ± (Timebase Error x T1) ± Trigger Level Timing Error* ± 2 ns**

*See Definitions
† 2LSD for 6-9 digits displayed
**A differential delay which may be reduced by numerical offset or external compensation.

Table 1.1 - 1991/1992 Specifications (Cont'd)

Time Delay	
Available on Time Interval and Totalize	
Range:	200 µs to 800 ms nominal
Step Size:	25 µs nominal
Accuracy:	± 0.1% Rdg. ± 50 µs
Period A	
Range:	6.25 ns to 1.7×10^3s
Digits Displayed:	3 to 9 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 100 MHz on both inputs
LSD Displayed: (for 6-9 digits selected)	$\left(\frac{10}{\text{Freq. B x Gate Time}}\right)$, rounded to nearest decade*
Resolution*:	± LSD ± (Trig. Error B*/Gate Time) x Ratio
Accuracy*:	± Resolution
Ratio C/B (Model 1992 only)	
Specified for higher frequency applied to Input C	
Range:	Input C 40 MHz to 1.3 GHz Input B DC to 100 MHz

*See Definitions
† 2LSD for 6-9 digits displayed

Table 1.1 - 1991/1992 Specifications (Cont'd)

LSD Displayed: **(for 6-9 digits selected)**	$\left(\frac{640}{\text{Freq. B x Gate Time}}\right)$, rounded to nearest decade*
Resolution* and Accuracy*:	As for Ratio A/B
Totalize A by B	
Accumulative or single totalize	
Input:	Input A
Range:	10^{12}-1 (Max. 9 most significant digits displayed)
Maximum Rate:	10^{8} events/s
Minimum Pulse Width:	5 ns min. at trigger points
Accuracy:	± 1 count
Start/Stop:	Electrical (Input B) or Manual
Phase (A rel. to B)	
Range:	0.1° to 360°
LSD Displayed:	0.1° to 1 MHz 1.0° to 10 MHz 10° to 100 MHz
Resolution* (degrees):	± LSD ± (TI Resolution/Period A) x 360°
Accuracy* (degrees):	± LSD ± (TI Accuracy/Period A) x 360°
Amplitude Measurement	
Peak*	
Frequency Range:	50 Hz to 20 MHz
Amplitude Range:	160 mV p-p to 51V p-p
Resolution:	
x1 attenuation:	20 mV
x10 attenuation:	200 mV
Accuracy:	
x1 attenuation:	± 50 mV ± 6%V p-p (Typically ± 40 mV ± 2%V p-p)
x10 attenuation:	± 500 mV ± 10%V p-p (Typically ± 400 mV ± 3%V p-p)

*See Definitions

DC (<15 mV p-p AC)	
Amplitude Range:	± 51V
Resolution:	
x1 attenuation:	20 mV
x10 attenuation:	200 mV
Accuracy:	
x1 attenuation:	± 40 mV ± 1% Rdg.
x10 attenuation:	± 400 mV ± 1% Rdg.

Math

Available on all measurements except Phase and Check

Function:	(Result - X)/Z
Entry Range:	$\pm 1 \times 10^{-10}$ to $\pm 1 \times 10^{10}$ to 9 significant figures

EXTERNAL ARMING

A comprehensive external arming capability to determine the START and/or STOP point of a measurement. Available on all measurement functions except phase.

Input Signal: (via Rear Panel)	TTL compatible (min. pulse width 200 ns)
Slope:	+ve or -ve independently selectable on START or STOP arm
Impedance:	1 kohm nominal

BASIC FREQUENCY STANDARD

Internal Frequency:	10 MHZ
Adjustment Range:	± 5 ppm min. at shipment, by single turn trimmer via rear panel
Aging:	
Initial	1 ppm/month at shipment
Long Term	2 ppm/first year
Temperature Stability:	± 10 ppm over the range 0^{o} to 50 ^{o}C, referenced to 25^{o}C
Frequency Standard Output:	
Frequency:	10 MHz
Amplitude:	>600 mV p-p into 50 ohms
Impedance:	250 ohms nominal
External Standard Input:	
Frequency:	10 MHz
Signal Amplitude:	Min. 100 mV rms
(Sine Wave)	Max. 10V rms
Impedance:	1 kohm nominal at 1V p-p 500 ohms nominal at 10V p-p

Table 1.1 - 1991/1992 Specifications (Cont'd)

GENERAL SPECIFICATIONS	
Gate Time: **(Frequency, Period, and Ratio modes)**	Automatically determined by resolution selected (Range 1 ms - 10s)* Resolution Selected: / Gate Time: (seconds) 9 + overflow / 10 9 / 1 8 / 0.1 7 / 0.01 6,5,4,3 / 0.001
Single Cycle: **(Hold)**	Enables a single measurement to be initiated and held
Display:	9-digit, high brightness, 14 mm LED display in engineering format with exponent digit
Power Requirements:	
Voltage:	90-110 103-127 193-237 207-253 VAC
Frequency:	45-450 Hz
Rating:	35 VA max.
Environmental Requirements:	
Temperature, Storage:	-40°C to +75°C at 75%RH
Temperature, Operating:	0°C to +50°C
Relative Humidity:	95% to 30°C 75% to 40°C 45% to 50°C
Altitude, Storage:	12,000 meters
Altitude, Operating:	3,050 meters
Vibration:	2 g
Shock:	30 g
Safety:	Designed to meet the requirements of IEC 348 and follow the guidelines of UL1244
Weight:	Net 3.63 kg (8 lb) Shipping 5.5 kg (11 lb)
Dimensions, Instrument:	331 x 212 x 88 mm (13.03 x 8.35 x 3.46 in)

*See Definitions

OPTIONS

List of Options and Accessories

01*	Rear Panel Inputs	11-1709 (Model 1991)
01*	Rear Panel Inputs	11-1732 (Model 1992)
04T**	Temperature Controlled Crystal Oscillator	11-1713
04A**	Oven Oscillator	11-1710
04E**	High Stability Oven Oscillator	404386
07†	Battery Pack	11-1625
10	Reference Frequency Multiplier	11-1645
55†	GPIB Interface	404574
60	Handles	11-1730
60A	Rack Mounting Kit (Fixed, Single)	11-1648
60B	Rack Mounting Kit (Fixed, Double)	11-1649
61	Carrying Case	15-0773
61M	Protectomuff Case	15-0736
65	Chassis Slides (incl. Rack Mounts)	11-1716
	Thru-line Connector	11-0167
	Telescopic Antenna	23-9020
	High Impedance Probe	23-9104
	1.3 GHz Fuse (Pkt. 5)	11-1718

*Installing Option 01 may affect certain specification parameters

**Only one frequency standard may be installed at any one time. The standard reference will be supplied unless Option 04T, 04A, or 04E is specified

† The battery pack and GPIB options cannot both be installed at the same time

Option 01 Rear Panel Inputs

A rear-panel input, factory-fitted option, is available for ATE applications. Inputs A and B are in parallel with those on the front panel while Input C (Model 1992 only) is fitted in place of the front panel input.

Option 04T Temperature Controlled Crystal Oscillator

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

Option 04A Ovened Oscillator

Frequency:	10MHz
Aging Rate:	$\leq 3 \times 10^{-9}$/day averaged over 10 days after 3 months continuous operation
Temperature Stability:	$\leq 3 \times 10^{-9}$/°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

Table 1.1 - 1991/1992 Specifications (Cont'd)

Option 04E High-Stability Ovened Oscillator	
Frequency:	10MHz
Aging Rate:	$\leq 5 \times 10^{-10}$/day at shipment averaged over 10 days
Temperature Stability:	$\leq 7 \times 10^{-9}$ over the range 0°C to 50°C
Line Voltage Stability:	$\leq 5 \times 10^{-10}$ two minutes after a 10% line voltage change
Adjustment	Via rear panel
Option 07 Rechargeable Battery Pack and External DC Operation	
Battery Type:	Sealed lead-acid cells
Battery Life:	Typically 4 hours at 25°C (10 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 10 MHz ($\pm 1 \times 10^{-5}$)
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 are programmable except power on/off 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 20/s dependent upon measurement function

SUPPLIED ACCESSORIES

Power Cord
Instruction Manual
Spare Fuse
Spare 1.3 GHz Fuse (Model 1992 only)

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, except on Input C for input frequency >1 GHz

Accuracy and **Resolution** is expressed as an RMS value

Trigger Error RMS

$$\text{Trigger Error (seconds)} = \sqrt{\frac{(e_{i1}^2 + e_{n1}^2)}{S1^2} + \frac{(e_{i2}^2 + e_{n2}^2)}{S2^2}}$$

where e_i = input amplifier RMS noise (typically 150 µV RMS in 160 MHz bandwidth)
e_n = input signal RMS noise in 160 MHz bandwidth
S = Slew rate at trigger point V/s
Suffix 1 denotes START edge
Suffix 2 denotes STOP edge
In Frequency A, Period A, Frequency B, and Period B modes, 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/s
S2 = Slew rate on STOP edge V/s

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:

(a). One period of the input signal(s) on Frequency B, Period B, and Ratio A/B

(b). Two periods of the input signal on Frequency A and Period A

(c). One period of input signal B on Ratio C/B (Model 1992 only)

Peak and Peak-to-Peak Amplitudes

Peak is defined as being the highest or lowest point at which the signal width is 5 ns. Similarly, Peak-to-Peak is the difference between the highest and lowest points at which the signal width is 5 ns.

ORDERING INFORMATION

1991 160 MHz Universal Counter
1992 1300 MHz Universal Counter

1.4 SAFETY

1.4.1 The 1991/1992 incorporates a protective ground terminal and is designed to meet international safety requirements. Refer to the Safety Page "FOR YOUR SAFETY" immediately preceding the Table of Contents. Follow all **NOTES**, **CAUTIONS**, and **WARNINGS** to ensure personal safety and prevent damage to the instrument.

1.5 PRODUCT SUPPORT

1.5.1 Racal-Dana supports the 1991/1992 with Product Engineering, Service, and Parts Departments. A complete listing of service centers and field representatives is provided on the last two pages of the manual.

1.6 GENERAL DESCRIPTION

1.6.1 The 1991/1992 is a universal timer/counter designed for system or bench use. Basic measurement functions (described briefly in Subsection 1.6.2) include Frequency, Period, Time Interval, Totalize, Phase, and Ratio.

1.6.2 Measurement Functions

1.6.2.1 Frequency A Function

1.6.2.1.1 Frequency A function is used to measure the frequency of the signal applied to the Channel A input. A resolution of nine digits is available with a one-second gate time.

1.6.2.2 Frequency B Function

1.6.2.2.1 Special Function 21 (see Subsection 3.8 "Special Functions"), permits Frequency B measurements. Frequency B function is used to measure the frequency of the signal applied to the Channel B input. A resolution of nine digits is available with a one-second gate time.

1.6.2.3 Frequency C Function (Model 1992 only)

1.6.2.3.1 Frequency C function is used to measure the frequency of the signal applied to the Channel C input. A resolution of nine digits is available with a one-second gate time.

1.6.2.4 Period A Function (See Note below)

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

1.6.2.5 Time Interval A→B Function (See Note below)

1.6.2.5.1 Time Interval function is used to perform single-shot measurements of the time interval between:

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

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

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

1.6.2.6 Total A Function (See Note below)

1.6.2.6.1 Total A function permits events occurring at the Channel A input to be totalized. The counting interval can be controlled by:

a. Electrical start and stop signals applied to the Channel B input (Total A by B)

b. Successive operations of a front-panel key (Manual Totalize)

1.6.2.6.2 Delayed arming of the stop circuit to prevent spurious triggering is available in the Total A by B measurement mode. The Manual Totalize mode provides the capability for totalizing cumulatively over a number of periods.

1.6.2.7 Phase A rel B Function (See Note below)

1.6.2.7.1 Phase A rel B function is used to measure the phase difference between the waveform applied to the Channel A 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. The signals for phase measurement must be continuous and have the same frequency.

1.6.2.8 Ratio A/B Function

1.6.2.8.1 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.

1.6.2.9 Ratio C/B Function (Model 1992 only)

1.6.2.9.1 Ratio C/B function is used to measure the ratio of the frequency applied to the Channel C input to that applied to the Channel B input.

NOTE:

Special Function 21 (see Subsection 3.8 "Special Functions") permits Period B, Time Interval B →A, Total B by A, and Phase B rel A. For these functions, note the following:

a. Period B is specified down to 10 ns

b. Total B by A operates for one complete cycle of the Channel A signal. The stop circuit delay is available on Channel A

1.6.3 Check Function

1.6.3.1 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 published specifications, they can be used to verify that the equipment is operating correctly following receipt or transportation to a new location. A brief, preliminary functional check procedure is given in Subsection 2.6.

1.6.4 Input Signal Channels

1.6.4.1 Inputs A and B are fully independent. However, provision is made for connection of the signal at the Channel A input into both channels. This is effected by selecting the COM(mon) A mode. When COM A is selected, Channel B's input socket is isolated from Channel B's circuitry.

1.6.4.2 Inputs A and B are provided with independent controls to permit the following selections:

a. AC or DC input coupling

b. 1MΩ or 50Ω input impedance

c. x1 or x10 input attenuation

d. Positive or negative-slope trigger

e. Manually or automatically-set input trigger level

1.6.4.2.1 The manually-set trigger level is entered as an internal store.

1.6.4.2.2 The auto-trigger level is derived by measuring the positive and negative peaks of the input signal. If the peak-to-peak value exceeds 5.1V or if either peak is outside the range ± 5.1V, the x10 attenuator is automatically switched in. The trigger level is then set to the arithmetic mean of the measured value.

1.6.4.2.3 When operating in the auto-trigger mode, with the x10 attenuator in circuit, the attenuator will be switched out if the peak-to-peak value is less than 4.6V and both peak values are within the range ± 4.6V.

1.6.4.2.4 The trigger levels in use are available at pins mounted on the rear panel of the instrument. The voltage range is ± 5.1V regardless of whether the attenuator is switched in or not, so the voltage should be multiplied by 10 when the x10 attenuator is selected.

1.6.4.3 Input C is available on the Model 1992 only. It has a nominal input impedance of 50Ω and is AC-coupled. Protection against excessive signal levels is provided by a fuse mounted in the input socket.

1.6.5 Low-Pass Filter

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

1.6.6 Math Function

1.6.6.1 When the math function is active, the displayed value is:

$$\frac{\text{Measurement Result} - X}{Z}$$

where X and Z are values entered into stores within the instrument by the operator. X is set to 0 and Z to 1 when the instrument is first switched on. By suitable choice of values for X and Z, ratio, offset (null), and percentage-difference displays can be obtained.

1.6.7 Special Functions

1.6.7.1 A number of special functions are available to the operator. These provide test procedures and operating facilities in addition to those available by operation of the front-panel controls. See Subsection 3.8 of this manual for further details.

1.6.8 Error Indication

1.6.8.1 When operating the 1991/1992, certain errors will result in displayed error codes. See Subsection 3.9 of this manual for further details.

1.6.9 External Arming

1.6.9.1 External arming of the start and stop circuits for the measurement interval can be carried out by means of signals connected to a rear-panel mounted socket. Any combination of internal and external arming can be selected by using the appropriate special function. For further details, refer to Subsections 3.8 and 3.11 along with Table 3.12 in this manual.

1.6.10 Display Format

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

1.6.11 Hold Feature

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

1.6.12 Resolution and Gate Time

1.6.12.1 The counting interval (gate time) in the Total A by B mode is controlled by the time interval between the start and stop signals at the Channel B input. In the Manual Totalize mode, the gate time is determined by successive operations of the HOLD key. In the Frequency A, Frequency C, Period A, Ratio A/B, and Ratio C/B modes, the gate time is determined by the selected display resolution. 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 provided in Subsection 3.6 of this manual.

1.6.13 External Frequency Standard Input

1.6.13.1 The 1991/1992 may be operated using an external frequency standard. The instrument will operate from the external standard whenever the signal at the EXT STD INPUT socket is of sufficient amplitude. The instrument will automatically revert to internal standard operation if the input from the external standard is removed.

1.6.14 Standby Mode

1.6.14.1 When the instrument is switched to standby, the internal frequency standard continues to operate, but the measuring circuits are disabled.

1.6.15 Initialization

1.6.15.1 When the 1991/1992 is first switched on or when it is initialized via the GPIB interface, it is set to the following conditions:

Measurement Function:	Frequency A
Display Resolution:	8 digits
Continuous Measurement Mode:	Enabled
Channel A and B Inputs:	Manual trigger AC coupling Positive-slope trigger 1MΩ input impedance Filter disabled Common input disabled
Trigger Level	0.00V
Delay:	Disabled
Delay Store:	200 µs
Math Function:	Disabled
X Store:	0
Z Store:	1
Hold:	Disabled
Special Functions:	Functions 10, 20, 30, 40, 50, 60, and 70 enabled
SRQ Message:	Generated upon error detection

1.6.16 Options

1.6.16.1 Frequency Standards (04X Options)

1.6.16.1.1 Frequency standard Options 04-T, 04-E, and 04-A are available. The technical specifications are given in Table 1.1 of this section. The frequency standard can be changed, if required, by the customer; instructions are provided in Section 2.

1.6.16.2 Reference Frequency Multiplier (Option 10)

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

1.6.16.3 GPIB Interface (Option 55)

1.6.16.3.1 An internally mounted interface to the IEEE-488-GPIB is available. This permits remote control of all the instrument's functions except the power ON/OFF and standby switching. The interface can be installed by the customer; instructions are given in Section 2.

1.6.16.3.2 The GPIB interface cannot be installed in an instrument already provided 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 optional accessory.

1.6.16.4 Battery Pack (Option 07)

1.6.16.4.1 Installing the internal battery pack option permits the counter to be used in locations where no suitable AC supply is available. This option also allows operation from an external DC supply.

1.6.16.4.2 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.

1.6.16.4.3 The counter will operate continuously for approximately 4 hours from a fully-charged battery. It will switch off automatically when the battery approaches the discharged condition. The STBY/CHRG LED starts to flash approximately 15 minutes before this occurs. The battery life can be extended by using the Battery-Save feature.

1.6.16.4.4 The battery pack option can be installed by the customer. Instructions are given in Section 2. The battery pack option cannot be installed to an instrument already provided with the GPIB interface option.

1.6.16.5 Rack Mounting Kits

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

a. 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.

b. 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.

1.6.16.5.2 All rack-mounting kits can be installed by the customer. Instructions are given in Section 2.

1.6.16.6 Elapsed Time Indicator (Option ETI)

1.6.16.6.1 A non-mercuric elapsed time indicator can be factory installed inside the instrument as an option. The elapsed time can be read by removing the instrument's top cover.

SECTION 2 INSTALLATION & PREPARATION FOR USE

2.1 INTRODUCTION

2.1.1 This section provides information on unpacking and inspection, reshipment, power connections, storage and temperature, functional checking, miscellaneous setup procedures, and option installation instructions for the 1991/1992.

2.2 UNPACKING AND INSPECTION

2.2.1 Before unpacking the counter, check the exterior of the shipping carton for any signs of damage. All irregularities should be noted on the shipping bill. Unpack and remove the instrument carefully from its carton, preserving the factory packaging as much as possible. Inspect the counter for any defect or damage. Notify the carrier immediately if any damage is apparent. Have a qualified person check the instrument for safety before use.

2.3 RESHIPMENT INSTRUCTIONS

2.3.1 Use the original packaging if it is necessary to return the counter to Racal-Dana for calibration and/or servicing. The original shipping carton and the instrument's plastic-foam form will provide the necessary support for safe reshipment. If the original packaging is unavailable, reconstruct it as much as possible. Wrap the counter in plastic; then use plastic spray foam to surround and protect the instrument. Reship in either the original or new, sturdy shipping carton.

2.4 POWER CONNECTIONS

2.4.1 Before operating the counter, verify that the AC voltage selector is correctly set for the local AC supply. The counter operates on 100, 120, 220, or 240 volts, 45 to 450 Hz. The present voltage range can be seen through the small open window in the rear panel to the left of the AC power plug.

2.4.2 Line Voltage Selection

2.4.2.1 The line voltage setting is easily changed by repositioning the small printed circuit card (voltage selector card) which is mounted horizontally in its slot and accessed via the small rear-panel window. Complete the following procedure to change the voltage setting:

a. Remove the AC power cord from the rear panel

b. Remove the keeper bracket with its one screw and washer from the voltage card window. This completely exposes the voltage selector card

c. Remove the voltage selector card via the small window; reposition it in its slot so that the desired line voltage designation is now visible through the window. (Using a small pair of needle-nose pliers in completing this last step is recommended.)

d. Securely replace the keeper bracket using its hardware

e. Connect the power cord to the counter again

2.4.3 Line Fuse

2.4.3.1 Verify that the rating of the line fuse is suitable for the AC voltage range selected. The fuse should be of the 1/4 in x 1- 1/4 in, glass cartridge, surge-resistant type. The required rating is:

90V to 127V: 500 mA (Racal-Dana P/N 920204)
123V to 253V: 250 mA (Racal-Dana P/N 920756)

2.4.4 Power Cord and Grounding

2.4.4.1 The front panel and instrument case meet the Type III grounding requirements of MIL-T-28800C, protecting the user from possible injury due to electrical shock.

NOTE:

The 1991/1992 is designed to meet IEC Publication 348, "Safety Requirements for Electronic Apparatus for Class I Instruments."

2.4.4.2 A protective ground terminal, forming part of the rear-panel power input socket, is provided. The 1991/1992 is supplied with a detachable 3-conductor power cord. Only this cord should be used.

2.4.4.3 Use only AC power outlets having a protective ground for connection to the counter. **DO NOT USE** 2-conductor extension cords or 3-prong to 2-prong adapters that don't provide a protective ground connection. Connection of the power cord to the power outlet must be made in accordance with the following standard color code:

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

2.5 STORAGE AND TEMPERATURE

2.5.1 The 1991/1992 can be stored at temperatures ranging from -40°C to 75°C at 75% relative humidity without adverse effects to PCBs or components. The counter must be brought within its specified operating range of 0°C to 50°C before power-on.

2.6 FUNCTIONAL CHECK

2.6.1 Introduction

2.6.1.1 The following procedure confirms whether or not the 1991/1992 is performing correctly by checking most of the counter's circuitry. The procedure should be conducted when the 1991/1992 is first put into service and after shipment to a new location. This procedure does not check that the instrument is operating to published specification. Detailed Performance Verification Procedures (PVPs) are given in Section 6 of this manual.

NOTE:

A 50 Ω coaxial test lead, fitted with BNC connectors, is required. This lead must be at least 60 cm, but not more than 1m long.

2.6.1.2 Perform the following procedure:

a. Connect the 1991/1992 to a suitable AC supply

b. Turn the instrument on. Verify that the instrument's model number appears in the display for approximately two seconds, followed by a number indicating the software version and issue numbers. The instrument should assume the following home state:

1. Display should be 00000000, providing a display resolution of 8 digits

2. Hz, RESOLUTION, FREQ A, INPUT A $\int$, and INPUT B $\int$ LEDs should be lit

3. INPUT A and B TRIG LEDs may or may not be lit

c. Press the FUNCTION ▼ key until the CHECK LED lights. Check that the display shows 10.0000000 E6 and that the GATE LED is flashing

d. Verify that the RESOLUTION LED is lit. Press the RESOLUTION ▼ key five times, ensuring that the resolution of the display is decreased by one digit each time

e. Press the RESOLUTION ▲ key to increase the display to nine digits

2.6.1.3 If required, the following additional checks may also be performed, using the instrument's special functions.

a. Complete the following key sequence:

[7] [1] [SHIFT] [STORE] [SF] [SHIFT] [SF]

Check that all LEDs, with the exception of TRIG A, TRIG B, GATE and STBY/CHRG flash on and off every two seconds. Verify that REM, ADDR, and SRQ LEDs are illuminated and do not flash

b. Connect the 10 MHz STD OUTPUT socket on the rear panel to the front panel INPUT A connector, using the coaxial test lead

c. Complete the following key sequence:

[7] [7] [SHIFT] [STORE] [SF]

Verify that the display shows *0.******* E0 Hz after about 6 seconds (where * indicates a blanked digit). The x10, 50 Ω, DC, FILTER and COM A LEDs for Channel A should light sequentially

d. Disconnect the coaxial lead from the INPUT A connector. The display should show an error number after a few seconds

e. Connect the coaxial lead to the INPUT B connector

f. Complete the following procedure:

[7] [8] [SHIFT] [STORE] [SF]

Check that the display shows *0.******* E0 Hz after about 4 seconds. The x10, 50 Ω and DC LEDs for Channel B should light sequentially

g. Disconnect the coaxial lead from the INPUT B connector and the 10 MHz STD OUT connector. The display should show an error number after a few seconds

h. Switch the instrument off

2.7 MISCELLANEOUS SETUP PROCEDURES

2.7.1 Frequency Standard

2.7.1.1 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 LED on the front panel of the instrument lights.

2.7.1.2 A 10 MHz signal, derived from the internal frequency standard, 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.

2.7.2 External Arming

2.7.2.1 If external arming is to be used, the arming signal should be connected to the EXT ARM INPUT connector on the rear panel.

2.7.3 Trigger Level Output

2.7.3.1 The trigger levels in use on Channels A and B are available via pins on the instrument's rear panel. If required, connection to the pins should be made using a clip-on probe or small alligator clip.

2.8 OPTION INSTALLATION INSTRUCTIONS

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

2.8.1.1 This 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, M4 x 5	4	24-4112
Screw, M6 x 16	4	24-7995
Finishing washer, M6	4	24-2809
Captive nut, M6	4	24-2240

2.8.1.2 Assemble the kit to the instrument as follows:

a. Disconnect the AC power cord at the rear panel

b. Remove the two screws which secure the bezel to the rear panel; remove the bezel

c. Remove the bottom cover by sliding it towards the rear of the instrument

d. Remove the instrument's feet from the bottom cover

e. Replace the bottom cover. Replace and secure the bezel

f. Remove the four plugs from the sides of the instrument. This will reveal two threaded holes in each side frame

g. On 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

h. Repeat step g on the other side of the instrument

i. Fit the finishing washers to the M6 screws. Hold the instrument up to the rack in the required position, and secure the brackets to the rack using the M6 screws and nuts

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

2.8.2.1 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
Finishing washer, M6	4	24-2809
Captive nut, M6	4	24-2240

2.8.2.2 Prepare both instruments as follows:

a. Disconnect the AC power cord at the rear panel

b. Remove the two screws which secure the bezel to the rear panel; remove the bezel

c. Remove the bottom cover by sliding it towards the rear of the instrument

d. Remove the instrument's feet from the bottom cover

e. Replace the bottom cover. Replace and secure the bezel

f. Remove the four plugs from the sides of the instrument. This will reveal two threaded holes in each side frame

g. Remove two buffers from the bezel at the side which is to be at the center of the rack

2.8.2.3 Assemble the kit to the instruments as follows:

a. At the sides which are to be at the center 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

b. 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

c. Fit the male spacers on one instrument into the female spacers on the other

d. 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

e. Fit the finishing washers to the M6 screws. Hold the two instruments up to the rack in the required position, and secure the brackets to the rack using the M6 screws and nuts

2.8.3 PCB-Mounted Frequency Standard (Option 04T)

2.8.3.1 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

2.8.3.2 Install the PCB-mounted frequency standard as follows:

a. Disconnect the AC power cord at the rear panel

b. Remove the two screws which secure the bezel to the rear panel; remove the bezel

c. Remove the top cover by sliding it towards the rear of the instrument

d. Remove the frequency standard already installed. Instructions are given in paragraphs 2.8.3.3 or 2.8.4.3, according to type

e. 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

f. Connect the PCB to the motherboard at PL14, with the plate assembly towards the rear panel of the instrument

g. 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

h. Replace the top cover. Replace and secure the bezel

2.8.3.3 Remove the PCB-mounted frequency standard as follows:

a. Remove the two screws adjacent to the FREQ STD ADJUST aperture in the rear panel

b. Pull the PCB and plate assembly upwards until the board is disconnected from the motherboard

2.8.4 Ovened Frequency Standards (Options 04A and 04E)

2.8.4.1 The kit comprises:

Item	Qty	Racal-Dana Part Number
Oscillator assembly	1	11-1710 for 04A 404386 for 04E
Crinkle washer, M3	2	24-2801
Screw, M3 x 6	2	24-7721

2.8.4.2 Install the frequency standard as follows:

a. Disconnect the AC power cord at the rear panel

b. Remove the two screws which secure the bezel to the rear panel; remove the bezel

c. Remove the top cover by sliding it towards the rear of the instrument

d. Remove the frequency standard already installed. Instructions are given in paragraph 2.8.3.3 or 2.8.4.3, according to type

e. Connect the flying lead on the oscillator assembly to SK14 on the motherboard

f. 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

g. Replace the top cover. Replace and secure the bezel

2.8.4.3 Remove the frequency standard as follows:

a. Remove the two screws adjacent to the FREQ STD ADJUST aperture in the rear panel

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

2.8.5 Reference Frequency Multiplier (Option 10)

2.8.5.1 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

2.8.5.2 Install the reference frequency multiplier as follows:

a. Disconnect the AC power cord at the rear panel

b. Remove the two screws which secure the bezel to the rear panel; remove the bezel

c. Remove the top cover by sliding it towards the rear of the instrument

d. Remove the frequency standard if an ovened type is installed

e. Remove the shorting link from between pins 8 and 9 on PL16

NOTE:

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

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

g. Secure the PCB to the side frame, using the M3 screws and washers

h. Replace and secure the frequency standard if it was removed in step d

i. Replace the top cover. Replace and secure the bezel

2.8.6 GPIB Interface (Option 55)

2.8.6.1 The kit comprises:

Item	Qty	Racal-Dana Part Number
GPIB PCB assembly	1	19-1146
Lock washer, M3	2	24-2813
Screw, M3 x 6	2	24-7721

NOTE 1:

This option cannot be installed in an instrument already provided with the battery pack option.

NOTE 2:

The software version number (the first part of the decimal number) on the GPIB ROM (IC10) must be the same as that for the main instrument ROM (IC22 on the motherboard).

2.8.6.2 Install the GPIB interface option as follows:

a. Disconnect the AC power cord at the rear panel

b. Remove the two screws which secure the bezel to the rear panel; remove the bezel

c. Remove the top cover by sliding it towards the rear of the instrument

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

e. Hold the GPIB PCB, component side down, with the GPIB connector towards the rear panel. Connect the ribbon cable to the motherboard at SK4

f. Tilt the board, and lower it into the instrument. Position it with the support brackets just below the top flanges of the side frames

g. Slide the board towards the rear panel so that the support brackets enter the grooves immediately below the top flanges of the side frames

h. Secure the bracket which carries the GPIB connector to the rear panel using the M3 screws and 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

i. Replace the top cover. Replace and secure the bezel

2.8.7 Battery Pack (Option 07)

2.8.7.1 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

NOTE:

This option cannot be installed in an instrument already fitted with the GPIB interface option

2.8.7.2 Install the battery pack as follows:

a. Disconnect the AC power cord at the rear panel

b. Remove the two screws which secure the bezel to the rear panel; remove the bezel

c. Remove the top cover by sliding it towards the rear of the instrument

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

e. If a PCB-mounted frequency standard is installed, remove the two screws adjacent to the FREQ STD ADJUST aperture

f. Remove the four screws which secure the rear panel to the side frames

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

h. Hold the PCB assembly with the switches towards the rear of the instrument and the PCB connector pointing downwards

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

j. Replace and secure the rear panel

k. If a PCB-mounted frequency standard is installed, secure it to the rear panel with the screws removed in step e

l. Position the cover plate over the switch protruding through the rear panel. Secure the cover plate and the rear panel to the PCB assembly using the M3 screws and washers

m. 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

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

o. Secure the supporting lugs to the mounting bracket using M4 screws and washers

p. Connect the flying lead on the battery pack to the connector on the PCB assembly

q. Replace the top cover. Replace and secure the bezel

3.1 INTRODUCTION

3.1.1 This section contains information for operating the 1991/1992 as a bench instrument. It provides Front and Rear Panel Descriptions, Measurements Procedures, and Miscellaneous Operating Instructions.

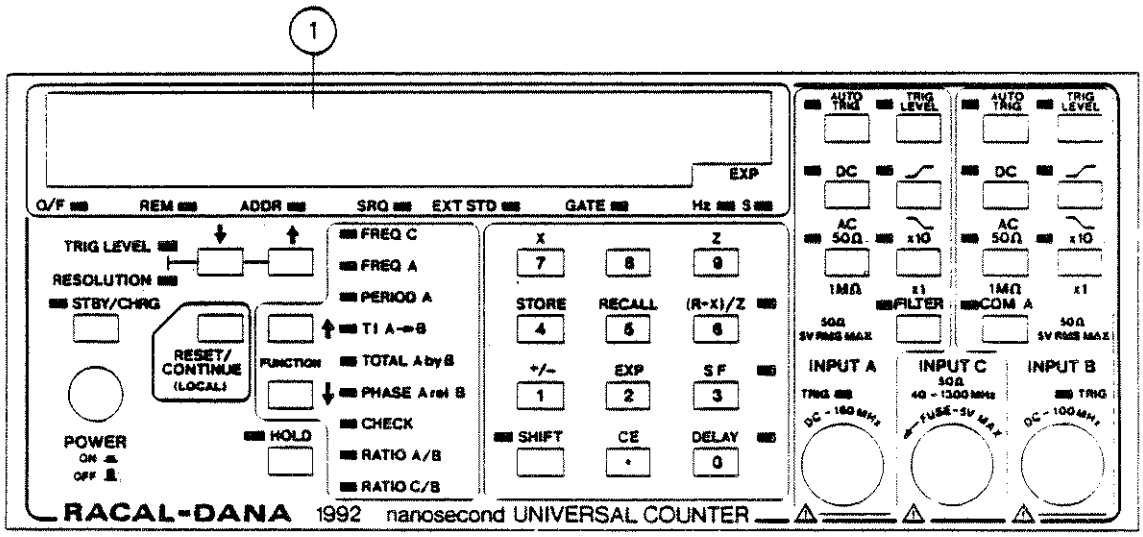
3.1.2 The instrument should be prepared for use in accordance with the instructions given in Section 2. If the instrument is being used for the first time or at a new location, ensure that the setting of the AC voltage selector is correct.

3.2 PANEL DESCRIPTIONS

3.2.1 Front Panel Features

3.2.1.1 Refer to Table 3.1 and the front-panel figures. They show and briefly describe the front-panel controls, indicators, and connectors.

Table 3.1 - Front-Panel Controls, Indicators, and Connectors

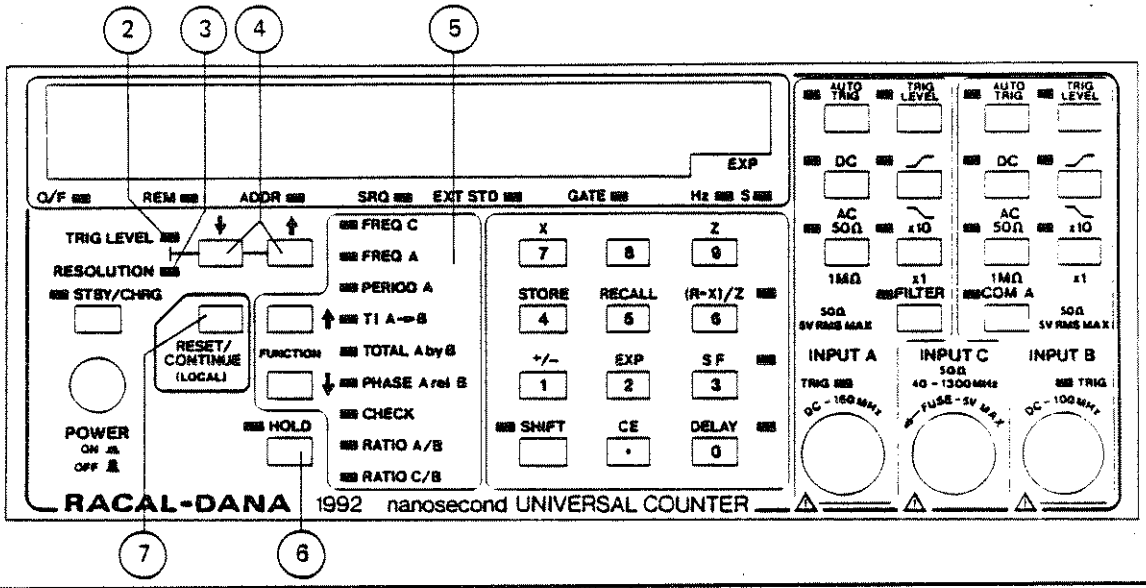


Reference	Item	Function/Description
1	Display	A 7-segment LED digital display. Used to display: - measurement results - numbers for entry into an internal store - numbers recalled from an internal store - error messages The display format uses an engineering format with 9-digit mantissa and 1-digit exponent. The exponent is normally a multiple of three

Table 3.1 - Front-Panel Controls, Indicators, and Connectors (Cont'd)

Reference	Item	Function/Description
		The exponent digit is blanked and should be assumed to be zero during the following: a. Phase measurement b. Totalize measurement with less than ten digits c. Number entries from the numeric keypad not involving an exponent
	O/F LED	Lights when the readout overflows the ninth digit of the display
	REM LED	Lights when the instrument is operating under remote control
	ADDR LED	Lights when the instrument is acting as a listener or as a talker
	SRQ LED	Lights when the instrument generates a service request
	EXT STD LED	Lights when the instrument is operating from an external frequency standard
	GATE LED	Lights while a measurement cycle is in progress
	Display Units LEDs	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, trigger level, or a number
(2)	TRIG LEVEL Control LED	Lights when a trigger level is being displayed. The displayed trigger level can be stepped up or down using the ↑ and ↓ keys, or can be changed using the numeric keypad
(3)	RESOLUTION Control LED	Lights to show that the resolution of the display can be changed by means of the ↑ or ↓ keys

Table 3.1 - Front-Panel Controls, Indicators, and Connectors (Cont'd)



Reference	Item	Function/Description
4	Step-Up ▲ and Step-Down ▼ Keys	Used to step the display resolution or the displayed trigger-level value up or down
5	FUNCTION Keys (▲▼)	Select in succession the counter's measurement functions. The corresponding FUNCTION LED is lit. Function selection "wraps around" at both ends
6	HOLD Key	Successive operation toggles the instrument in and out of the Hold (single-shot measurement) mode. The LED lights in the Hold mode. Readings are triggered using the RESET key When the instrument is in the Manual Totalize mode (using Special Function 61), successive operation of the HOLD key will start and stop the measurement cycle
7	RESET/CONTINUE (LOCAL) Key	This key has the following three functions: RESET Clears the display and triggers a new measurement cycle when the instrument is in the measurement mode

Table 3.1 - Front-Panel Controls, Indicators, and Connectors (Cont'd)

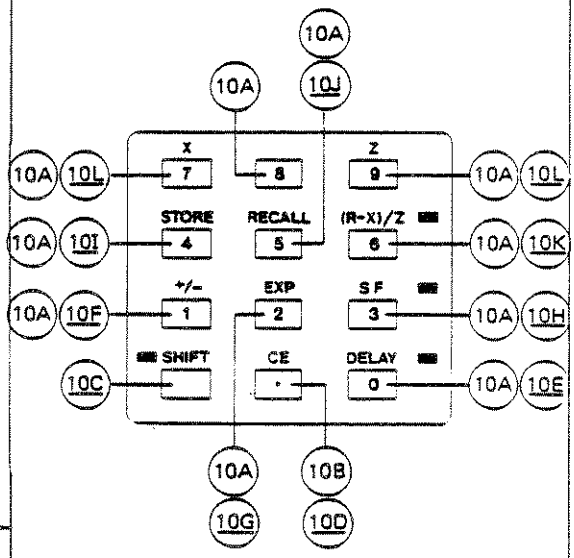
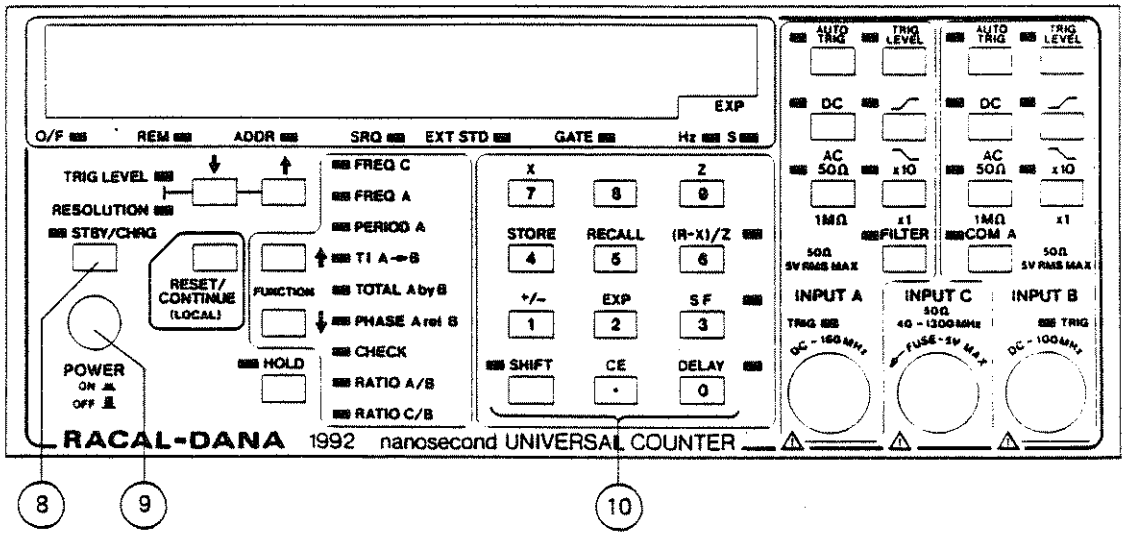
Reference	Item	Function/Description
		CONTINUE Returns the instrument to the measurement mode and triggers a measurement cycle, following the display of a number or constant recalled from store. It can also be used to clear the OP Er display LOCAL Returns the instrument to front-panel control from remote GPIB control, provided local lockout is not set
(8)	STBY/CHRG Key	Successive operation toggles the instrument in and out of the standby state. The LED lights when the instrument is in the standby state. In standby, power is supplied only to internal frequency standard and memories
(9)	POWER (ON/OFF) Button	Controls the AC power to the instrument
(10)	Data Entry Keys/LEDs	Permit data entry and user interface with the 1991/1992 other than input signal conditioning and measurement functions
	NOTE: Designators for shifted key functions are underlined	
	Unshifted Key Functions:	
(10A)	Numeric Keys (0-9)	Entry of numbers and constants for math, special functions, time-interval stop delays and trigger levels. When a numeric key is pressed, the measurement in progress is aborted and the display shows the entered number

Table 3.1 - Front-Panel Controls, Indicators, and Connectors (Cont'd)



Reference	Item	Function/Description
10B	Decimal Point (.) Key	Inserts a decimal point during numeric entry
	Shifted Key Functions:	
10C	SHIFT Key/LED	Enables any shifted key function. After pressing a shifted key function (except for STORE and RECALL), counter returns to its unshifted state with the SHIFT LED turning off
10D	CE Key	Clears current display number and entry
10E	DELAY Key/LED	Enables a TI A→B or Totalize A by B stop delay (SHIFT DELAY). Also, stores (⟨value⟩ SHIFT STORE DELAY), and recalls (SHIFT RECALL DELAY) a stored stop delay
10F	Positive/Negative (+/-) Sign Key	Toggles sign of entered number (mantissa and/or exponent) between positive (no sign displayed) and negative (sign displayed)
10G	EXP Key	Changes the data entry mode so that the next number entered is the exponent

Table 3.1 - Front-Panel Controls, Indicators, and Connectors (Cont'd)

Reference	Item	Function/Description
10H	SF Key/LED	Enables all selected special functions (SHIFT SF). Also, stores (⟨NN⟩ SHIFT STORE SF) and recalls (SHIFT RECALL SF) special functions. See Subsection 3.8 for further details
10I	STORE Key	Stores constants for math functions, time-interval delay, and special functions
10J	RECALL Key	Recalls constants for math functions, time-interval delay, and special functions
10K	(R-X)/Z Math Key/LED	Enables selection of math computation mode
10L	X/Z Keys	Store and recall math computation constants (X and Z)
11	INPUT A and B Signal Conditioning Keys/LEDs	
11A	AUTO TRIG Keys/LEDs	Toggles to select auto-trigger or manual trigger level. The LED lights when auto-trigger is selected

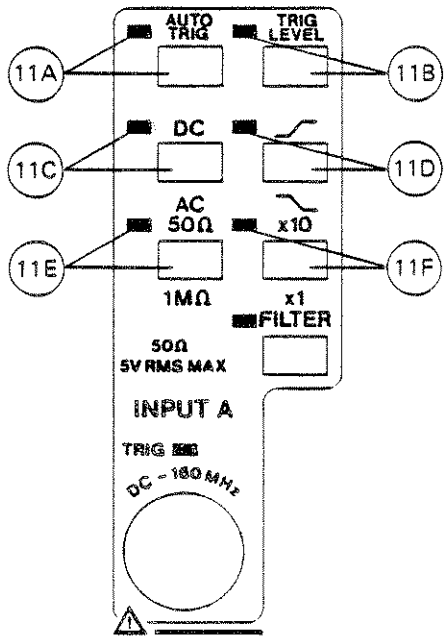
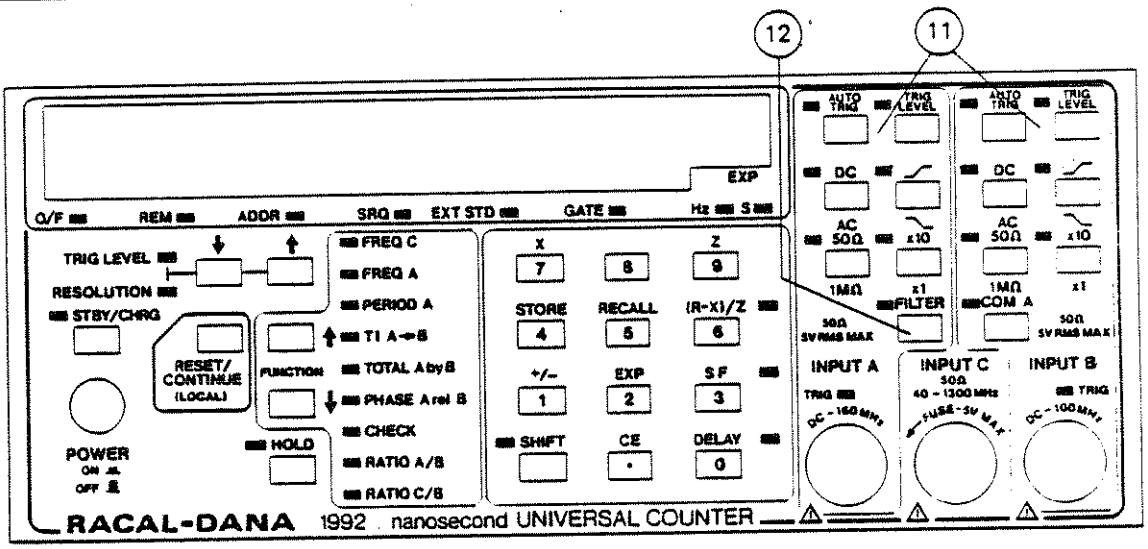


Table 3.1 - Front-Panel Controls, Indicators, and Connectors (Cont'd)

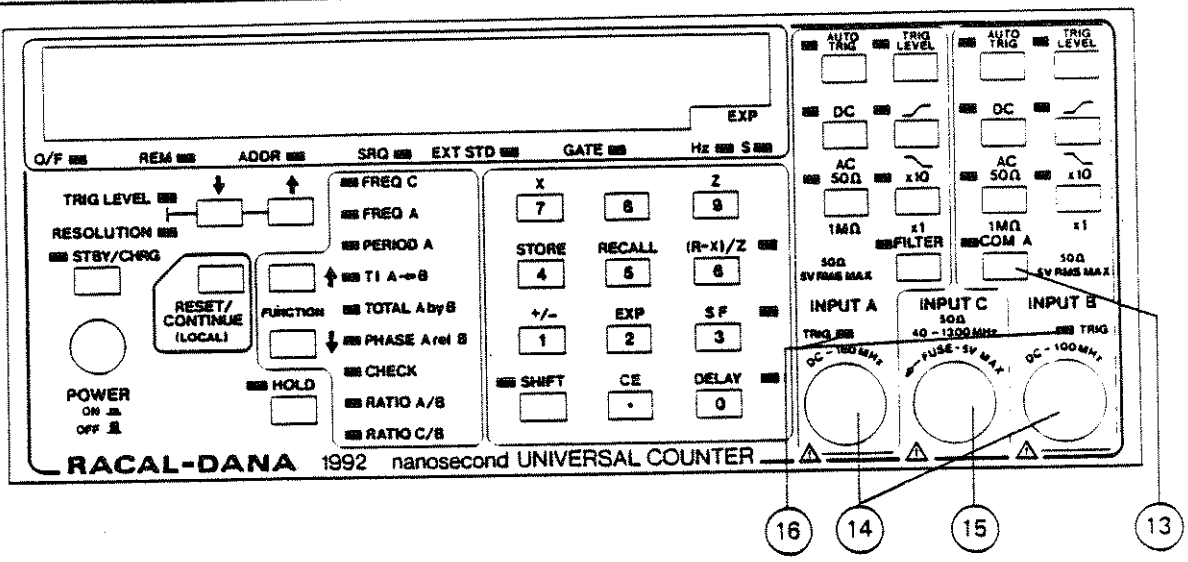


Reference	Item	Function/Description
(11B)	TRIG LEVEL Keys/LEDs	Toggles to display the trigger level in use or to enter a new trigger level. The LED flashes when the trigger level is being displayed. (The trigger-level control LED (2) will also light.)
(11C)	DC/AC Keys/LEDs	Toggles to select AC or DC coupling of the input signal. The LED lights when DC coupling is selected
(11D)	⎍/⎍ Keys/LEDs	Toggles to select the positive-going (⎍) or negative-going (⎍) edge of the input waveform for triggering The LED lights when the positive-going edge is selected
(11E)	50Ω/1MΩ Keys/LEDs	Toggles to select 50Ω or 1MΩ input impedance. The LED lights when 50Ω is selected
(11F)	x10/x1 Keys/LEDs	Toggles to select attenuation of the input signal. With x10 selected, the input is attenuated by a factor of 10. The LED lights when x10 is selected
(12)	FILTER Key/LED	Toggles to enable or disable the Channel A's input filter. LED lights when the filter is enabled

Table 3.1 - Front-Panel Controls, Indicators, and Connectors (Cont'd)

Reference	Item	Function/Description
(13)	COM A Key/LED	Toggles to connect or disconnect the signal at Channel A's input into both Channels A and B (parallel COMmon configuration) LED lights when the COM mode is selected In COM mode, Channel A's AUTO TRIG key controls both Channels A and B. Channel B's AUTO TRIG key is rendered inoperative. Channel B's AUTO TRIG LED follows the lit/unlit state of Channel A's LED Both Channels A and B adopt the same trigger level with auto-trigger level selected. Different trigger levels can be set in the two channels , however, when manual trigger level is selected Channel A's 50Ω/1MΩ, x10/x1 and DC/AC keys control both channels. Channel B's x10/x1 and DC/AC LEDs follow the lit/unlit state of Channel A's LEDs. Channel B's 50Ω/1MΩ LED continues to show the impedance of Channel B's input
(14)	INPUT(s) A and B	BNC connectors for INPUT(s) A and B. INPUT A (DC to 160 MHz) is used for all functions except Frequency C. INPUT B (DC to 100 MHz) is used with INPUT A for Time Interval, Ratio A/B, Totalize, and Phase measurement. INPUT B is used with INPUT C for Ratio C/B. Special Function 21 internally exchanges INPUTs A and B (providing, e.g., PERIOD B, etc. measurement capability)

Table 3.1 - Front-Panel Controls, Indicators, and Connectors (Cont'd)



Reference	Item	Function/Description
(15)	INPUT C (Model 1992 only)	BNC connector for high-frequency INPUT C (40 MHz - 1.3 GHz). INPUT C is used with INPUT B for Ratio C/B. Special Function 21 provides Ratio C/A capability. Protection against excessive signal levels (> 5V rms) is provided by a fuse mounted in the input socket
(16)	TRIG LEDs/Inputs A and B	Tri-state LEDs indicating the counter's trigger status: a. **LED On** - trigger level too low or input signal level held in a high state b. **LED Flashing** - channel being triggered c. **LED Off** - trigger level too high or input signal level held in a low state

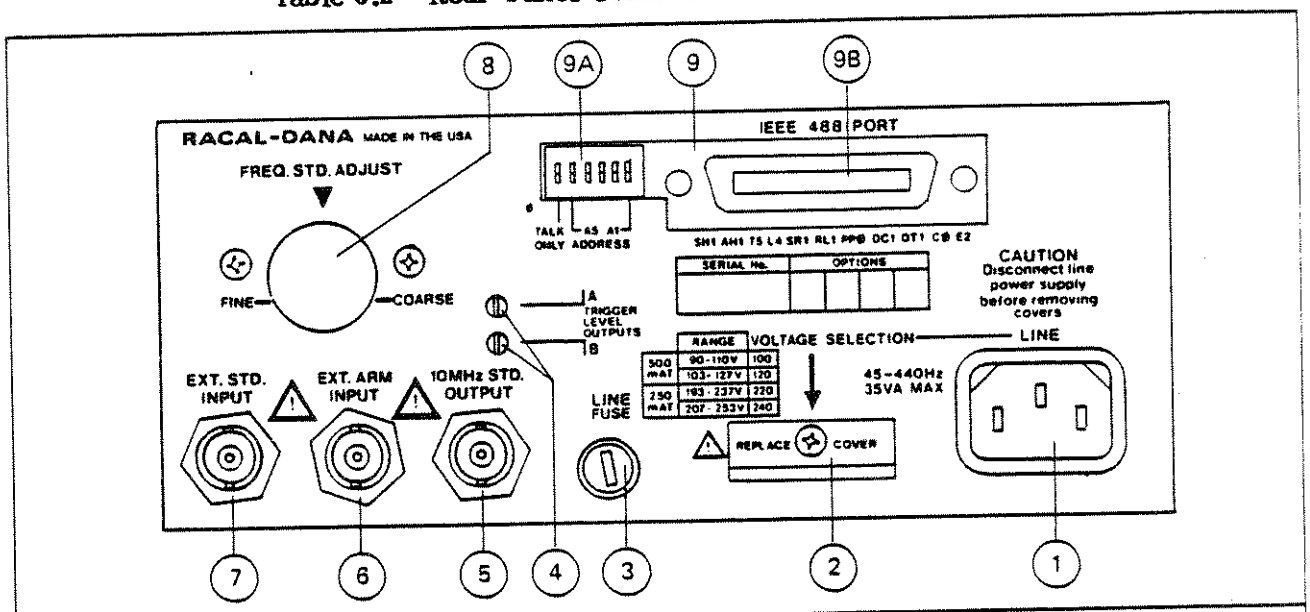
3.2.2 Rear Panel Features

3.2.2.1 Refer to Table 3.2 and figure at top. They show and briefly describe the rear-panel controls and connectors.

Table 3.2 - Rear-Panel Controls and Connectors

Reference	Item	Function/Description
(1)	AC Power Input Socket	Standard connector for the AC power supply. A RFI filter is incorporated on the instrument motherboard
(2)	VOLTAGE SELECTION Window	Line voltage selection is changed by repositioning a small printed circuit card inside the instrument. The selected voltage can be viewed through the small open window. See Subsection 2.4.2 for line voltage selection procedure
(3)	LINE FUSE	A 1/4 in x 1-1/4 in glass cartridge Slow-Blow fuse. Line fuse ratings for available line voltages are shown on the rear panel to the right of the fuse receptacle. See also Subsection 2.4.3 in this manual
(4)	TRIGGER LEVEL OUTPUTS (A, B)	Outputs for Inputs A and B trigger levels. Voltage range at both output pins is ± 5.1V, regardless of attenuation
	NOTE: Connectors (5) through (7) are BNCs	
(5)	10 MHz STD. OUTPUT Connector	Output for 10 MHz signal from the internal reference standard
(6)	EXT. ARM INPUT Connector	Input for accepting external arming/gating control signals
(7)	EXT. STD. INPUT Connector	Input 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
(8)	FREQ. STD. ADJUST	Aperture providing access for adjusting the internal frequency standard

Table 3.2 - Rear-Panel Controls and Connectors (Cont'd)



Reference	Item	Function/Description
(9)	GPIB Option	
(9A)	GPIB Address Switches	Switches A1 to A5 define the listen and talk addresses for GPIB operation in the addressed mode The 2-digit GPIB address can be recalled to display using key sequence SHIFT RECALL RESET
(9B)	GPIB Connector	An IEEE-488-1978 standard connector

3.3 OPERATING PROCEDURES

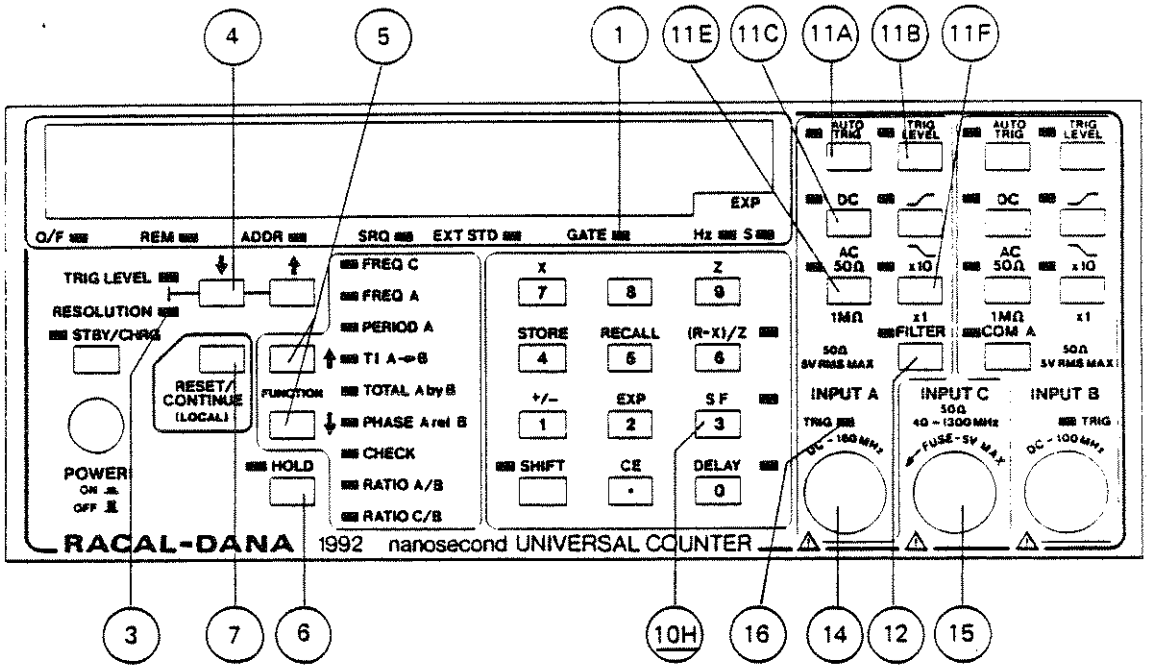
3.3.1 Measurement Functions

3.3.1.1 Tables 3.3 - 3.9 with figures describe the basic bench functions of the 1991/19

NOTE:

Review as required Table 3.1, References (14) and (15), for use of Inputs A, B, and C, including Special Function 21 permitting interchange of Inputs A and B. See also Subsection 3.8 and Table 3.12 for special functions.

Table 3.3 - Frequency Measurement



1. Turn power on.

2. Select FREQ A or FREQ C (Model 1992 only) using FUNCTION keys (5).

3. If FREQ A is selected, set the AC/DC coupling (11C), input impedance (11E), and attenuator (11F) as required.

CAUTION

Ensure that the input signal does not exceed the damage levels specified in Table 1.1 of this manual.

4. Connect the measurement signal to INPUT A (DC to 160 MHz) (14) or INPUT C (40 MHz to 1.3 GHz) (15).

5. If FREQ A is selected, select AUTO-TRIG (11A), or set the manual trigger level (11B) to the required value. Check that Input A TRIG LED (16) flashes.

6. Select the required display resolution (3) (4).

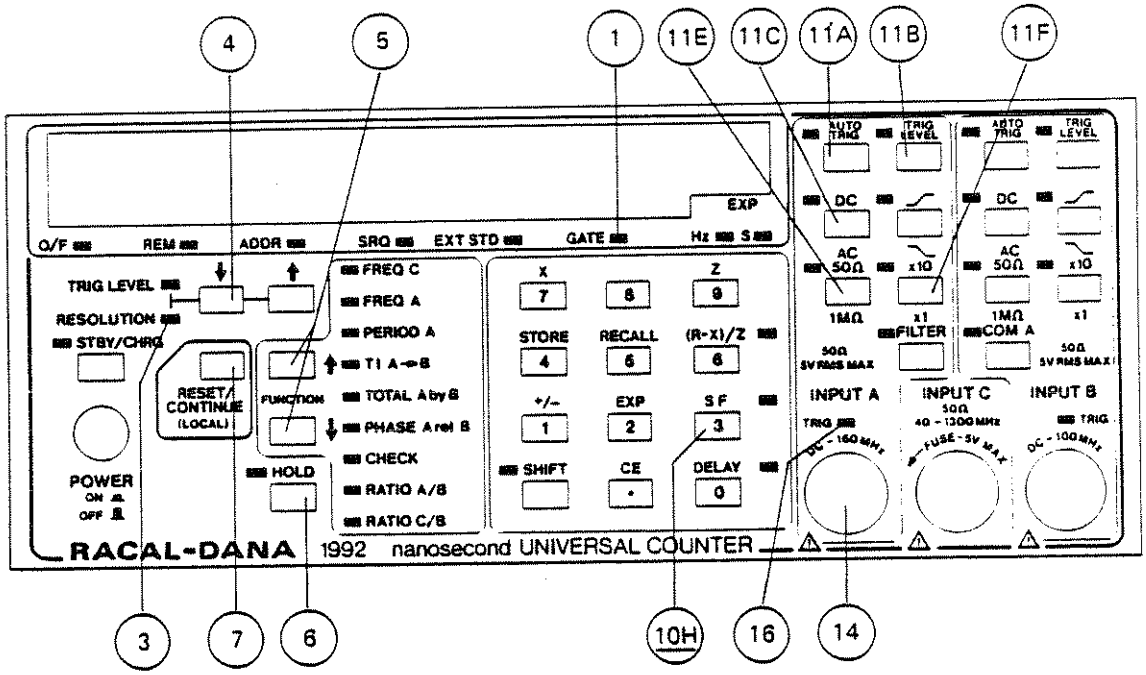
7. If a frequency below 50 kHz is to be measured in the presence of noise, select the filter (12).

8. If external arming is to be used, connect the arming signal and enter the required special function number. Enable the special functions (10H). Refer to Subsection 3.8. for special function numbers and procedures.

9. Verify that the GATE LED (1) flashes on during gating.

10. If single-shot operation is required, select HOLD (6) and press the RESET key (7) to trigger each new measurement.

Table 3.4 - Period Measurement



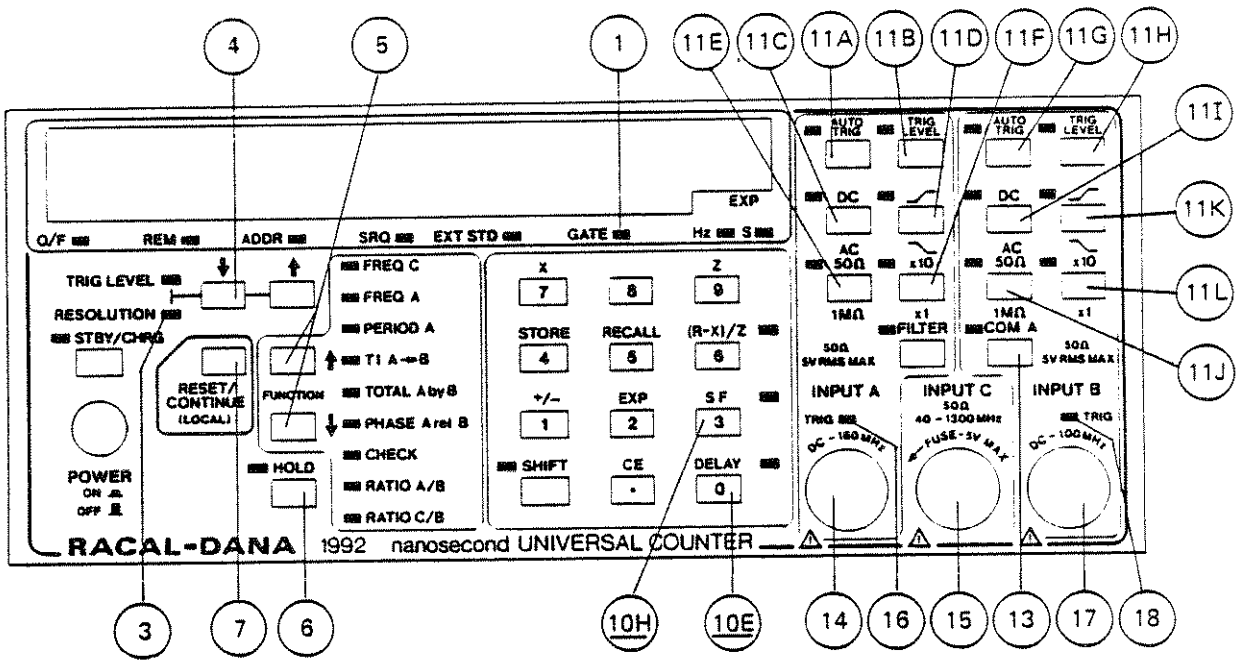
1. Turn power on.
2. Select PERIOD A using FUNCTION keys (5).
3. Set the AC/DC coupling (11C), input impedance (11E), and attenuator (11F) for Channel A, as required.

CAUTION

Ensure that the input signal does not exceed the damage levels specified in Table 1.1 of this manual.

4. Connect the measurement signal to INPUT A (14).
5. Select AUTO-TRIG (11A) or set the manual trigger level (11B) to the required value. Check that Input A TRIG LED (16) flashes.
6. Select the required display resolution (3) (4).
7. If external arming is to be used, connect the arming signal and enter the required special function number. Enable the special functions (10H). Refer to Subsection 3.8 for special function numbers and procedures.
8. Verify that the GATE LED (1) flashes on during gating.
9. If single-shot operation is required, select HOLD (6) and press the RESET key (7) to trigger each new measurement.

Table 3.5 - Time Interval Measurement



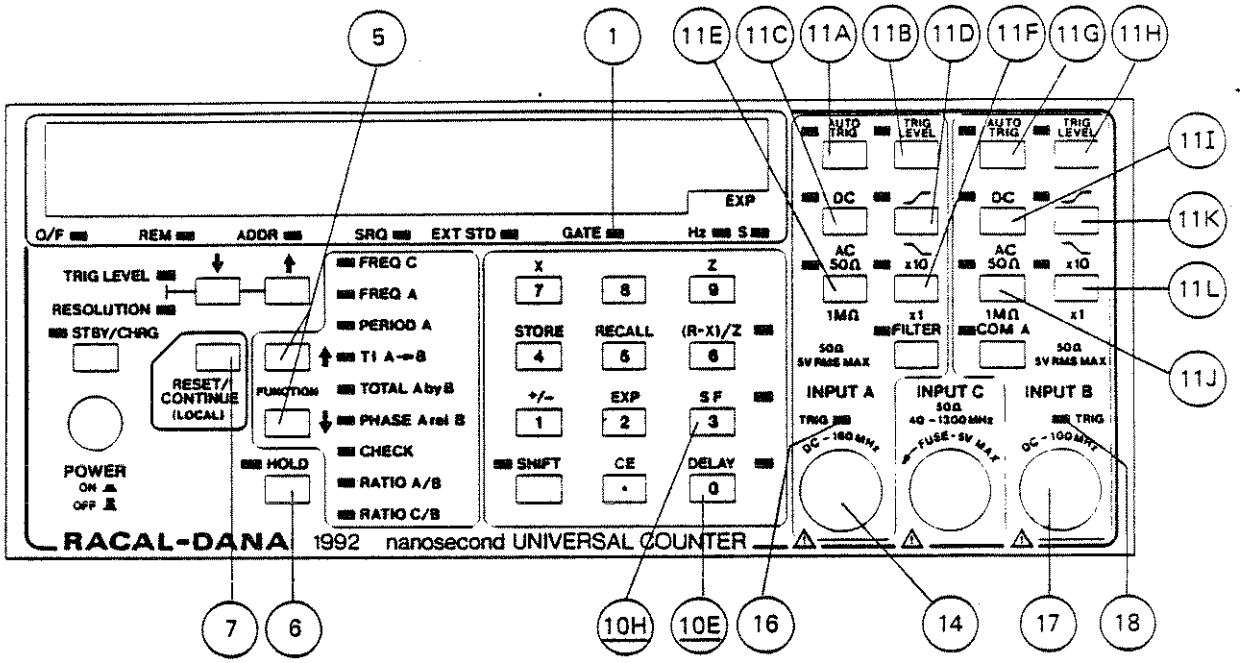
1. Turn power on.
2. Select T.I. A➔B using FUNCTION keys (5).
3. Set the AC/DC coupling (11C) / (11I), input impedance (11E) / (11J), attenuator (11F) / (11L), and slope (11D) / (11K), as required. If the start and stop signals are from the **same source**, select COM A (13).

CAUTION

Ensure that the input signals do not exceed the damage levels specified in Table 1.1 of this manual.

4. Connect the start signal to INPUT A (14). If a separate source for the stop signal is used, connect the stop signal to INPUT B (17) and set the associated input controls as needed.
5. Select AUTO-TRIG (11A) / (11G) or set the manual trigger levels (11B) / (11H) to the required values. Check that Inputs A and B TRIG LEDs (16) and (18) flash, respectively.
6. Select the required display resolution (3)(4).
7. If internal delayed arming of the stop circuit is required, enter the delay into memory and enable the delay (10E).
8. If external arming is to be used, connect the the arming signal and enter the required special function number. Enable the special functions (10H). Refer to Subsection 3.8 for special function numbers and procedures.
9. Verify that the GATE LED (1) flashes on during gating.
10. If single-shot operation is required, select HOLD (6) and press the RESET key (7) to trigger each new measurement.

Table 3.6 - Total A by B Measurement



1. Turn power on.
2. Select TOTAL A by B using FUNCTION keys (5).
3. Set the AC/DC coupling (11C) / (11I), input impedance (11E) / (11J), attenuator (11F) / (11L), and slope (11D) / (11K) as required for both Channels A and B.

NOTE:

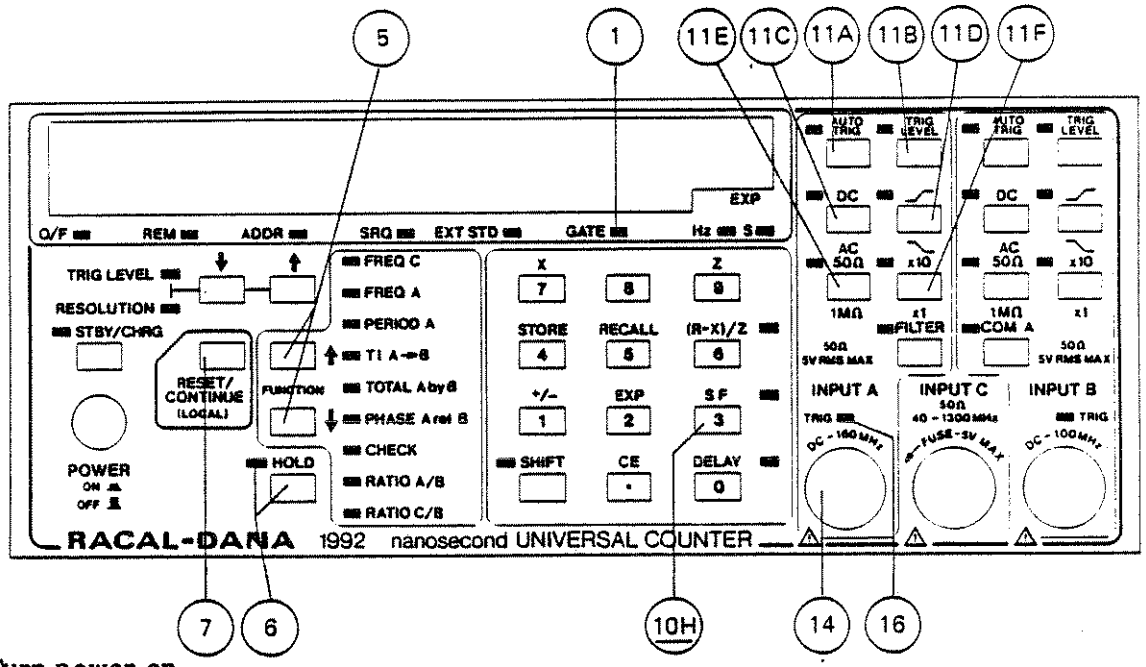
The INPUT A slope key selects the slope of the events which are counted. The gate time, however, starts on the slope of the Channel B signal selected by the INPUT B slope key and stops on the opposite slope.

CAUTION

Ensure that the signal levels do not exceed the damage levels specified in Table 1.1 of this manual.

4. Connect the signal to be totalized to INPUT A (14) and the control signal to INPUT B (17).
5. Select AUTO-TRIG (11A) / (11G) or set the manual trigger levels (11B) / (11H) to the required values. Check that Inputs A and B TRIG LEDS (16) and (18) flash, respectively.
6. If internal delayed arming of the stop circuit is to be used, enter the delay into memory and enable the delay (10E).
7. If external arming is to be used, connect the arming signal and enter the required special function number. Enable special functions (10H). Refer to Subsection 3.8 for special function numbers and procedures.
8. Verify that the GATE LED (1) flashes on when Channel B signal is either high or low.
9. If single-shot operation is required, select HOLD (6) and press the RESET key (7) to trigger each new measurement.

Table 3.7 - Manual Totalize Measurement



1. Turn power on.

2. Select TOTAL A by B using FUNCTION keys (5).

3. Set the AC/DC coupling (11C), input impedance (11E), attenuator (11F), and slope (11D) of Channel A as required.

4. Enter Special Function number 61 and enable special functions (10H). The HOLD LED (6) will light.

CAUTION

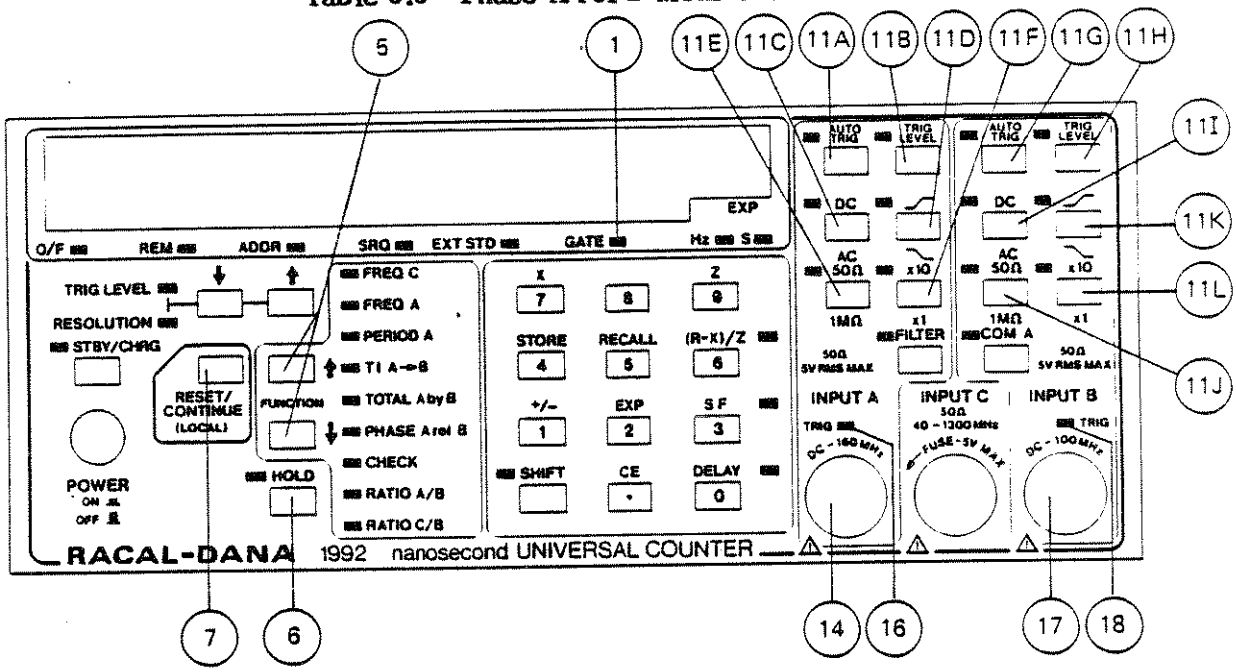
Ensure that the input signal level does not exceed the damage levels specified in Table 1.1 of this manual.

5. Connect the signal to be totalized to INPUT A (14).

6. Select AUTO-TRIG (11A) or set the manual trigger level (11B) to the required value. Check that Input A TRIG LED (16) flashes.

7. Start and stop a measurement using the HOLD key (6). The HOLD LED will turn off and the GATE LED (1) will light during gating. The displayed result is cumulative over successive measurement cycles. If required, use the RESET key (7) to clear the display after a measurement cycle.

Table 3.8 - Phase A rel B Measurement



1. Turn power on.
2. Select PHASE A rel B using FUNCTION keys (5).
3. Set the AC/DC coupling (11C) / (11I), input impedance (11E) / (11J), attenuator (11F) / (11L), and slope (11D) / (11K) as required for INPUTs A and B (14) and (17), respectively . Selected slopes for input signals for Channels A and B should be the same.

CAUTION

Ensure that the input signals do not exceed the damage levels specified in Table 1.1 of this manual.

4. Connect the signals to be compared to INPUT A and INPUT B (14) and (17).

NOTE:

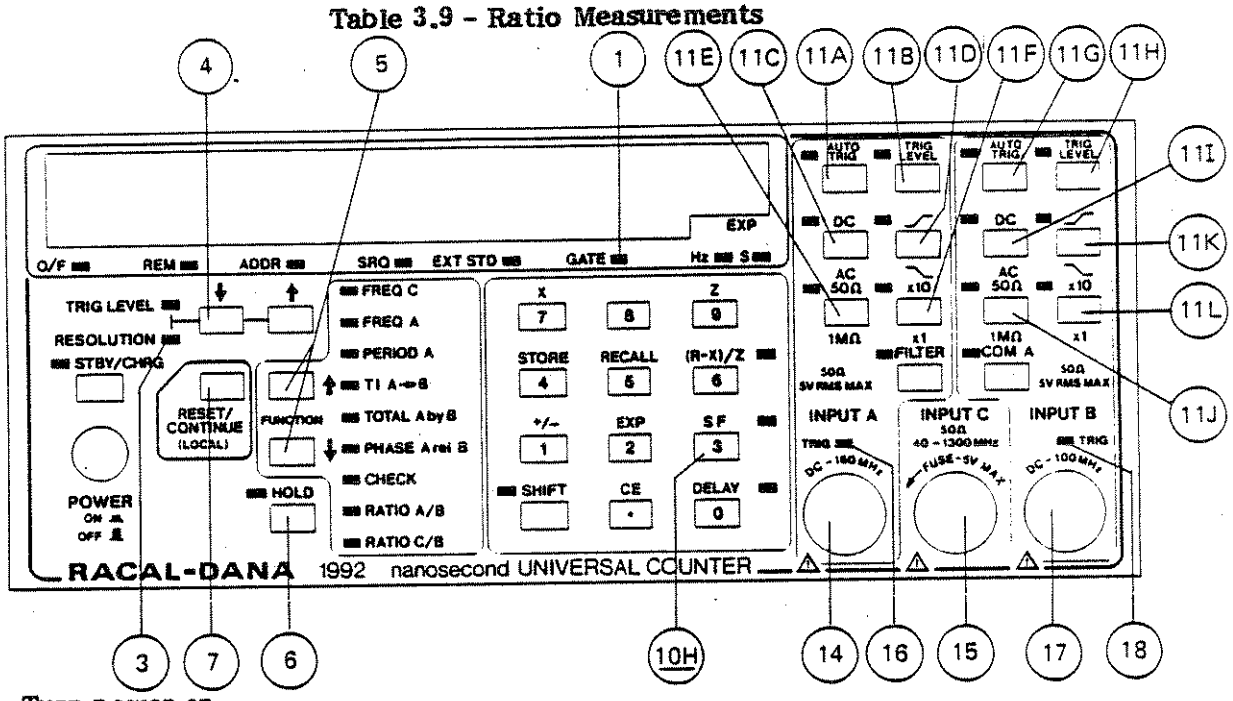
For maximum accuracy, connect the larger and cleaner signal to INPUT A.

5. Select AUTO-TRIG (11A) / (11G) or set the manual trigger levels (11B) / (11H) to the required values. Check that Inputs A and B TRIG LEDs (16) and (18) flash, respectively.
6. Verify that the GATE LED (1) flashes on during gating.
7. If single-shot operation is required, select HOLD (6) and press the RESET key (7) to trigger each new measurement.

NOTE:

A phase measurement is always positive, representing the angle by which Input A's signal leads that of Input B. The signals for phase measurement must be continuous and have the same frequency.

Table 3.9 - Ratio Measurements



1. Turn power on.

2. Select RATIO A/B or RATIO C/B (Model 1992 only) using FUNCTION keys (5).

3. Set the AC/DC coupling (11C) / (11I), input impedance (11E) / (11J), attenuator (11F) / (11L), and slope (11D) / (11K), as required, for INPUTs A (14) and B (17) and INPUT C (15).

CAUTION

Ensure that the input signals do not exceed the damage levels specified in Table 1.1 of this manual.

4. Connect one of the signals to INPUT B (17) and the other to INPUT A (14) or C (15). The lower frequency signal should be connected to INPUT B (14).

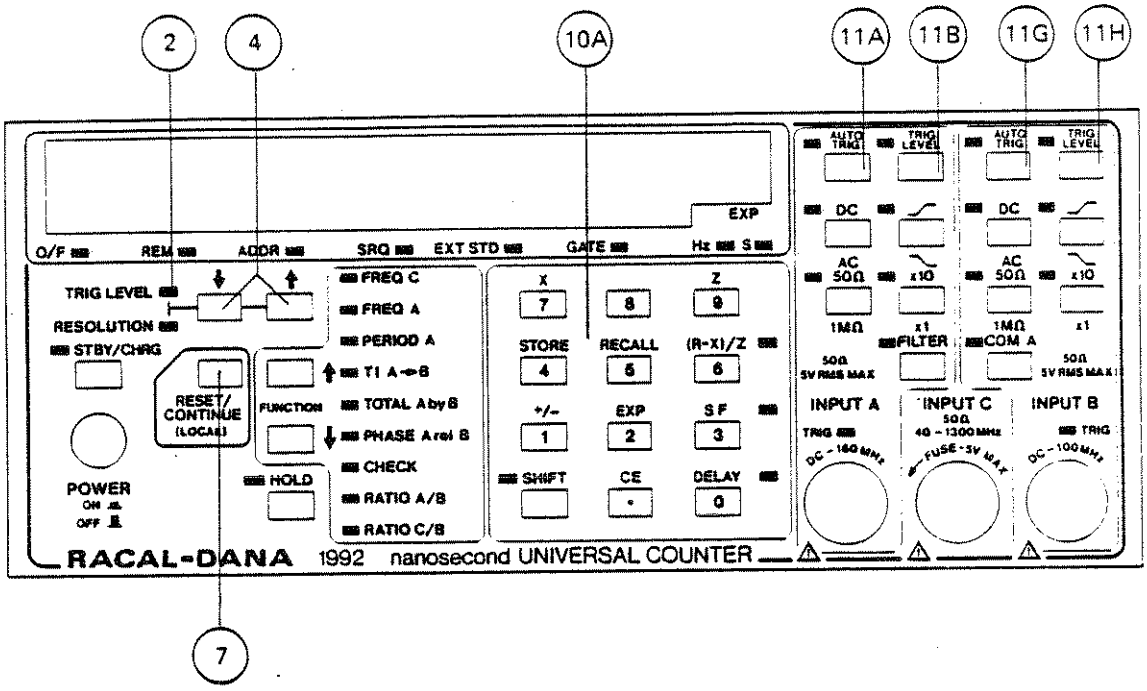
5. Select AUTO-TRIG (11A) / (11G) or set the manual trigger levels (11B) / (11H) to the required values. Check that Inputs A and B TRIG LEDs (16) and (18) flash, respectively.

6. Select the required display resolution (3)(4).

7. If external arming is to be used, connect the the arming signal and enter the required special function number. Enable the special functions (10H). Refer to Subsection 3.8 for special function numbers and procedures.

8. Verify that the GATE LED (1) flashes on during gating.

9. If single-shot operation is required, select HOLD (6) and press the RESET key (7).



3.4 TRIGGER LEVEL

3.4.1 Trigger Level Modes

3.4.1.1 The trigger level may be set by the operator (manual trigger level) or determined automatically by the instrument (auto-trigger level). The auto-trigger level is the arithmetic mean of the positive and negative-peak values of the input signal. The two modes are enabled alternately by successive operations of the AUTO TRIG key (11A) / (11G). The LED lights when the auto-trigger mode is selected.

3.4.2 Displaying and Setting the Manual Trigger Level

3.4.2.1 Perform the following procedure:

a. Select the manual trigger mode using the AUTO TRIG key (11A) / (11G)

b. Display the trigger level by pressing the TRIG LEVEL key (11B) / (11H). The associated LED will flash and the trigger level control LED (2) will light

c. To change the trigger level:

1. Enter the required value, using the numeric keypad (10A)

NOTE:

Up to this point, the instrument can be returned to the measurement mode with the trigger level unchanged by pressing the CONTINUE key (7)

or

2. Using the step up ▲ or step down ▼ control key (4). The desired trigger level can be entered in 20 mV steps

d. Return the instrument to the measurement mode by pressing the TRIG LEVEL key (11B) / (11H). The TRIG LEVEL LED and the trigger level control LED (2) will extinguish

NOTE:

There is only one trigger level store for each channel. Use of the auto-trigger mode will result in the manual trigger level being overwritten.

3.4.3 Displaying the Auto-Trigger Level

3.4.3.1 Perform the following procedure:

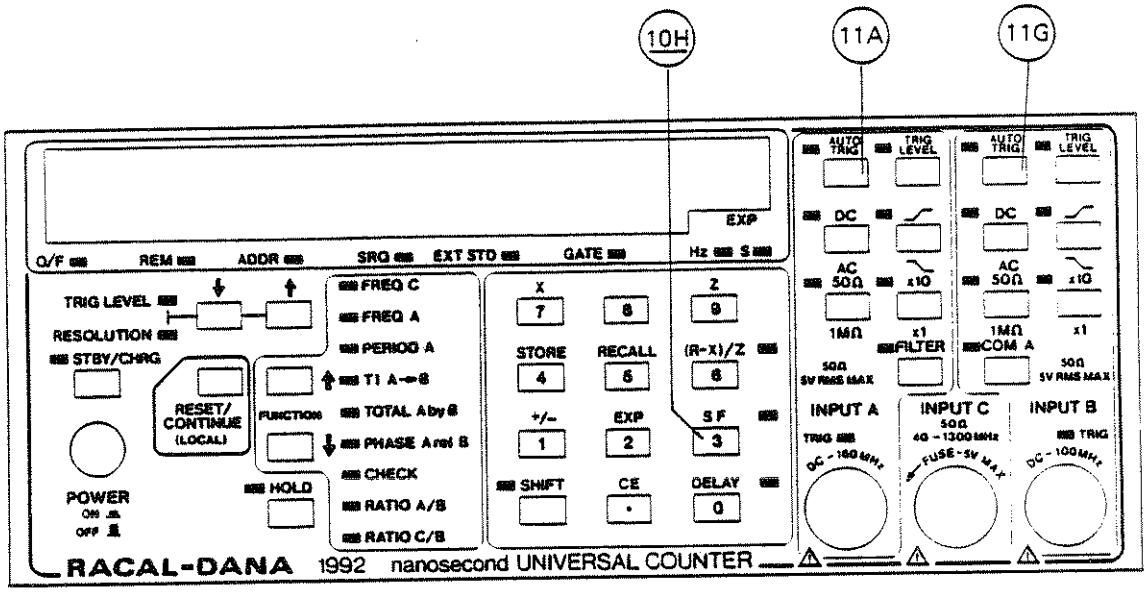
a. Select the auto-trigger mode, using the AUTO TRIG key (11A) / (11G)

b. Display the auto-trigger level by pressing the TRIG LEVEL key (11B) / (11H). The associated LED will flash and the trigger level control LED (2) will light

NOTE:

Any attempt to make a numeric entry while the auto-trigger level is being displayed will cause the OP Er (Operator Error) message to be displayed.

c. Return the instrument to the measurement mode by pressing the TRIG LEVEL key (11B) / (11H) or the CONTINUE key (7). The TRIG LEVEL LED and the trigger level control LED (2) will extinguish



3.4.4 Single-Shot Auto-Trigger Level

3.4.4.1 The auto-trigger level is normally measured continuously and varies if the peak levels of the signal change. A single-shot measurement of auto-trigger level can be made using Special Function 31. This value remains stored as a manual trigger level until:

a. Another single-shot measurement is made, or

b. A new manual trigger level is entered

3.4.4.2 Complete the following to make a single-shot measurement of auto-trigger level:

a. Enter Special Function number 31 into the special function register (10H)

b. Enable the special functions (10H)

c. Select AUTO TRIG (11A) / (11G). The associated LED lights while the level is calculated and stored, and then extinguishes

3.4.4.3 Further single-shot measurements are made by selecting AUTO TRIG (11A) / (11G) with Special Function 31 active.

3.4.5 Automatic Attenuation Setting

3.4.5.1 When operating in the auto-trigger mode, automatic switching of the x10 attenuator occurs as follows:

a. The attenuator is switched in if the peak-to-peak value of the measured signal exceeds 5.1V or if either peak is outside the ±5.1V range

b. The attenuator is switched out if the peak-to-peak value of the measured signal is less than 4.6V and both peaks are within the ±4.6V range

3.5 DISPLAY RESOLUTION

3.5.1 General Information

3.5.1.1 For all measurement functions except TOTAL A by 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 10 digits. (For a resolution of 10, the most significant digit overflows the display.) 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.

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

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

3.5.1.4 For the TOTAL A by B, the display shows the true total of events counted from 1 to 999 999 999. For higher totals, the exponent is used.

3.5.1.5 For the PHASE A rel B, up to four digits may be displayed for frequencies up to 1 MHz and up to three digits for higher frequencies. Leading zeros are suppressed. For frequencies above 10 MHz, the resolution of the display is 10°, and a place-holding zero is displayed as the least-significant digit.

3.5.2 Setting the Display Resolution

3.5.2.1 Whenever the resolution control LED is lit, the resolution can be changed using the step-up ▲ and step-down ▼ keys. To step up from nine to ten digits, hold the step-up key down for approximately two seconds.

3.5.3 Resolution with External Stop Circuit Arming

3.5.3.1 When external arming of the stop circuit is used, the minimum display resolution is governed by the arming period as shown in Table 3.10.

Table 3.10 – Resolution with External Arming

Arming Period	Minimum Resolution
Less than 100 µs	4
100 µs to 1 ms	5
1 ms to 10 ms	6
10 ms to 100 ms	7
100 ms to 1s	8
1s to 10s	9

3.6 GATE TIME

3.6.1 For frequency, period, and ratio measurements, the gate time is related to the selected resolution selected as shown in Table 3.11.

Table 3.11 - Resolution and Gate Time

Resolution	Gate Time
10 (9 digits + overflow)	10s
9	1s
8	100 ms (see NOTE 2)
7	10 ms
6	1 ms
5	1 ms (see NOTE 3)
4	1 ms (see NOTE 3)
3	1 ms (see NOTE 3)

NOTE 1:

The gate times shown in the above table are nominal. Due to the use of the recipromatic counting technique, the gate time may be extended by:

a. Up to one period of the input signal on FREQ B and RATIO A/B

b. Up to two periods of the input signal on FREQ A and PERIOD A

c. Up to 64 periods of the input signal on FREQ C and RATIO C/B

NOTE 2:

At power-on, a display resolution of 8 is selected.

NOTE 3:

Measurements are averaged when resolutions of 3, 4, or 5 are selected.

3.6.2 For PHASE A rel B, the gate time depends upon the signal frequency. The gate time is approximately 25 ms for frequencies above 200 Hz, but is increased at lower frequencies.

3.7 STOP CIRCUIT DELAY (HOLD OFF)

3.7.1 Use of the Delay

3.7.1.1 The stop circuit can be delayed when T.I. A → B or TOTAL A by B 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. At power-up, the delay is set to 204.8 us (minimum delay).

3.7.1.2 The delay can be used to prevent the stop circuit from being triggered prematurely by spurious signals such as those resulting from relay contact bounce. The principle of stop circuit delay is shown in Figure 3.1.

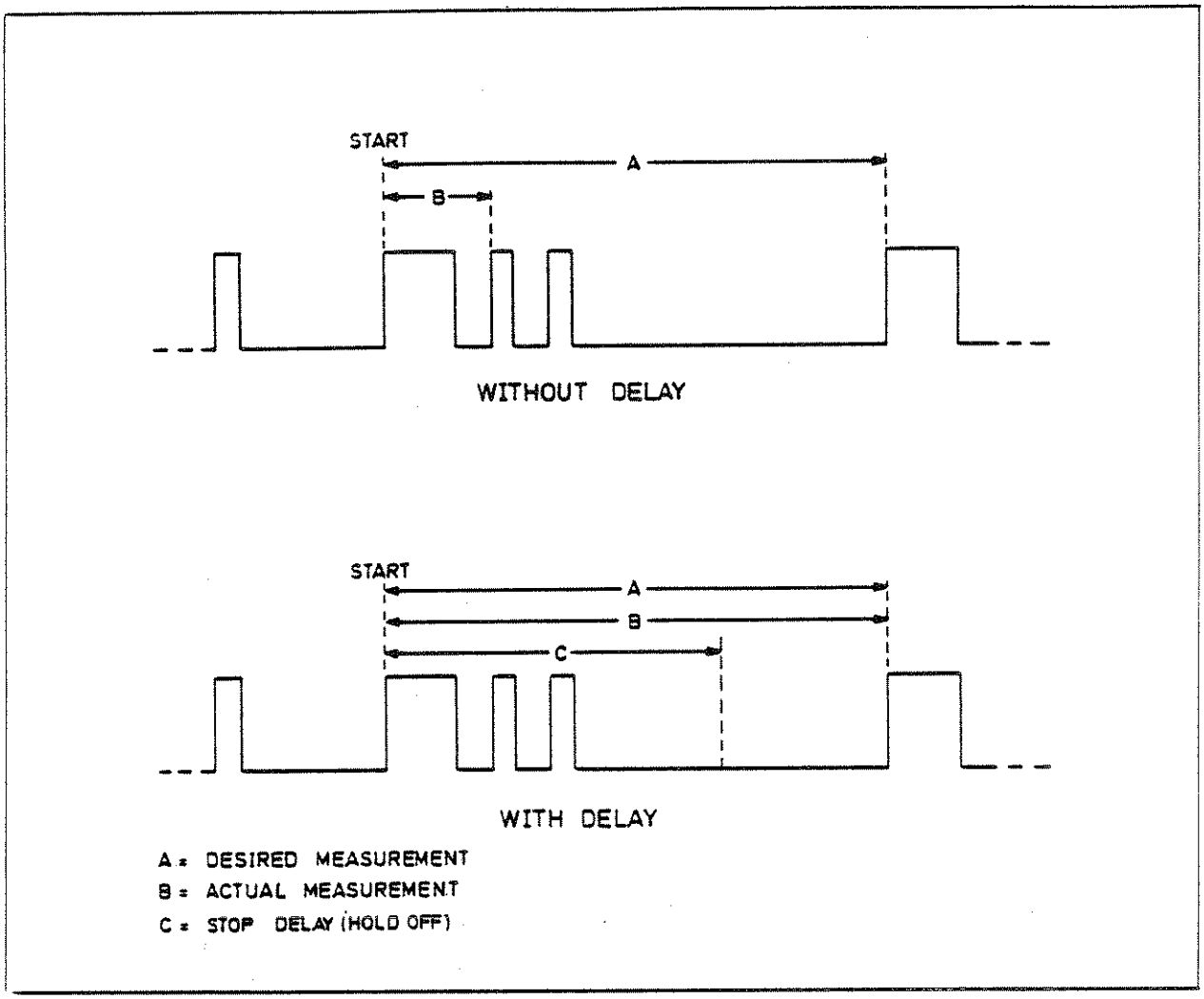


Figure 3.1 - Use of Stop Circuit Delay

3.7.2 Displaying the Delay

3.7.2.1 The value of the delay being stored can be displayed by pressing

[SHIFT] [RECALL] [DELAY]

3.7.3 Changing the Delay

3.7.3.1 A new delay value is entered into its store by using the numeric keypad. Employ either direct decimal or exponential format. For example, a delay of 305 μs may be entered using one of the following key sequences:

[.] [0] [0] [0] [3] [0] [5] [SHIFT] [STORE] [DELAY]

or [3] [0] [5] [SHIFT] [EXP] [6] [SHIFT] [+/-] [SHIFT] [STORE] [DELAY]

The instrument returns to the measurement mode automatically once the new delay value is stored.

3.7.3.2 The value of the delay entered is rounded to the nearest 25.6 µs before it is stored. The permitted range of delay is from 204.8 µs to 800 ms. Attempted entry of an out-of-range value will result in the display of OP Er. The number in the delay store is retained when the instrument is switched to standby.

3.7.4 Enabling and Disabling the Delay

3.7.4.1 The stop delay is enabled and disabled by means of the sequence

SHIFT DELAY

The DELAY LED lights when the delay is enabled.

3.8 SPECIAL FUNCTIONS

3.8.1 Special Function Numbering

3.8.1.1 The special functions provided for operator use are listed in Table 3.12. Each special function is defined by a two-digit number.

3.8.2 Special Function Register

3.8.2.1 One special function from each decade is entered into a special function register. Only the second digit is stored: the decade is indicated by the position of the digit in the register. The default state is with 0 entered in each position. The contents of the register can be displayed by pressing:

SHIFT RECALL SF

A typical display is illustrated in Figure 3.2.

Table 3.12 - Special Functions

Function Number	Function			
		Start	Stop	
10	Arming	Internal	Internal	
11		External +ve	Internal	
12		External -ve	Internal	
13		Internal	External +ve	
14		Internal	External -ve	
15		External +ve	External +ve	
16		External +ve	External -ve	
17		External -ve	External +ve	
18		External -ve	External -ve	
20	Normal Operation			
21	Channel A and B interchanged (see NOTE 1)			
30	Continuous measurement of auto-trigger level			
31	Single-shot measurement of auto-trigger level			
40	Select elapsed time between displayed measurement cycles	150 ms	between displays	See NOTE 2
41		0	between displays	
42		1s	between displays	
43		10s	between displays	
44		300s	between displays	
50	Value displayed by operation of TRIG LEVEL	Trigger level		
51		Signal positive peak		
52		Signal negative peak		
60	Measurement made with TOTAL A by B selected	Normal TOTAL A by B		
61		Manual Totalize		
70	Function with CHECK selected	10 MHz check		
71		LED check		
72-76	Reserved for diagnostic testing			
77	Channel A relay check			
78	Channel B relay check			

NOTE 1:

Special Function 21 permits FREQ B, PERIOD B, T.I. B→A, TOTAL B by A, and Phase B rel A. For these functions:

a. FREQ B is specified to 100 MHz only
b. PERIOD B is specified down to 10 ns
c. TOTAL B by A operates for one complete cycle of the Channel A signal. The stop circuit delay is available on Channel A

NOTE 2:

Special Functions 40, 42, 43, and 44 are only available when in local control. Special Function 41 is selected automatically when in remote control.

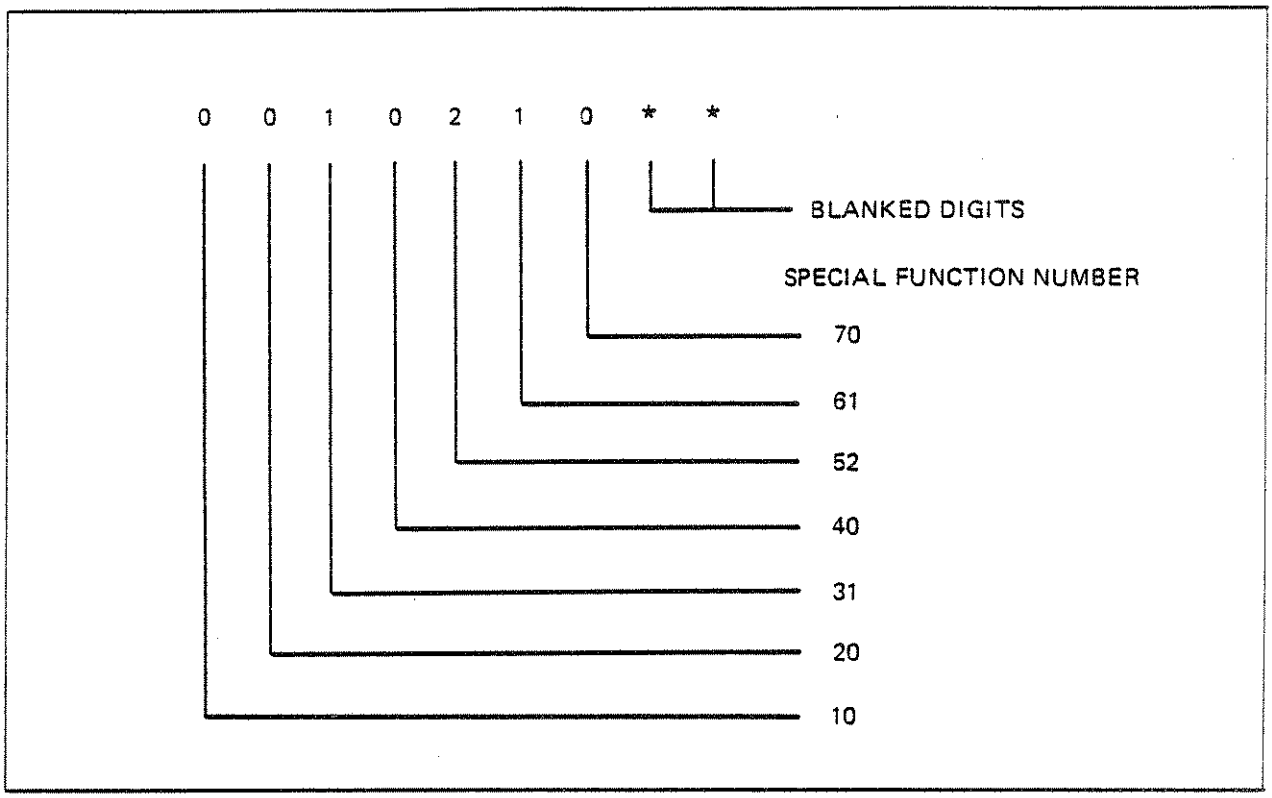


Figure 3.2 - Special Function Register Display

3.8.3 Setting the Special Function Register

3.8.3.1 Before a special function can be used, its unique number must first be entered into the special function register. Use key sequence:

[N] [N] [SHIFT] [STORE] [SF]

where NN is the special function number to be stored. The digits enter the display as the keys are pressed. The instrument returns to the measurement mode automatically once the special function number is stored.

3.8.3.2 When a special function number is stored, it overwrites the number stored in the same decade. To remove a number from the register, another special function number from the same decade must be stored.

3.8.3.3 The numbers stored in the register are retained while the instrument is in the standby mode.

3.8.4 Enabling and Disabling the Special Functions

3.8.4.1 The default state corresponds to the default state of the special function register, i.e., with Special Functions 10, 20, 30, 40, 50, 60, and 70 enabled. Special functions whose numbers are entered in the special function register are enabled and disabled using the following key sequence:

[SHIFT] [SF]

The SF LED lights when special functions are enabled.

NOTE:

A special function entered into its register while the special functions are enabled will be enabled immediately.

3.9 ERROR CODES

3.9.1 The instrument is able to detect a number of error states which are indicated on the display. Table 3.13 list the meanings of the various error codes.

Table 3.13 - Error Codes

Display	Error Description
Er 01	Phase measurement attempted on signals of different frequencies
Er 02	Measurement result too large for the display
Er 03	Overflow of internal counters
OP Er	Error in numerical entry
Er 50	Incorrect result obtained when in Check mode
Er 51	Relay or amplifier failure — Channel A — x10/x1
Er 52	Relay or amplifier failure — Channel A — 50Ω/1 MΩ
Er 53	Relay or amplifier failure — Channel A — DC/AC
Er 54	Relay or amplifier failure — Channel A — FILTER
Er 55	Relay or amplifier failure — COM A
Er 56	Relay or amplifier failure — Channel B — x10/x1
Er 57	Relay or amplifier failure — Channel B — 50Ω/1 MΩ
Er 58	Relay or amplifier failure — Channel B — DC/AC
Er 60	Microprocessor paging fault — During power-up self check
Er 61	Microprocessor RAM fault — During power-up self check

NOTE:

Error codes Er 51 to Er 55 will only be generated with Special Function 77 active. Error codes Er 56 to Er 58 will only be generated with Special Function 78 active.

3.9.2 Clearing the Error Codes

3.9.2.1 Error code Er 01 is cleared by:

a. Making a phase measurement on signals of equal frequency

b. Selecting another measurement function

3.9.2.2 Error codes Er 02 and Er 03 are cleared by:

a. Obtaining a measurement result that is within range

b. Selecting another measurement function

3.9.2.3 OP Er is cleared by pressing RESET

3.9.2.4 To clear Er 60 and 61 refer to the Fault Finding Chart in Figure 6.12

3.10 MATH FUNCTION

3.10.1 General Information

3.10.1.1 The math function may be used with all measurement functions except Phase A rel B and CHECK. Its use permits the measured value to be offset and/or scaled before being displayed.

3.10.1.2 When the math function is active, the display indicates:

$$\frac{\text{Measurement Result} - X}{Z}$$

where X and Z are values entered by the operator into instrument stores. When the instrument is first powered on, X is set to 0 and Z to 1.

NOTE:

It is possible to set the constant Z to zero. However, any attempt to use the math function with this value set will cause an error code to be generated.

3.10.1.3 Table 3.14 shows how to set constants X and Z to obtain displays of ratio, offset (null), and percentage difference.

Table 3.14 - Uses of Math Function

Function Displayed	X	Z
Ratio: Measurement/N	0	N
Offset: Measurement - N	N	1
Percentage difference: 100 (Measurement-N)/N	N	N/100

3.10.2 Displaying the Math Constants

3.10.2.1 The values held in the X and Z stores can be displayed by pressing either

[SHIFT] [RECALL] [X] or

[SHIFT] [RECALL] [Z]

3.10.3 Changing the Math Constants

3.10.3.1 New values are entered into the math-constant stores using the numeric keypad. Employ either direct decimal or exponential format. For example, a value for X of 0.0231 may be entered using one of the following key sequences:

[.] [0] [2] [3] [1] [SHIFT] [STORE] [X]

or [2] [3] [1] [SHIFT] [EXP] [4] [SHIFT] [+/-] [SHIFT] [STORE] [X]

The instrument returns to the measurement mode automatically once the new math constant is stored.

3.10.3.2 The ranges of permissible values are as follows:

a. $1 \times 10^{-9} \leq Z < 1 \times 10^{10}$

b. 0

c. $-1 \times 10^{10} < Z \leq -1 \times 10^{-9}$

For negative numbers, the ninth digit is available, but not displayed.

3.10.4 Enabling and Disabling the Math Function

3.10.4.1 The math function is enabled and disabled by means of the key sequence

SHIFT (R-X)/Z

The (R-X)/Z LED lights when the math function is enabled.

3.11 EXTERNAL ARMING

3.11.1 General Information

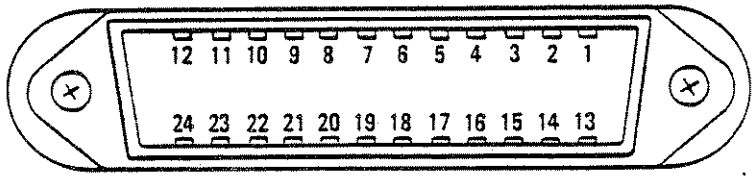
3.11.1.1 This feature allows the start and/or stop point to be synchronized to a real-time event or complex signal. The arming signal is connected to the rear-panel input and the appropriate special function selected (see Table 3.12). Measurement gate opening and closing are still determined by the input signal, but now can be conditioned (armed) by the external arming signal. Minimum start-to-stop external arming period is 50 µs (80 µs for RATIO A/B).

SECTION 4 GPIB OPERATION

4.1 GENERAL PURPOSE INTERFACE BUS (GPIB)

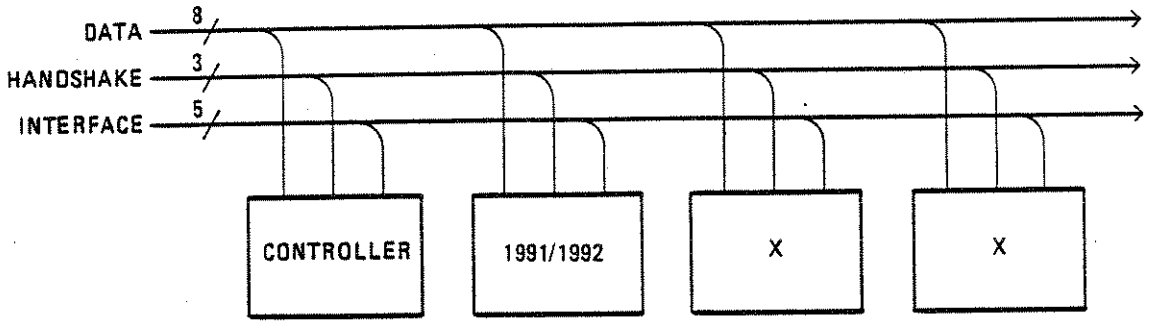
4.1.1 Introduction

4.1.1.1 This subsection provides operating information for the 1991/1992 using the GPIB interface. The IEEE-488-1978 interface permits remote control of all the counter's functions except POWER ON/OFF and STBY. Inputs and outputs are made via a standard 24-pin connector (see Figure 4.1) on the rear panel. Pin location, signal line identification, and GPIB operation comply with IEEE-STD-488-1978. An adapter, Racal-Dana P/N 23-3254, to convert the connector to the IEC 625-1 standard is available as an optional accessory. The GPIB provides interface capability with other instruments and a controller also using the interface-bus structure (see Figure 4.2). This figure also shows signal line designations and pin assignments. IEEE-STD-488-1978 subsets available are listed in Table 4.1.



Pin No.	Assignment	Pin No.	Assignment
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)

Figure 4.1 - GPIB Connector (Rear Panel)



Pin	Nomenclature	Description
1	DIO-1 Data In/Out Bit 1 (LSB)	Data lines are used to transfer data from one instrument to another
2	DIO-2 Data In/Out Bit 2	
3	DIO-3 Data In/Out Bit 3	
4	DIO-4 Data In/Out Bit 4	
13	DIO-5 Data In/Out Bit 5	
14	DIO-6 Data In/Out Bit 6	
15	DIO-7 Data In/Out Bit 7	
16	DIO-8 Data In/Out Bit 8	
6	DAV (Data Valid)	Handshake lines operate in a proper time sequence for complete communication between instruments
7	NRFD (Not Ready for Data)	
8	NDAC (Not Data Accepted)	
5	EOI (End or Identify)	Interface lines are used to provide an orderly flow of information between units
9	IFC (Interface Clear)	
10	SRQ (Service Request)	
11	ATN (Attention)	
17	REN (Remote Enable)	
12	SHIELD	
18	GND (6)	
19	GND (7)	
20	GND (8)	
21	GND (9)	
22	GND (10)	
23	GND (11)	
24	GND (5 and 17)	

Figure 4.2 - Interface Signal Pin Assignments

4.2 GPIB DESCRIPTION

4.2.1 Refer to Figure 4.2. There are 24 lines available at the GPIB connector, including 16 signal and 7 ground return lines, and one shield. All of the data bus lines are either input or output lines, having the following characteristics:

Logic Levels: 1 = Low = $\leq$ .8V

0 = High = $\geq$ 2.0V

Input Loading: Each input = one TTL load

Output: The output is capable of driving 15 interface bus loads. It consists of an open-collector driver and is capable of sinking 48 mA with a maximum voltage drop of 0.4 volts. See the IEEE-488 Electrical Specifications

Table 4.1 - IEEE-488-1978 Standard Interface Subset Capability

GPIB Subset	Description	Applicable Capability
SH1	Source Handshake	Complete Capability
AH1	Acceptor Handshake	Complete Capability
T5	Talker	Complete Capability: (1) Basic Talker (2) Serial Poll (3) Talk Only Mode (4) Unaddress if MLA
TE0	Extended Talker	None
L4	Listener	Complete except Listen Only (1) Basic Listener (2) Unaddress if MTA
LE0	Extended Listener	None
SR1	Service Request	Complete Capability
RL1	Remote/Local	Complete Capability: (1) REN - Remote Enable (2) LL0 - Local Lockout (3) GTL - Go to Local
PP0	Parallel Poll	No Capability
DC1	Device Clear	Complete Capability: (1) DCL - Device Clear (2) SDC - Selected Device Clear
DT1	Device Trigger	Complete Capability: GET - Group Execute Trigger
C0	Controller	No Capability
E1	Open Collector Bus Drivers	

4.2.2 The signal lines shown in Figure 4.2 consist of three functionally separate sets: Data, Handshake, and Interface.

4.2.2.1 **Data** - the data lines consist of DIO-1 to DIO-8. These lines are the signal channels over which data flows between all instruments on the bus in bit-parallel, byte-serial form.

4.2.2.2 **Handshake** - these three transfer lines consist of: DAV (Data Valid), NDAC (Not Data Accepted), and NRFD (Not Ready for Data). These lines provide communication between GPIB bus members (i.e., between the instrument that is talking and the instrument(s) that are listening) to synchronize the information flow across the eight data lines. These lines derive their nomenclature from their meaning in the low or 1 state (e.g., when NRFD is low, the device is Not Ready for Data).

a. **DAV** - when low, it signifies that valid information is available on the data lines

b. **NRFD** - when low, it signifies that the instrument is not ready to accept information

c. **NDAC** - when low, it signifies that information is not accepted by the acceptor bus device

4.2.2.3 **Interface** - these five interface lines coordinate the information flow on the bus.

a. **IFC (Interface Clear)** - places the instrument in the Idle state (i.e., Untalk, Unlisten)

b. **ATN (Attention)** - indicates the kind of information on the data lines during a handshake transfer sequence. Low indicates data lines carry interface commands; high indicates that the data lines carry data

c. **REN (Remote Enable)** - arms the instrument to select Remote operation when it's addressed as a listener

d. **SRQ (Service Request)** - signals the system controller that a peripheral device or bus member wants attention for purposes such as transmitting measurement, status, or condition information to the system controller

e. **EOI (End or Identify)** - used for (1) signifying the end of a message and (2) together with ATN, signalling bus peripherals to set the I/O bit assigned for parallel poll identification

4.2.3 GPIB Handshake

4.2.3.1 The handshake sequence is the process by which each data byte is transferred from the source to the acceptor.

4.2.3.2 Refer to Figure 4.3. It shows the sequential relationship between the DAV, NRFD, and NDAC lines used to transfer data bytes. Figure 4.4 shows the handshake flow chart.

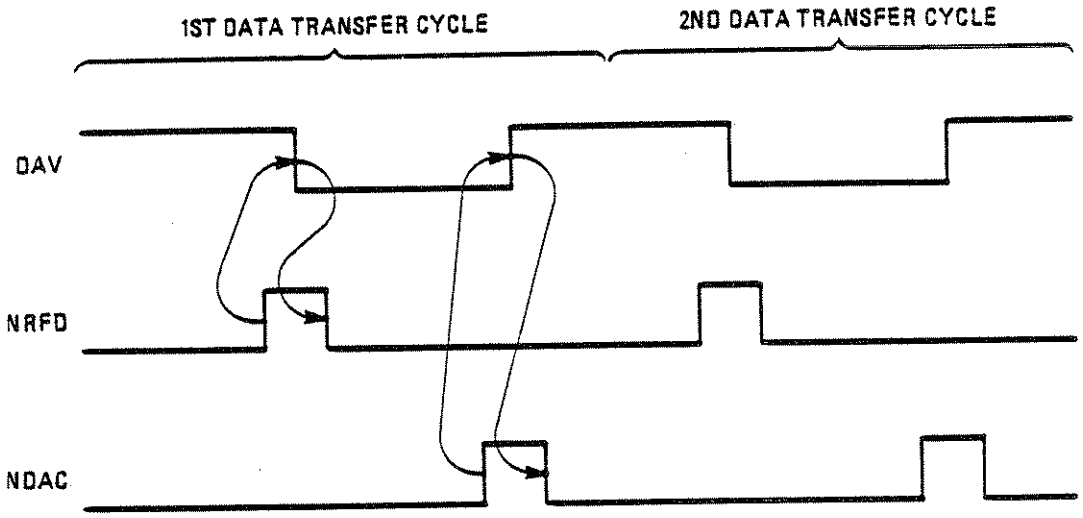


Figure 4.3 - Handshake Sequence

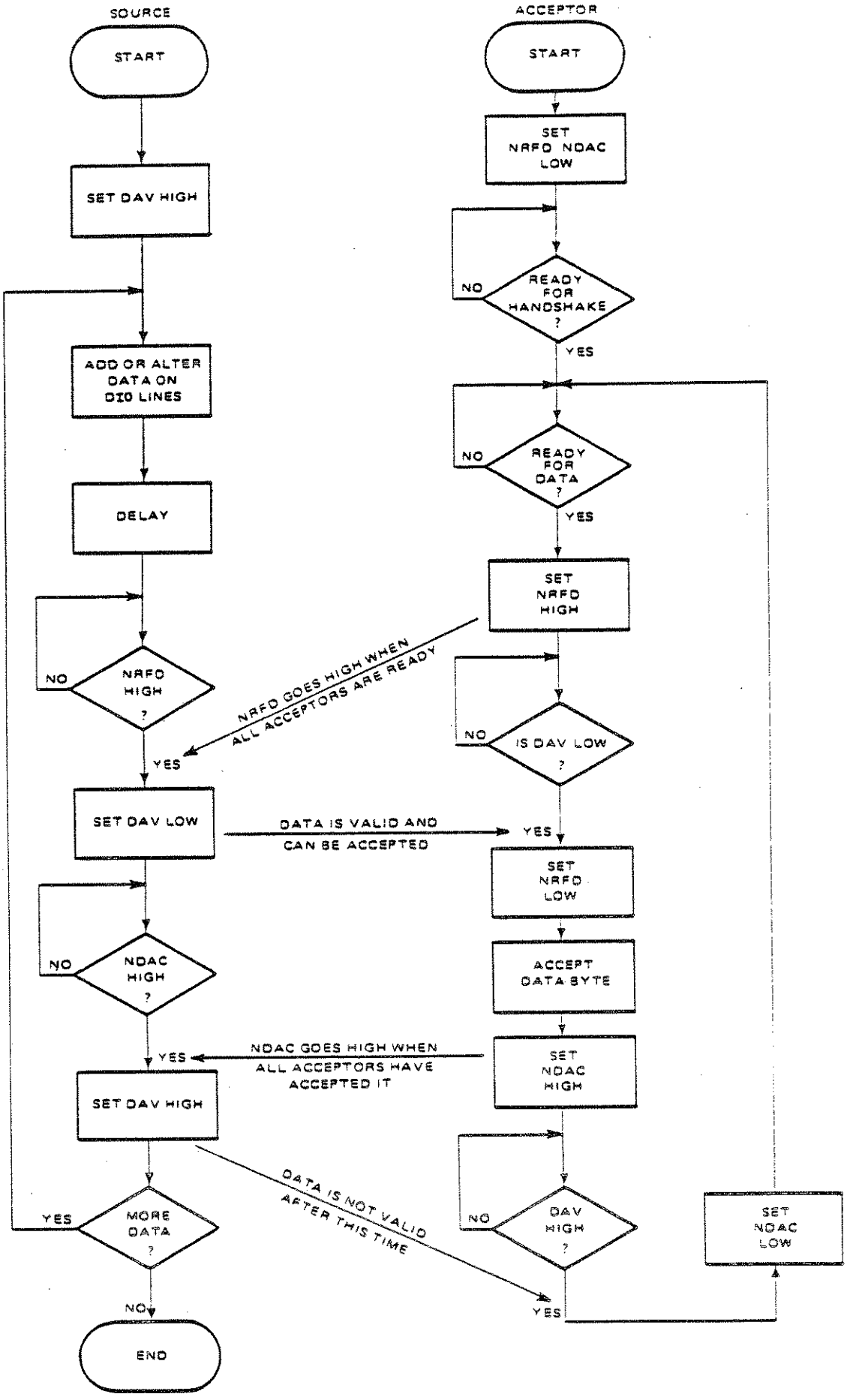


Figure 4.4 – Handshake Flow Chart

4.3 GPIB ADDRESS ASSIGNMENT

4.3.1 The 1991/1992 must be assigned an address as a bus member when operating in a GPIB system. Assigning an address to the counter permits it to be "called up" by the system controller or other resident bus device without interfering with them.

NOTE:

Only a total of 15 devices, including the 1991/1992, can reside on any single 488-bus.

4.3.2 The counter is equipped with a rear-panel switch bank, enabling the user to assign one of 31 addresses (numbers 00 to 30).

4.3.3 Table 4.2 contains all the information required for setting the counter's address and determining the talk and listen address codes used in programming the controller.

Table 4.2 – 1991/1992 GPIB Address Assignment

ASCII CHARACTERS		DATA LINES							ADDRESS SWITCH SETTING ** TALK ONLY 1 / 0 — A5 A4 A3 A2 A1	DECIMAL ADDRESS
		D_7	D_6	D_5	D_4	D_3	D_2	D_1		
TALK	LISTEN	TALK	LISTEN	ADDRESS						
				16	8	4	2	1		
	SP	0	1	0	0	0	0	0		00
@		1	0	0	0	0	0	0		
	!	0	1	0	0	0	0	1		01
A		1	0	0	0	0	0	1		
	"	0	1	0	0	0	1	0		02
B		1	0	0	0	0	1	0		
	#	0	1	0	0	0	1	1		03
C		1	0	0	0	0	1	1		
	$	0	1	0	0	1	0	0		04
D		1	0	0	0	1	0	0		
	%	0	1	0	0	1	0	1		05
E		1	0	0	0	1	0	1		
	&	0	1	0	0	1	1	0		06
F		1	0	0	0	1	1	0		
	' (APOSTROPHE)	0	1	0	0	1	1	1		07
G		1	0	0	0	1	1	1		
	(	0	1	0	1	0	0	0		08
H		1	0	0	1	0	0	0		
	)	0	1	0	1	0	0	1		09
I		1	0	0	1	0	0	1		
	*	0	1	0	1	0	1	0		10
J		1	0	0	1	0	1	0		
	+	0	1	0	1	0	1	1		11
K		1	0	0	1	0	1	1		
	,	0	1	0	1	1	0	0		12
L		1	0	0	1	1	0	0		
	–	0	1	0	1	1	0	1		13
M		1	0	0	1	1	0	1		
	.	0	1	0	1	1	1	0		14
N		1	0	0	1	1	1	0		
	/	0	1	0	1	1	1	1		15
O		1	0	0	1	1	1	1		

**The "Talk Only" switch is set to "ON" when used with a printer or other "listen only" device.

Table 4.2 – 1991/1992 GPIB Address Assignment (Cont'd)

ASCII CHARACTERS		DATA LINES							ADDRESS SWITCH SETTING ** TALK ONLY 1 / 0 — A5 A4 A3 A2 A1	DECIMAL ADDRESS
		D_7	D_6	D_5	D_4	D_3	D_2	D_1		
TALK	LISTEN	TALK	LISTEN	ADDRESS						
				16	8	4	2	1		
	Ø	0	1	1	0	0	0	0		16
P		1	0	1	0	0	0	0		
	1	0	1	1	0	0	0	1		17
Q		1	0	1	0	0	0	1		
	2	0	1	1	0	0	1	0		18
R		1	0	1	0	0	1	0		
	3	0	1	1	0	0	1	1		19
S		1	0	1	0	0	1	1		
	4	0	1	1	0	1	0	0		20
T		1	0	1	0	1	0	0		
	5	0	1	1	0	1	0	1		21
U		1	0	1	0	1	0	1		
	6	0	1	1	0	1	1	0		22
V		1	0	1	0	1	1	0		
	7	0	1	1	0	1	1	1		23
W		1	0	1	0	1	1	1		
	8	0	1	1	1	0	0	0		24
X		1	0	1	1	0	0	0		
	9	0	1	1	1	0	0	1		25
Y		1	0	1	1	0	0	1		
	:	0	1	1	1	0	1	0		26
Z		1	0	1	1	0	1	0		
	;	0	1	1	1	0	1	1		27
[		1	0	1	1	0	1	1		
	<	0	1	1	1	1	0	0		28
\		1	0	1	1	1	0	0		
	=	0	1	1	1	1	0	1		29
]		1	0	1	1	1	0	1		
	>	0	1	1	1	1	1	0		30
^		1	0	1	1	1	1	0		
NONE		ILLEGAL							NONE	31

**The "Talk Only" switch is set to "ON" when used with a printer or other "listen only" device.

4.3.4 Note in the table the column headed "ADDRESS SWITCH SETTING". It illustrates the positions of switches A1 to A5 for each number address listed in the far right column. To set the GPIB address, simply select the desired decimal address for the counter, refer to the table, and set the switches on the address selector to the corresponding pattern shown in the column.

4.3.5 Once an address has been assigned and stored, the controller may then address the 1991/1992 as a talker/listener by transmitting the appropriate ASCII character on the data lines. The "DATA LINES" column of the table shows the 7-bit binary codes for every talk/listen address assigned to the counter. The controller transmits these codes to the counter to establish its talker/listener status.

4.3.6 Note also in the table that there are two address codes for each GPIB address number. Each code represents a different ASCII character. For example, if an address of 02 is assigned to the counter, the talk address is the ASCII character B and the listen address is the ASCII character ". The only difference in the binary code in each case is the state of data lines D6 and D7.

4.3.7 The counter's GPIB address can be displayed in decimal form using key sequence SHIFT RECALL RESET. If the 1991/1992's bus address is changed, the previous key sequence must be repeated to display the new address. Press the CONTINUE key to return the 1991/1992 to the measurement mode.

4.3.8 The rear-panel GPIB switch bank provides a TALK ONLY selector switch (see Subsection 4.6.2). For addressed operation, the TALK ONLY switch must be in the logic 0 position (down).

4.3.9 The 1991/1992 is preset at GPIB address 14, 15, 16 or 17 when shipped.

4.4 GPIB FUNCTIONAL CHECK

4.4.1 Introduction

4.4.1.1 The following procedure verifies the 1991/1992's capability to accept, process, and transmit GPIB messages. Complete a satisfactory functional check of the counter under local control before starting this procedure (see Subsection 2.6).

4.4.1.2 Successful completion of this GPIB check indicates that the counter's GPIB interface is operating properly. This procedure does not check that all the device-function commands can be executed. However, if the GPIB interface works correctly and the counter operates correctly under local control, there is a high probability that it will respond to all device-function commands.

4.4.1.3 For recommended test equipment use a Hewlett-Packard Model HP-85 GPIB controller with I/O ROM in a drawer. It is assumed that the select code for the controller I/O port is 7 and the GPIB address of the counter is 15.

NOTE:

If any other controller or selected/GPIB address combination is used, the GPIB commands in the following procedure will require change.

4.4.1.4 Connect the controller to the GPIB interface of the counter using a standard GPIB cable. No connection should be made to Inputs A, B, or C.

4.4.2 Remote and Local Check

4.4.2.1 Now perform the following procedure:

a. Power-on the counter. Verify that the REM, ADDR, and SRQ LEDs flash on and off once. If the indicators do not flash or flash continuously, there is a fault on the GPIB PCB. Verify that the counter assumes the home state described in Subsection 2.6.1.2.

b. Test as shown below:

Action	HP-85 Code	Your Controller
Send the REN command true, together with the 1991/1992's listen address	REMOTE 715	

c. Verify that the REM LED lights

d. Test as shown below:

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

e. Verify that the ADDR LED lights and that the Check mode is selected

f. Test as shown below:

Action	HP-85 Code	Your Controller
Send the 1991/1992's listen address followed by the GTL command	LOCAL 715	

g. Verify that the REM LED is off. The ADDR LED will also turn off if the controller automatically transmits the UNL (unlisten) command true, as is the case using the HP-85

4.4.3 Local Lockout and Clear Lockout Check

4.4.3.1 Test as shown below:

Action	HP-85 Code	Your Controller
Send the REN command true, together with the 1991/1992's listen address	REMOTE 715	
Send the LLO command	LOCAL LOCKOUT 7	

a. Verify that the REM LED lights. Operate the LOCAL key on the front panel and check that the REM LED remains lit

b. Test as shown below:

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

c. Verify that the REM LED is off

d. Test as shown below:

Action	HP-85 Code	Your Controller
Send the REN command true, together with the 1991/1992's listen address	REMOTE 715	

e. Verify that the REM LED lights. Operate the LOCAL key and check that the REM LED turns off

4.4.4 Data Output Check

4.4.4.1 Test as shown below:

Action	HP-85 Code	Your Controller
Set the 1991/1992 in the Check mode by sending the counter's 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 1991/1992's talk address. Store the 21-byte data string in the prepared store	ENTER 715; Z$	
Display the contents of the store	DISP 7$	

a. Verify that the HP-85 display reads CK+0010.0000000E+06 with the cursor moved to the next line, indicating that carriage return (CR) and line feed (LF) have been accepted

4.4.5 SRQ and Status Byte Check

4.4.5.1 Test as shown below:

Action	HP-85 Code	Your Controller
Send the REN command true	REMOTE 7	
Set the 1991/1992 to transmit the SRQ command when an error is detected, and force the generation of error code 0_ by sending device-dependent command 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)	

a. Verify that the HP-85 display reads SRQ=1, the SRQ status bit is at logic 1 or the SRQ line is $\leq$0.8 V. Confirm that the SRQ LED is lit

b. Test as shown below:

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	

c. Verify that the SRQ LED 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, verify that the ADDR LED is turned off

4.4.6 Device Clear and Selected Device Clear Check

4.4.6.1 Test as shown below:

Action	HP-85 Code	Your Controller
Set the 1991/1992 to the Total A by B mode by sending the instrument's listen address, followed by device-dependent command TA	OUTPUT 715; "TA"	
Send the DCL command true	CLEAR 7	

a. Verify that the function indicated on the front panel changes to FREQ A

b. Test as shown below:

Action	HP-85 Code	Your Controller
Reset the 1991/1992 to the Total A by B mode by sending the instrument's listen address, followed by device-dependent command TA	OUTPUT 715; "TA"	
Send the SDC message true	CLEAR 715	

c. Verify that the function indicated on the front panel changes to FREQ A

4.4.7 IFC Check

4.4.7.1 Test as shown below:

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

a. Verify that the ADDR LED is turned off

4.4.8 TALK ONLY Selector Check

4.4.8.1 Perform the following procedure:

a. Set the TALK ONLY switch on the counter's rear panel to 1. Verify that the REM LED is turned off and the ADDR LED lights

b. Set the TALK ONLY switch to 0. Verify that the ADDR LED is turned off

4.5 INTERFACE MESSAGE REPERTOIRE and RESPONSE

4.5.1 Introduction

4.5.1.1 The 1991/1992 is equipped with a standard GPIB interface designed to meet IEEE-STD-488-1978 specifications. These specifications provide a definition of multiline interface messages, dividing them into two main groups:

a. Primary command group

b. Secondary command group

This counter includes only the primary commands in its interface repertoire.

4.5.1.2 The primary command group is further divided into four categories:

a. Listen address commands

b. Talk address commands

c. Addressed commands

d. Universal commands

4.5.2 Listen and Talk Address Commands

4.5.2.1 The counter responds to address messages defined by the programmed GPIB address set from the rear panel. Refer back to Table 4.2 as required for a listing of the 31 talk and 31 listen addresses. The 1991/1992 will respond to talk and listen address messages regardless of its addressed state.

4.5.2.2 Listen Addresses

4.5.2.2.1 Receipt by the counter of a listen address makes it a listener. If previously addressed to talk, the counter ceases to be a talker. In in Local mode, the counter reverts to its Remote state, provided the REN message is true.

4.5.2.3 Talk Addresses

4.5.2.3.1 Receipt by the counter of a talk address makes it a talker. If previously addressed to listen, the counter ceases to be a listener. If in Local mode, the counter will remain under local control.

4.5.2.4 Talk Addresses - Other Devices

4.5.2.4.1 If the counter was previously addressed to talk, then receives the talk address of another bus device, the 1991/1992 ceases to be a talker.

4.5.3 Addressed and Universal Commands

4.5.3.1 Table 4.3 lists the Addressed and Universal commands to which the 1991/1992 responds. These multiline interface commands are recognized because they are sent with the ATN message as true. The following paragraphs describe the counter's response to each of these commands.

Table 4.3 - Addressed and Universal Commands

Message	Meaning	Hex Code	Decimal Equivalent	Data Line Code						
				7	6	5	4	3	2	1
GTL	Go To Local	01	1	0	0	0	0	0	0	1
SDC	Selected Device Clear	04	4	0	0	0	0	1	0	0
GET	Group Execute Trigger	08	8	0	0	0	1	0	0	0
LLO	Local Lock Out	11	17	0	0	1	0	0	0	1
DCL	Device Clear	14	10	0	0	1	0	1	0	0
SPE	Serial Poll Enable	18	24	0	0	1	1	0	0	0
SPD	Serial Poll Disable	19	25	0	0	1	1	0	0	1
UNL	Unlisten	3F	63	0	1	1	1	1	1	1
UNT	Untalk	5F	9	1	0	1	1	1	1	1

4.5.3.2 Go To Local (GTL)

4.5.3.2.1 Provided the counter is in remote and a listener, it reverts to local operation. The counter remains addressed to listen. It now operates by front-panel controls, until returned to remote control by receipt of the first byte of a device-dependent message. The decimal and hex equivalents are both 01.

4.5.3.3 Selected Device Clear (SDC)

4.5.3.3.1 Provided the counter is in remote and a listener, it reverts to home state. The condition of the GPIB interface remains unchanged. The decimal and hex equivalents are both 04.

4.5.3.4 Group Execute Trigger (GET)

4.5.3.4.1 Provided the counter is a listener and no measurement is in progress, it triggers a previously programmed measurement. The GET command permits several bus devices to simultaneously perform a number of different operations. (All bus members have been previously programmed to perform a function on receiving the GET command or trigger command.) The decimal and hex equivalents are both 08.

4.5.3.5 Local Lockout (LLO)

4.5.3.5.1 The counter responds to the LLO command regardless of its addressed state. The LLO command disables the LOCAL key on the front panel. Local lockout is cleared by sending the REN message as false, returning all bus devices to the local control state. A GTL command returns the counter to local control. The decimal and hex equivalents are 17 and 11, respectively.

4.5.3.6 Device Clear (DCL)

4.5.3.6.1 Same as the SDC command, except that all bus devices in remote are cleared. The counter responds to this command regardless of its addressed state. The decimal and hex equivalents are 10 and 14, respectively.

4.5.3.7 Serial Poll Enable (SPE)

4.5.3.7.1 This command permits all bus members, including the counter, to set their SRQ line to binary 1, informing the controller that attention is required. The 1991/1992 responds to this command regardless of its addressed state. Each bus member, having been made a talker, is then serially interrogated by the controller to determine which bus member(s) requested service and the purpose of each request. Bus members respond by transmitting their respective status bytes to the controller. All members respond to the SPE regardless of their addressed state. The hex and decimal equivalents are 18 and 24, respectively.

4.5.3.8 Serial Poll Disable (SPD)

4.5.3.8.1 This command returns all bus members to normal operation after completion of a serial poll. All bus members respond to the SPD command regardless of their addressed state. If addressed to talk, a bus device will put its data output string on the GPIB, provided such data is available in its output buffer. The decimal and hex equivalents are 25 and 19, respectively.

4.5.3.9 Untalk (UNT)

4.5.3.9.1 This universal command instructs all talkers, including the counter, to return to their untalk or talker-idle state. All bus members are also removed from their talker state whenever a talk address other than their own is received. In the Untalk state, the front-panel ADDR LED is turned off. The decimal and hex equivalents are 9 and 5F, respectively.

4.5.3.10 Unlisten (UNL)

4.5.3.10.1 This universal command instructs all listeners, including the counter, to return to their unlisten or listen-idle state. In the Unlisten state, the front-panel ADDR LED is turned off. The decimal and hex equivalents are 63 and 3F, respectively.

4.6 GPIB OPERATING MODES

4.6.1 Introduction

4.6.1.1 Before operating the counter on the GPIB, ensure that the instrument has been assigned its correct bus address (see Subsection 4.3) and that the correct AC line voltage has been selected (see Subsection 2.4.2). The last instruction is especially important if the 1991/1992 is being used for the first time or at a new location.

4.6.1.2 The 1991/1992 can be operated on the GPIB in either its Talk-Only or Addressed mode.

4.6.2 Talk-Only Mode

4.6.2.1 To set the counter in this mode, place the TALK ONLY switch of the GPIB switch bank in its logic "1" position. The GPIB interface is now in the Talk-Only mode and the settings of switches A1 to A5 are irrelevant.

4.6.2.2 The Talk-Only mode may be used in systems not having a controller. Such a system permits remote reading of counter measurement data, however, the instrument is controlled from the front panel (see Section 3).

4.6.2.3 The counter determines the rate at which measurements are made. The output buffer is updated at the end of each measurement cycle, overwriting the previous measurement data if not transferred to the listener.

4.6.2.4 The listener triggers the transfer of data from the counter. The counter's output buffer is cleared when data transfer is completed.

4.6.2.5 Differences between the measurement rate and data-transfer trigger-rate are resolved as follows:

a. If data transfer is in progress at the end of a measurement cycle, updating of the output buffer is delayed. Data transferred will correspond to the previous measurement cycle

b. If data transfer is requested during a measurement cycle and the output buffer is empty, data transfer is delayed until the buffer is updated. Data transferred will then correspond to the latest measurement cycle

c. If a measurement cycle is completed before the results of the previous cycle have commenced transfer to the listener, the buffer will be updated. The data from the previous cycle will be overwritten and lost.

4.6.2.6 Measurement rate in the 1991/1992 can be controlled in the following ways:

a. The gate time can be controlled by selecting an appropriate display resolution

b. A time interval delay can be set between measurement cycles by using Special Functions 40 to 44

c. The counter can be operated in the Hold mode (single-shot measurements). Readings are displayed indefinitely in Hold until the RESET key is pressed, initiating a new measurement cycle

4.6.3 Addressed Mode

4.6.3.1 In the Addressed mode, all of the counter's functions (except POWER ON/OFF and STBY) can be controlled by device-dependent commands (see Subsection 4.10). These commands are sent over the GPIB after the counter has been addressed to listen. Completed measurement readings and counter status information are then read back over the bus after the counter is addressed to talk. If the counter is addressed to talk when its output buffer is empty, no data transfer will occur and bus activity will cease. Data transfer will start again after the output buffer is updated at the completion of the next measurement cycle.

4.7 OUTPUT MESSAGE FORMAT (TALKER)

4.7.1 Introduction

4.7.1.1 Refer to Table 4.4. The 1991/1992 uses the same output message format for both transmitting measurement values as well as numbers recalled from the counter's internal stores.

4.7.1.2 The output message consists of a string of 21 ASCII characters for each transmitted value. Output messages should be interpreted using Tables 4.4 and 4.5. Measurement units should be assumed as hertz, seconds, volts, degrees, or a ratio, depending on commands previously sent to the counter.

NOTE:

An SRQ message is not enabled by data recall from the counter's stores.

Table 4.4 - Output Message Format

Byte No.	Interpretation	Permitted ASCII Characters	Notes
1	Function letter or space	See Table 4.5	Spaces are transmitted only if programmed with Special Function 81 active
2	Function letter or space	See Table 4.5	
3	Measurement sign	+ or -	
4	Most significant digit	0 to 9	Bytes 4 to 15 will always include 11 digits and decimal point. Zeros are added when necessary in the more significant positions
5	Digit	0 to 9 or.	
6	↓	↓	
7			
8			
9			
10			
11			
12			
13			
14			
15	Least significant digit		
16	Exponent indicator	E	Upper case only
17	Exponent sign	+ or -	
18	More significant digit	0 to 9	Exponent is a multiple of 3
19	Less significant digit	0 to 9	
20	Carriage return	CR	
21	Line feed	LF	

Table 4.5 - Function Letters

Function	Function Letters
Frequency A	FA
Frequency C (Model 1992 only)	FC
Ratio A/B	RA
Ratio C/B (Model 1992 only)	RC
Time Interval A→B	TI
Totalize A by B	TA
Phase A rel B	PH
Period A	PA
Check	CK
Recalled Data	**Function Letters**
Unit Type	UT
Resolution	RS
Trigger Level A	LA
Trigger Level B	LB
Math Constant X	MX
Math Constant Z	MZ
Delay Time	DT
Special Function	SF
Master Software Issue Number	MS
GPIB Software Issue Number	GS

4.8 SERVICE REQUEST (SRQ)

4.8.1 The counter can be set, by means of device-dependent commands, to enable an SRQ message whenever:

a. A measurement cycle is completed

b. A change of frequency standard occurs

c. An error state is detected

d. Any combination of a, b, and c

4.8.2 The front-panel SRQ LED lights when an SRQ message is asserted.

4.8.3 SRQ enablement may also be inhibited. Refer to Table 4.17 which provides the necessary SRQ commands. When in home state, condition "c" indicated above is active.

NOTE:

An SRQ message is not enabled by data recall from the counter's stores.

4.9 STATUS BYTE

4.9.1 To inform the controller of its status, the counter assembles and transmits a status message referred to as a status byte. The controller generates a serial poll enable cycle to determine which bus member has requested service and the purpose of the request. When the 1991/1992 receives the SPE command, and has been made a talker, it outputs the status byte to the controller. Table 4.6 shows the format of the counter's status byte.

Table 4.6 - Status Byte Format

DIO Line	Function
1	Error - Least significant bit - See NOTE 1
2	Codes
3	in Binary - Most significant bit
4	1 = Frequency standard changed
5	1 = Reading ready - See NOTE 2
6	1 = Error detected
7	1 = Service requested
8	1 = Gate open

Table 4.6 - Status Byte Format (Cont'd)

DIO Line	Function
	NOTE 1: The error codes and numbers are as follows: 1 = Phase measurement attempted on waveforms of differing frequency (Ratio ≠ 1) 2 = Result out-of-range of display 3 = Overflow of internal counters 4 = Numerical entry error 5 = GPIB syntax (programming) error See NOTE 3 No measurement output string is available if error codes 1, 2, or 3 is produced. **NOTE 2:** Regardless of the current SRQ mode, the SRQ message that a reading is ready is not generated after a data-recall operation. **NOTE 3:** The five error codes are cleared as follows: Error 1 - correct the difference in input frequencies or change the measurement mode Error 2 - complete an in-range measurement Error 3 - complete an in-range measurement Error 4 - complete a valid numerical entry Error 5 - the erroneous command string will be correctly executed up to the error; the rest will be handshaken, but not executed. Receipt of the next valid command clears the error

4.10 INPUT COMMANDS (LISTENER)

4.10.1 Introduction

4.10.1.1 The 1991/1992 responds to device-dependent commands in a "deferred" mode. This means that the GPIB interface continues to accept commands until a terminating character or message is received, then the entire string will be executed. There is no "immediate" mode in which commands are obeyed as they are received.

4.10.2 Device-Dependent Commands

4.10.2.1 When the counter is addressed to listen, it can be controlled by device-dependent commands. These commands are listed below, and tabulated in Tables 4.8 to 4.18.

a. Table 4.8 - Instrument Preset Code
b. Table 4.9 - Numerical Input Format
c. Table 4.10 - Measurement Function Codes
d. Table 4.11 - Numerical Input Ranges
e. Table 4.12 - Resolution Selection
f. Table 4.13 - Input Control Codes
g. Table 4.14 - Measurement Control Codes
h. Table 4.15 - Store and Recall Codes
i. Table 4.16 - Special Function Codes
j. Table 4.17 - Service Request Codes
k. Table 4.18 - Alphabetic List of Command Codes

4.10.2.2 Device-dependent commands are executed sequentially beginning with the first one sent and ending with the last.

4.10.2.3 If more than one command is to be sent, no delimiters are required. If necessary, commas, spaces, and semicolons may be included in the command strings for clarification without affecting counter operation.

4.10.2.4 Each command string must be followed by an end-of-string terminating group. Table 4.7 shows the valid terminator groups.

Table 4. 7 - Permitted Terminators

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

Where LF=Line feed, CR=carriage return; EOI is considered true

NOTE:

Data output terminators are CR LF without EOI asserted.

4.10.2.5 Table 4.8 provides the instrument preset code for the 1991/1992. Refer to Subsection 1.6.15 for a listing of the counter's initialization conditions.

Table 4.8 - Instrument Preset Code

Function	Code
Sets counter functions and settings to home state	IP

4.10.2.6 Some of the device-dependent commands in the following tables require additional numerical input data. Such numerical input succeeds its command and is indicated by an asterisk (*) in the tabulations. Also, home-states are underlined. Refer to Table 4.9 as required for numerical input format.

Table 4.9 - Numerical Input Format

Byte No.	Interpretation	Permitted ASCII Characters
1	Sign of mantissa	+ or -
2	Most significant digit	0 to 9 or .
3	Digit	↓
4	↓	
5		
6		
7		
8		
9		
10		
11	Least significant digit	↓
12	Exponent indicator	E or e
13	Exponent sign/space	+ or - or space
14	More significant digit	0 to 9
15	Less significant digit	0 to 9

NOTE 1:

Spaces, nulls, or zeros occurring before byte 1 are ignored by the counter.

NOTE 2:

Byte 1 may be omitted and a positive mantissa assumed.

NOTE 3:

Bytes 2 to 11 may have up to 9 digits and a decimal point. The decimal point, however, is not essential. After entry of 9 digits (without a decimal point), additional digits are ignored and a GPIB programming error is generated. Excess digits that are truncated will still increase the power-of-ten stored. Also, if fewer than 9 digits are needed, unused bytes may be omitted.

NOTE 4:

Spaces or nulls entered between bytes 11 and 12 are ignored by the counter.

Table 4.9 - Numerical Input Format (Cont'd)

NOTE 5:

Bytes 12 to 15 (exponent group) may be omitted. Also, byte 13 may be omitted or transmitted as a space (a positive exponent should be assumed in either instance).

NOTE 6:

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

NOTE 7:

Numbers may be terminated by one of the same terminators used for output messages, or by another device-dependent message.

NOTE 8:

Units are implied; volts for trigger levels, seconds for delay times.

4.10.2.7 Table 4.10 presents the measurement function codes for the 1991/1992.

Table 4.10 - Measurement Function Codes

Function	Code
Frequency A	FA
Frequency C (Model 1992 only)	FC
Period A	PA
Time Interval A→B	TI
Totalize A by B	TA
Ratio A/B	RA
Ratio C/B (Model 1992 only)	RC
Phase A rel B	PH
Check	CK

NOTE:

Only the 1992 accepts FC and RC as valid commands.

4.10.2.8 Table 4.11 provides the various numerical input ranges for the 1991/1992.

Table 4.11 - Numerical Input Ranges

Function	Command Code	Numerical Limits	
		Low	High
Resolution	SRS	3	10
Trigger Level (x1)	SLA, SLB	-5.1	+5.1
Trigger Level (x10)	SLA, SLB	-51	+51
Math Constant	SMX, SMZ	$\geq 1 \times 10^{-9}$	$< 1 \times 10^{10}$
		0	
		$> -1 \times 10^{10}$	$\leq -1 \times 10^{-9}$
Delay Time	SDT	200×10^{-6}	0.8

NOTE 1:

Entered numbers will be rounded up before storage as follows:

a. Trigger level x1 to next multiple of 20 mV

b. Trigger level x10 to next multiple of 200 mV

c. Delay to next multiple of 25.6 μs

NOTE 2:

Resolution entries are rounded down to the next integer. Refer to Table 4.12 for related gate times and GPIB resolution numbers.

NOTE 3:

Math constant Z can be set to zero. However, an error message will result if the Math function is enabled with this value set.

4.10.2.9 Table 4.12 provides the 1991/1992 GPIB resolution selection.

Table 4.12 - Resolution Selection

GPIB Resolution Number	Number of Selected Digits in Frequency, Period, Ratio, and Check	Gate Time
10	9 + Overflow	10 s
9	9	1 s
8	8	100 ms
7	7	10 ms
6	6	1 ms
5	5	1 ms
4	4	1 ms
3	3	1 ms

NOTE:

Refer to Table 3.11 as required. It shows the relationship of gate time and display resolution in the 1991/1992.

4.10.2.10 The following tables complete the necessary GPIB commands for the 1991/1992:

Table 4.13 - Input Control Codes

Function	Code
FILTER Disable/Enable	AFD/AFE
COM A Disable/Enable	BCS/BCC
DC/AC Coupling A	ADC/AAC
DC/AC Coupling B	BDC/BAC
1 MΩ/50Ω impedance A	AHI/ALI
1 MΩ/50Ω impedance B	BHI/BLI
Slope A +ve/-ve	APS/ANS
Slope B +ve/-ve	BPS/BNS
x10 attenuator A Disable/Enable	AAD/AAE
x10 attenuator B Disable/Enable	BAD/BAE
Manual/AUTO-TRIG A	AMN/AAU
Manual/AUTO-TRIG B	BMN/BAU

Table 4.14 - Measurement Control Codes

Function	Code
Continuous measurement mode selection	T0 (See NOTE 1)
Single (One-Shot) measurement mode selection	T1 (See NOTE 2)
Start Totalize or trigger a measurement (T1 mode)	T2 (See NOTE 3)
Stop Totalize	T3 (See NOTE 3)
Read current value while measurement is in progress (i.e., next reading on the fly)	RF (See NOTE 4)
Math function Disable/Enable	MD/ME
Delay Disable/Enable	DD/DE
Reset measurement	RE

NOTE 1:

In continuous measurement mode, the output buffer is updated at the end of each gate period. If the buffer is being read out via the bus when the gate period ends, updating is delayed until reading is complete.

NOTE 2:

In single-measurement mode, the output buffer is cleared every time a T1 command is received. The measurement completed must be read, therefore, before the next measurement cycle is triggered.

NOTE 3:

In making totalize measurements, T2 and T3 commands are used with the TA command and Special Function 61. In this mode, the readings executed in successive totalize periods are cumulative; the RE command is used to reset the count to zero when required.

NOTE 4:

The RF command must be sent each time a reading is required. The reading is obtained when the counter is made a talker.

Table 4.15 - Store and Recall Codes

Function	Code
Recall unit type	RUT
Store display resolution number	SRS
Recall display resolution number	RRS
Store A channel manual trigger level	SLA (See NOTE 1)
Recall A channel manual trigger level or peak level	RLA (See NOTES 1 and 2)
Store B channel manual trigger level	SLB (See NOTE 1)
Recall B channel manual trigger level or peak level	RLB (See NOTES 1 and 2)
Store math constant X	SMX
Recall math constant X	RMX
Store math constant Z	SMZ
Recall math constant Z	RMZ
Store arming delay value	SDT
Recall arming delay value	RDT
Recall special function register	RSF
Recall master software issue number	RMS
Recall GPIB software issue number	RGS

NOTE 1:

The manual trigger level is automatically scaled by a factor of 10 when the x10 attenuator is switched in or out of circuit. Ensure that the correct input attenuation is selected before storing or recalling the trigger level.

NOTE 2:

The levels recalled by commands RLA and RLB depend upon the enablement of Special Functions 50, 51, and 52.

NOTE 3:

Numbers to be stored should follow the store command. The format to be used for numerical entry is provided in Table 4.9. The limiting values for numerical entries are given in Table 4.11.

NOTE 4:

The counter returns to the measurement mode automatically at the completion of a store or recall operation.

NOTE 5:

No SRQ message is generated for recalled data.

Table 4.16 - Special Function Codes

Function	Code
Special functions Disabled/Enabled	SFD/SFE
Store special function nn	Snn

NOTE 1:

The list of special functions (SFs) is provided in Table 3.12.

NOTE 2:

Storing a special function when special functions are enabled immediately enables that special function.

Table 4.17 - Service Request Codes

Function	Code
SRQ generation inhibited	Q0
upon error detection	Q1
for measurement ready	Q2
for measurement ready or error detection	Q3
for frequency standard change	Q4
for frequency standard change or error detection	Q5
for measurement ready or frequency standard change	Q6
for measurement ready, frequency standard change, or error detection	Q7

NOTE:

An SRQ message is not generated by data recalled from stores.

Table 4.18 - Alphabetic List of Command Codes

Code	Command	Code	Command
AAC	A Channel, AC coupling	PA	Period A
AAD	A Channel, x10 attenuator disabled	PH	Phase A relative to B
		Qn	SRQ mode
AAE	A Channel, x10 attenuator enabled	RA	Ratio A/B
		RC	Ratio C/B (Model 1992 only)
AAU	A Channel auto-trigger		
ADC	A Channel, DC coupling	RDT	Recall arming delay time
AFD	A Channel filter disabled	RE	Reset measurement
AFE	A Channel filter enabled	RF	Read total so far
AHI	A Channel, 1 Mohm	RGS	Recall GPIB software issue number
ALI	A Channel, 50 ohms		
AMN	A Channel manual trigger	RLA	Recall trigger level A or peak level
ANS	A Channel, -ve slope		
APS	A Channel, +ve slope	RLB	Recall trigger level B or peak level
BAC	B Channel, AC coupling		
BAD	B Channel, x10 attenuator disabled	RMS	Recall master software issue number
BAE	B Channel, x10 attenuator enabled	RMX	Recall math constant X
		RMZ	Recall math constant Z
BAU	B Channel auto-trigger	RRS	Recall display resolution
BCC	A and B Channels common	RSF	Recall special function
BCS	A and B Channels separate	RUT	Recall unit type
BDC	B Channel, DC coupling	Snn	Special function number
BHI	B Channel, 1 Mohm	SDT	Store arming delay time
BLI	B Channel, 50 ohms	SFD	Special function disabled
BMN	B Channel manual trigger	SFE	Special function enabled
BNS	B Channel, -ve slope	SLA	Store trigger level A
BPS	B Channel, +ve slope	SLB	Store trigger level B
CK	Check	SMX	Store math constant X
DD	Delay disabled	SMZ	Store math constant Z
DE	Delay enabled	SRS	Store display resolution
FA	Frequency A	Tn	Measurement mode or start/stop reading
FC	Frequency C (Model 1992 only)		
IP	Instrument Preset	TA	Total A by B
MD	Math function disabled	TI	Time Interval
ME	Math function enabled		

SECTION 5 GENERAL THEORY OF OPERATION

5.1 INTRODUCTION

5.1.1 This section describes the general theory of operation for the 1991/1992.

5.1.2 The theory of operation provided is based on the simplified overall block diagram shown in Figure 5.1. Key circuit blocks of the 1991/1992 are described and supported in this section using simplified block and schematic diagrams. These diagrams supplement the complete schematics found in Section 7 of this manual. As much as possible, the simplified schematic and block diagrams provided here use the same reference designators found in the complete schematics. This should facilitate cross-referencing between this section of the manual and the schematics.

5.1.3 Integrated circuits (ICs) in the following circuit descriptions are designated by circuit references provided on the supporting simplified block and schematic diagrams. The IC designations employed in the following key circuit descriptions follow those found in supplied schematics.

When an IC package contains more than one circuit, suffix letters are used to distinguish them (e.g., IC1a). Finally, when it is necessary to identify a specific pin in an IC, the reference designator, with a suffix letter if necessary, is followed by a hyphen and then the required pin number (e.g., IC1a-1).

5.2 FUNCTIONAL BLOCKS

5.2.1 The 1991/1992 contains the following ten main functional blocks:

a. Channel A/B block (see Subsection 5.3.1)

b. Channel C (Model 1992 only) block (see Subsection 5.3.2)

c. Measurement block (see Subsection 5.3.3)

d. Display block (see Subsection 5.3.4)

e. Keyboard block (see Subsection 5.3.5)

f. Microprocessor block (see Subsection 5.3.6)

g. Standby and IRQ block (see Subsection 5.3.7)

h. Power Supply block (see Subsection 5.3.8)

i. Internal Frequency Standard block (see Subsection 5.3.9)

j. GPIB Interface (see Subsection 5.3.10)

5.2.2 The functional relationship between the blocks of the 1991/1992 is illustrated in Figure 5.1. The measurement block is internally configured by the microprocessor according to the instructions entered via the keyboard or over the GPIB. The signal to be measured and the signal from the frequency standard are fed to the measurement block. The measured result is passed to the microprocessor. If mathematical manipulation of the result is required, this is performed by the