

8840A

MULTIMETER

Instruction Manual

P/N 684365
MAY 1984

©1984 John Fluke Mfg. Co., Inc. All rights reserved. Litho in U.S.A.



WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive:

The JOHN FLUKE MFG. CO., INC., warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of 1-year from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90-days), or any product or parts which have been subject to misuse, neglect, accident, or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, John Fluke Mfg. Co., Inc., will repair and calibrate an instrument returned to an authorized Service Facility within 1 year of the original purchase; provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within 1 year of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident, or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. JOHN FLUKE MFG. CO., INC., SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

If any failure occurs, the following steps should be taken:

1. Notify the JOHN FLUKE MFG. CO., INC., or nearest Service facility, giving full details of the difficulty, and include the model number, type number, and serial number. On receipt of this information, service data, or shipping instructions will be forwarded to you.
2. On receipt of the shipping instructions, forward the instrument, transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

SHIPPING TO MANUFACTURER FOR REPAIR OR ADJUSTMENT

All shipments of JOHN FLUKE MFG. CO., INC., instruments should be made via United Parcel Service or "Best Way"® prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid and of adequate size. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon original delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

The JOHN FLUKE MFG. CO., INC., will be happy to answer all applications or use questions, which will enhance your use of this instrument. Please address your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. BOX C9090, EVERETT, WASHINGTON 98206, ATTN: Sales Dept. For European Customers: Fluke (Holland) B.V., P.O. Box 5053, 5004 EB, Tilburg, The Netherlands.

*For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206

SECTION GUIDE












Introduction and Specifications	
Operating Instructions	
Remote Programming	
Measurement Tutorial	
Theory of Operation	
Maintenance	
List of Replaceable Parts	
Options and Accessories	
Manual Change Information	
Schematic Diagrams	
Index	

Table of Contents

SECTION	TITLE	PAGE
1	INTRODUCTION AND SPECIFICATIONS	1-1
1-1.	INTRODUCTION	1-1
1-2.	THE 8840A DIGITAL MULTIMETER	1-1
1-3.	OPTIONS AND ACCESSORIES	1-1
1-4.	SPECIFICATIONS	1-1
2	OPERATING INSTRUCTIONS	2-1
2-1.	INTRODUCTION	2-1
2-2.	INSTALLATION	2-1
2-3.	Installing the Power-Line Fuse	2-1
2-4.	Connecting to Line Power	2-1
2-5.	Adjusting the Handle	2-1
2-6.	Rack Mounting Kits	2-1
2-7.	OPERATING FEATURES	2-1
2-8.	Power-Up Features	2-1
2-9.	Front and Rear Panel Features	2-3
2-10.	Display Features	2-3
2-11.	Error Messages	2-3
2-12.	Overrange Indication	2-3
2-13.	Diagnostic Self-Tests	2-3
2-14.	Ranging	2-8
2-17.	Triggering	2-8
2-20.	Reading Rates and Noise Rejection	2-8
2-21.	Automatic Settling Time Delay	2-9
2-22.	External Trigger Input (Option -05 Only)	2-9
2-23.	Sample Complete Output (Option -05 Only)	2-9
2-24.	MAKING MEASUREMENTS	2-9
2-25.	Input Overload Protection Limits	2-9
2-26.	Measuring Voltage and Resistance	2-10
2-27.	Measuring Current	2-10
2-28.	Current Fuse Protection	2-10
2-29.	Offset Measurements	2-11
2-30.	EXTERNAL CLEANING	2-12

(continued on page ii)

TABLE OF CONTENTS

SECTION	TITLE	PAGE
3	REMOTE PROGRAMMING	3-1
3-1.	INTRODUCTION	3-1
3-2.	CAPABILITIES	3-1
3-3.	BUS SET-UP PROCEDURE	3-1
3-4.	AN OVERVIEW OF REMOTE OPERATION	3-1
3-5.	A NOTE ABOUT EXAMPLES	3-2
3-6.	DEVICE-DEPENDENT COMMAND SET	3-2
3-7.	Bn (Offset Commands)	3-2
3-8.	Cn (Calibration Commands)	3-4
3-9.	Dn (Display Commands)	3-4
3-10.	Fn (Function Commands)	3-4
3-11.	Get Commands	3-4
3-12.	G0 (Get Instrument Configuration)	3-7
3-13.	G1 (Get SRQ Mask)	3-7
3-14.	G2 (Get Calibration Prompt)	3-7
3-15.	G3 (Get User-Defined Message)	3-9
3-16.	G4 (Get Calibration Status)	3-9
3-17.	G5 (Get IAB Status)	3-9
3-18.	G6 (Get YW Status)	3-9
3-19.	G7 (Get Error Status)	3-9
3-20.	N (Numeric Entry Command)	3-11
3-21.	Put Commands	3-11
3-22.	P0 (Put Instrument Configuration)	3-11
3-23.	P1 (Put SRQ Mask)	3-11
3-24.	P2 (Put Calibration Value)	3-12
3-25.	P3 (Put User-Defined Message)	3-12
3-26.	Rn (Range Commands)	3-12
3-27.	Sn (Reading Rate Commands)	3-12
3-28.	Tn (Trigger Mode Commands)	3-12
3-29.	Wn (Terminator Commands)	3-14
3-30.	X0 (Clear Error Register Command)	3-14
3-31.	Yn (Suffix Commands)	3-14
3-32.	Z0 (Self-Test Command)	3-14
3-33.	* (Device-Clear Command)	3-14
3-34.	? (Single-Trigger Command)	3-15
3-35.	INPUT SYNTAX	3-15
3-36.	Definitions	3-15
3-37.	Input Processing	3-15
3-38.	Syntax Rules	3-15
3-39.	OUTPUT DATA	3-17
3-40.	Loading Output Data	3-17
3-41.	Types of Output Data	3-18
3-42.	Numeric Data and Error Messages	3-18
3-45.	Status Data	3-18
3-46.	Output Priority	3-19
3-47.	SERVICE REQUESTS	3-19
3-48.	The Serial Poll Register	3-19
3-49.	The SRQ Mask	3-20
3-50.	INTERFACE MESSAGES	3-20
3-51.	Address Messages	3-20

(continued on page iii)

SECTION	TITLE	PAGE
3-52.	Universal Commands	3-20
3-53.	Addressed Commands	3-21
3-54.	TALK-ONLY MODE	3-21
3-55.	TIMING CONSIDERATIONS	3-21
3-56.	REMOTE CALIBRATION	3-21
3-57.	IMMEDIATE MODE COMMANDS	3-21
3-58.	EXAMPLE PROGRAMS	3-22
4	MEASUREMENT TUTORIAL	4-1
4-1.	INTRODUCTION	4-1
4-2.	DC VOLTAGE MEASUREMENT	4-1
4-3.	Circuit Loading Error	4-1
4-4.	Input Bias Current Error	4-1
4-5.	RESISTANCE MEASUREMENT	4-2
4-6.	2-Wire Ohms	4-2
4-7.	Correcting for Test Lead Resistance in 2-Wire Ohms	4-2
4-8.	4-Wire Ohms	4-4
4-9.	Applications of the Ohms Functions	4-4
4-13.	DC CURRENT MEASUREMENT	4-6
4-14.	REDUCING THERMAL VOLTAGES	4-7
4-15.	AC VOLTAGE AND CURRENT MEASUREMENT	4-7
4-16.	True RMS Measurement	4-7
4-17.	Waveform Comparison	4-7
4-18.	Crest Factor	4-7
4-19.	AC-Coupled AC Measurements	4-8
4-20.	Combined AC and DC Measurements	4-8
4-21.	Bandwidth	4-8
4-22.	Zero-Input VAC Error	4-8
5	THEORY OF OPERATION	5-1
5-1.	INTRODUCTION	5-1
5-2.	OVERALL FUNCTIONAL DESCRIPTION	5-1
5-3.	DETAILED CIRCUIT DESCRIPTION	5-1
5-4.	DC SCALING	5-1
5-5.	VDC Scaling	5-3
5-6.	VDC Protection	5-4
5-7.	mA DC Scaling	5-4
5-8.	Analog Filter	5-4
5-9.	TRACK/HOLD CIRCUIT	5-4
5-10.	Track Configuration	5-4
5-11.	Settling Configuration	5-4
5-12.	Hold Configuration	5-4
5-13.	Pre-Charge Configuration	5-6
5-14.	PRECISION VOLTAGE REFERENCE	5-6
5-15.	OHMS CURRENT SOURCE	5-6
5-16.	OHMS PROTECTION	5-8
5-17.	OHMS FUNCTIONS	5-8
5-18.	2-Wire Ohms	5-8
5-19.	4-Wire Ohms	5-9
5-20.	A/D CONVERTER	5-11

(continued on page iv)

TABLE OF CONTENTS

SECTION	TITLE	PAGE
5-21.	Timing/Data Control	5-12
5-22.	Precision DAC	5-12
5-23.	A/D Amplifier	5-12
5-24.	Bootstrap Supplies	5-13
5-25.	DISPLAY	5-13
5-26.	KEYBOARD	5-13
5-27.	DIGITAL CONTROLLER	5-13
5-28.	In-Guard Microcomputer	5-13
5-29.	Function and Range Control	5-15
5-30.	A/D Control and Computation	5-15
5-31.	Calibration Correction	5-15
5-32.	Keyboard/Display Control	5-15
5-33.	Troubleshooting Mode	5-17
5-34.	Guard-Crossing Communication	5-17
5-35.	GUARD CROSSING	5-17
5-36.	POWER SUPPLY	5-18
5-37.	IEEE-488 INTERFACE (OPTION -05)	5-18
5-38.	Out-Guard Microcomputer	5-18
5-39.	Guard Crossing	5-18
5-40.	Bus Transceiver	5-18
5-41.	Signal Conditioning	5-18
5-42.	IEEE-488 Interface Power Supply	5-18
5-43.	TRUE RMS AC (OPTION -09)	5-18
5-44.	VAC Scaling	5-19
5-45.	mA AC Scaling	5-20
5-46.	Frequency Response Trimming	5-20
5-47.	True RMS AC-to-DC Conversion	5-20
6	MAINTENANCE	6-1
6-1.	INTRODUCTION	6-1
6-2.	PERFORMANCE TEST	6-1
6-3.	Diagnostic Self-Tests	6-1
6-4.	DC Voltage Test	6-1
6-5.	AC Voltage Test (Option -09 Only)	6-4
6-6.	Resistance Test	6-5
6-7.	DC Current Test	6-5
6-8.	AC Current Test (Option -09 Only)	6-5
6-9.	CALIBRATION	6-5
6-10.	Basic Calibration Procedure	6-6
6-15.	Advanced Features and Special Considerations	6-10
6-23.	Remote Calibration	6-14
6-27.	DISASSEMBLY PROCEDURE	6-16
6-28.	Case Disassembly	6-17
6-29.	True RMS AC PCA Removal (Option -09 Only)	6-17
6-30.	IEEE-488 Interface PCA Removal (Option -05 Only)	6-17
6-31.	Main PCA Removal	6-18
6-32.	Front Panel Disassembly	6-19
6-33.	REASSEMBLY PROCEDURE	6-21
6-34.	INTERNAL FUSE REPLACEMENT	6-23
6-35.	EXTERNAL TRIGGER POLARITY SELECTION (Option -05 Only)	6-23

(continued on page v)

SECTION	TITLE	PAGE
6-36.	TROUBLESHOOTING	6-23
6-37.	Initial Troubleshooting Procedure	6-23
6-38.	Diagnostic Self-Tests	6-26
6-39.	Self-Test Descriptions	6-27
6-40.	Digital Controller Troubleshooting	6-29
6-62.	DC Scaling Troubleshooting	6-34
6-63.	Track/ Hold Troubleshooting	6-36
6-64.	Ohms Current Source Troubleshooting	6-36
6-65.	Precision Voltage Reference Troubleshooting	6-37
6-66.	A/D Converter Troubleshooting	6-37
6-67.	Power Supply Troubleshooting	6-40
6-68.	IEEE-488 Interface Troubleshooting (Option -05)	6-42
6-71.	True RMS AC Troubleshooting (Option -09)	6-43
6-75.	Guard Crossing Troubleshooting	6-46
6-76.	INTERNAL CLEANING	6-47
6-77.	Cleaning Printed Circuit Assemblies	6-47
6-78.	Cleaning After Soldering	6-47
7	LIST OF REPLACEABLE PARTS	7-1
7-1.	INTRODUCTION	7-1
7-2.	HOW TO OBTAIN PARTS	7-1
8	OPTION AND ACCESSORY INFORMATION	8-1
8-1.	INTRODUCTION	8-1
8-2.	ACCESSORIES	8-1
805	IEEE-488 INTERFACE (OPTION -05)	805-1
805-1.	INTRODUCTION	805-1
805-2.	CAPABILITIES	805-1
805-3.	EXTERNAL CONTROLS	805-1
805-4.	INSTALLATION	805-1
805-5.	PROGRAMMING INSTRUCTIONS	805-4
805-6.	MAINTENANCE	805-4
805-7.	LIST OF REPLACEABLE PARTS	805-4
809	TRUE RMS AC (OPTION -09)	809-1
809-1.	INTRODUCTION	809-1
809-2.	INSTALLATION	809-1
809-3.	OPERATING INSTRUCTIONS	809-1
809-4.	MAINTENANCE	809-1
809-5.	LIST OF REPLACEABLE PARTS	809-1
9	MANUAL CHANGE INFORMATION	9-1
9-1.	INTRODUCTION	9-1
9-2.	BACKDATING INSTRUCTIONS	9-1
10	SCHEMATIC DIAGRAMS	10-1
	INDEX	

List of Tables

TABLE	TITLE	PAGE
1-1.	Specifications	1-2
2-1.	Error Codes	2-7
2-2.	Input Overload Limits	2-9
3-1.	Status Data	3-10
3-2.	Numeric Output Data Format	3-18
3-3.	Immediate-Mode Commands for Various Controllers	3-22
3-4.	ASCII/IEEE Std 488-1978 Bus Codes	3-28
4-1.	Ohms Test Current	4-4
5-1.	Sample Rates and Reading Rates	5-17
6-1.	Recommended Test Equipment	6-2
6-2.	DC Voltage Test	6-3
6-3.	Low- and Mid-Frequency AC Voltage Test	6-4
6-4.	High-Frequency AC Voltage Test	6-4
6-5.	Resistance Test	6-5
6-6.	DC Current Test	6-6
6-7.	AC Current Test	6-6
6-8.	A/D Calibration	6-8
6-9.	A/D Calibration Test	6-8
6-10.	Offset and Gain Calibration	6-9
6-11.	High-Frequency AC Calibration	6-10
6-12.	Prompts When Calibrating Individual Ranges	6-11
6-13.	Tolerance Limits	6-12
6-14.	Commands Used During Remote Calibration	6-15
6-15.	Times at Which Commands are Invalid	6-16
6-16.	Overall State Table	6-24
6-17.	Circuitry Tested by the Analog Self-Tests	6-26
6-18.	Self-Test Voltages	6-27
6-19.	Keyboard Wiring	6-33
6-20.	Analog Control Devices	6-34
6-21.	Analog Control Logic States	6-35
6-22.	DC Scaling and Track/Hold Supply Voltages	6-37
6-23.	Power Supply Voltages	6-42
6-24.	Diagnostic Modes	6-44
6-25.	I/O Port Configurations	6-44
6-26.	Isolating a Defective Stage	6-45
6-27.	AC Signal Tracing	6-45

(continued on page vii)

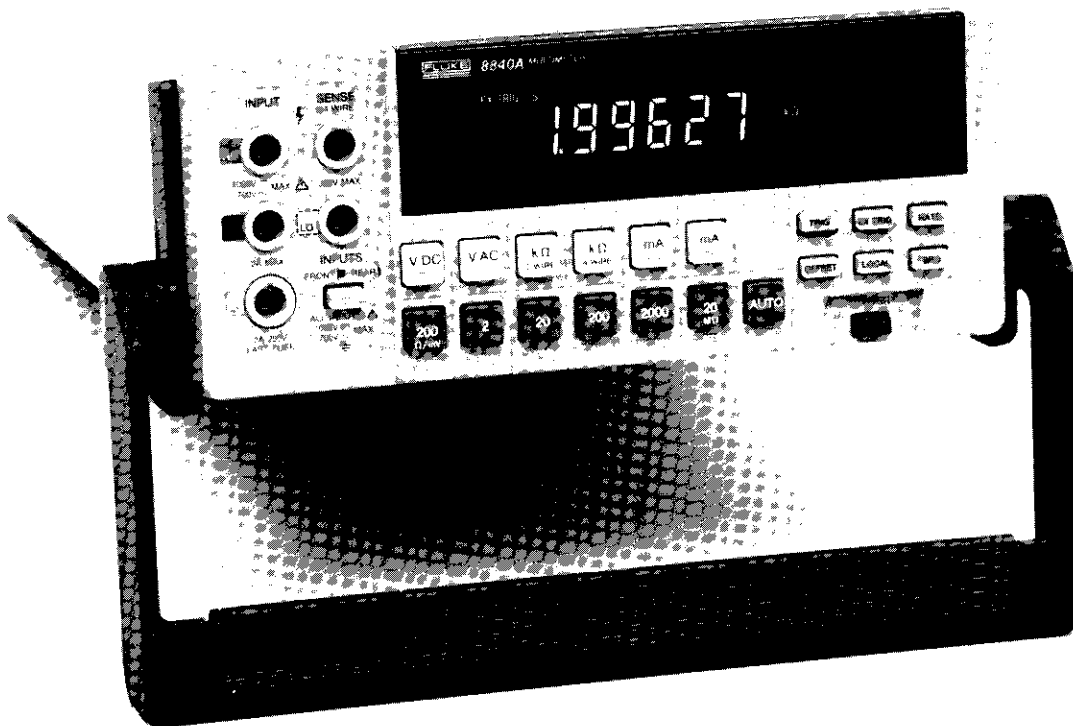
TABLE	TITLE	PAGE
6-28.	Truth Table for U804 and K2	6-45
7-1.	8840A Digital Multimeter	7-3
7-2.	Federal Supply Code for Manufacturers	7-10
8-1.	Accessories	8-1
8-2.	Options	8-1
805-1.	IEEE-488 Interface Printed Circuit Assembly	805-5
809-1.	True RMS AC Printed Circuit Assembly	809-3
9-1.	Manual Status and Backdating Information	9-1

List of Illustrations

FIGURE	TITLE	PAGE
1-1.	External Dimensions	1-8
2-1.	Line Voltage Selection Settings	2-2
2-2.	Adjusting the Handle	2-2
2-3.	Rack-Mount Kits	2-2
2-4.	Installing the Single Rack Mount Kit	2-3
2-5.	Front Panel Features	2-4
2-6.	Rear Panel Features	2-5
2-7.	Typical Error Message	2-7
2-8.	Overrange Indication	2-7
2-9.	Measuring Voltage and Resistance	2-10
2-10.	Measuring Current	2-10
3-1.	IEEE-488 Address Selection	3-2
3-2.	Remote Operation Block Diagram	3-3
3-3.	Typical Command String	3-4
3-4.	Commands Which Correspond to the Front Panel	3-5
3-5.	Device-Dependent Command Set	3-6
3-6.	Output Data Format	3-8
3-7.	Trigger Selection Logic Diagram	3-13
3-8.	Interpretation of Messages	3-16
3-9.	Serial Poll Register	3-19
3-10.	Example Program: Taking 10 Readings	3-23
3-11.	Example Program: Taking Readings with Local Control	3-24
3-12.	Example Program: Using the Serial Poll Register	3-25
3-13.	Example Program: Interrupt Processing	3-26
4-1.	Circuit Loading Error Calculation	4-2
4-2.	Measuring Input Bias Current Error	4-3
4-3.	2-Wire Ohms Measurement	4-3
4-4.	4-Wire Ohms Measurement	4-5
4-5.	Burden Voltage Error Calculation	4-6
4-6.	Waveform Comparison Chart	4-8
4-7.	Typical Crest Factors for Various Waveforms	4-9
4-8.	Combined AC and DC Measurement	4-9
4-9.	Reduction of Zero-Input Error	4-10
5-1.	Overall Functional Block Diagram	5-2
5-2.	DC Scaling (VDC and mA DC)	5-3
5-3.	Track/Hold Amplifier	5-5

(continued on page ix)

FIGURE	TITLE	PAGE
5-4.	Track/Hold Circuit Configurations	5-6
5-5.	Timing Diagram for One A/D Cycle	5-7
5-6.	Precision Voltage Reference	5-8
5-7.	Ohms Current Source	5-9
5-8.	Ohms Scaling	5-10
5-9.	Analog-to-Digital Converter	5-11
5-10.	First Remainder-Store Period	5-12
5-11.	Autozero Period	5-13
5-12.	Vacuum Fluorescent Display	5-13
5-13.	Digital Controller Block Diagram	5-14
5-14.	Read/Write Timing Diagrams for Internal Bus	5-16
5-15.	Guard Crossing Circuit	5-17
5-16.	IEEE-488 Interface Block Diagram	5-19
5-17.	True RMS AC Option Block Diagram	5-19
5-18.	True RMS AC-to-DC Converter	5-20
6-1.	Connections for Kelvin-Varley Voltage Divider	6-3
6-2.	First A/D Calibration Prompt	6-7
6-3.	Calibration Functions	6-7
6-4.	Optimizing 5450A Calibration	6-13
6-5.	Example A/D Calibration Program	6-17
6-6.	Rear Panel (Outside View)	6-18
6-7.	Rear Panel (Inside View)	6-19
6-8.	Front Panel Disassembly	6-20
6-9.	Removing the Display Window	6-21
6-10.	Installing the POWER Switch Push Rod	6-22
6-11.	Waveforms for In-Guard Troubleshooting Mode	6-30
6-12.	Waveforms for Display Logic	6-32
6-13.	Typical Dynamic Control Signals	6-36
6-14.	Typical Output Waveform of Track/Hold Circuit (TP103)	6-38
6-15.	Output of A/D Amplifier (TP101)	6-39
6-16.	Waveforms at U101-24 and U101-25	6-39
6-17.	Typical Bus Data Line Waveform	6-40
6-18.	Waveforms at TP102 for Several Inputs on 2V DC Range	6-41
6-19.	Calculating the A/D Reading from TP102 Waveform	6-41
6-20.	Option -05 Service Position	6-43
6-21.	Option -09 Service Position	6-45
6-22.	Guard Crossing Test Waveforms	6-46
7-1.	8840A Digital Multimeter	7-2
805-1.	Installing Option -05	805-2
809-1.	Installing Option -09	809-2



MODEL 8840A MULTIMETER

Section 1

Introduction and Specifications

1-1. INTRODUCTION

This manual provides complete operating instructions and service information for the 8840A. If you want to get started using your 8840A right away, proceed to the operating instructions in Section 2. If you intend to use the 8840A with the IEEE-488 Interface (Option -05), read Sections 2 and 3.

1-2. THE 8840A DIGITAL MULTIMETER

The Fluke 8840A Digital Multimeter is a high-performance 5-1/2 digit instrument designed for general-purpose bench or systems applications. Features of the 8840A include:

- Highly legible vacuum fluorescent display
- Intuitively easy front panel operation
- Basic dc accuracy of 0.005% for 1 year
- 2-wire and 4-wire resistance measurement
- DC current measurement
- Up to 100 readings per second
- Closed-case calibration (no internal adjustments)
- Built-in self-tests

1-3. OPTIONS AND ACCESSORIES

A number of options and accessories are available for the 8840A which can be easily installed at any time. The options include:

- IEEE-488 Interface (Option -05), featuring:

- Full programmability
- Simple and predictable command set
- Fast measurement throughput
- External trigger connector
- Sample complete connector
- Automated calibration
- Low cost

- True RMS AC (Option -09), featuring:

- AC voltage measurement
- AC current measurement

Accessories include a variety of rack mounting kits, probes, test leads, and cables. Full information about options and accessories can be found in Section 8.

1-4. SPECIFICATIONS

Specifications for the 8840A are given in Table 1-1. External dimensions are shown in Figure 1-1.

Table 1-1. Specifications

DC VOLTAGE
Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION		INPUT RESISTANCE
		5½ DIGITS	4½ DIGITS*	
200 mV	199.999 mV	1 µV	10 µV	≥10,000 MΩ
2V	1.99999V	10 µV	100 µV	≥10,000 MΩ
20V	19.9999V	100 µV	1 mV	≥10,000 MΩ
200V	199.999V	1 mV	10 mV	10 MΩ
1000V	1000.00V	10 mV	100 mV	10 MΩ

*4½ digits at the fastest reading rate.

Accuracy

NORMAL (S) READING RATE ±(% of Reading + Number of Counts).

RANGE	24 HOUR 23±1°C ¹	90 DAY 23±5°C	1 YEAR 23±5°C
200 mV ²	0.003 + 3	0.007 + 4	0.008 + 4
2V	0.002 + 2	0.004 + 3	0.005 + 3
20V	0.002 + 2	0.005 + 3	0.006 + 3
200V	0.002 + 2	0.005 + 3	0.006 + 3
1000V	0.003 + 2	0.005 + 3	0.007 + 3

¹ Relative to calibration standards.

² Using Offset control.

MEDIUM AND FAST RATES: In medium rate, add 2 counts to number of counts. In fast rate, use 2 counts for the number of counts.

Operating Characteristics

TEMPERATURE COEFFICIENT <±(0.0006% of Reading + 0.3 Count) per °C from 0°C to 18°C and 28°C to 50°C.

MAXIMUM INPUT 1000V dc or peak ac on any range.

NOISE REJECTION Automatically optimized at power-up for 50, 60, or 400 Hz.

RATE	READINGS/ SECOND ¹	FILTER	NMRR ²	PEAK NM SIGNAL	CMRR ³
S	2.5	Analog & Digital	>98 dB	20V or 2x FS ⁴	>140 dB
M	20	Digital	>45 dB	1x FS	>100 dB
F	100	None	—	1x FS	>60 dB

¹ Reading rate with internal trigger and 60 Hz power line frequency. See "Reading Rates" for more detail.

² Normal Mode Rejection Ratio, at 50 or 60 Hz ±0.1%. The NMRR for 400 Hz ±0.1% is 85 dB in S rate and 35 dB in M rate.

³ Common Mode Rejection Ratio at 50 or 60 Hz ±0.1%, with 1 kΩ in series with either lead. The CMRR is >140 dB at dc for all reading rates.

⁴ 20 volts or 2 times Full Scale whichever is greater, not to exceed 1000V.

Table 1-1. Specifications (cont)

TRUE RMS AC VOLTAGE (OPTION -09)**Input Characteristics**

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION		INPUT IMPEDANCE
		5½ DIGITS	4½ DIGITS*	
200 mV	199.999 mV	1 μ V	10 μ V	1 M Ω shunted by <100 pF
2V	1.99999V	10 μ V	100 μ V	
20V	19.9999V	100 μ V	1 mV	
200V	199.999V	1 mV	10 mV	
700V	700.00V	10 mV	100 mV	

*4½ digits at the fastest reading rate.

Accuracy

NORMAL (S) READING RATE \pm (% of Reading + Number of Counts).
For sinewave inputs \geq 10,000 counts¹.

FREQUENCY (Hz)	24 HOURS ² 23 \pm 1°C	90 DAY 23 \pm 5°C	1 YEAR 23 \pm 5°C
20-45	1.2 + 100	1.2 + 100	1.2 + 100
45-100	0.3 + 100	0.35 + 100	0.4 + 100
100-20k	0.07 + 100	0.14 + 100	0.16 + 100
20k-50k	0.15 + 120	0.19 + 150	0.21 + 200
50k-100k	0.4 + 300	0.5 + 300	0.5 + 400

¹ For sinewave inputs between 1,000 and 10,000 counts, add to Number of Counts 100 counts for frequencies 20 Hz to 20 kHz, 200 counts for 20 kHz to 50 kHz, and 500 counts for 50 kHz to 100 kHz.

² Relative to calibration standards.

MEDIUM AND FAST READING RATES ... In medium rate, add 50 counts to number of counts. In fast rate the specifications apply for sinewave inputs \geq 1000 counts and >100 Hz.

NONSINUSOIDAL INPUTS For nonsinusoidal inputs \geq 10,000 counts with frequency components \leq 100 kHz, add the following % of reading to the accuracy specifications.

FUNDAMENTAL FREQUENCY	CREST FACTOR		
	1.0 TO 1.5	1.5 TO 2.0	2.0 TO 3.0
45 Hz to 20 kHz	0.05	0.15	0.3
20 Hz to 45 Hz and 20 kHz to 50 kHz	0.2	0.7	1.5

Table 1-1. Specifications (cont)

Operating Characteristics

TEMPERATURE COEFFICIENT \pm (% of Reading + Number of Counts) per °C, 0°C to 18°C and 28°C to 50°C.

FOR INPUTS	FREQUENCY IN HERTZ		
	20-20k	20k-50k	50k-100k
$\geq 10,000$ counts	0.019 + 9	0.021 + 9	0.027 + 10
$\geq 1,000$ counts	0.019 + 12	0.021 + 15	0.027 + 21

MAXIMUM INPUT 700V rms, 1000V peak or 2×10^7 Volts-Hertz product (whichever is less) for any range.

COMMON MODE REJECTION >60 dB at 50 or 60 Hz with 1 k Ω in either lead.

CURRENT

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION	
		5½ DIGITS	4½ DIGITS*
2000 mA	1999.99 mA	10 μ A	100 μ A

*4½ digits at the fastest reading rate.

DC Accuracy

NORMAL (S) READING RATE \pm (% of Reading + Number of Counts).

	90 DAYS 23 \pm 5°C	1 YEAR 23 \pm 5°C
	$\leq 1A$	0.04 + 4	0.05 + 4
$> 1A$	0.1 + 4	0.1 + 4

MEDIUM AND FAST READING RATES ... In medium reading rate, add 2 counts to number of counts. In fast reading rate, use 2 counts for number of counts.

AC Accuracy (Option -09)

NORMAL (S) READING RATE \pm (% of Reading + Number of Counts).
1 Year, 23 \pm 5°C, for sinewave inputs $\geq 10,000$ counts.

FREQUENCY IN HERTZ		
20-45	45-100	100-5k*
2.0 + 200	0.5 + 200	0.4 + 200

*Typically 20 kHz

Table 1-1. Specifications (cont)

MEDIUM AND FAST READING RATES ... In medium rate, add 50 counts to number of counts. In fast reading rate, for sinewave inputs ≥ 1000 counts and frequencies > 100 Hz, the accuracy is $\pm(0.4\%$ of reading + 30 counts).

NONSINUSOIDAL INPUTS For nonsinusoidal inputs $\geq 10,000$ counts with frequency components ≤ 100 kHz, add the following % of reading to the accuracy specifications.

FUNDAMENTAL FREQUENCY	CREST FACTOR		
	1.0 TO 1.5	1.5 TO 2.0	2.0 TO 3.0
45 Hz to 5 kHz	0.05	0.15	0.3
20 Hz to 45 Hz	0.2	0.7	1.5

Operating Characteristics

TEMPERATURE COEFFICIENT Less than 0.1 x accuracy specification per °C from 0°C to 18°C and 28°C to 50°C.

MAXIMUM INPUT 2A dc or rms ac. Protected with 2A, 250V fuse accessible at front panel, and internal 3A, 600V fuse.

BURDEN VOLTAGE 1V dc or rms ac typical at full scale.

RESISTANCE

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION		CURRENT THROUGH UNKNOWN
		5½ DIGITS	4½ DIGITS*	
200Ω	199.999Ω	1 mΩ	10 mΩ	1 mA
2 kΩ	1.99999 kΩ	10 mΩ	100 mΩ	1 mA
20 kΩ	19.9999 kΩ	100 mΩ	1Ω	100 μA
200 kΩ	199.999 kΩ	1Ω	10Ω	10 μA
2000 kΩ	1999.99 kΩ	10Ω	100Ω	5 μA
20 MΩ	19.9999 MΩ	100Ω	1 kΩ	0.5 μA

*4½ digits at the fastest reading rate.

Accuracy

NORMAL (S) READING RATE $\pm(\%$ of Reading + Number of Counts)¹

RANGE	24 HOUR 23±1°C ²	90 DAY 23±5°C	1 YEAR 23±5°C
200Ω	0.004 + 3	0.011 + 4	0.014 + 4
2 kΩ	0.0028 + 2	0.01 + 3	0.013 + 3
20 kΩ	0.0028 + 2	0.01 + 3	0.013 + 3
200 kΩ	0.0028 + 2	0.01 + 3	0.013 + 3
2000 kΩ	0.023 + 3	0.027 + 3	0.028 + 3
20 MΩ	0.023 + 3	0.043 + 4	0.044 + 4

¹ Using Offset control.

² Relative to calibration standards.

Table 1-1. Specifications (cont)

Accuracy, cont

MEDIUM AND FAST READING RATES ... In medium rate, add 2 counts to the number of counts for the 200Ω through 200 kΩ ranges and 3 counts for the 2000 kΩ and 20 MΩ ranges. In fast reading rate, use 3 counts for the number of counts for the 200Ω range, and 2 counts for all other ranges.

Operating Characteristics

TEMPERATURE COEFFICIENT Less than 0.1 x accuracy specification per °C from 0°C to 18°C and 28°C to 50°C.

MEASUREMENT CONFIGURATION 2-wire or 4-wire.

OPEN CIRCUIT VOLTAGE Less than 6.5V on the 200Ω through 200 kΩ ranges. Less than 13V on the 2000 kΩ and 20 MΩ ranges.

INPUT PROTECTION To 300V rms.

READING RATES

READING RATES WITH INTERNAL TRIGGER (readings per second).

RATE	POWER LINE FREQUENCY*		
	50 HZ	60 HZ	400 HZ
S	2.08	2.5	2.38
M	16.7	20	19.0
F	100	100	100

*Sensed automatically at power-up.

AUTOMATIC SETTling TIME DELAY

Time in milliseconds from single trigger to start of A/D conversion, Autorange off.

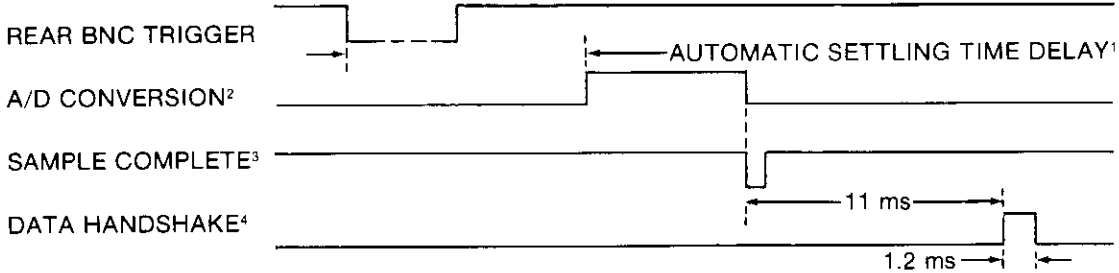
FUNCTION	RANGE	READING RATE			NUMBER OF COUNTS FROM FINAL VALUE ¹
		S	M	F	
VDC	200 mV	342	61	9	5
	2V-1000V	342	17	9	9
VAC	All	551	551	551	30 (Note 2)
mA DC	2000 mA	342	17	9	5
mA AC	2000 mA	551	551	551	30 (Note 2)
Ohms	200Ω	362	89	13	5
	2 kΩ	322	17	13	5
	20 kΩ	342	17	13	5
	200 kΩ	141	121	21	5
	2000 kΩ	141	101	81	10
	20 MΩ	1020	964	723	10

1. Difference between first reading and final value for an in-range step change coincident with trigger.
2. For slow reading rate. 50 counts for medium rate; 10 counts for fast rate.

Table 1-1. Specifications (cont)

EXTERNAL TRIGGER TIMING CHARACTERISTICS

The following diagram shows the nominal timing for the various processes which take place between an external trigger and data sent out on the IEEE-488 interface. Delays will vary if a second trigger comes before the data handshake is complete.



- NOTES:
1. Time from single trigger to start of A/D conversion. (See "Automatic Settling Time Delay" on previous page.) If the delay is disabled by using the T3 or T4 command, then the delay is $1\text{ ms} \pm 150\ \mu\text{s}$. When the 8840A is triggered with an IEEE-488 command (GET or ?), the automatic settling time delay begins after the trigger command has been processed and recognized.
 2. A/D conversion time is dependent on the reading rate and power-line frequency:

RATE	A/D CONVERSION TIME (ms)		
	50 Hz	60 Hz	400 Hz
S	472	395	414
M	52	45	47
F	7	7	7

3. Sample Complete is a $2.5\ \mu\text{s}$ pulse which indicates that the analog input may be changed for the next reading.
4. When talking to a fast controller.

GENERAL

- COMMON MODE VOLTAGE 1000V dc or peak ac, or 700V rms ac from any input to earth.
- TEMPERATURE RANGE 0 to 50°C operating, -40 to 70°C storage.
- HUMIDITY RANGE 80% RH from 0 to 35°C, 70% to 50°C.
- WARMUP TIME 1 hour to rated specifications.
- POWER 100, 120, 220, or 240V ac $\pm 10\%$ (250V ac maximum), switch selectable at rear panel. 50, 60, or 400 Hz, automatically sensed at power-up. 20 VA maximum.
- VIBRATION Meets requirements of MIL-T-28800C for Type III, Class 3, Style E equipment.
- PROTECTION ANSI C39.5 and IEC 348, Class I.
- SIZE 8.9 cm high, 21.6 cm wide, 37.1 cm deep (3.47 in high, 8.5 in wide, 14.4 in deep).
- WEIGHT Net, 3.4 kg (7.5 lb); shipping, 5.0 kg (11 lb).
- INCLUDED Line cord, test leads, Instruction/Service Manual, IEEE-488 Quick Reference Guide, (Option -05 only), and instrument performance record.
- IEEE-488 INTERFACE FUNCTION Option allows complete control and data output capability, and supports the following interface function subsets: SH1, AH1, T5, L4, SR1, RL1, DC1, DT1, E1, PP0, and C0.

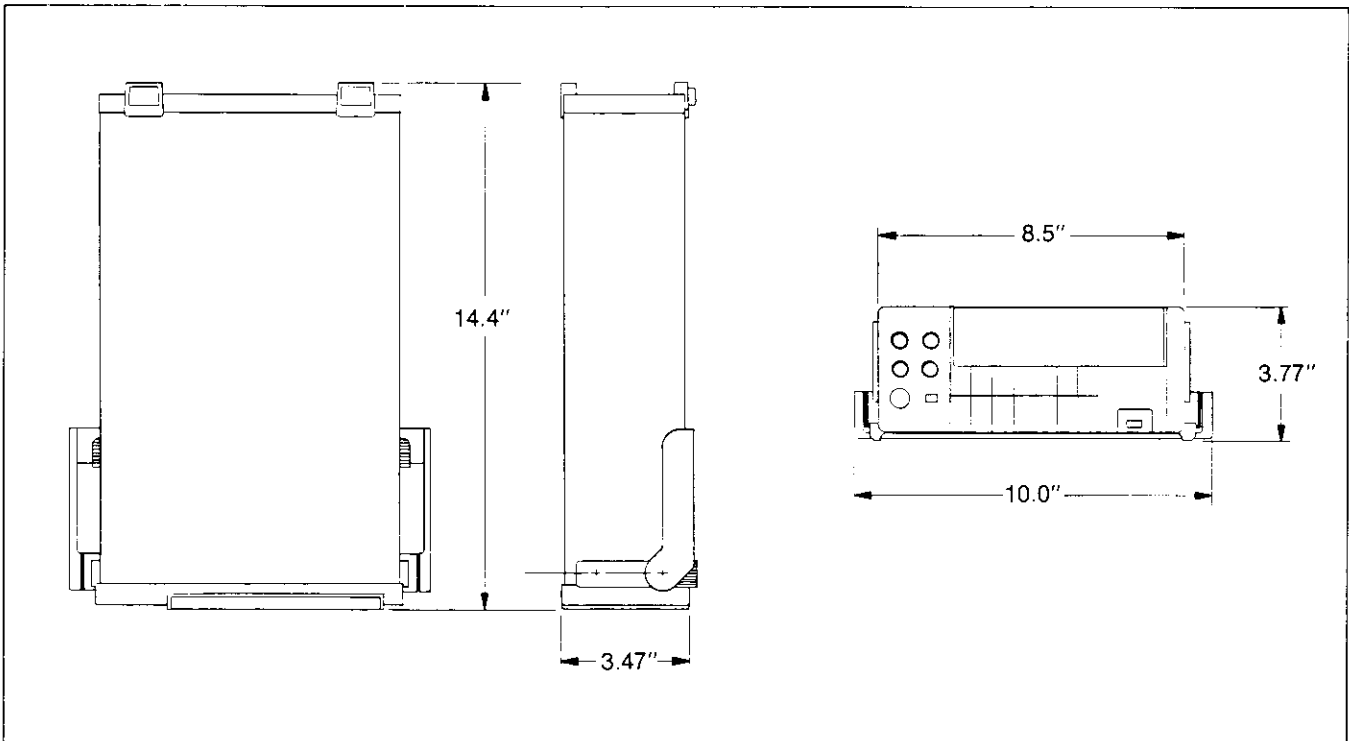


Figure 1-1. External Dimensions

Section 2

Operating Instructions

2-1. INTRODUCTION

This section provides instructions for installing and operating the 8840A. Refer to Section 4 for measurement considerations.

2-2. INSTALLATION

2-3. Installing the Power-Line Fuse

WARNING

FOR POWER-LINE VOLTAGES OF 198V TO 250V, THE POWER-LINE FUSE MUST BE REPLACED WITH A 1/8A, 250V SLO-BLO FUSE FOR FIRE PROTECTION. TO AVOID ELECTRIC SHOCK, REMOVE THE POWER CORD BEFORE REPLACING THE EXTERNAL LINE FUSE.

The 8840A has a rear-panel power-line fuse in series with the power supply. A 1/4A, 250V fast-blo fuse is installed in the factory for operation from 90V to 132V. For operation with power-line voltages of 198V to 250V, the fuse must be replaced with a 1/8A, 250V slo-blo fuse. (One is supplied with the instrument.)

To replace the power-line fuse, first remove the power cord. Then turn the rear-panel fuse cover 1/4-turn counterclockwise with a screwdriver.

For power-line voltages of 198V to 250V, use only a 1/4 x 1 1/4 (6.3mm x 32mm) fuse with at least a 100A breaking capacity.

2-4. Connecting to Line Power

WARNING

TO AVOID SHOCK HAZARD, CONNECT THE INSTRUMENT POWER CORD TO A

POWER RECEPTACLE WITH EARTH GROUND. TO AVOID INSTRUMENT DAMAGE, CHECK THAT THE REAR PANEL LINE VOLTAGE SELECTION SWITCHES ARE SET TO THE POWER-LINE VOLTAGE IN YOUR AREA.

The 8840A can be configured to accept line power of 100, 120, 220, or 240V ac ($\pm 10\%$, 250V maximum) at 50, 60, or 400 Hz. The voltage must be selected by setting the rear panel LINE SET switches as shown in Figure 2-1. The 8840A automatically senses the power-line frequency at power-up, so that no adjustment for frequency is necessary.

2-5. Adjusting the Handle

The handle provides two viewing angles for bench-top use. To adjust its position, pull the ends out to a hard stop (about 1/4 inch on each side) and rotate it to one of the four stop positions shown in Figure 2-2. To remove the handle, adjust it to the vertical stop position and pull the ends all the way out.

2-6. Rack Mounting Kits

You can mount the 8840A in a standard 19-inch rack panel using the accessory rack mounting kits shown in Figure 2-3. To install the Single Rack Mount Kit, remove the handle and handle mounting plates, and attach the rack ears with the screws provided (Figure 2-4). The Dual Rack Mount Kit is installed similarly. (Both kits include mounting instructions.)

The rear feet may be rotated 180 degrees to clear a narrow rack space.

2-7. OPERATING FEATURES

2-8. Power-Up Features

When the 8840A is turned on, all display segments light up for about 2 seconds while the instrument performs an

internal self-test of its digital circuitry. The 8840A then assumes the following configuration:

- VDC function
- Autorange, starting in the 1000V range
- Slow reading rate
- Continuous, internal trigger

- OFFSET off
- Local (front panel) control

While all display segments are lit during the power-up self-test, you can freeze the display by pressing the SRQ button. All display segments will then remain lit until you press any button.

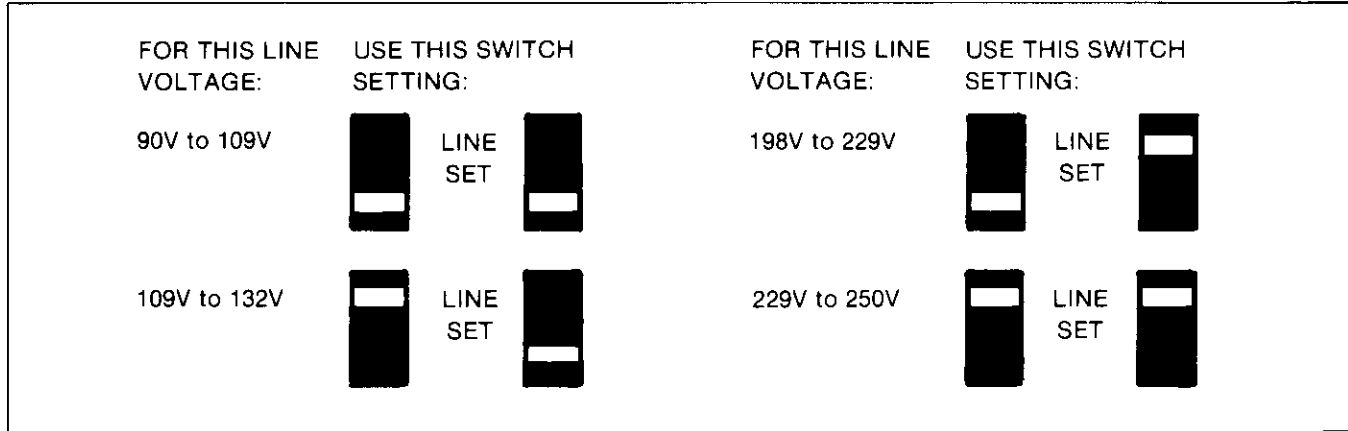


Figure 2-1. Line Voltage Selection Settings

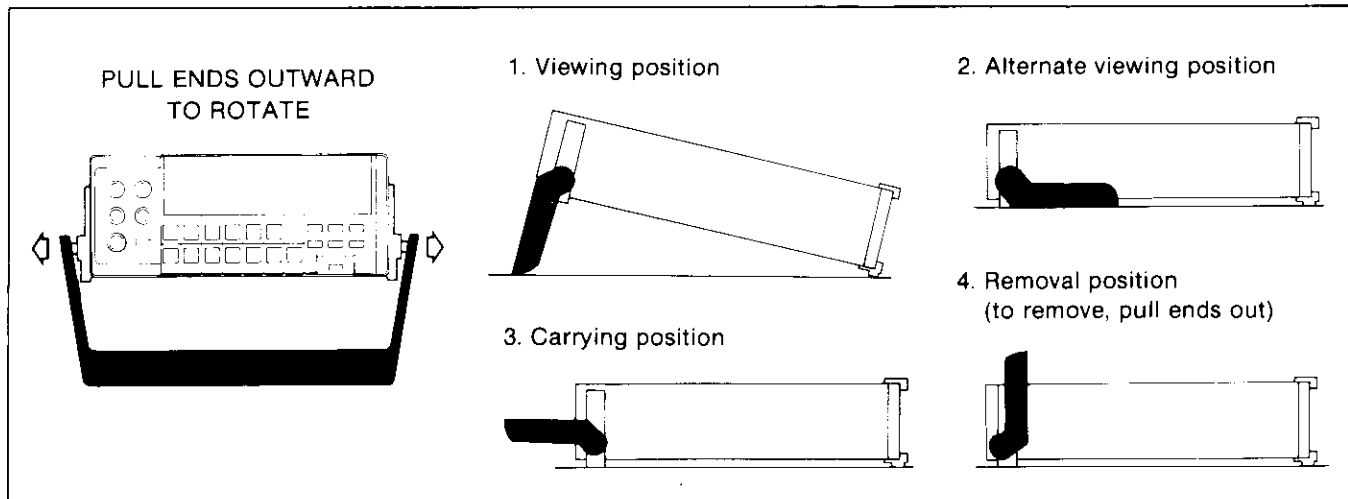


Figure 2-2. Adjusting the Handle

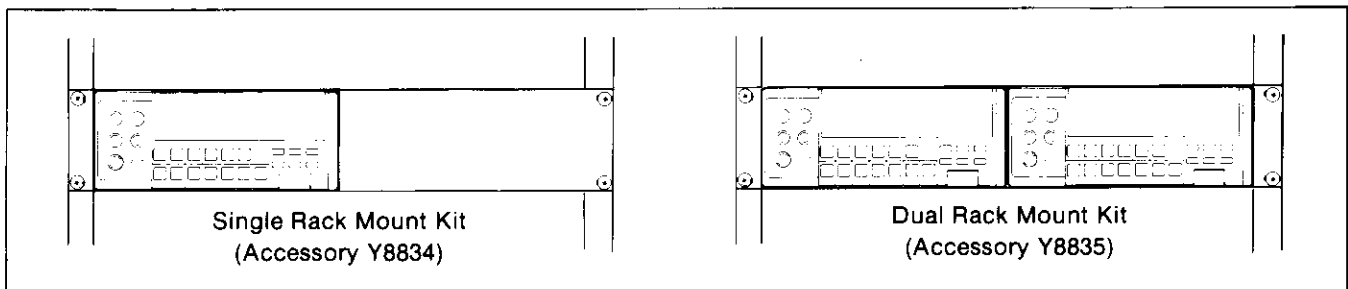


Figure 2-3. Rack-Mount Kits

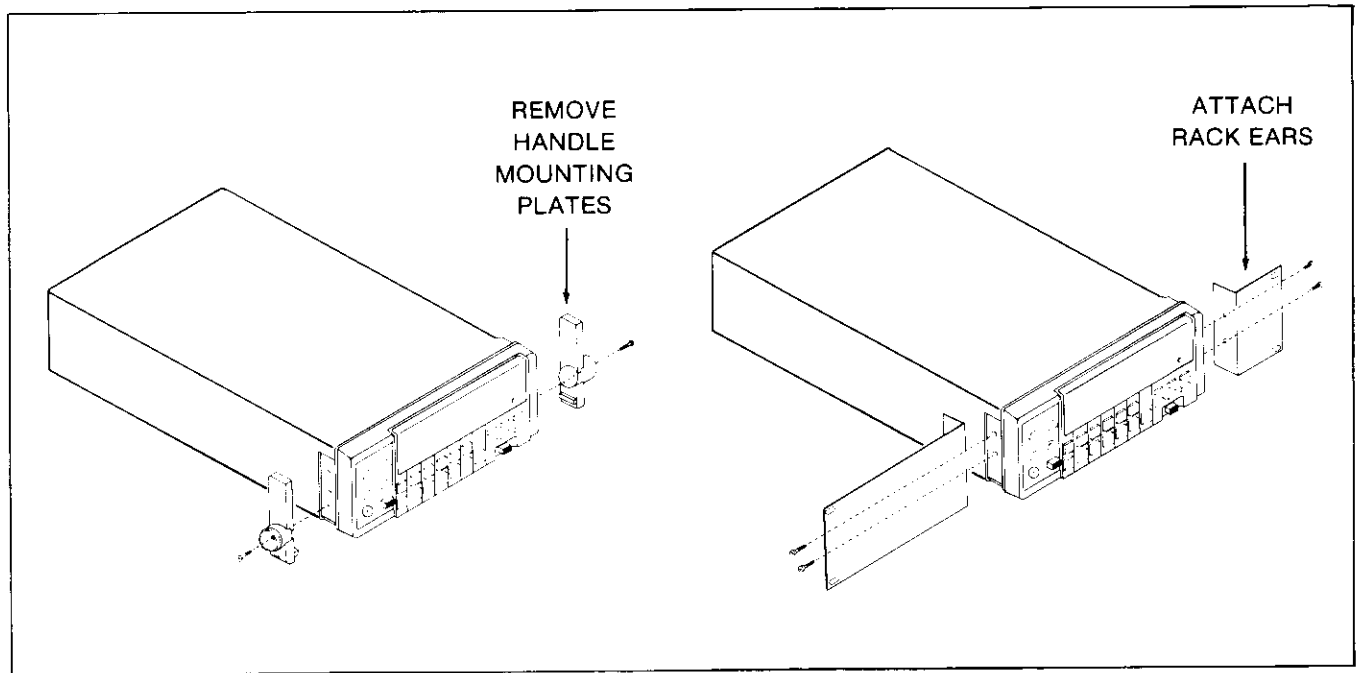


Figure 2-4. Installing the Single Rack Mount Kit

2-9. Front and Rear Panel Features

Front panel features are explained in Figure 2-5. Rear panel features are explained in Figure 2-6.

The alternate functions embossed below the front panel range buttons and the special feature buttons are enabled by the CAL ENABLE switch. These functions are for use only when calibrating the instrument. See the Maintenance section for further explanation.

CAUTION

To avoid accidentally uncalibrating the 8840A, do not press the CAL ENABLE switch unless calibrating the instrument. Never cycle power on or off while the CAL ENABLE switch is on.

Note that the VAC and mA AC functions are available only with the True RMS AC option. If this option is absent, pressing the VAC and mA AC function buttons causes the 8840A to briefly display an error message (ERROR 30).

2-10. Display Features

The 8840A features a vacuum fluorescent display with a numeric field and annunciators. The annunciators are explained in Figure 2-5.

2-11. Error Messages

If the 8840A detects an operator error or an internal failure, it displays an error message for about 2-1/2 seconds and then resumes normal operation. During this time, the front panel buttons are ignored. The error message consists of the ERROR annunciator and a two-

digit error code. (See Figure 2-7.) Error codes are explained in Table 2-1.

If the FRONT/REAR switch is set to the REAR position while the mA DC or mA AC function is selected, ERROR 31 is displayed. In this case the error message is displayed until you return the switch to the FRONT position or select another function.

2-12. Overrange Indication

An input is overrange if it exceeds the full scale of the selected range. In most ranges, the 8840A indicates an input is overrange by lighting the OVER annunciator and showing a "1" on the display. (See Figure 2-8.) The sign, the position of the decimal point, and the other annunciators are not affected.

As a safety feature, the 8840A treats the 1000V dc and 700V ac ranges differently. In these ranges, the 8840A indicates when the input exceeds the input overload limit of 1000V dc or 700V ac, respectively, by lighting the OVER annunciator and flashing the display. Readings are still displayed.

2-13. Diagnostic Self-Tests

The 8840A features diagnostic self-tests which check both the digital and analog circuitry in the instrument. The self-tests consist of 21 analog tests followed by the power-up self-test. To initiate the self-tests, press the SRQ button for 3 seconds. The instrument can be stopped in any of the test configurations by pressing the SRQ button while the test number is displayed. Press any button to continue the tests.

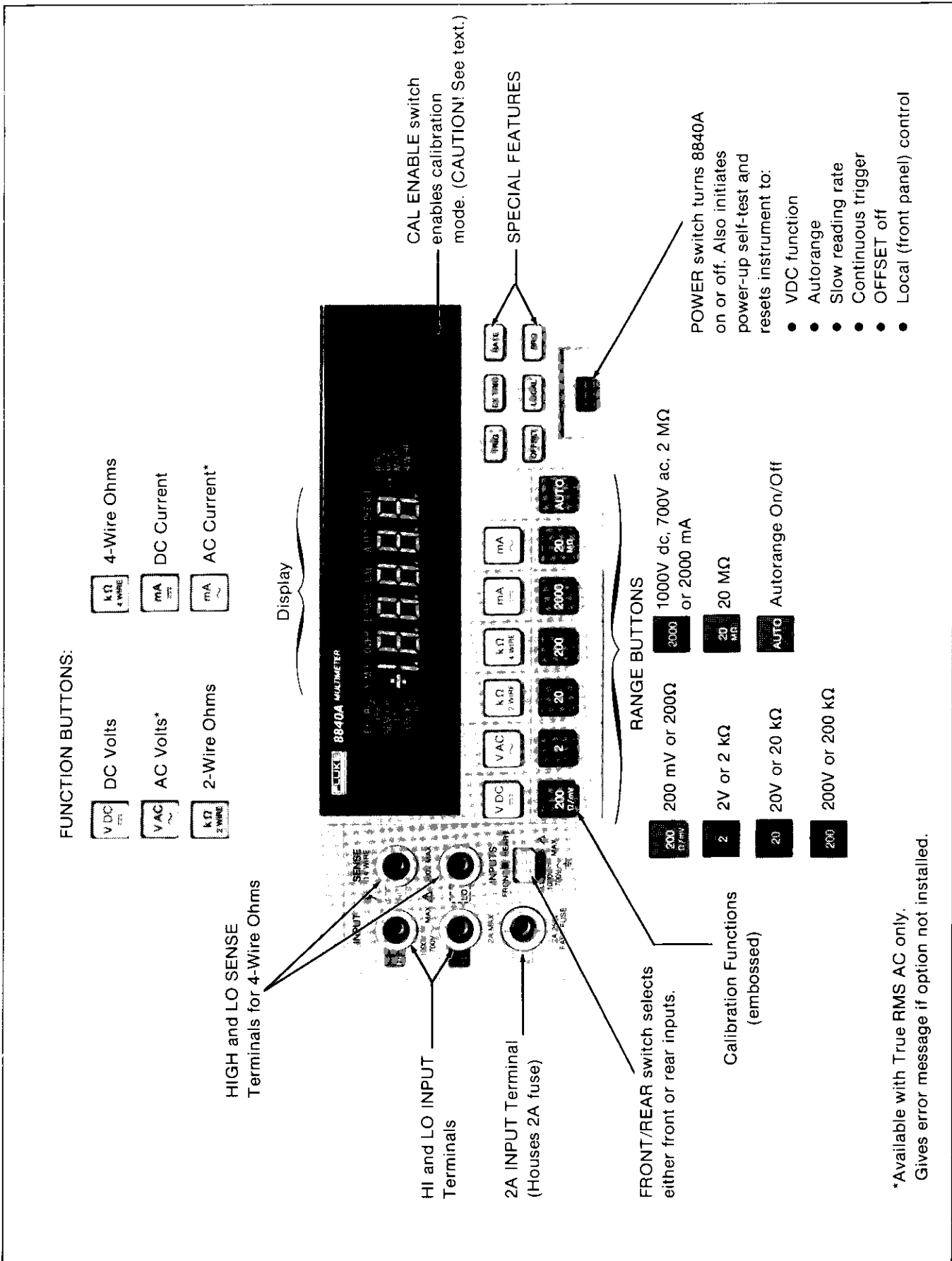


Figure 2-5. Front Panel Features

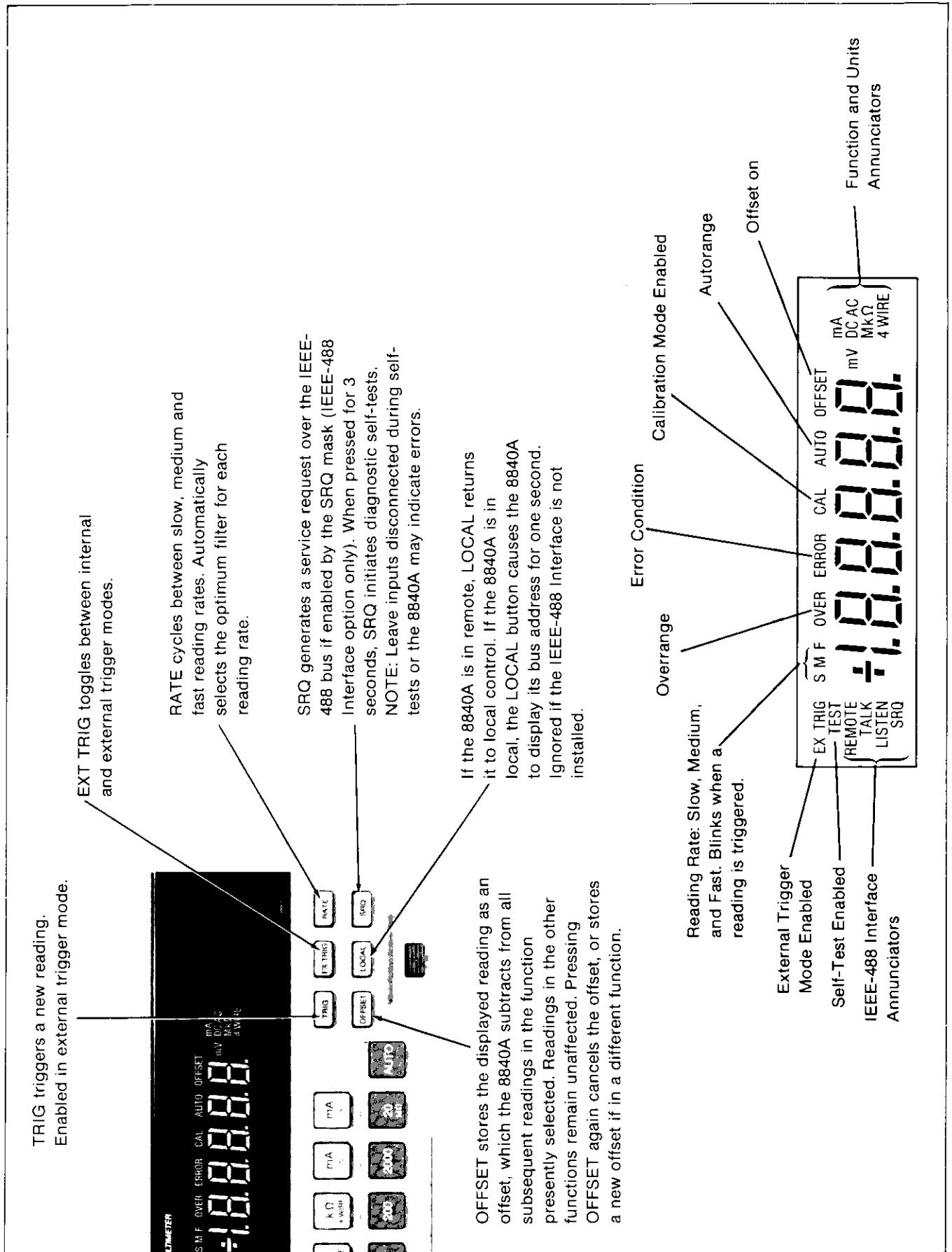


Figure 2-5. Front Panel Features (continued)

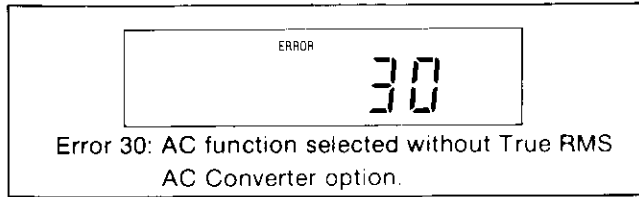


Figure 2-7. Typical Error Message

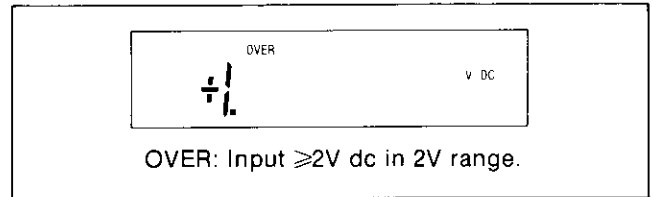


Figure 2-8. Overrange Indication

Table 2-1. Error Codes

ERROR CODE	MEANING	ERROR CODE	MEANING
	ANALOG SELF-TEST ERRORS		
1	200 VAC, Zero	40	Computed calibration constant out of range. (Previous cal may be wrong or there may be a hardware problem.)
2	700 VAC, Zero	41	Calibration input out of acceptable range. Check that input is correct. (Previous cal may be wrong or there may be a hardware problem.)
3	mA AC, Zero	42	Calibration memory write error. (Probably a hardware problem.)
4	mA DC, Zero	50	Guard crossing error detected by In-Guard uC.
5	200 VDC, Zero	51	Calibration command not valid unless calibration mode is enabled.
6	1000 VDC, Zero	52	Command not valid at this time. Check whether 8840A is in cal mode and if so which part of the cal procedure it is in.
7	1000 VDC + 20 MΩ	53	Invalid calibration value in Put command. (Example: Sending a negative value during ac calibration.)
8	20 VDC + 20 MΩ	54	Command not valid in calibration verification.
9	20 VDC + 2000 kΩ	56	Variable inputs not allowed during A/D calibration. Use prompted value.
10	2 VDC + 2000 kΩ	60	Device-dependent commands not valid during self-tests.
11	200Ω, Overrange	71	Syntax error in device-dependent command string.
12	2 kΩ, Overrange	72	Guard crossing error detected by Out-Guard uC.
13	20 kΩ, Overrange	77	IEEE-488 Interface self-test error.
14	200 kΩ, Overrange		
15	1000 VDC + X10 T/H + 20 MΩ		
16	200 VDC + 200 kΩ		
17	200 VDC + 20 kΩ		
18	200 VDC + 2 kΩ		
19	200 VDC, Filter On		
20	200 VDC + 2 kΩ, Filter Off		
21	200 VDC, Filter Off		
	DIGITAL SELF-TEST ERRORS		
25	In-Guard uC Internal RAM		
26	Display RAM		
27	In-Guard uC Internal Program Memory		
28	External Program Memory		
29	Calibration Memory		
	OPERATION ERRORS		
30	AC functions available only with True RMS AC option.		
31	mA AC or mA DC function selected while REAR inputs selected.		
32	OFFSET selected with reading unavailable or overrange.		

NOTE: See the Maintenance section for a detailed description of self-tests.

During the test, the TEST annunciator lights, and the numeric field displays the number of each analog test as it is performed. Then all display segments light up while the instrument performs the power-up self-test. The 8840A then returns to the power-up configuration. The self-tests are described in greater detail in the Maintenance section.

NOTE

The inputs must be left disconnected while the self-tests are performed or the 8840A may indicate that errors are present.

If the 8840A detects an error, it displays an error message for about 2-1/2 seconds. (Error codes 01 through 29 correspond to the self-tests.) If self-test errors are displayed even when the input terminals are disconnected, there may be a hardware problem in your 8840A. In that event, refer to the Maintenance section or contact your local Fluke representative.

2-14. Ranging

Measurement ranges can be selected using either autorange (by pressing the AUTO button) or manual range (by pressing another range button). The 8840A displays explicit units in every range, so that the display may be read directly.

2-15. AUTORANGE

In autorange, the 8840A goes to a higher range when the input exceeds full scale (199999 counts), and goes to a lower range when the input falls below 9% of full scale (18000 counts). While the instrument changes range, the numeric field on the display is blanked until a new reading is completed. However, the decimal point and units annunciators always indicate what range the instrument is in.

Pressing the AUTO button when the instrument is already in autorange toggles the 8840A from autorange to manual range. This causes the instrument to remain locked in the present range.

2-16. MANUAL RANGE

In manual range, the 8840A remains fixed in the selected range until you select another range or press AUTO. If you select a range which is not valid for the present function, or select a function which is not valid for the present range, the 8840A selects the nearest valid range. For example, if the 8840A is in the VDC function and you press the 20 MΩ button, the 8840A selects the 1000V range.

The range buttons are disabled in the mA DC and mA AC functions, since all measurements in these functions are made in the 2000 mA range.

2-17. Triggering

Triggering causes the 8840A to execute a measurement cycle and display the result. During each measurement cycle, the instrument samples the input a number of times and then averages the samples to compute a reading. The number of samples averaged for each reading depends upon the reading rate.

Each time a reading is triggered, the rate annunciator (S, M, or F) blinks. In the fast reading rate, the F annunciator flashes so rapidly it appears to be almost constant.

How the 8840A is triggered depends on whether the continuous trigger mode or external trigger mode is selected. Pressing the EX TRIG (external trigger) button toggles the 8840A between the two modes.

2-18. CONTINUOUS TRIGGER MODE

In the continuous trigger mode, readings are triggered by a continuous, internal trigger. The rate of the trigger is set by the RATE button.

2-19. EXTERNAL TRIGGER MODE

In the external trigger mode, readings are triggered by pressing the TRIG button. If the IEEE-488 Interface option is installed, readings can also be triggered by remote commands or by using the rear panel external trigger (EXT TRIG) connector. (See the Options and Accessories section.)

In the external trigger mode, pressing any front panel button blanks the numeric field on the display until a new measurement is triggered. This ensures that all readings correspond to the instrument configuration indicated by the display annunciators. The blanking also occurs in the continuous trigger mode, but usually isn't noticed because new measurements are triggered automatically.

The TRIG button does not trigger readings in the continuous trigger mode. However, it does blank the last reading to acknowledge a button was pressed.

2-20. Reading Rates and Noise Rejection

The RATE button allows you to optimize either measurement speed or noise rejection. The 8840A uses both analog and digital filtering to allow measurements in the presence of unwanted environmental noise (especially line-related noise). However, since filtering introduces a delay in response to a change in the input signal, there is an inherent trade-off between noise rejection and measurement speed.

The instrument has three reading rates: slow (S) and medium (M), with a 5-1/2 digit display, and fast (F), with a 4-1/2 digit display. To provide optimum combinations

of measurement speed and noise rejection, the RATE button allows control of both the internal trigger rate and the degree of filtering. The same degree of filtering is used in both the continuous and external trigger modes.

In the continuous trigger mode, the actual number of readings displayed per second for each reading rate is determined by the line-power frequency. At power-up, the 8840A senses the line-power frequency and adjusts the analog-to-digital converter timing characteristics for optimum normal-mode noise rejection. The resulting reading rates are shown in the specifications in Section 1.

2-21. Automatic Settling Time Delay

When the external trigger mode is selected, the 8840A automatically inserts a delay after receiving a trigger signal, but before starting the first input sample. The delay is just long enough so that the reading will be correct (within a specified number of counts of the final value) even if the trigger signal occurs as the input makes a step change between zero and full scale (10,000 counts and full scale in the ac functions). For resistance measurements, the delay also allows for settling when the step change is made from an open circuit to an in-range value.

The length of the delay depends on the range, function, and reading rate, as shown in the specifications in Section 1. The delay is enabled only in the external trigger mode. It can be turned off with a remote command over the IEEE-488 interface bus to accommodate special timing considerations.

2-22. External Trigger Input (Option -05 Only)

The rear panel EXT TRIG input is a TTL-level input which can be used to trigger measurements when the 8840A is in the external trigger mode. A measurement is triggered on the falling edge of the input. Since the EXT

TRIG input is pulled high internally, it can also be controlled by a normally open switch. A measurement is triggered when the switch is closed.

For special applications using the IEEE-488 Interface, the automatic setting time delay can be disabled using remote commands. (See Section 3.) Refer to Section 1 for timing details.

The polarity of the EXT TRIG input can be reversed by changing internal jumpers. Refer to the Maintenance section for instructions.

2-23. Sample Complete Output (Option -05 Only)

The SAMPLE COMPLETE output indicates when analog input sampling for a reading is completed. The output is a TTL-level signal which is pulsed low for approximately 2.5 μ s when the input-sampling portion of the A/D conversion is completed. The signal is useful for interfacing with other equipment when the 8840A is used in an instrumentation system. For example, the SAMPLE COMPLETE output could be used to advance a scanner to the next channel.

2-24. MAKING MEASUREMENTS

2-25. Input Overload Protection Limits

WARNING

TO AVOID SHOCK HAZARD AND/OR INSTRUMENT DAMAGE, DO NOT APPLY INPUT POTENTIALS THAT EXCEED THE INPUT OVERLOAD LIMITS SHOWN IN TABLE 2-2.

The 8840A is protected against input overloads up to the limits shown in Table 2-2. Exceeding these limits may damage the instrument and/or pose a shock hazard.

Table 2-2. Input Overload Limits

FUNCTION	CONNECTORS	MAXIMUM INPUT
VDC	INPUT HI and LO:	1000V dc
mA DC	2A INPUT and INPUT LO:	2000 mA
2 WIRE/4 WIRE k Ω	INPUT HI and LO: SENSE HI and LO:	300V rms 300V rms
VAC	INPUT HI and LO:	700V rms, 1000V peak, or 2 x 10 ⁷ V-Hz (whichever is less)
mA AC	2A INPUT and INPUT LO:	2000 mA rms
All Functions	Any terminal to earth:	1000V dc or peak ac

2-26. Measuring Voltage and Resistance

To measure voltage or resistance, select the desired function and connect the test leads as shown in Figure 2-9. Resistance can be measured in either the 2-wire or 4-wire configuration.

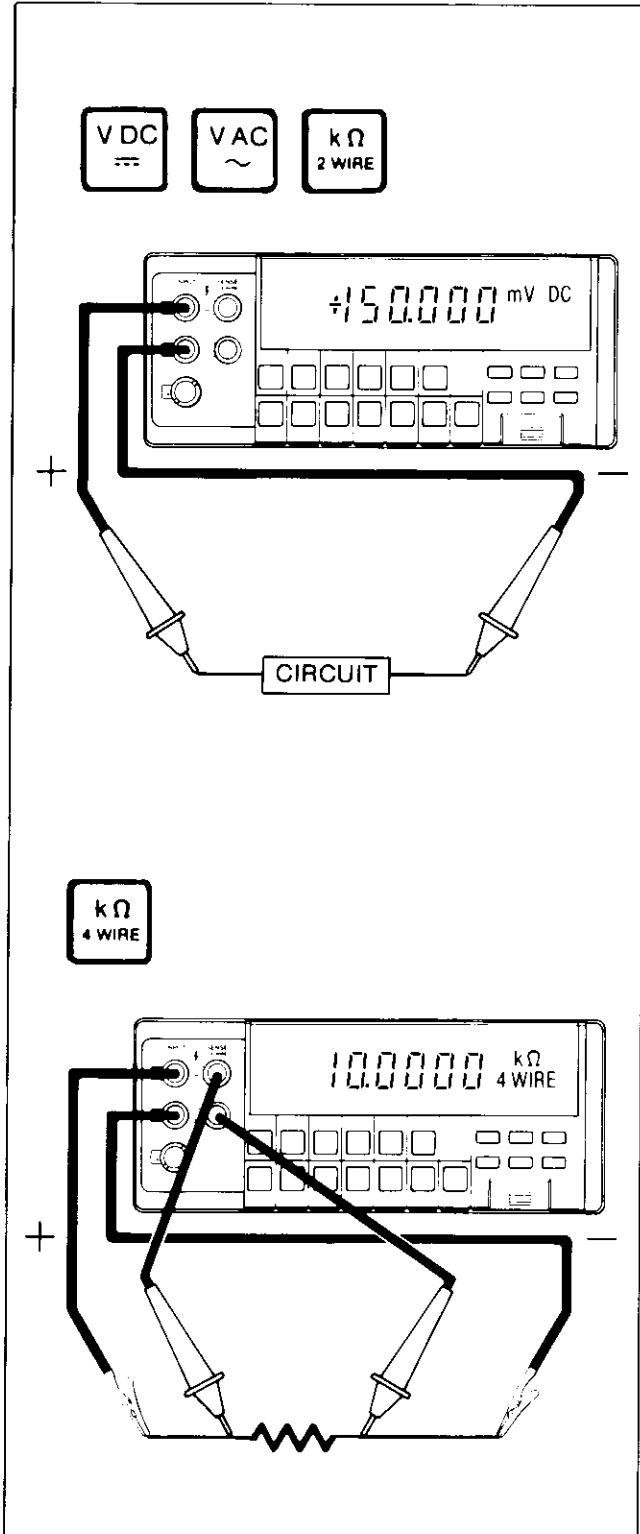


Figure 2-9. Measuring Voltage and Resistance

2-27. Measuring Current

To measure current, select the desired function and connect the test leads as follows:

1. Turn off power in the circuit to be measured (Figure 2-10).
2. Break the circuit (preferably on the ground side to minimize the common mode voltage), and place the 8840A in series at that point.
3. Turn on power in the circuit, and read the display.
4. Turn off power in the circuit, and disconnect the 8840A.

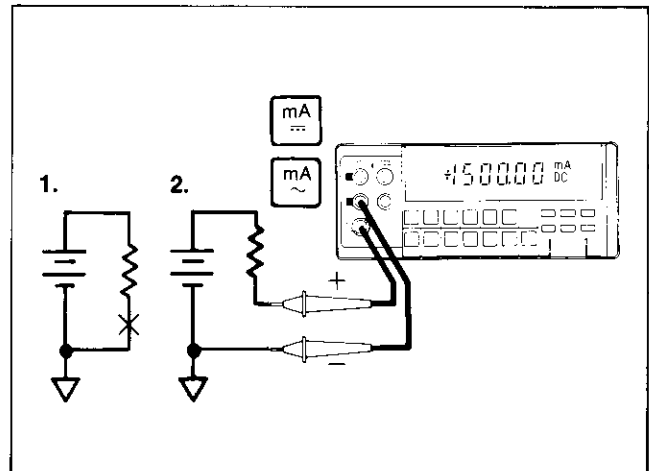


Figure 2-10. Measuring Current

2-28. Current Fuse Protection

The 2A input terminal is protected from overloads by a 2A, 250V fuse which is accessible from the front panel, and by an internal 3A, 600V fuse. If either fuse blows, the 8840A will respond as though the input were zero.

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE THE TEST LEADS BEFORE REPLACING THE FRONT PANEL FUSE.

To replace the front panel fuse, first remove the test leads. Then press in the lip of the 2A input terminal slightly and rotate it 1/4-turn counterclockwise. Spring tension will force the fuse and fuse holder out of the front panel. The internal 3A fuse should be replaced only by qualified service personnel.

2-29. Offset Measurements**WARNING**

WHEN THE OFFSET FEATURE IS IN USE, DISPLAYED READINGS ARE RELATIVE AND MAY NOT INDICATE THE PRESENCE OF DANGEROUS POTENTIALS AT THE INPUT CONNECTORS OR TEST LEADS. USE CAUTION TO AVOID ELECTRIC SHOCK OR INSTRUMENT DAMAGE.

The OFFSET feature allows you to store a reading as a relative reference value. When the OFFSET button is pressed, the 8840A stores the present reading and displays subsequent measurements as the difference between the measured value and the stored reading. The OFFSET annunciator is lit whenever an offset is in use.

The OFFSET feature may be used in all functions. Since the display represents a numeric difference, it always has a sign, even in the resistance and ac functions.

The offset can be cancelled by pressing the OFFSET button again, in which case the OFFSET annunciator disappears from the display. The offset can also be cancelled by storing an offset in another function. If a reading is overrange or unavailable when the OFFSET button is pressed, the 8840A indicates ERROR 32 and does not store the offset.

If you change functions while an offset is stored, the OFFSET annunciator disappears and the offset temporarily disappears. However, when you return to the original function, the offset is restored (and the OFFSET annunciator reappears) unless a new offset was established in another function.

Note that the input overload limits are not changed by the use of the offset feature. However, the display flashes if the 8840A is in the 1000V dc or 700V ac ranges and the input exceeds 1000V dc or 700V ac, respectively.

While an offset is enabled, the 8840A indicates an overrange condition if either of the following conditions occur:

- The input signal is overrange
- The calculated reading is overrange

For example, suppose the instrument is in the 20V range of the VDC function and you store an offset of +15V. The maximum positive voltage reading that can be displayed without overranging is +4.9999V, which is actually a +19.9999V input signal. The maximum negative voltage reading that can be displayed without overranging is -19.9999V, which is actually a -4.9999V input signal. You can measure a greater range of voltages by selecting a higher range.

When in autorange, the 8840A selects the range appropriate for the input signal, regardless of any stored offset. If, for example, a +10V offset is stored, and a +1V input is applied, the 8840A will autorange to the 2V range and display an overrange condition since it cannot display -9V on the 2V range. Manual range control could be used to lock the 8840A into the 20V range in this case.

Applications of the offset feature include correcting for test lead resistance in 2-wire resistance measurements, nulling offset currents or voltages, measuring voltage deviations, and matching resistors.

2-30. EXTERNAL CLEANING**WARNING**

TO AVOID ELECTRIC SHOCK OR INSTRUMENT DAMAGE, NEVER GET WATER INSIDE THE CASE. TO AVOID INSTRUMENT DAMAGE, NEVER APPLY SOLVENTS TO THE INSTRUMENT.

Should the 8840A case require cleaning, wipe the instrument with a cloth that is lightly dampened with water or a mild detergent solution.

Section 3

Remote Programming

NOTE

This section contains programming instructions for use with the IEEE-488 Interface (Option -05). For installation instructions, refer to the Options and Accessories section.

3-1. INTRODUCTION

The IEEE-488 Interface turns the 8840A into a fully programmable instrument for use with the IEEE Standard 488-1978 interface bus (IEEE-488 bus). With the IEEE-488 Interface, the 8840A can become part of an automated instrumentation system. The 8840A can be under complete, interactive control from a remote bus controller; or it can be set to the talk-only mode, connected to a data logger or printer, and dedicated to a single task.

This manual assumes you know the basics of the IEEE-488 interface bus. For an introduction to the bus, request Fluke Application Bulletin AB-36, "IEEE Standard 488-1978 Digital Interface for Programmable Instrumentation."

3-2 CAPABILITIES

The IEEE-488 Interface provides remote control of all front panel controls except for the POWER, CAL ENABLE, and FRONT/REAR switches. Other features include:

- A simple and predictable command set
- Fast measurement throughput
- Full talk/listen capability, including talk-only operation
- Full serial poll capability, with bit-maskable SRQ
- Full remote/local capability, including local lockout
- EXTERNAL TRIGGER and SAMPLE COMPLETE connectors
- Remote calibration

- Programmable trigger sources, including two bus triggers
- Informative output suffix (suppressible)
- Selectable output terminators

The 8840A supports the following interface function subsets: SH1, AH1, T5, L4, SR1, RL1, DC1, DT1, E1, PP0, and C0.

3-3. BUS SET-UP PROCEDURE

To set up the 8840A on the IEEE-488 bus, proceed as follows:

1. Turn the 8840A POWER switch OFF and set the 8840A IEEE-488 address using the rear panel IEEE-488 address switches shown in Figure 3-1.
2. Plug the IEEE-488 cable into the 8840A rear panel IEEE-488 connector.
3. Switch on the 8840A.

Whenever the 8840A is in the local state, the IEEE-488 address can be displayed on the front panel by pressing the LOCAL button.

3-4. AN OVERVIEW OF REMOTE OPERATION

An overview of remote operation is presented in the block diagram in Figure 3-2. Each block represents a register, buffer, etc., contained in the 8840A. The status registers in the center column indicate the instrument's status, including its function, range, reading rate, etc. The input buffer receives data from the IEEE-488 bus. The output buffer receives data from the blocks to its left, and sends data on to the IEEE-488 bus.

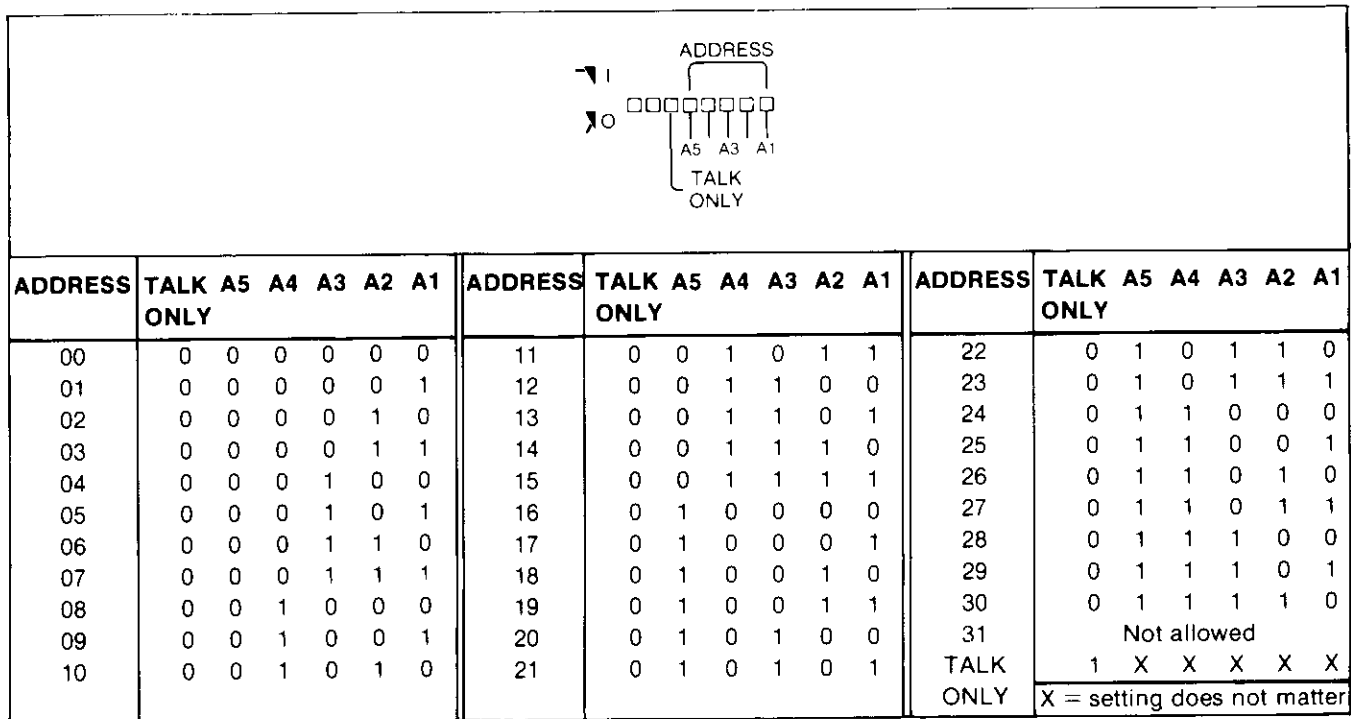


Figure 3-1. IEEE-488 Address Selection

Information is transferred between blocks by device-dependent commands. Each command is shown next to an arrowhead which indicates the resulting information transfer. For example, Put command P0 takes a number from the input buffer and stores it in the primary status registers. Likewise, Get command G0 gets the content of the primary status registers and copies it into the output buffer.

3-5. A NOTE ABOUT EXAMPLES

In the examples in this manual, device-dependent commands are shown enclosed within quotation marks, as they would be entered in Fluke BASIC. For clarity, the commands are also separated by spaces. However, the spaces are not necessary and may be omitted.

Example

Explanation

"* F3 R1 S1 T2" This example is equivalent to "*F3R1S1T2" or "* ,F3,R1,S1,T2".

Using the Fluke 1722A Instrument Controller, these commands might be written into a BASIC program as shown in Figure 3-3. Examples using other controllers are given at the end of this section.

Examples of 8840A output data show the terminators CR and LF. The terminator EOI is not shown because it is a uniline message. However, the terminators CR, LF, and EOI are all selectable using the Write commands.

For reference, the ASCII and IEEE Std 488-1978 bus codes are shown at the back of this section.

3-6. DEVICE-DEPENDENT COMMAND SET

Device-dependent commands are the heart of 8840A remote control. They tell the 8840A how and when to make measurements, when to put data on the bus, when to make service requests, etc. Commands which correspond directly to the front panel controls or display are shown in Figure 3-4. The complete set of device-dependent commands is listed in Figure 3-5. The commands may be entered using either upper- or lower-case letters.

Device-dependent commands are device-dependent messages. For the 8840A to receive them, they must be sent over the IEEE-488 bus when the 8840A is in remote and has been addressed as a listener.

The following paragraphs describe the device-dependent commands in alphabetical order. Special characters (* and ?) are described last.

3-7. Bn (Offset Commands)

The Offset commands duplicate the function of the front panel OFFSET button. When the 8840A receives the B1 command, the 8840A stores the present reading as an offset for the present function. The B0 command cancels the offset. As with front panel operation, only one offset is allowed at a time.

The offset status (not the offset value) can be read using the G5 command. The 8840A defaults to B0 on both power-up and on any device-clear command (*, DCL, or SDC).

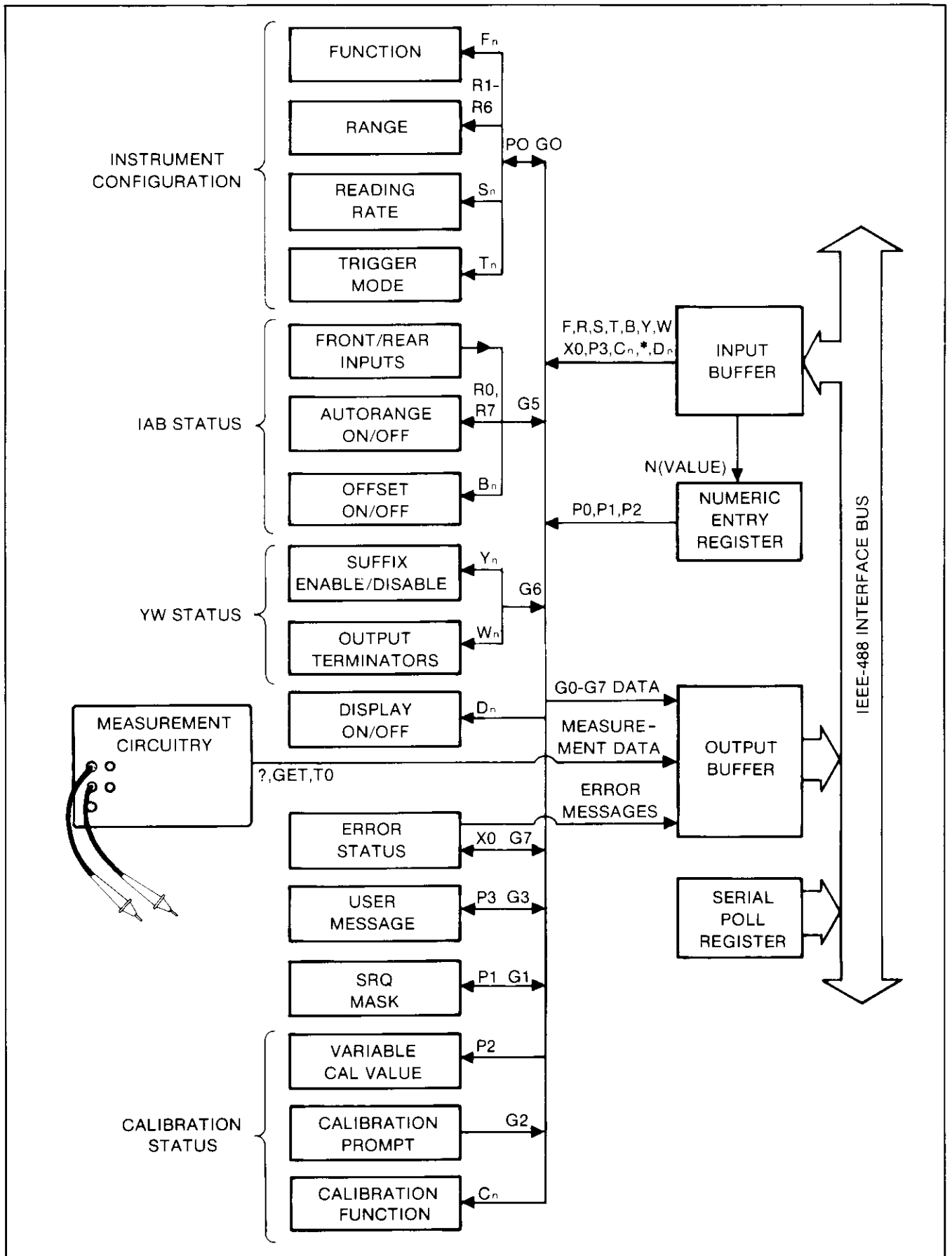


Figure 3-2. Remote Operation Block Diagram

Here is a typical command string as it might be sent from a Fluke 1722A Instrument Controller. The string configures the 8840A and triggers a reading. The PRINT command automatically sends terminators (CR, LF, and/or EOI) to the 8840A at the end of the command string.

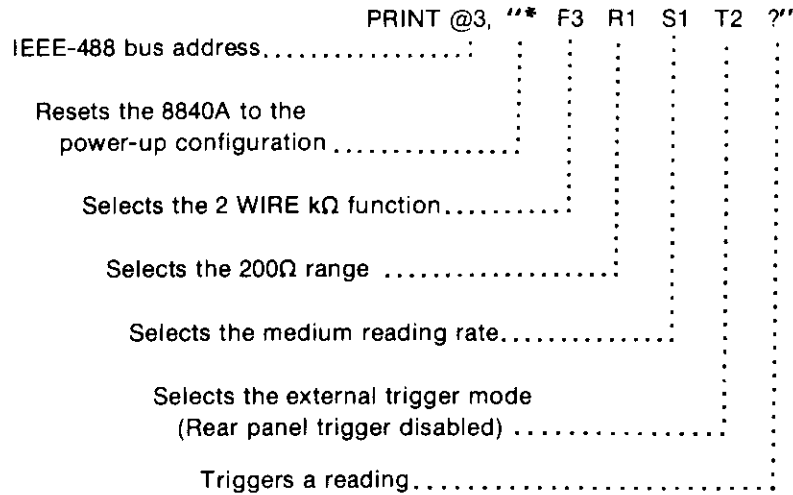


Figure 3-3. Typical Command String

3-8. Cn (Calibration Commands)

CAUTION

The command string "C3 C0" erases the entire calibration memory. A complete calibration must then be performed.

The Calibration commands allow the 8840A to be calibrated under remote control. Commands C0, C1, and C2 duplicate the front panel calibration functions STORE, A/D, and HF AC, respectively. For a complete description of remote calibration, see the Maintenance section of this manual.

For the 8840A to accept these commands, the 8840A must be in the calibration mode (enabled by pressing the front panel CAL ENABLE switch). Otherwise, the commands generate an error message.

3-9. Dn (Display Commands)

The Display commands allow the user to blank the numeric field in the 8840A front panel display. The D0 command causes the display to operate normally, and is the default on power-up and upon any device-clear command (*, DCL, or SDC).

The D1 command blanks the numeric field in the display. The annunciators remain active, and all of the annunciators still flash if the input exceeds 1000V dc or 700V ac in the respective ranges.

3-10. Fn (Function Commands)

The function commands duplicate the front panel function buttons. The 8840A defaults to F1 on power-up

and on any device-clear command (*, DCL, or SDC). If F0 is sent to the 8840A, it is internally converted to F1. The function setting can be read using the G0 command.

As with the front panel commands, selecting F5 or F6 automatically selects the 2000 mA range (R5). Also, if the instrument is in a resistance function (F3 or F4) and in R6, selecting any other function automatically selects R5.

<i>Example</i>	<i>Explanation</i>
"F3"	Selects 2 WIRE kΩ function; it does not affect any other settings.
"* F5"	Selects mA DC function and 2000 mA range. Resets all other settings to default

3-11. Get Commands

The Get commands "get" information from the 8840A for the controller. Each Get command loads the output buffer with an output string in the format shown in Figure 3-6. Status data (the output from Get commands G0, G1, G3, G4, G5, G6, and G7) is interpreted as shown in Table 3-1. The Get commands should not be confused with the interface message GET (Group Execute Trigger).

The output data from some Get commands starts with a leading 1 or 10. This prevents the controller from suppressing leading zeroes and gives a uniform four-character length to all instrument configuration data (the data from Get commands G0, G4, G5, G6, and G7).

The Get commands are described further in the following paragraphs. For more information about output data, see paragraph 3-39.

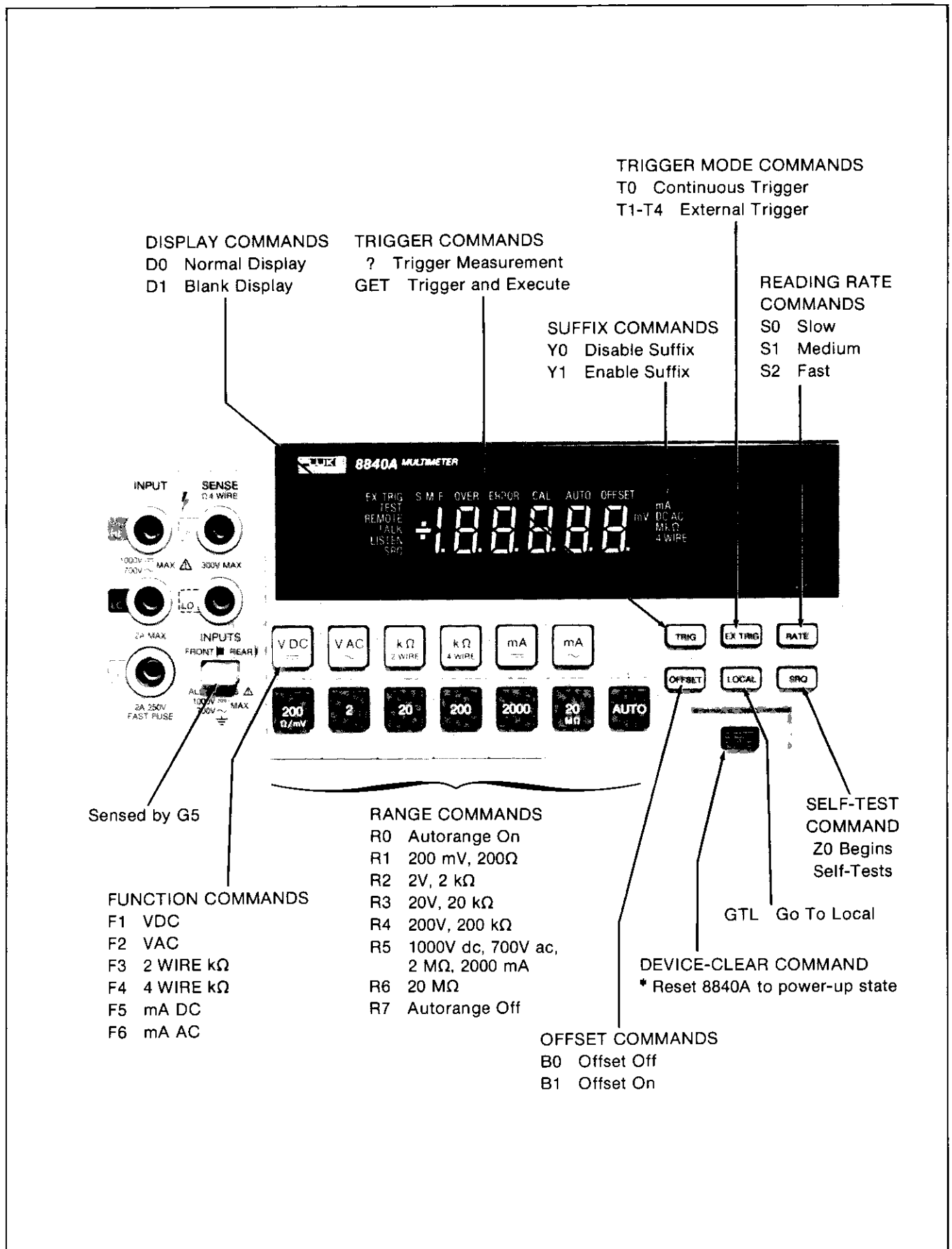


Figure 3-4. Commands Which Correspond to the Front Panel

FUNCTION COMMANDS

- F1 VDC (Default)
- F2 VAC
- F3 2 WIRE kΩ
- F4 4 WIRE kΩ
- F5 mA DC
- F6 mA AC

RANGE COMMANDS

- R0 Autorange On (Default)
- R1 200 mV, 200Ω
- R2 2V, 2 kΩ
- R3 20V, 20 kΩ
- R4 200V, 200 kΩ
- R5 1000V dc, 700V ac, 2 MΩ, 2000 mA
- R6 20 MΩ
- R7 Autorange Off

READING RATE COMMANDS

- S0 Slow (Default)
- S1 Medium
- S2 Fast

TRIGGER MODE COMMANDS

COMMAND	TRIGGER MODE	REAR PANEL TRIGGER	SETTLING DELAY
T0 (Default)	Internal	Disabled	—
T1	External	Enabled	On
T2	External	Disabled	On
T3	External	Enabled	Off
T4	External	Disabled	Off

Note: Delay is enabled by entering EX TRIG mode while in local.

OFFSET COMMANDS

- B0 Offset Off (Default)
- B1 Offset On

DISPLAY COMMANDS

- D0 Normal Display (Default)
- D1 Blank Display

SUFFIX COMMANDS

- Y0 Disable Output Suffix (Default if talker/listener)
- Y1 Enable Output Suffix (Default in talk-only mode)

TERMINATOR COMMANDS

- W0 Enable CR LF EOI (Default)
- W1 Enable CR LF Only
- W2 Enable CR EOI Only
- W3 Enable CR Only
- W4 Enable LF EOI Only
- W5 Enable LF Only
- W6 Enable EOI Only
- W7 Disable All Output Terminators

CLEAR COMMANDS

- * Device Clear (Resets 8840A to default conditions)
- X0 Clear Error Register

SINGLE-TRIGGER COMMAND

- ? Trigger Measurement

GET COMMANDS

- G0 Get Instrument Configuration (F,R,S, and T)
- G1 Get SRQ Mask
- G2 Get Calibration Input Prompt
- G3 Get User-Defined Message
- G4 Get Calibration Status
- G5 Get IAB Status (Input F/R, Autorange On/Off, Offset On/Off)
- G6 Get YW Status (Suffix Enabled/Disabled, Terminator Selection)
- G7 Get Error Status

Note: G2 valid only in calibration mode.

PUT COMMANDS

- P0 Put Instrument Configuration (F,R,S, and T)
- P1 Put SRQ Mask
- P2 Put Variable Calibration Value
- P3 Put User-Defined Message

Note: P2 and P3 valid only in calibration mode.

PUT COMMAND FORMAT

- N <value> P0
- N <value> P1
- N <value> P2
- P3 <16 ASCII characters>

Figure 3-5. Device-Dependent Command Set

SRQ MASK VALUES	CALIBRATION COMMANDS
00 for SRQ Disabled (Default)	C0 Store Present Input as Calibration Value
01 for SRQ On Overrange	C1 Begin A/D Calibration
04 for SRQ On Front Panel SRQ	C2 Begin HF AC Calibration
08 for SRQ On Cal Step Complete	C3 Enter Erase Mode (CAUTION! The command string "C3 C0" erases the entire calibration memory. A complete calibration must then be performed.
16 for SRQ On Data Available	
32 for SRQ On Any Error	
Note: Add SRQ mask values for combinations. Example: 33 for SRQ on overrange or any error.	Note: C3-C0 valid only in calibration mode
SELF-TEST COMMAND	TERMINATORS
Z0 Begin Self-Tests	CR (Carriage Return) Execute
	LF (Line Feed) Execute
	EOI (End Or Identify) Execute
	GET (Group Execute Trigger) Trigger and execute
	Note: GET is an interface message.

Figure 3-5. Device-Dependent Command Set (cont)

3-12. G0 (Get Instrument Configuration)

The G0 command copies the 8840A function, range, reading rate, and trigger mode into the output buffer in the format shown in Figure 3-6. The four digits returned represent the arguments for the equivalent F, R, S, and T commands, as shown in Table 3-1. An example output string follows.

<i>Example</i>	<i>Meaning</i>
3410 CR LF	3: F3 (2 WIRE k Ω function)
	4: R4 (200 k Ω range)
	1: S1 (Medium reading rate)
	0: T0 (Continuous trigger)

The second digit, which can vary from 1 to 6, indicates what measurement range the 8840A is in regardless of whether the 8840A is in autorange or manual range.

The output string from a G0 command is acceptable as an argument for an "N" command. This allows you to configure the 8840A from the front panel and then record the configuration over the bus for future use with a P0 command.

3-13. G1 (Get SRQ Mask)

The G1 command copies the present SRQ mask into the output buffer in the format shown in Figure 3-6. The SRQ mask values are explained in Table 3-1. An example output string follows. For more about the SRQ mask, see paragraph 3-47.

Example *Meaning*

33 CR LF Enable SRQ on any error or overrange

3-14. G2 (Get Calibration Prompt)

The G2 command is used when calibrating the 8840A under remote control. The command loads the output buffer with a calibration prompt that represents the input expected at the analog inputs. The calibration prompt is formatted as a signed decimal with exponent, as shown in Figure 3-6. The suffix may be enabled with the Y1 command. Example output strings follow.

<i>Examples</i>	<i>Meaning</i>
+1.00000E+0 CR LF	Calibration prompt
+190.000E-3 CR LF	Calibration prompt
+1.90000E+0, VDC CR LF	Calibration prompt (Suffix enabled)

If an error has occurred, the G2 command loads the output buffer with an error message instead of the prompt. (See paragraph 3-39 for more about error messages.)

The G2 command is valid only when the calibration mode is enabled by pressing the front panel CAL ENABLE switch. If the 8840A is not in the calibration mode, the G2 command generates an error message.

OUTPUT DATA TYPE

FORMAT

NUMERIC DATA (from trigger or G2)	$\pm n.nnnnnE\pm nn$ [CR] [LF] [EOI] [suffix]	
	EXAMPLES:	
	+12.3456E+6	Measured value
	+12.3456E+6, OHM	Measured value
	-9.99999E+9	Overrange
+9.99999E+9,>VDC	Overrange	
+1.0032E+21	Error message	
INSTRUMENT CONFIGURATION DATA (From G0, G4, G5, G6, and G7)	nnnn [CR] [LF] [EOI]	
	EXAMPLE: 1100	Default G0 value
SRQ MASK DATA (From G1)	nn [CR] [LF] [EOI]	
	EXAMPLE: 32	SRQ on any error
USER-DEFINED MESSAGE (From G3)	aaaaaaaaaaaaaaaa [CR] [LF] [EOI]	
	EXAMPLE: FL8840A.01-25-84	

- Numeric data is always in volts, amps, or ohms.
- The terminators CR, LF, and EOI are selected with the Terminator Commands (Wn).
- The suffix, defined below, is enabled with the Y1 command and disabled with the Y0 command. (Default = Y0.)

SUFFIX FORMAT

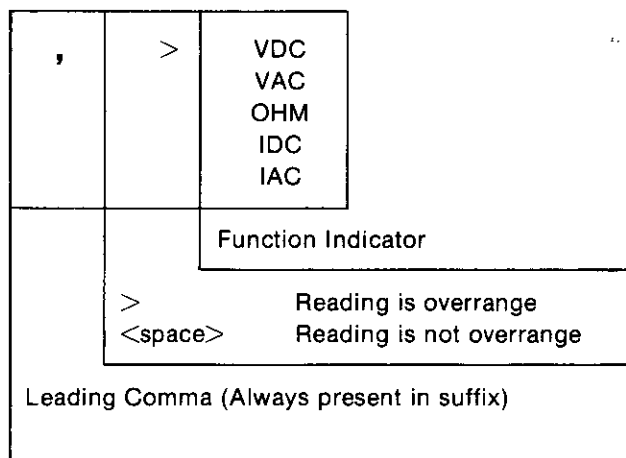


Figure 3-6. Output Data Format

3-15. G3 (Get User-Defined Message)

The G3 command loads the output buffer with the user-defined message stored in calibration memory during the calibration procedure. The message consists of 16 ASCII characters, as shown in Figure 3-6.

The message is stored in calibration memory during calibration using the P3 command. If fewer than 16 characters have been stored, the remaining characters returned are spaces. Some example output strings follow.

<i>Example</i>	<i>Meaning</i>
FL8840A.12-17-83 CR LF	Identifies instrument and gives cal date.
01-25-84 CR LF	Gives cal date. The last eight characters are blank.

3-16. G4 (Get Calibration Status)

The G4 command is used when calibrating the 8840A under remote control. The command loads the output buffer with the instrument's calibration status in the format shown in Figure 3-6. The status is represented by a four-digit integer which is interpreted in Table 3-1.

The first two digits are always 1 and 0. The third digit indicates whether or not the calibration verification mode is enabled. (This mode is enabled only when the calibration mode is enabled.) The fourth digit indicates whether or not the calibration mode is enabled, and if so, which part of the calibration procedure the 8840A is in. Example output strings follow.

<i>Example</i>	<i>Meaning</i>
1000 CR LF	1: Leading 1 0: Leading 0 0: Not in cal verification 0: Cal mode disabled
1001 CR LF	1: Leading 1 0: Leading 0 0: Not in cal verification 1: Cal mode enabled; A/D cal selected

3-17. G5 (Get IAB Status)

The G5 command loads the output buffer with the IAB status in the format shown in Figure 3-6. As Table 3-1 explains, the IAB status is a four-character string which

indicates the status of the FRONT/REAR switch (front or rear analog inputs selected), the autorange feature (autorange on or off), and the OFFSET feature (OFFSET on or off). The first digit is always 1. An example output string follows.

<i>Example</i>	<i>Meaning</i>
1011 CR LF	1: Leading 1 0: FRONT inputs 1: Autorange off 1: OFFSET feature on

It is useful to know whether autorange is on or off because this information is not available from the G0 command. For example, the G0 command could indicate that the 8840A was in the 200 mV range, but it would not indicate whether the 8840A was in autorange or manual range.

3-18. G6 (Get YW Status)

The G6 command loads the output buffer with the YW status in the format shown in Figure 3-6. The YW status is a four-character string which indicates which terminators are selected and whether the output suffix is enabled or disabled, as shown in Table 3-1. The first two digits are always 1 and 0. An example output string follows.

<i>Example</i>	<i>Meaning</i>
1015 LF CR	1: Leading 1 0: Leading 0 1: Y1 (enable output suffix) 5: W5 (enable LF only)

3-19. G7 (Get Error Status)

The G7 command copies the error status register into the output buffer in the format shown in Figure 3-6. The first two digits are always 1 and 0. The second two digits represent the appropriate error code, if an error has occurred. (Error codes are listed in Table 2-1, Section 2). If an error has not occurred, the second two digits are 00. An example output string follows.

<i>Example</i>	<i>Meaning</i>
1071 CR LF	1: Leading 1 0: Leading 0 71: Syntax error in device-dependent command string

Table 3-1. Status Data

COMMAND	OUTPUT STRING	MEANING
G0	frst	f = 1 - 6 as in Function commands (Fn) r = 1 - 6 as in Range commands (Rn) s = 0 - 2 as in Reading Rate commands (Sn) t = 0 - 4 as in Trigger Mode commands (Tn)
G1	nn	nn = 00 for SRQ disabled (default) 01 for SRQ on overrange 04 for SRQ on front panel SRQ 08 for SRQ on cal step complete 16 for SRQ on data available 32 for SRQ on any error Note: SRQ mask values may be added for combinations. Example: 33 for SRQ on overrange or any error.
G3	aaaaaaaaaaaaaaaa	16 user-defined ASCII characters
G4	10vm	v = 0 Not in cal verification 1 Cal verification m = 0 Not in calibration mode 1 A/D calibration 2 Offset and gain calibration 4 HF AC calibration
G5	1iab	i = 0 FRONT inputs selected 1 REAR inputs selected a = 0 Autorange on 1 Autorange off (Manual range) b = 0 OFFSET off 1 OFFSET on
G6	10yw	y = 0 output suffix disabled 1 output suffix enabled w = 0 - 7 as in Terminator commands (Wn)
G7	10nn	nn represents error code (See Table 2-1)

The G7 command gives the error status as it exists when the command is executed at its position in the input string. The G7 command does not clear the error status register. For more information about error messages, see paragraph 3-39.

3-20. N (Numeric Entry Command)

Format

N<numeric entry> Where <numeric entry> is one of the following:

<signed integer>

<signed real number without exponent>

<signed real number>E<signed exponent>

Example Explanation

“N12001” Enters the five-digit integer 12001

“N-1.23E2” Enters -1.23×10^2

“N+154.33E-1” Enters 1.5433×10^1

The N command enters numeric values for use with subsequent Put commands. The interpretation of the numeric value depends on which Put command it is used with.

The E can be used within an N command for entering an exponent of 10. The N can be used without an E, but an E requires a prior N. The exponent can be any integer from -9 to +9.

The mantissa may exceed 5-1/2 digits. The 8840A accurately calculates the appropriate exponent and then disregards all but the first 5-1/2 digits of the mantissa. However, a syntax error will occur if the numeric entry overflows the input buffer.

Example Explanation

“N123456789” Enters $+1.23456 \times 10^8$

3-21. Put Commands

The Put commands P0 through P3 set up the 8840A's configuration and operating modes by entering (“putting”) information in the appropriate registers. The put commands are described further in the following paragraphs.

3-22. P0 (Put Instrument Configuration)

Format

N frst P0 Where frst is a four-digit integer interpreted as arguments for the F, R, S, and T commands.

Example Explanation

“ N3120 P0” Identical to F3 R1 S2 T0. Selects 2 WIRE $k\Omega$ function, 200 Ω range, fast sample rate, continuous trigger.

The P0 command allows broadside loading of the Function, Range, Reading Rate, and Trigger Mode commands (F, R, S, and T). The codes for these commands are listed in Figure 3-5.

A numeric entry for P0 must be within +1000 and +6724. Each of the four digits must not exceed its maximum allowed value (6,7,2, and 4, respectively ram error will occur and the instrument configuration will remain unchanged.). The entry may be expressed as an integer, real number, or real number with exponent, as described under the N command. Any fractional part is ignored.

Example Explanation

“N3112 P0” Sets the 8840A to F3, R1, S1, and T2.

3-23. P1 (Put SRQ Mask)

Format

N<SRQ mask>P1 Where <SRQ mask> is a two-digit integer from 00 to 63.

The P1 command is used to program the 8840A to make service requests on user-specified conditions. The two-digit code for the SRQ mask is interpreted in Table 3-1 under the G1 command. For more about the SRQ mask, see paragraph 3-47.

Numeric entries for the P1 command must be between 0 and +63 (inclusive), or an error will occur and the SRQ mask will remain unchanged. The entry may be expressed as an integer, real number, or real number with exponent, as described under the N command. Any fractional part is ignored.

Example Explanation

“N0.17E+2 P1” Sets SRQ mask to 17. Enables SRQ on data available or overrange.

“N1 P1” Sets SRQ mask to 01. (A leading zero is assumed.) Enables SRQ on overrange.

3-24. P2 (Put Calibration Value)

Format

N<value>P2 Where <value> can be an integer, real number, or real number with exponent, as described under the N command.

Example Explanation

“N1 P2” If the 8840A is in VDC, the next calibration input expected is 1.00000V dc.

The P2 command is used to enter variable input calibration values just like the front panel VAR IN button. To accept the P2 command, the 8840A must be in the calibration mode (enabled by pressing the front panel CAL ENABLE switch). Otherwise, the P2 command will generate an error message.

The variable input is a measurement value that is to be used as the calibration value for the next calibration step. Its format is the same as a measurement value. But since it is coming from the controller, the value can be specified using any valid format (signed integer, real number, or real number with exponent). For example, if the 8840A prompts for an input value of 100Ω for the next calibration step, but the available source is 98.97Ω, the variable input can be specified as “N+9.897E+1”, “N0.9897E2”, “N9897E-2”, etc. All of these strings result in the same value being used for the next calibration step. For complete information about remote calibration, refer to the Maintenance section.

Numeric values exceeding full scale and negative values for ohms and AC generate error messages.

3-25. P3 (Put User-Defined Message)

Format

P3<value> Where <value> is a string of up to 16 ASCII characters.

Example Explanation

“P3FL.8840.12-17-83” Loads the message “FL.8840.12-17-83” into calibration memory.

“P3HIMOM” Loads the message “HIMOM” into calibration memory. The remaining eight characters are assumed to be blank.

The P3 command stores a user-defined message in the internal calibration memory during remote calibration.

The message may be read with a subsequent G3 command.

The message may consist of up to 16 ASCII characters, and typically represents the instrument’s identification, calibration date, calibration facility, etc. If fewer than 16 characters are specified, spaces are appended to fill the message to 16 characters. Spaces and commas in the 16-character input string are suppressed. Lower-case letters are converted to upper-case.

NOTE

If fewer than 16 characters are specified, the P3 command must not be followed by other commands in the same input command string. Otherwise, the subsequent commands will be misinterpreted as part of the 16-character string.

To accept the P3 command, the 8840A must be in the calibration mode (enabled by pressing the front panel CAL ENABLE switch). Otherwise, the P3 command will generate an error message.

3-26. Rn (Range Commands)

The Range commands duplicate the front panel range buttons. For example, R0 selects autorange, and R4 selects the 200V/200 kΩ range.

The R7 command turns autorange off, just as the AUTO button does when it is toggled. Command R7 puts the 8840A into manual range, selecting whatever range the instrument is in when the command is received.

The 8840A defaults to R0 on power-up and any device-clear command (*, DCL, or SDC). The range setting can be read using the G0 command.

3-27. Sn (Reading Rate Commands)

The Reading Rate commands duplicate the front panel RATE button. Like the RATE button, the reading rate command also selects the number of digits displayed and the filter setting. (Filter settings are shown in the specifications in Section 1).

The 8840A defaults to S0 on power-up and any device-clear command (*, DCL, or SDC). The reading rate can be read using the G0 command.

3-28. Tn (Trigger Mode Commands)

The Trigger Mode commands duplicate the front panel EX TRIG button. In addition, the commands can enable or disable the rear panel trigger and the automatic settling time delay.

Figure 3-7 illustrates how to select among the five types of triggers: continuous trigger, front panel trigger, rear panel trigger, and two bus triggers. Note that the front panel TRIG button is enabled only while the instrument is under local control.

In the continuous trigger mode (T0), triggers are initiated at the selected reading rate. Each new reading is loaded

into the output buffer as it becomes available, unless the instrument is busy sending previous output data.

The trigger mode can be read using the G0 command. The 8840A defaults to T0 on both power-up and any device-clear command (*, DCL, or SDC).

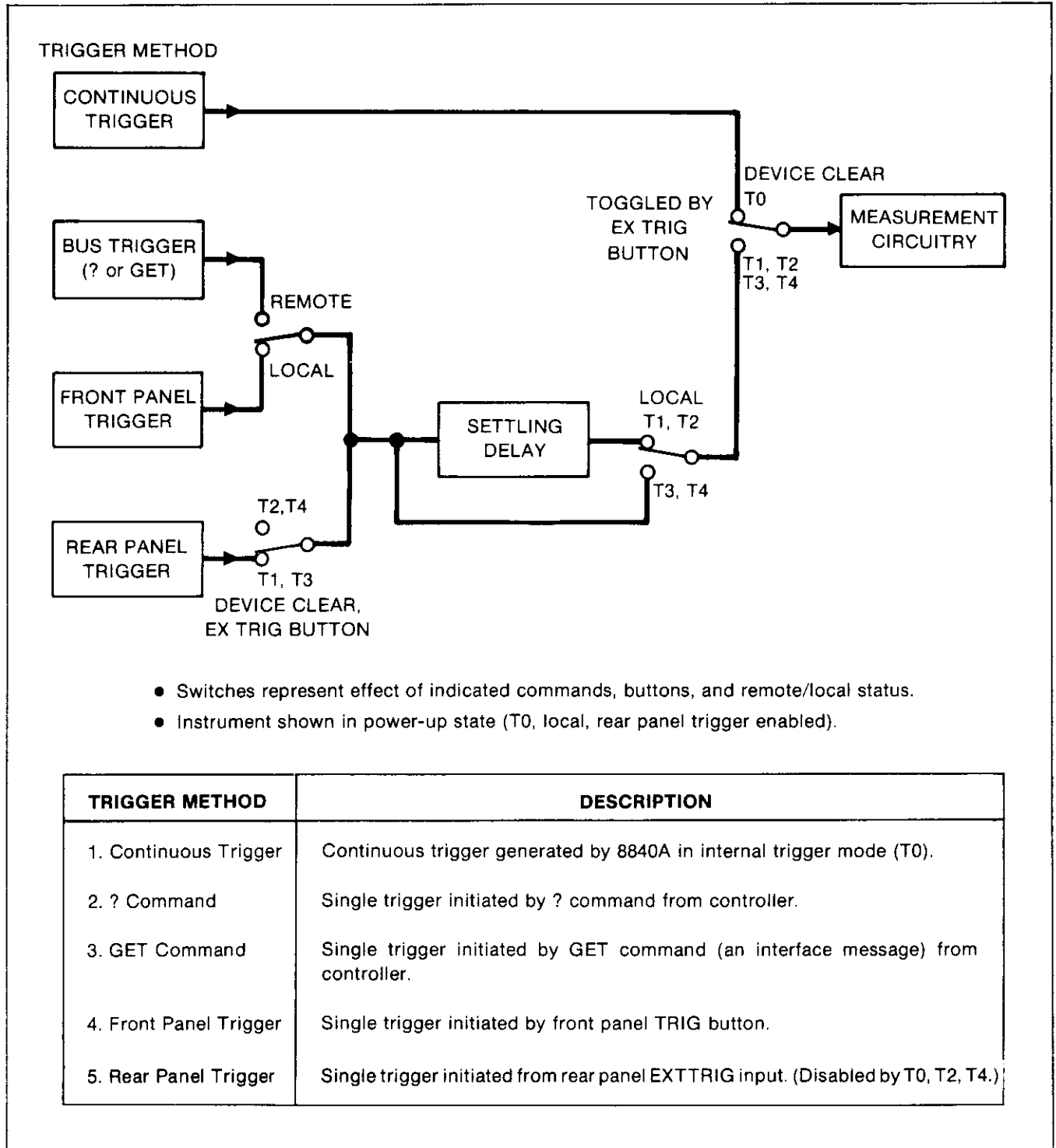


Figure 3-7. Trigger Selection Logic Diagram

3-29. Wn (Terminator Commands)

The Terminator commands select what terminators the 8840A appends to every output string. The available terminators are: Carriage Return (CR), Line Feed (LF), and End Or Identify (EOI).

CR and LF are ASCII control codes, sent over the data lines just like output data. EOI is a uniline message which is sent simultaneously with the last character in the output string. Normally, each output string is terminated with CR followed by LF and EOI.

The terminator selection can be read using the G6 command. The 8840A defaults to W0 on power-up and any device-clear command.

3-30. X0 (Clear Error Register Command)

The X0 command clears the 8840A's error status register. After an X0 command is executed, a G7 command (Get Error Status) would return 1000 (no errors).

Note that the error status register is also cleared when any device-clear command (*, DCL, or SDC) is executed. However, X0 is useful for clearing the error status register without forcing a complete instrument clear (as do the device-clear commands).

3-31. Yn (Suffix Commands)

The Suffix commands enable or disable a suffix which the 8840A can append to all numeric data (the data in response to G2 or trigger commands). The suffix includes a comma, an overrange indicator (>), and a function indicator (VDC, VAC, OHM, IDC, or IAC). The suffix is illustrated in Figure 3-6. An example of suffixed data is given in paragraph 3-42.

To read suffixed data with a controller using BASIC, one can read the whole line into a string variable and then convert the numeric part into a numeric variable. However, it is much easier to read the numeric part directly into a numeric variable and the suffix into a string variable. The leading comma of the suffix serves as a convenient delimiter. For example, a BASIC program statement might be:

```
INPUT @1,A, B$
```

The suffix status can be read using the G6 command. The 8840A defaults to Y0 on power-up and any device-clear command (*, DCL or SDC), unless in talk-only mode.

3-32. Z0 (Self-Test Command)

The Z0 command initiates the diagnostic self-tests as does pressing the front panel SRQ button for 3 seconds. The 8840A then runs through the tests in sequence. (For a description of the self-tests, see the Maintenance section.)

If the 8840A detects an error, an error message is loaded into the output buffer and displayed on the front panel. After the last test, the 8840A is reset to the power-up configuration, and it begins taking readings.

It is an error to send the 8840A device-dependent commands during the self-tests. However, the controller can still make the 8840A a talker to read the output buffer during the test, and thus record each error that occurs, except that only the last of the digital self-test errors can be read. After the tests, only the last error is stored in the output buffer if more than one error occurred.

Error messages are indicated by an exponent of +21. For more about error messages, see paragraph 3-39.

Since the 8840A is reset at the end of the self-tests, the Z0 command should be the last command in a given command string. The 8840A will ignore any subsequent commands in the same command string.

When the self-tests are complete and no errors have occurred, the serial poll register will have bit 5 (Data Available) true and bit 6 (Any Error) false. See paragraph 3-47 for more about the serial poll register.

3-33. * (Device-Clear Command)

The asterisk command (*) is a device-dependent message which resets the 8840A to the power-up default settings and clears all registers and buffers except for the input buffer. The remote/local status remains unchanged. The asterisk command performs the following:

1. Implements the default settings F1, R0, S0, T0, D0, B0, Y0, W0.
2. Clears the error status register (equivalent to X0).
3. Zeros the SRQ mask, prohibiting service requests (equivalent to N0 P1).
4. Zeros the numeric entry register (equivalent to N0).
5. Zeros the serial poll register.
6. Sets the SRQ line false.

The asterisk command is executed in its proper turn in a string, just like any other command, without affecting the contents of the input buffer. All commands which precede the asterisk command are performed.

The asterisk command is useful to ensure that the 8840A is initialized to the same state each time a program is run. By contrast, the similar interface messages DCL (Device Clear) and SDC (Selected Device Clear) cause the entire input buffer to be cleared immediately.

DCL, SDC, and the asterisk command are all considered to be device-clear commands because the results are so similar; however, DCL and SDC are not identical to the asterisk command described here. DCL and SDC are discussed further in the paragraph on interface messages.

3-34. ? (Single-Trigger Command)

The Single-Trigger command (?) causes the 8840A to take a reading and place the result into the output buffer. To accept this command, the 8840A must be in external trigger mode (selected by the T1, T2, T3, or T4 command).

The Single-Trigger command is one of five ways to trigger a reading. (See Figure 3-7.) Of these, only the Single-Trigger command (?) and the Group Execute Trigger command (GET) are loaded into the input buffer.

The following paragraphs describe how to construct groups of commands for the 8840A. A few definitions are presented first, followed by a description of how the 8840A processes input commands. Guidelines are then summarized in four syntax rules.

3-36. Definitions

- Output commands: Commands which load data into the output buffer. The output commands are: the Get commands (G0 through G7); the Single-Trigger Command (?); the Continuous Trigger command (T0); and Group Execute Trigger (GET), not to be confused with the Get commands.
- Input terminator: An ASCII control code sent by the controller which tells the 8840A to execute all device-dependent commands since the previous terminator. Terminators are CR (Carriage Return), LF (Line Feed), EOI (End Or Identify), and GET (Group Execute Trigger).
- Input command string: One or more device-dependent commands followed by a terminator.

3-37. Input Processing

When the 8840A receives commands from the bus, it stores them in a 32-character input buffer as a continuous string of characters. Commands in the input buffer are not executed or checked for syntax until an input terminator is received or the input buffer becomes full. The only valid input terminators are CR, LF, GET (Group Execute Trigger), and/or EOI.

When the 8840A receives an input terminator, it executes the previous commands in the order in which they were received. As input characters are processed and executed, space is made available in the input buffer for new characters.

If the input buffer becomes full, the 8840A stops accepting characters from the bus until all complete command strings currently in the input buffer have been executed. In this way, characters sent to the 8840A are never lost due to buffer overflow.

In some instances, a terminator is automatically transmitted at the end of the controller's output string. For example, in Fluke BASIC, the PRINT statement always finishes with a CR LF pair. If a controller does not have this feature, the programmer must transmit a terminator explicitly.

The 8840A accepts alphabetic characters in either upper or lower case. Spaces, commas, and control codes are ignored and are not placed in the input buffer. If the 8840A receives a group of terminators (such as CR LF or CR LF EOI), only a single terminator is loaded into the input buffer. Numeric values may be in NR1, NR2, or NR3 format as described in the IEEE-488 Codes and Formats Recommended Practice. (These correspond to the signed integer, real number, and real-number-with-exponent formats described under the N command.) For reference, Figure 3-8 shows how the 8840A interprets messages.

Illegal commands (e.g., F9) generate an error message, but are otherwise ignored, and do not affect the instrument's configuration.

Example Explanation

“* F9” This would load the output buffer with an error message and select F0 (established by the * command).

3-38. Syntax Rules

Four syntax rules should be followed when constructing input command strings. They are:

- RULE 1: Read output data only once.

To prevent old (previously read) data from being read a second time by mistake, the output buffer is always cleared after it has been read. If the output buffer is read twice without an intervening output command, the 8840A will not respond to the second attempt to read the output buffer. (However, if the 8840A is in T0, no intervening command is necessary.)

- RULE 2: Use no more than one output command per input command string.

Because the 8840A has only one output buffer, it writes new data over old. If an input command string contains more than one output command, only the data from the last command can be read.

DEVICE-DEPENDENT MESSAGES

Single-character Commands

? *

These two commands are complete in themselves (except for string terminator).

Two-character Commands

Bn Cn Dn Fn Gn Pn
Rn Sn Wn Xn Yn Zn

Each of these commands requires the single numeric digit (n).

Numeric-entry Characters

N E . + - 0 1 2 3 4 5 6 7 8 9

These characters are used for entering numbers

Terminators

CR
LF
GET
EOI

Carriage Return
Line Feed
Group Execute Trigger
End Or Identify (used as END/DAB)

INTERFACE MESSAGES

Address Messages

MLA
MTA
UNL
UNT

My Listen Address
My Talk Address
Unlisten
Untalk

Universal Commands

ATN
DCL
IFC
LLO
REN
SPD
SPE

Attention
Device Clear
Interface Clear
Local Lockout
Remote Enable
Serial Poll Disable
Serial Poll Enable

Addressed Commands

GET
GTL
SDC

Group Execute Trigger
Go To Local
Selected Device Clear

Ignored Characters

, comma
space
All other ASCII non-printing
characters (except CR and LF)

These characters may be inserted anywhere in a character string without affecting the string. They carry no special meaning and are ignored by the 8840A. They are not placed in the input buffer.

ERROR-PRODUCING CHARACTERS

! " # \$ ' () / : < = > ;
@ [/] ~
H I J K L M O Q U V

The error annunciator is displayed on the 8840A front panel when one of these characters is encountered (ERROR 71).

Figure 3-8. Interpretation of Messages

<i>Example</i>	<i>Explanation</i>
"F1 T3 ? F2 ?"	Improper construction. The second trigger writes over the first. To obtain two readings, send two complete command strings (separated by terminators).
"F2 R3 S0 T3 ?"	Correct construction. The string contains only one output command.
"F2 R3 S0"	Correct construction. It is permissible for a string not to contain an output command.

- **RULE 3:** Read the output data generated by one input command string before sending the next input command string.

Output data remains available in the output buffer until it is read, or until the next input command string is received. As soon as the controller finishes reading the output buffer, or as soon as the 8840A receives a new input terminator, the Data Available bit in the serial poll register is set false. When this bit is false, data can no longer be read from the output buffer. Therefore, an output string which is available must be read by the controller before, rather than after, the next input command string is sent.

Rule 3 is most evident in the external trigger mode, and is best demonstrated by a programming example. The following program is written first incorrectly, and then correctly, in Fluke BASIC using the 1722A Instrument Controller.

Incorrect example

```
100 PRINT @3, "T1 ?"
200 PRINT @3, "F4"
300 INPUT @3, A
```

In this incorrect example, the INPUT statement is located incorrectly for reading the measurement data from line 100. The new input command string "F4" disallows the reading of data from the output buffer.

Correct example

```
100 PRINT @3, "T1 ?"
200 INPUT @3, A
300 PRINT @3, "F4"
```

In this example, the reading taken at line 100 is read at line 200. Then the F4 command is sent. Note that in the external trigger mode, the reading from line 100 flashes on the 8840A display too briefly to see. This is because the function change at line 300 blanks the display until the next trigger.

The previous example could also be correctly programmed as follows:

```
100 PRINT @3, "T1 ? F4"
200 INPUT @3, A
```

- **RULE 4:** If an input command string contains a trigger, enter the commands in the following order:
 - Commands to configure the instrument (if any).
 - The trigger command.
 - Commands to re-configure the instrument (if any).
 - Terminator(s).

The principle behind this rule is that the 8840A executes all commands in the exact order they are received, from left to right as written.

<i>Example</i>	<i>Explanation</i>
----------------	--------------------

"F3 F4 ?"	Improper construction. F3 is effectively discarded.
"F3 ? F4"	Correct construction. The 8840A is configured in F3, and the trigger is executed. Then the 8840A is left in F4.

3-39. OUTPUT DATA

The following paragraphs describe the data that can be loaded into the 8840A output buffer and sent to the IEEE-488 bus. The paragraphs describe how and when data is loaded into the output buffer, the types of output data, and their relative priority.

Note that the 8840A can also send data to the IEEE-488 bus from the serial poll register. For a description of this data, see paragraph 3-47.

3-40. Loading Output Data

The output buffer is loaded when the 8840A receives an output command, or when an error occurs. Output commands are those device-dependent commands which load the output buffer with data:

- Get commands (G0 through G7)
- Single-trigger command (?)
- Group execute trigger (GET)
- Continuous Trigger (T0)

Because the 8840A gives priority to input processing, it completely processes all characters in the input buffer before it loads the output buffer. When the output buffer is loaded, the Data Available bit in the serial poll register is set true.

Data from the output buffer is not actually loaded onto the IEEE-488 bus until the controller addresses the 8840A as a talker. This is done by sending the interface message MTA (My Talk Address).

3-41. Types of Output Data

The types of data that can be loaded into the output buffer are shown in Figure 3-6. Each type has its own format. Error messages, which are loaded into the output buffer if an error occurs, are formatted as numeric data.

3-42. Numeric Data and Error Messages

Numeric data is loaded into the output buffer in response to the G2 command or an instrument trigger, and has the format shown in Table 3-2. The exponent is always a multiple of 3, as in engineering notation. The position of the decimal point matches the front panel display.

Numeric data is of constant length. It is 11 characters (plus terminators) when the suffix is disabled, and 16 characters (plus terminators) when the suffix is enabled.

The suffix is enabled by the Y1 command, and consists of five ASCII characters as shown in Figure 3-6. The suffix is appended only to numeric data, never to status data. The terminators are determined by the Terminator commands. The default is CR LF EOI.

There are three types of numeric data: measurement data, overrange indication, and error messages.

3-43. MEASUREMENT DATA

Measurement data has the numeric data format shown in Table 3-2, and is always in the units of volts, amps, or ohms.

3-44. OVERRANGE INDICATION

If a reading is overrange, the measurement data always has the following format:

$\pm 9.99999E+9$ (suffix) (terminators)

If the 8840A detects an error, it loads an error message into the output buffer in the following numeric format:

$+1.00xxE+21$ (terminators)

The digits xx represent a two-digit error code. (Error codes are listed in Table 2-1, Section 2.) The suffix is always suppressed for error messages.

Example

Explanation

+1.0071E+21 CR LF ERROR 71: Syntax error in device-dependent command string.

As with local operation, none of the errors are latching except for ERROR 31. If the mA DC or mA AC function is requested while the FRONT/REAR switch is in the REAR position, ERROR 31 will persist until the switch is set to FRONT or another function is selected.

To check for an error condition, test whether the output buffer data is greater than or equal to +1E+21, or test the Any Error bit (bit 6) in the serial poll register.

3-45. Status Data

Status data is the output in response to G0, G1, G3, G4, G5, G6, and G7 commands. The data is formatted as shown in Figure 3-6, and is interpreted in Table 3-1. Examples of status data can be found in the description of the Get commands.

Table 3-2. Numeric Output Data Format

RANGE	MEASUREMENT DATA			OVERRANGE INDICATION	ERROR MESSAGES
	VDC, VAC	2-, 4-WIRE kΩ	mA DC, mA AC		
R1	$\pm 1xx.xxxE-3$	$\pm 1xx.xxxE+0$	--	↓	↓
R2	$\pm 1.xxxxxE+0$	$\pm 1.xxxxxE+3$	--		
R3	$\pm 1x.xxxxE+0$	$\pm 1x.xxxxE+3$	--		
R4	$\pm 1xx.xxxE+0$	$\pm 1xx.xxxE+3$	--		
R5	$\pm 1xxx.xxE+0$	$\pm 1xxx.xxE+3$	$\pm 1xxx.xxE-3$		
R6	--	$\pm 1x.xxxxE+6$	--		

The user-defined message loaded by the G3 command consists of 16 characters plus terminators. The SRQ mask loaded by the G1 command consists of two integers plus terminators. All other status data is always a four-digit integer plus terminators. The terminators LF (Line Feed) and CR (Carriage Return) each add an extra character when enabled.

The 8840A begins some status data with a leading ASCII one (1) or a one and a zero (10). This prevents the controller from suppressing any leading zeros present in the 8840A's output string. It also gives a uniform four-character length to all instrument configuration data.

Status data from the Get commands reflects the status of the 8840A at the time the command is executed at its place in the input command string.

3-46. Output Priority

Since only one output string is allowed per input command string, the 8840A gives priority to some types of data over others. An input command string may call for more than one output string. (For example, an input string may contain a Get command but also cause an error message.) However, the output buffer is loaded with only one output string. That string is selected according to the following priority:

1. Status data (from G0, G1, G3, G4, G5, G6, or G7)
2. Error messages (if an error exists)
3. Numeric data (from G2 or a trigger)

This means that an error message always overrides numeric data, but status data is sent even in the presence of an error. However, the status data does not clear the error message; the error message is sent the next time numeric data is requested.

3-47. SERVICE REQUESTS

Service requests let bus instruments get the attention of the system controller. The requests are sent over the SRQ

line (one of the IEEE-488 bus lines). If more than one instrument on the bus is capable of sending service requests, the controller can learn which one made the request by taking a serial poll. Each device (including the 8840A) responds to the poll by sending the contents of its serial poll register. The serial poll register indicates whether or not the device requested service, and if so, the reason for the request.

The 8840A may be programmed to make a service request on user-specified conditions. The conditions are specified by entering a value for the service request mask (SRQ mask) with the P1 command. The SRQ mask works by monitoring the serial poll register, which in turn monitors various conditions in the 8840A.

Service requests may also be initiated using the front panel SRQ button if it has been enabled by the SRQ mask.

3-48. The Serial Poll Register

The serial poll register is a binary-encoded register which contains eight bits, as illustrated in Figure 3-9. The controller can read the 8840A serial poll register at any time by taking a serial poll. Because serial poll register data is loaded directly onto the bus (instead of being loaded into the output buffer first), reading the serial poll register leaves data in the output buffer intact.

The eight bits of the serial poll register are described below. Note that the SRQ mask uses bits 1 through 6 to set bit 7 (the RQS bit). When the RQS bit is set true, the 8840A sets the SRQ line true, which generates a service request. A bit is considered true when it is set to 1.

- Bit 1 (the lowest-order bit) is set true on overrange. When overrange occurs, the output buffer is loaded $\pm 9.99999E+9$ (and a suffix, if enabled).
- Bit 2 is not used. It is always set to 0.
- Bit 3 is set true when the front panel SRQ button is pressed.

BIT: 8	7	6	5	4	3	2	1
0	RQS	ANY ERROR	DATA AVAIL-ABLE	CAL STEP COMPLETE	FRONT PANEL SRQ	0	OVER-RANGE
DECIMAL VALUE:	64	32	16	8	4	2	1

Figure 3-9. Serial Poll Register

- Bit 4, Cal Step Complete, is set true when a store command is completed in the calibration procedure.
- Bit 5, Data Available, is set true every time the output buffer is loaded, regardless of the kind of output data (including error messages). This bit is cleared (set to 0) when any new bus input occurs, when the output buffer is read, or when an external trigger occurs.
- Bit 6, Any Error, is set true whenever an error condition occurs. At the same time that bit 6 is set true, the output buffer is loaded with an error message.
- Bit 7, RQS (request service), is set true if any mask-enabled bit is set true. This bit is cleared (set to 0) when the serial poll register is read.
- Bit 8 is not used. It is always set to 0.

For example, the serial poll register reads 00010000 (binary) when data is available. This value is read in binary by the controller, which might numerically reformat the value to 16 (decimal) or 10 (hexadecimal).

The serial poll register is cleared whenever the 8840A receives a new input command string.

3-49. The SRQ Mask

The SRQ mask is a two-digit integer that specifies which conditions will generate a service request. The SRQ mask is entered using the P1 command and can be read with the G1 command. The conditions corresponding to each SRQ mask value are listed under G1 in Table 3-1.

The SRQ mask can enable any combination of serial poll register bits 1 through 6. Its six-bit binary representation is ANDed bit-for-bit with serial poll register bits 1 through 6 whenever the output buffer is loaded. If any mask-enabled bit in the serial poll register comes true, the RQS bit (bit 7) is set true, generating a service request.

<i>Example</i>	<i>Explanation</i>
“* N4 P1 ?”	An SRQ is generated if the front panel SRQ button is pressed. The string sets the SRQ mask to 04, which is 000100 in binary. This mask is ANDed with the lower six bits of the serial poll register. The mask thus enables bit 3, the Front Panel SRQ bit.

The SRQ mask codes can be added to select combinations of conditions.

<i>Example</i>	<i>Explanation</i>
“* N5 P1 ?”	An SRQ is generated if the SRQ button is pressed or if the trigger results in an overrange reading. The SRQ mask is set to 05, which is 000101 in binary.

At power-up or on any device-clear command, the SRQ mask is set to 00 (decimal). This prevents service requests by holding the RQS bit false under all conditions. For other examples of the SRQ mask, see the description of the P1 command.

3-50. INTERFACE MESSAGES

The interface messages understood by the 8840A can be separated into the three main classes described in the IEEE-488 Standard: address messages (AD), universal commands (UC), and addressed commands (AC). All interface messages described here originate at the controller.

3-51. Address Messages

Address messages are used by the controller to communicate talk and listen control to other devices on the bus. Address messages are sent over the eight data lines of the bus while the controller holds ATN true. Address messages are processed immediately and are not placed in the input buffer. The address messages are:

- MLA My Listen Address -- Addresses a device to listen
- MTA My Talk Address -- Addresses a device to talk
- UNL Unlisten -- Addresses all listeners to unlisten
- UNT Untalk -- Addresses all talkers to untalk

3-52. Universal Commands

Universal commands are accepted and interpreted by all devices on the bus. The commands are of two types, multiline messages and uniline messages. Multiline messages are sent over the eight parallel data lines in the IEEE-488 bus. Uniline messages are sent over one of the individual interface management lines in the IEEE-488 bus. All universal commands except DCL are processed immediately by the 8840A, ahead of any device-dependent commands. Only DCL enters the 8840A input buffer.

The 8840A responds to the following universal messages:

ATN	Attention -- A uniline message which causes the 8840A to interpret multiline messages as interface messages (AD, AC, or UC). When false, multiline messages are interpreted as device-dependent messages.
-----	---

IFC	Interface Clear -- A uniline message which clears only the interface (not the 8840A) by placing it in a known quiescent state.
REN	Remote Enable -- A uniline message which, when received with MLA, switches the 8840A to remote. When REN is set false, the 8840A switches to local and removes local lockout.
DCL	Device Clear -- A multiline message which is loaded into the input buffer as a special device-clear command. DCL performs the same operation as the device-dependent command *, except that it is read before any other characters that are already present in the input buffer, and clears the entire input buffer. Processing then continues normally. The action of DCL is not immediate; if the 8840A is performing an A/D conversion when DCL is received, the DCL command is executed after the measurement is finished.
LLO	Local Lockout -- A multiline message which disables the front panel LOCAL button. The result is that the local mode is not accessible by front panel control.
SPD	Serial Poll Disable -- A multiline message which removes the serial poll enable state.
SPE	Serial Poll Enable -- A multiline message which causes the serial poll data (rather than output buffer data) to be transferred on the bus once ATN becomes false.

3-53. Addressed Commands

Addressed commands are multiline messages which are accepted and interpreted by only those devices currently addressed to listen. The 8840A responds to the following addressed commands:

GET	Group Execute Trigger -- (Not to be confused with the device-dependent Get commands.) GET loads a trigger command into the input buffer and also terminates the string at that point. Only a single character is loaded into the input buffer. The trigger command is executed in its proper turn in the input string, rather than immediately. When executed, GET initiates a measurement.
GTL	Go To Local -- Causes the 8840A to immediately switch to local. This command does not enter the input buffer.

SDC	Selected Device Clear -- Identical to the universal command DCL, but is accepted and interpreted by current listeners only. Therefore, it clears the 8840A only if it is addressed to listen.
-----	---

3-54. TALK-ONLY MODE

The talk-only mode lets you take advantage of the remote capability of the 8840A without having to use an instrument controller. To put the 8840A in the talk-only mode:

1. Turn the 8840A POWER switch OFF.
2. Set the rear panel TALK ONLY bit switch to 1 (the up position).
3. Connect the 8840A via the IEEE-488 bus to your printer, data logger, or other device.
4. Configure the other device as a listener only.
5. Turn the 8840A POWER switch ON.
6. Configure the 8840A with the front panel controls.

The 8840A reads the TALK ONLY bit switch on power-up and when it receives the interface command IFC. You can therefore set the TALK ONLY switch to 1 after power-up as long as you then send the 8840A the IFC command.

3-55. REMOTE CALIBRATION

The 8840A can be calibrated over the 8840A bus using remote commands. Refer to the Maintenance section for details.

3-56. TIMING CONSIDERATIONS

To help you take the best advantage of the speed of the 8840A, external trigger timing for the IEEE-488 Interface is described in the specifications in Section 1.

3-57. IMMEDIATE MODE COMMANDS

Many controllers have some amount of "immediate mode" capability. That is, commands may be given interactively to the 8840A via the run-time-system without the need for actually running a program. The controller accepts and executes these commands one at a time. Some commonly used commands are listed in Table 3-3 for several controllers. These are provided for the convenience of instrument demonstrations, set-up and check-out, and for those with limited experience with IEEE-488 bus operations.

As a general note: The entire 8840A command set should work well provided the "port clear" and "device clear" commands are given first. You should then be able to send any other commands in the 8840A command set without repeating the clearing commands.

In each of these examples, the instrument is cleared prior to configuration set-ups. This ensures that the 8840A configuration has been completely defined.

3-58. EXAMPLE PROGRAMS

Several example programs for the 8840A using various controllers are presented in the remaining figures in this section. In all of these examples, the 8840A is set to IEEE-488 address 4 (rear panel switch setting 000100). Of course, any other address (00 to 30) could be substituted.

To run these programs, it is not necessary to type in all the comments (which appear to the right of the exclamation marks). Also, spaces are placed between commands for ease of reading; they are not required.

NOTE

For the examples using the Fluke 1720A or 1722A, the 8840A is plugged into port 0. The port is initialized by the INIT statement, which sends IFC (interface clear).

Table 3-3. Immediate-Mode Commands for Various Controllers

FUNCTION PERFORMED	FLUKE-BASIC on 1720A or 1722A	HP-HPL on HP9825 Calculator	HP-BASIC on HP9816-PC and HP-85 Calculator	TEK-BASIC on 4051 Graphics System
INITIALIZE Port	INIT PORT 0	cli 7	CLEAR 7	INIT
CLEAR Instrument	CLEAR @4	clr 704	CLEAR 704	PRINT @4:"*"
REMOTE Commands	REMOTE @4	rem 704	REMOTE 704	WBYTE @36,17:
LOCAL Control	LOCAL @4	lcl 704	LOCAL 704	WBYTE @36,1:
EXTERNAL TRIGGER	PRINT @4,"T1"	wrt 704,"T1"	OUTPUT 704;"T1"	PRINT @4:"T1"
TRIGGER Instrument	TRIG @4	trg 704	TRIGGER 704	PRINT @4:"?"
GET Output Data	INPUT @4,A	red 704, A	ENTER 704;A (Note 2)	INPUT @4:A
PRINT Data to Screen	PRINT A	prt A	PRINT A (Note 2)	PRINT A
CONFIGURE for VAC	PRINT @4,"F2"	wrt 704,"F2"	OUTPUT 704;"F2"	PRINT @4:"F2"
CONFIGURE for 200Vac	PRINT @4,"R4"	wrt 704,"R4"	OUTPUT 704;"R4"	PRINT @4:"R4"
TRIGGER Continuously	PRINT @4,"T0"	wrt 704,"T0"	OUTPUT 704;"T0"	PRINT @4:"T0"
SUFFIXES Enable	PRINT @4,"Y1"	wrt 704,"Y1"	OUTPUT 704;"Y1"	PRINT @4:"Y1"
GET Data & Suffix	INPUT @4, A,A\$	red 704,A,A\$ (Note 1)	ENTER 704;A,A\$ (Note 2)	INPUT %4:A,A\$
PRINT Data & Suffix	PRINT A,A\$	prt A\$,A	PRINT A,A\$ (Note 2)	PRINT A,A\$

Notes:

1. Before using A\$ on the 9825 is necessary to enter "dim A\$[6]" to allocate a string variable. This statement allows six characters.
2. In the HP9816 system, variables cannot be created from the keyboard; they must be created by running a program. (See error 910 for that system.) To get around this, type in a very short program as follows:

```

SCRATCH      (Hit "EXEC" key)
10 A = 0     (Hit "ENTER" key)
20 A$ = ""   (Hit "ENTER" key)
30 END      (Hit "ENTER" key)
(Hit "RUN" key)
    
```

This program creates the variables 'A' and 'A\$' so that they may be accessed in immediate mode and changed at will. This program is not necessary for the HP-85 Calculator.


```

1! This program selects VDC (F1), Autorange(RO), Slow rate(SO), continuous
2! trigger(TO), Suffixes enabled (Y1). The program takes 10 readings and
3! stops. The BB40A is addressed to port 0 device #4 under control of a
4! Fluke 1720A or 1722A Instrument Controller. In the INPUT statement, the
5! controller assigns the first part of the BB40A output response (the
6! measurement value) to R, and assigns the second part (the suffix) to R$.
7!
18! =====FLUKE-BASIC on 1720A, 1722A=====
19!
20 INIT PORT 0 !Clear port
25 CLEAR PORT 0 !Clear instr to default functions
35 PRINT @4, "F1 RO SO TO Y1" !Write functions to instrument
40 FOR I = 1 TO 10
45 INPUT @4, R, R$ !Get data from BB40A
50 PRINT " ", I, R, R$ !Print to 1722 display
55 NEXT I
60 END

17! EQUIVALENT PROGRAM FOR HP9816 PC AND HP-85 CALCULATOR IN HP-BASIC
18! =====
19!
20 CLEAR 7 !Clear port
25 CLEAR 704 !Clear instr to default functions
35 OUTPUT 704; "F1 RO SO TO Y1" !Write functions to instrument
40 FOR I = 1 TO 10
45 ENTER 704; R, R$ !Get data from BB40A
50 PRINT " ", I, R, R$ !Print to HP9816 display
55 PRINT I; R; R$ !Substitute this PRINT statement for HP-85
60 END

EQUIVALENT PROGRAM FOR HP9825 CALCULATOR
=====
0: dim R$(6) !Allocate string variable up to 6 characters
1: fxd 5 !Set display to 5 decimal places
2: cli 7 !Clear port
3: clr 704 !Clear instr to default functions
4: 10 -> I !Initialize reading counter
5: wrt 704, "F1 RO SO TO Y1" !Write functions to instrument
6: "IN": I-1 -> I !Decrement reading counter
7: red 704, R, R$ !Get data from BB40A
8: prt R$, R !Print to HP9825 printer
9: if I < 0; goto "IN"
10: end

17REM EQUIVALENT PROGRAM FOR TEKTRONIX 4051 SERIES GRAPHICS SYSTEM IN TEK-BASIC
18REM =====
19REM
20 INIT REM Clear port
35 PRINT @4: "F1 RO SO TO Y1" REM Write functions to instrument
40 FOR I = 1 TO 10
45 INPUT %4: R, R$ REM Get data from BB40A
50 PRINT " ", I, R, R$ REM Print to 1722 display
55 NEXT I
60 END

```

Figure 3-10. Example Program: Taking 10 Readings

```

1! This is a sample program which commands the BB40A to the default state of
2! VDC, autorange, slow rate, continuous trigger. All readings appear simul-
3! taneously on the instrument display while being logged on the controller
4! display with suffixes enabled for function readout. Full local control is
5! given to the BB40A so that any range or function may be invoked easily. The
6! controller always echos the BB40A display while this program is running.
7! The first copy of this program runs on Fluke 1720A and 1722A Controllers.
8! The second runs on the HP9816 personal computer running HP-BASIC. The third
9! runs on the HP9825 (HPL) calculator.
10
11 =====FLUKE BASIC on 1720A,1722A=====
12
20 =====INITIALIZATION
30 INIT PORT 0 !Clear port
40 CLEAR PORT 0 !Clear Instrument
50 WAIT 1000 !Wait 1 second before sending command
60 PRINT @4,"F1 RO SO TO Y1" !F1=VAC, RO=autorange, SO=slow rate
70 !TO=continuous trigger, Y1=enable suffix
80 X=0
90 LOCAL @4 !Give local control to instrument
95
100 =====MAIN
110 INPUT @4,A,A$ !Get reading and suffix
120 X=X+1 !Increment reading count
130 PRINT " ",X,A,A$ !Display readings incl suffix
140 GOTO 110
145
200 END

11! EQUIVALENT PROGRAM FOR HP9816 PC AND HP-85 CALCULATOR IN HP-BASIC
12! =====
20! =====INITIALIZATION
30 CLEAR 7 !Clear HP1B port
40 CLEAR 704 !Clear instrument
60 OUTPUT 704;"F1 RO SO TO Y1" !F1=VAC, RO=autorange, SO=slow rate
70 !TO=continuous trigger, Y1=enable suffix
80 X=0
90 LOCAL 704 !Give local control to instrument
95
100! =====MAIN
110 ENTER 704;A,A$ !Get reading and suffix
120 X=X+1 !Increment reading count
130 PRINT " ",X,A,A$ !Display readings incl suffix (Use for HP9816
130 DISP X;A,A$ !For HP-85, substitute this line for PRINT statement above
140 GOTO 110
145
200 END

! =====EQUIVALENT PROGRAM FOR HP9825 CALCULATOR
! =====
! =====INITIALIZATION
0: dim A$[6] !Allocate string variable up to 6 characters
1: fxd 5 !Set display to 5 decimal places
2: cli 7 !Clear HP1B port
3: clr 704 !Clear instrument
4: wait 1000
5: wrt 704,"F1 RO SO TO Y1" !F1=VAC, RO=autorange, SO=slow rate
!TO=continuous trigger, Y1=enable suffix
6: 0 -> X
7: lcl 704 !Give local control to instrument

! =====MAIN
8: "IN": red 704,A,A$ !Get reading and suffix
9: X+1 -> X !Increment reading count
10: dsp X,A,A$ !Display readings incl suffix
11: gto "IN"
12: end

10REM EQUIVALENT PROGRAM FOR TEKTRONIX 4051 SERIES GRAPHICS SYSTEM IN TEK-BASIC
11REM =====
12REM
20REM =====INITIALIZATION
30 INIT REM Clear port
60 PRINT @4: "F1 RO SO TO Y1" REM F1=VAC, RO=autorange, SO=slow rate
70REM REM TO=continuous trigger, Y1=enable suffix
80 X=0
90 WBYTE @36,1: REM Give local control to instrument
95REM
100REM =====MAIN
110 INPUT @4:A,A$ REM Get reading and suffix
120 X=X+1 REM Increment reading count
130 PRINT " ",X,A,A$ REM Display readings incl suffix
140 GOTO 110
145REM
200 END

```

Figure 3-11. Example Program: Taking Readings with Local Control

```

1! The following program illustrates one possible use of the serial poll
2! register. In this case it is merely looking for data available. The in-
3! strument is addressed to port 0 device #4 under control of a FLUKE 1720A
4! 1720A or 1722A controller. The function of the program is to display on the
5! 1720A screen the lowest resistance seen across the input terminals of the
6! 8840A using the 2-wire ohms function in autorange. See function list for
7! interpretation of line 110.
8!
98! =====FLUKE BASIC on 1720A or 1722A=====
99!
100 INIT PORT 0 \ CLEAR PORT 0 \ WAIT 500 !Clear port,clear inst, delay
110 PRINT @4, "N3001PO Y1 ?" !Instr functions + trigger
120 INPUT @4, A, A$ !Get first reading
130 PRINT " ", A, A$, "S (2-wire) LOWEST READING"
140 TRIG @4
160 B%=SPL(4) !get Serial Poll Reg @ addr #1
170 IF (B%=0%) THEN 160 !Looking for data available
175 INPUT @4, R, A$ !Get next data
180 IF R)=A THEN 140 !Throw away data if not lowest
185 A=R !Update lowest reading
190 GOTO 130 !Print new low
900 END

97! EQUIVALENT PROGRAM FOR HP9816 PC AND HP-85 CALCULATOR IN HP-BASIC
98! =====
99!
100 CLEAR 7 !Clear HPIB port
101 CLEAR 704 !Clear 8840A
110 OUTPUT 704; "N3001PO Y1 ?" !Instr functions + trigger
120 ENTER 704; A, A$ !Get first reading
130 PRINT " ", A, A$, "S (2-wire) LOWEST READING" !Use this line for HP9816
130 DISP A, A$, "S LOWEST READ" !For HP-85, substitute this for PRINT statement above
140 TRIGGER 704
160 B=SPOLL(704) !get Serial Poll Reg @ addr #1
170 IF (B=0) THEN 160 !Looking for data available
175 ENTER 704; R, A$ !Get next data
180 IF R)=A THEN 140 !Throw away data if not lowest
185 A=R !Udata lowest reading
190 GOTO 130 !Print new low
900 END

! =====
! EQUIVALENT PROGRAM FOR HP9825 CALCULATOR
! =====
0: dim A$(6) !Allocate string variable up to 6
! characters
1: fxd 3 !Fix 3 decimal places
2: clr 7 !Clear HPIB port
3: clr 704 !clear inst
4: wrt 704, "N3001PO Y1 ?" !Instr functions + trigger
5: red 704, A, A$ !Get first reading
6: "DISP": dsp A, A$, "-2w LOWEST READ"
7: "TRIG": trg 704
8: "POLL": rds (704) -) X !get Serial Poll Reg @ addr #1
9: if (B=0); gto "POLL" !Looking for data available
10: red 704, R, A$ !Get next data
11: if R)=A; gto "TRIG" !Throw away data if not lowest
12: R -) A; gto "DISP" !Udata lowest reading
13: END

97REM EQUIVALENT PROGRAM FOR TEKTRONIX 4051 SERIES GRAPHICS SYSTEM IN TEK-BASIC
98REM =====
99REM
100 INIT REM Clear port
110 PRINT @4: "N3001PO Y1 ?" REM Instr functions + trigger
120 INPUT %4: A, A$ REM Get first reading
130 PRINT " ", A, A$, "S (2-wire) LOWEST READING"
140 PRINT @4: "?" REM Trigger reading
160 WBYTE @95, 24: REM Turn on serial-poll-enable
165 WBYTE @68: REM At address #4
167 RBYTE B REM Get serial poll register
168 WBYTE @95, 25: REM Turn off serial-poll-enable
170 IF (B=0) THEN 160 REM Looking for data available
175 INPUT %4: R, A$ REM Get next data
180 IF R)=A THEN 140 REM Throw away data if not lowest
185 A=R REM Update lowest reading
190 GOTO 130 REM Print new low
900 END

```

Figure 3-12. Example Program: Using the Serial Poll Register

```

1! This example illustrates the use of interrupt processing to allow a con-
2! troller to be doing other tasks while waiting for data. The 8840A is dev #4
3! on port 0 and full front panel control is maintained. Push any function or
4! range button and apply any signal to its inputs. For any readings you want
5! to display on the 1722, simply push the SRG button. One reading will be
6! recorded. When the 1720 (or 1722) screen is full, it will scroll upward.
7!
100! =====INITIALIZE=====
110 INIT PORT 0 \ CLEAR PORT 0 \ WAIT 500 !Clear port, clear instr, delay
120 PRINT @4, "N4P1 Y1" !SRG mask (interrupt only on SRG)
130 LOCAL @4 !Prev output to instr set REMOTE
140 ON SRG GOTO 500

400! =====MAIN=====
410 GOTO 410 !This is, of course, a locked loop but it represents
420! !an arbitrary amount of time when the controller
430! !can be doing other things while waiting for readings
440! !from port 0 on an INTERRUPT basis.

500! =====SERIAL POLL=====
510 IF (SPL(4) AND 4%)=4% THEN 600 !These IF statements are not really
520 IF (SPL(5) AND 4%)=4% THEN 700 !necessary since there is only one
530 IF (SPL(6) AND 4%)=4% THEN 800 !instrument on port 0 (i.e., the SRG
540! !could only have come from dev #4).
550! !They are shown for sake of generality.

600! =====INTERRUPT ROUTINE for 8840A=====
610 INPUT @4, A, A$ !Get data
620 PRINT " ", A, A$ !Print to 1722A screen
630 RESUME !Resume previous task. Return
640! !address is memorized automatically
650! !just like the "ON ERROR" mechanism
660! !in BASIC (in this case line 410).

900 END

1! EQUIVALENT PROGRAM FOR HP9816 PC AND HP-85 CALCULATOR USING HP-BASIC
2! =====
100! =====INITIALIZE=====
110 CLEAR 7 !Clear HPIB port
120 CLEAR 704 !Clear instrument
130 OUTPUT 704; "N4P1 Y1"
140 LOCAL 704
150 ON INTR 7 GOSUB 500 !Direct interrupts on channel 7 to instr 500
160 ENABLE INTR 7; 2 !Enable interrupts. Use this for HP9816 only!
160 ENABLE INTR 7; 8 !Enable interrupts. Use this for HP-85 only!

400! =====MAIN=====
410 GOTO 410 !Simulated Controller activity with other matters

500! =====SERIAL POLL=====
505 CONTROL 7, 1; 0 !Disable interrupts. Use this statement for HP-85 only!
510 X=SPOLL(704) !This code is looking for the interrupting device.
520 IF X(0) THEN 600 !Since there is only one device of interest, lines
530 X=SPOLL(705) !530 and 540 are commented out but illustrated one
540! !possible way to implement other devices.

600! =====INTERRUPT ROUTINE FOR 8840A=====
610 ENTER 704; A, A$ !Get data from 8840A
620 PRINT " ", A, A$ !Print data to HP9816 PC
630 PRINT A; A$ !Print data to HP-85 Calculator
640 ENABLE INTR 7 !Re-enable interrupts (Use this for HP9816 only!)
640 ENABLE INTR 7; 8 !Re-enable interrupts (Use this for HP-85 only!)
640 RETURN

900 END

```

Figure 3-13. Example Program: Interrupt Processing

```

=====
EQUIVALENT PROGRAM FOR HP9825 CALCULATOR
=====
=====INITIALIZE=====
0: dim A$[6]           !Allocate string variable up to 6 characters
1: flt 5              !Set display to 5 places
2: cli 7              !Clear HPIB port
3: clr 704            !Clear instrument
4: wrt 704, "N4P1 Y1"
5: lcl 704
6: oni 7, "SRQ"       !Direct interrupts on chan 7 to instr 500
7: eir 7              !Enable interrupts on HPIB (SRQ)
=====MAIN=====
8: "HERE": gto "HERE" !Simulated Controller activity with other matters
=====SERIAL POLL=====
9: "SRQ": rds (704) -> X !This code is looking for the interrupting device.
10: if X()0; gto "DVM" !Since there is only one device of interest, lines
    rds (705) -> X !530 and 540 are commented out but illustrated one
    if X()0; gto "CAL" !possible way to implement
=====INTERRUPT ROUTINE FOR 8840A=====
11: "DVM": red 704, A, A$ !Get data from 8840A
12: prt A$,A           !Print data to HP9825
13: eir 7              !Re-enable interrupts on HPIB
14: iret
15: end

```

```

98REM EQUIVALENT PROGRAM FOR TEKTRONIX 4051 SERIES GRAPHICS SYSTEM IN TEK-BASIC
99REM=====
100REM=====INITIALIZE=====
110 INIT              REM Clear port
120 PRINT @4: "N4P1 Y1" REM SRQ mask (interrupt only on SRQ)
130 WBYTE @36,1:     REM Set instrument to LOCAL control
140 ON SRQ THEN 500

400REM=====MAIN=====
410 GOTO 410          REM This is, of course, a locked loop but it represents
420REM              REM an arbitrary amount of time when the controller
430REM              REM can be doing other things while waiting for readings
440REM              REM from port 0 on an INTERRUPT basis.

500REM=====SERIAL POLL=====
510 POLL P1,P2:4;5;6 REM This statement is generalized to
520 GOTO P1 OF 600,700,800 REM include devices 4, 5, 6 but of course
530REM              REM 5 and 6 do not exist in this example.
540REM              REM Parallel poll is particularly
550REM              REM convenient in this controller.

600REM=====INTERRUPT ROUTINE for 8840A=====
610 INPUT %4: A, A$  REM Get data.
620 PRINT "      ", A, A$ REM Print to 4051 screen.
630 RETURN          REM Resume previous task. Return
640REM              REM address is memorized automatically
650REM              REM just like the "ON ERROR" mechanism
660REM              REM in BASIC (in this case line 410).

900 END

```

Figure 3-13. Example Program: Interrupt Processing (cont)

Table 3-4. ASCII/IEEE Std 488-1978 Bus Codes

ASCII CHAR.	DECIMAL	OCTAL	HEX	BINARY 7854 3210	DEV. NO.	MESSAGE ATN=TRUE	
NUL	0	000	00	0000 0000			ADDRESSED COMMANDS
SQH	1	001	01	0000 0001		GTL	
STX	2	002	02	0000 0010			
ETX	3	003	03	0000 0011			
EOT	4	004	04	0000 0100		SDC	
ENQ	5	005	05	0000 0101		PPC	
ACK	6	006	06	0000 0110			
BELL	7	007	07	0000 0111			
BS	8	010	08	0000 1000		GET	
HT	9	011	09	0000 1001		TCT	
LF	10	012	0A	0000 1010			
VT	11	013	0B	0000 1011			
FF	12	014	0C	0000 1100			
CR	13	015	0D	0000 1101			
SO	14	016	0E	0000 1110			
SI	15	017	0F	0000 1111			
DLE	16	020	10	0001 0000			UNIVERSAL COMMANDS
DC1	17	021	11	0001 0001		LLO	
DC2	18	022	12	0001 0010			
DC3	19	023	13	0001 0011			
DC4	20	024	14	0001 0100		DCL	
NAK	21	025	15	0001 0101		PPU	
SYN	22	026	16	0001 0110			
ETB	23	027	17	0001 0111			
CAN	24	030	18	0001 1000		SPE	
EM	25	031	19	0001 1001		SPD	
SUB	26	032	1A	0001 1010			
ESC	27	033	1B	0001 1011			
FS	28	034	1C	0001 1100			
GS	29	035	1D	0001 1101			
RS	30	036	1E	0001 1110			
US	31	037	1F	0001 1111			
SPACE	32	040	20	0010 0000	0	MLA	LISTEN ADDRESSES
!	33	041	21	0010 0001	1	MLA	
"	34	042	22	0010 0010	2	MLA	
#	35	043	23	0010 0011	3	MLA	
\$	36	044	24	0010 0100	4	MLA	
%	37	045	25	0010 0101	5	MLA	
&	38	046	26	0010 0110	6	MLA	
'	39	047	27	0010 0111	7	MLA	
(	40	050	28	0010 1000	8	MLA
)	41	051	29	0010 1001	9	MLA	
*	42	052	2A	0010 1010	10	MLA	
+	43	053	2B	0010 1011	11	MLA	
,	44	054	2C	0010 1100	12	MLA	
-	45	055	2D	0010 1101	13	MLA	
.	46	056	2E	0010 1110	14	MLA	
/	47	057	2F	0010 1111	15	MLA	
0	48	060	30	0011 0000	16	MLA	
1	49	061	31	0011 0001	17	MLA	
2	50	062	32	0011 0010	18	MLA	
3	51	063	33	0011 0011	19	MLA	
4	52	064	34	0011 0100	20	MLA	
5	53	065	35	0011 0101	21	MLA	
6	54	066	36	0011 0110	22	MLA	
7	55	067	37	0011 0111	23	MLA	
8	56	070	38	0011 1000	24	MLA	
9	57	071	39	0011 1001	25	MLA	
:	58	072	3A	0011 1010	26	MLA	
;	59	073	3B	0011 1011	27	MLA	
<	60	074	3C	0011 1100	28	MLA	
=	61	075	3D	0011 1101	29	MLA	
>	62	076	3E	0011 1110	30	MLA	
?	63	077	3F	0011 1111		UNL	

ASCII CHAR.	DECIMAL	OCTAL	HEX	BINARY 7654 3210	DEV. NO.	MESSAGE ATN=TRUE		
@	64	100	40	0100 0000	0	MTA	TALK ADDRESSES	
A	65	101	41	0100 0001	1	MTA		
B	66	102	42	0100 0010	2	MTA		
C	67	103	43	0100 0011	3	MTA		
D	68	104	44	0100 0100	4	MTA		
E	69	105	45	0100 0101	5	MTA		
F	70	106	46	0100 0110	6	MTA		
G	71	107	47	0100 0111	7	MTA		
H	72	110	48	0100 1000	8	MTA		
I	73	111	49	0100 1001	9	MTA		
J	74	112	4A	0100 1010	10	MTA		
K	75	113	4B	0100 1011	11	MTA		
L	76	114	4C	0100 1100	12	MTA		
M	77	115	4D	0100 1101	13	MTA		
N	78	116	4E	0100 1110	14	MTA		
O	79	117	4F	0100 1111	15	MTA		
P	80	120	50	0101 0000	16	MTA		
Q	81	121	51	0101 0001	17	MTA		
R	82	122	52	0101 0010	18	MTA		
S	83	123	53	0101 0011	19	MTA		
T	84	124	54	0101 0100	20	MTA		
U	85	125	55	0101 0101	21	MTA		
V	86	126	56	0101 0110	22	MTA		
W	87	127	57	0101 0111	23	MTA		
X	88	130	58	0101 1000	24	MTA		
Y	89	131	59	0101 1001	25	MTA		
Z	90	132	5A	0101 1010	26	MTA		
[	91	133	5B	0101 1011	27	MTA	
\	92	134	5C	0101 1100	28	MTA		
]	93	135	5D	0101 1101	29	MTA		
^	94	136	5E	0101 1110	30	MTA		
_	95	137	5F	0101 1111		UNT		
a	96	140	60	0110 0000	0	MSA		SECONDARY ADDRESSES
b	97	141	61	0110 0001	1	MSA		
c	98	142	62	0110 0010	2	MSA		
d	99	143	63	0110 0011	3	MSA		
e	100	144	64	0110 0100	4	MSA		
f	101	145	65	0110 0101	5	MSA		
g	102	146	66	0110 0110	6	MSA		
h	103	147	67	0110 0111	7	MSA		
i	104	150	68	0110 1000	8	MSA		
j	105	151	69	0110 1001	9	MSA		
k	106	152	6A	0110 1010	10	MSA		
l	107	153	6B	0110 1011	11	MSA		
m	108	154	6C	0110 1100	12	MSA		
n	109	155	6D	0110 1101	13	MSA		
o	110	156	6E	0110 1110	14	MSA		
p	111	157	6F	0110 1111	15	MSA		
q	112	160	70	0111 0000	16	MSA		
r	113	161	71	0111 0001	17	MSA		
s	114	162	72	0111 0010	18	MSA		
t	115	163	73	0111 0011	19	MSA		
u	116	164	74	0111 0100	20	MSA		
v	117	165	75	0111 0101	21	MSA		
w	118	166	76	0111 0110	22	MSA		
x	119	167	77	0111 0111	23	MSA		
y	120	170	78	0111 1000	24	MSA		
z	121	171	79	0111 1001	25	MSA		
{	122	172	7A	0111 1010	26	MSA		
}	123	173	7B	0111 1011	27	MSA		
|	124	174	7C	0111 1100	28	MSA		
~	125	175	7D	0111 1101	29	MSA		
?	126	176	7E	0111 1110	30	MSA		
?	127	177	7F	0111 1111		MSA		

Section 4

Measurement Tutorial

4-1. INTRODUCTION

This section discusses considerations and techniques to help you use the 8840A effectively. Among other things, this section discusses sources of error which are an inherent part of the measurement process and which occur for all multimeters. By understanding why and when these errors occur, and by knowing how and when to correct for them, you can make accurate measurements with confidence.

This section also discusses the relative benefits of 2-wire and 4-wire ohms, describes special considerations for making ac measurements, and presents some unusual applications—for example, using the test current in the 2-wire ohms function as a troubleshooting tool in itself.

4-2. DC VOLTAGE MEASUREMENT

When measuring dc voltages in high-impedance circuits, there are two possible sources of error to consider: circuit loading and input bias current.

4-3. Circuit Loading Error

Whenever a voltmeter is connected to a circuit, the voltmeter's internal resistance changes the voltage of the circuit under test. The resulting error is called circuit loading error. The error is negligible as long as the resistance of the circuit under test (the source impedance) is small compared to the input impedance of the meter. As the source impedance approaches the input impedance of the voltmeter, the error can be considerable. The percentage of error can be calculated using the formula in Figure 4-1.

The input impedance of the 8840A is 10 M Ω in the 200V and 1000V ranges, and is greater than 10,000 M Ω in the 200 mV, 2V, and 20V ranges. Therefore, for the 8840A, circuit loading error is less than 0.01% as long as the source impedance is less than 1 M Ω in the 200 mV, 2V, and 20V ranges, and less than 1 k Ω in the 200V and 1000V

ranges. The exceptionally high input impedance on the 20V dc range allows high-accuracy readings in CMOS and high-impedance analog circuitry.

NOTE

Input protection circuitry can reduce the input impedance to as low as 100 k Ω when the input is overrange. This may also occur momentarily when the instrument autoranges to a higher range.

4-4. Input Bias Current Error

Input bias current error occurs because a voltmeter's input bias current always changes the voltage of the circuit under test. However, the error is significant only when measuring voltages in circuits with very high source impedance. The error can be measured as shown in Figure 4-2.

With the 8840A, it is easy to correct for this error using the OFFSET button:

1. Select the VDC function and the desired range.
2. Connect the 8840A INPUT terminals to a resistor which matches the source impedance of the circuit to be tested.
3. Allow the displayed reading to settle.
4. Press the OFFSET button.
5. Remove the resistor.
6. Proceed with the desired measurement.

Example:

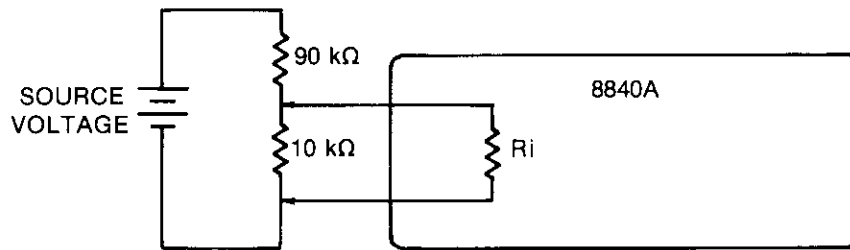
Measure a 1.5V source with 1 M Ω source impedance, correcting for input bias current.

$$\text{CIRCUIT LOADING ERROR IN \%} = \frac{100 \times R_s}{R_s + R_i}$$

where R_s = Source impedance
 R_i = 8840A input impedance
 ($R_i \geq 10,000 \text{ M}\Omega$ in 200 mV, 2V, and 20V ranges)
 ($R_i = 10 \text{ M}\Omega$ in 200V and 1000V ranges)

EXAMPLE

When measuring the voltage across the 10 k Ω leg of a 90 k Ω over 10 k Ω voltage divider, the circuit loading error is less than 0.1% in the upper ranges, and less than 0.0001% in the lower ranges:



$$R_s = \frac{(90 \text{ k}\Omega) \times (10 \text{ k}\Omega)}{90 \text{ k}\Omega + 10 \text{ k}\Omega} = 9 \text{ k}\Omega$$

$$\text{Error in the 200V and 1000V ranges} = 100 \times \frac{9 \text{ k}\Omega}{9 \text{ k}\Omega + 10 \text{ M}\Omega} = 0.09\%$$

$$\text{Error in the 200 mV, 2V and 20V ranges} = 100 \times \frac{9 \text{ k}\Omega}{9 \text{ k}\Omega + 10,000 \text{ M}\Omega} = 0.00009\%$$

Figure 4-1. Circuit Loading Error Calculation

1. Connect a 1 M Ω resistor between the INPUT HI and INPUT LO terminals.
2. Select the VDC function and the 2V range.
3. Allow the display to settle.
4. Press OFFSET. (This zeroes the input bias current error.)
5. Remove the 1 M Ω resistor.
6. Measure the voltage of the circuit under test.

Note that this procedure does not correct for circuit loading error. Also note that if input bias current error is not corrected for, it may be added to the circuit loading error.

4-5. RESISTANCE MEASUREMENT

The 8840A allows you to measure resistance in both 2-wire and 4-wire configurations. Each has its benefits.

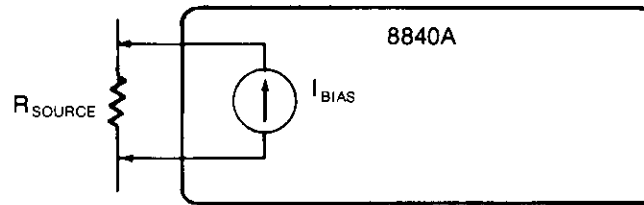
4-6. 2-Wire Ohms

Two-Wire ohms measurements are simple to set up and yield good results for most measurement conditions. Measurements are made as shown in Figure 4-3. An internal current source (the “ohms current source”) passes a known test current (I_{TEST}) through the resistance being tested ($R_{UNKNOWN}$). The 8840A measures the voltage drop across $R_{UNKNOWN}$, calculates $R_{UNKNOWN}$ using Ohm’s law ($R_{UNKNOWN} = V_{TEST}/I_{TEST}$), and displays the result.

The test current and full-scale voltage for each resistance range are shown in Table 4-1. Since the HI INPUT test lead is positive with respect to the LO INPUT lead, these test leads are not interchangeable when a semiconductor device is being measured.

4-7. Correcting for Test Lead Resistance in 2-Wire Ohms

In 2-wire ohms, the resistance of the test leads can introduce error when measuring low resistances. Typical test leads may add as much as 0.5 Ω to 2-wire ohms readings.



TO MEASURE INPUT BIAS CURRENT ERROR:

1. Select the VDC function and the desired range.
2. Eliminate any offset voltages by shorting the HI INPUT and LO INPUT terminals and then pressing OFFSET.
3. Select a resistor which matches the source impedance (R_{SOURCE}) of the circuit to be tested, and connect it to the HI INPUT and LO INPUT terminals.
4. Allow the circuit to settle.
5. Record the displayed voltage. This is the input bias current error (V_{ERROR}).

The input bias current error may be calculated as a percentage as follows:

$$\text{ERROR (IN \%)} = \frac{V_{ERROR}}{\text{VOLTAGE MEASUREMENT}} \times 100\%$$

The input bias current itself (I_{BIAS}) may be calculated as follows:

$$I_{BIAS} = \frac{V_{ERROR}}{R_{SOURCE}}$$

Figure 4-2. Measuring Input Bias Current Error

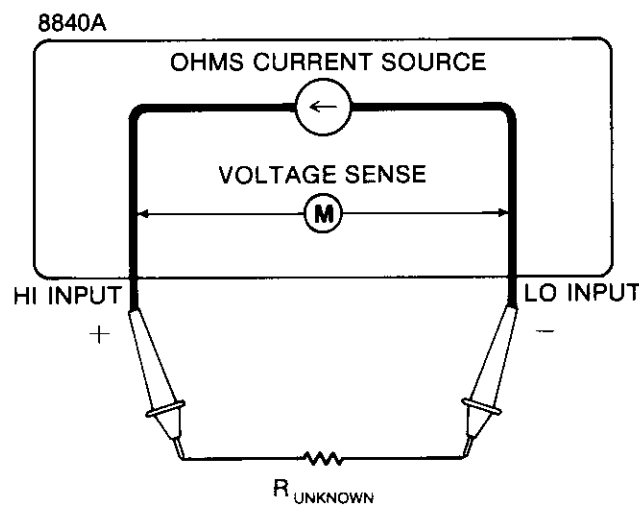


Figure 4-3. 2-Wire Ohms Measurement

With the 8840A, it is easy to correct for this error using the OFFSET button:

1. Select the 2-wire ohms function.
2. Touch the test leads together. The 8840A should indicate the resistance of the test leads.
3. With the test leads still touching, press the OFFSET button. The 8840A should read 0Ω.

4-8. 4-Wire Ohms

Four-Wire ohms measurements provide the highest accuracy for low resistance measurements. The 4-wire configuration automatically corrects for both test lead resistance and contact resistance. Contact resistance (the resistance between the test probe tips and the circuit being tested) is unpredictable, and therefore cannot be reliably corrected with a fixed offset.

Four-Wire ohms measurements are especially important when using long test leads. In a typical automated test system, for example, the test leads could be connected through four or five switching relays, each with 2Ω of resistance!

The 8840A makes 4-wire ohms measurements as shown in Figure 4-4. The HI and LO INPUT leads apply a known, internal current source to the unknown resistance, just as in 2-wire ohms. (See Table 4-1.) However, the voltage drop across the unknown resistance is measured with the SENSE leads rather than the INPUT leads. Since the current flow in the SENSE leads is negligible, the error caused by the voltage drop across the leads is also negligible.

NOTE

In the 2 MΩ and 20 MΩ ranges of the 4-wire ohms function, the voltage across the unknown resistance is sensed between the HI SENSE and LO INPUT terminals. Accuracy is not affected as long as the resistance of the LO INPUT lead is less than 10Ω in the 2 MΩ range, and less than 100Ω in the 20 MΩ range.

Table 4-1. Ohms Test Current

RANGE	TEST CURRENT	FULL SCALE VOLTAGE
200Ω	1 mA	0.2V
2 kΩ	1 mA	2.0V
20 kΩ	100 μA	2.0V
200 kΩ	10 μA	2.0V
2000 kΩ	5 μA	10.0V
20 MΩ	500 nA	10.0V

4-9. Applications of the Ohms Functions

The 2-wire and 4-wire ohms functions can be used for a variety of purposes in addition to measuring resistance, as the following applications show.

4-10. TESTING DIODES

The 2-wire ohms function can also be used to test diodes.

1. Select the 2-wire ohms function and the 2 kΩ range.
2. Measure the resistance of the diode. If the diode is good, when forward-biased it will measure about 0.6 kΩ to 0.7 kΩ for silicon (0.25 kΩ to 0.3 kΩ for germanium), and when reverse-biased it will cause the 8840A to indicate overrange. (The forward-biased reading depends upon the range used.)

The 2 kΩ range is used because its 1 mA test current provides a typical operating point, and its 2V full-scale voltage is sufficient to turn on most diodes (even two diodes in series).

4-11. TESTING ELECTROLYTIC CAPACITORS

The 2-wire ohms function can also give a rough test of an electrolytic capacitor's leakage and dielectric absorption. This test works well for capacitors 0.5 μF and larger.

1. Select the 2-wire ohms function, the 2 kΩ range, and the medium reading rate.
2. Connect the test leads to the capacitor (with the INPUT HI lead to the + lead and the INPUT LO lead to the - lead). The 8840A will try to charge it to the open-circuit voltage of the 2 kΩ range (about 6V).
3. Disconnect the + test lead.
4. To test for leakage, select the VDC function and the 20V range (leave the 8840A in the medium reading rate), and measure the voltage that was stored on the capacitor during step 2.
 - a. If the capacitor is good, the voltage across the capacitor will be about 6V, and will be relatively stable.
 - b. If the capacitor is leaky, the voltage across the capacitor will be much less than 6V, and the voltage will be decreasing. The rate of change depends on how leaky the capacitor is.
 - c. With some electrolytic capacitors, the reading will increase. This usually indicates the capacitor is defective.

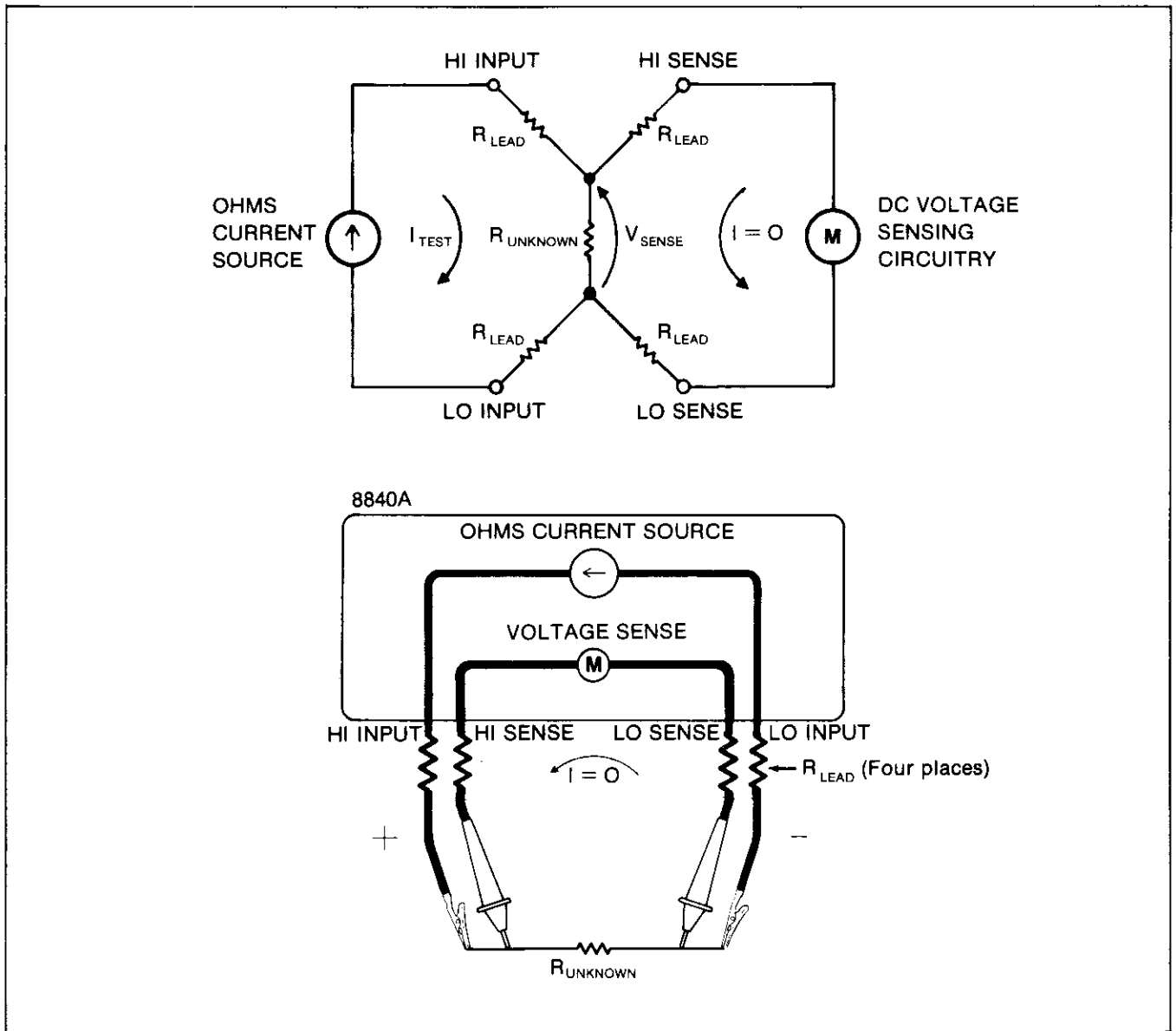


Figure 4-4. 4-Wire Ohms Measurement

5. To test the capacitor's dielectric absorption, briefly short the capacitor's leads together and then measure the voltage across the capacitor.
 - a. If the dielectric is good (i.e., has low dielectric absorption), the voltage across the capacitor will be nearly zero volts.
 - b. If the dielectric is poor (i.e., has high dielectric absorption), the voltage across the capacitor will be significantly above zero.

4-12. A PRECISION CURRENT SOURCE

The ohms current source (the internal current source used in the ohms functions) makes a useful troubleshooting tool in itself. It has excellent linearity and temperature

stability. Its compliance voltage is typically 5V in the lower four ohms ranges, and 12V in the upper two ohms ranges. The inputs are protected against accidental applications of voltage up to 300V rms.

To use the ohms current source, connect the test leads to the HI and LO INPUTS, and select either the 2-wire or 4-wire ohms function. Press the range buttons to select any of the current levels shown in Table 4-1.

The ohms current source can be used to troubleshoot circuits by injecting current into selected nodes, forcing the circuits to be in a specific test state. For example, the ohms current source can be used to set or modify the bias of amplifier circuits. The current level can be changed simply by changing range.

The ohms current source can also be used to test mA or μA panel meters. The accuracy of the current source is more than enough to verify panel meters, whose accuracy is typically 1% to 5%. To test an analog panel meter, simply connect the current source across the meter movement (as though measuring its resistance). A 1 mA meter should show full scale when the ohms function is set on the 2 k Ω range. The same technique also works with digital panel meters.

4-13. DC CURRENT MEASUREMENT

To get the best accuracy using the mA DC function, it is important to understand the concept of burden voltage error.

When a meter is placed in series with a circuit to measure current, error can be caused by the small voltage drop across the meter (in this case, across the protective fuses and current shunt). This voltage drop is called the burden voltage, and it is highest for full-scale measurements. The full-scale burden voltage for the 8840A is typically less than 1V.

The burden voltage can present a significant error if the current source being measured is unregulated (i.e., not a true current source) and if the resistance of the fuse and shunt is a significant part of the source resistance. If burden voltage does present a significant error, the percentage of error can be calculated and corrected for using the formulas in Figure 4-5.

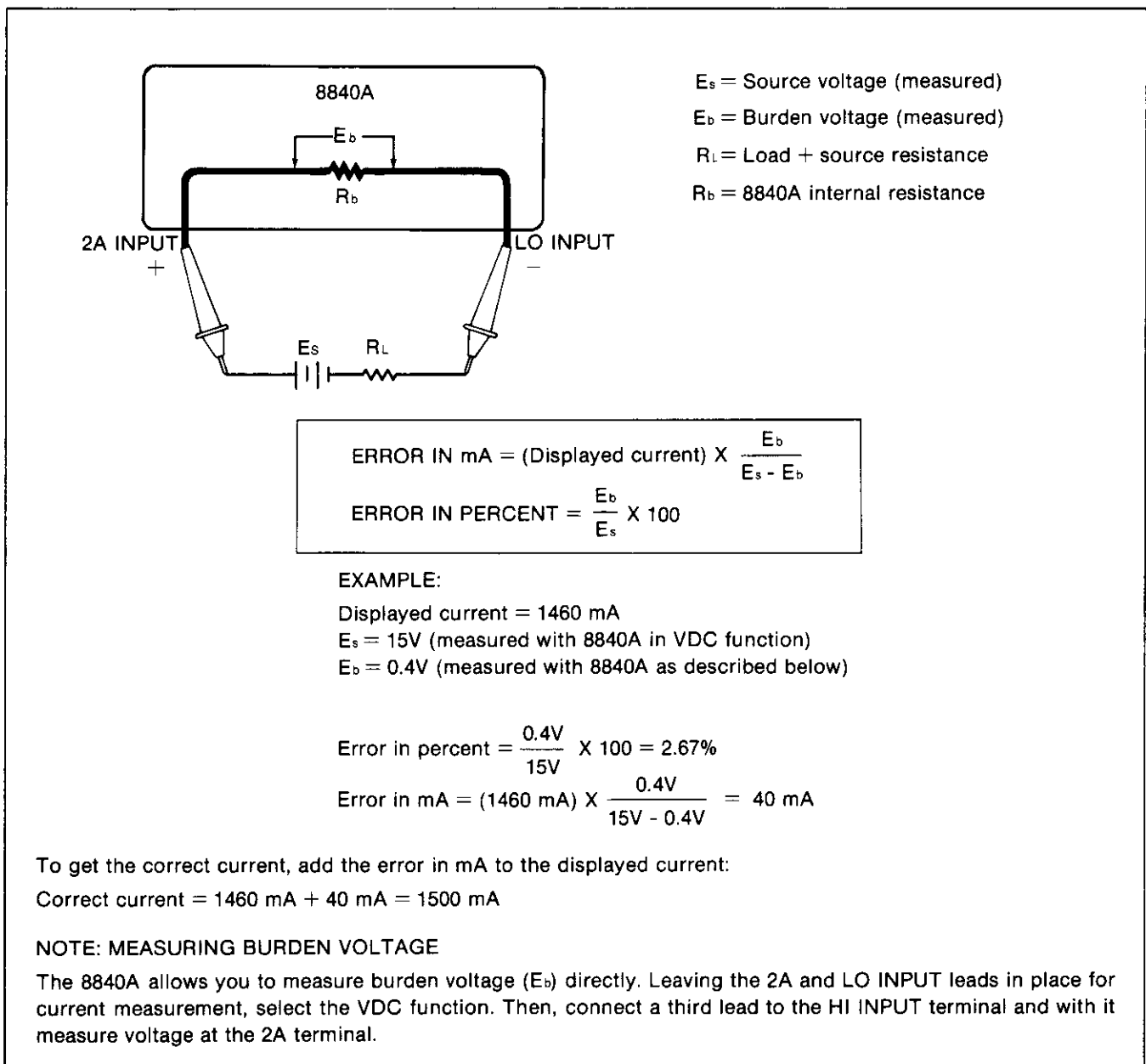


Figure 4-5. Burden Voltage Error Calculation

4-14. REDUCING THERMAL VOLTAGES

When making very low-level dc measurements, thermal voltages can present an additional source of error. Thermal voltages are the thermovoltaic potentials generated at the junction between dissimilar metals. Thermal voltages typically occur at binding posts and can be greater than 10 μV .

Thermal voltages can also cause problems in the low ohms ranges. Some low-value resistors are constructed with dissimilar metals. Just handling such resistors can cause thermal voltages large enough to introduce measurement errors.

The effect of thermal voltages can be reduced by using the following techniques:

1. Use tight connections.
2. Use clean connections (especially free of grease and dirt).
3. Use similar metals for connections wherever possible (e.g., copper-to-copper, gold-to-gold, etc.).
4. Use caution when handling the circuit under test.
5. Wait for the circuit to reach thermal equilibrium. (Thermal voltages are generated only where there is a temperature gradient.)

4-15. AC VOLTAGE AND CURRENT MEASUREMENT

When making precise measurements of ac voltage and current, there are several considerations in addition to those discussed under dc voltage and current measurement. These include the concepts of rms conversion, crest factor, bandwidth, and zero-input error.

4-16. True RMS Measurement

The True RMS AC Option measures the true rms value of ac voltages and currents. In physical terms, the rms (root-mean-square) value of a waveform is the equivalent dc value that causes the same amount of heat to be dissipated in a resistor. True rms measurement greatly simplifies the analysis of complex ac signals. Since the rms value is the dc equivalent of the original waveform, it provides a reliable basis for comparing dissimilar waveforms.

By contrast, many meters in use today use average-responding ac converters rather than true rms converters. The scale factor in these meters is adjusted so that they display the rms value for harmonic-free sinusoids.

However, if a signal is not sinusoidal, average-responding meters do not display correct rms readings.

The 8840A actually derives the rms value using analog computation. This means that the 8840A readings represent true rms values not only for harmonic-free sinusoids, but also for mixed frequencies, modulated signals, square waves, sawtooths, random noise, rectangular pulses with 10% duty cycle, etc.

4-17. Waveform Comparison

Figure 4-6 illustrates the relationship between ac and dc components for common waveforms, and compares readings for true rms meters and average-responding meters. For example, consider the first waveform, a 1.41421V (zero-to-peak) sine wave. Both the 8840A and rms-calibrated average-responding meters display the correct rms reading of 1.00000V (the dc component equals 0). However, consider the 2V (peak-to-peak) square wave. Both types of meter correctly measure the dc component (0V), but only the 8840A correctly measures the ac component (1.00000V). The average-responding meter measures 1.110V, which amounts to an 11% error.

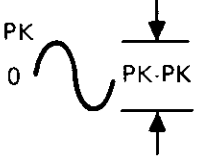
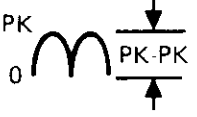
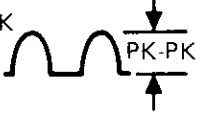
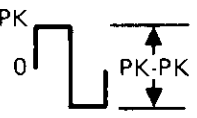
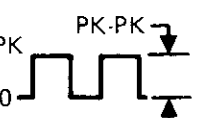
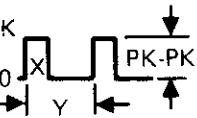
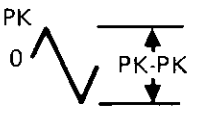
Since average-responding meters have been in use for so long, you may have accumulated test or reference data based on them. The conversion factors in Figure 4-6 should help you convert between the two measurement methods.

4-18. Crest Factor

Crest factors are useful for expressing the ability of an instrument to measure a variety of waveforms accurately. The crest factor of a waveform is the ratio of its peak voltage to its rms voltage. (For waveforms where the positive and negative half-cycles have different peak voltages, the more extreme peak is used in computing the crest factor.) Crest factors start at 1.0 for square waves (for which the peak voltage equals the rms voltage) and increase for more "pointed" waveforms as shown in Figure 4-7.

The 8840A has a full-scale crest factor limit of 3.0 for the 20V and 700V ranges, and 6.0 for the other ranges. For full-scale input signals with a crest factor above these limits, dynamic range limitations can begin to cause large errors. However, as Figure 4-7 shows, signals with a crest factor above 3.0 are unusual.

If you don't know the crest factor of a particular waveform but wish to know if it falls within the crest factor limit of the 8840A, measure the signal with both the 8840A and an ac-coupled oscilloscope. If the rms reading on the 8840A is 1/3 or more of the waveform's zero-to-peak voltage, the crest factor is 3.0 or less.

AC-COUPLED INPUT WAVEFORM	PEAK VOLTAGES		METERED VOLTAGES			DC AND AC TOTAL RMS
	PK-PK	0-PK	AC COMPONENT ONLY		DC COMPONENT ONLY	
			RMS CAL *	8840A		TRUE RMS = $\sqrt{ac^2 + dc^2}$
SINE 	2.828	1.414	1.000	1.000	0.000	1.000
RECTIFIED SINE (FULL WAVE) 	1.414	1.414	0.421	0.435	0.900	1.000
RECTIFIED SINE (HALF WAVE) 	2.000	2.000	0.764	0.771	0.636	1.000
SQUARE 	2.000	1.000	1.110	1.000	0.000	1.000
RECTIFIED SQUARE 	1.414	1.414	0.785	0.707	0.707	1.000
RECTANGULAR PULSE  $D = X/Y$ $K = D - D^2$	2.000	2.000	2.22K	2K	2D	$2\sqrt{D}$
TRIANGLE SAWTOOTH 	3.464	1.732	0.960	1.000	0.000	1.000

* RMS CAL IS THE DISPLAYED VALUE FOR AVERAGE RESPONDING METERS THAT ARE CALIBRATED TO DISPLAY RMS FOR SINE WAVES

Figure 4-6. Waveform Comparison Chart

4-19. AC-Coupled AC Measurements

Input signals are ac-coupled in the ac functions. One of the advantages of ac coupling is that ac measurements can be made on power supply outputs, phone lines, etc. Ripple measurements, for instance, cannot be made with dc coupling. Remember, however, that when the 8840A measures signals with the ac functions, the reading on the display does not include the dc component (if one exists). For example, consider Figure 4-8, which shows a simple ac signal riding on a dc level. The VAC function would measure the ac component-only.

4-20. Combined AC and DC Measurements

The 8840A can be used to evaluate the true rms value of waveforms such as the one shown in Figure 4-8, which includes both ac and dc components. First, measure the rms value of the ac component using the VAC function. Next, measure the dc component using the VDC function. Finally, calculate the total rms value as follows:

$$V_{RMS} = \sqrt{V_{AC}^2 + V_{DC}^2}$$

WAVEFORM	CREST FACTOR
SQUARE WAVE	1.0
SINE WAVE	1.414
TRIANGLE SAWTOOTH	1.732
MIXED FREQUENCIES	1.414 to 2.0
SCR OUTPUT OF 100% - 10%	1.414 to 3.0
WHITE NOISE	3.0 to 4.0
AC COUPLED PULSE TRAIN $t_0 = 1/10 T$	3.0
SPIKE	> 9.0

Figure 4-7. Typical Crest Factors for Various Waveforms

4-21. Bandwidth

Bandwidth defines the range of frequencies to which an instrument can respond accurately. The accuracy of the 8840A is specified for sinusoidal waveforms up to 100 kHz, or for nonsinusoidal waveforms with frequency components up to 100 kHz. The small-signal bandwidth (the frequency at which the response is 3 dB down) is typically around 300 kHz.

For signals with components greater than 100 kHz, the measurement accuracy is reduced because of frequency bandwidth and slew-rate limitations. Because of this, accuracy may be reduced when measuring signals with fast rise times, such as high-frequency square waves or switching supply waveforms. As a rule of thumb, an ac voltage input signal is within the bandwidth limitations if the rise time is longer than 2 μs, and within the slew-rate limitations if the input slew rate is slower than (1/μs)x(full scale of range).

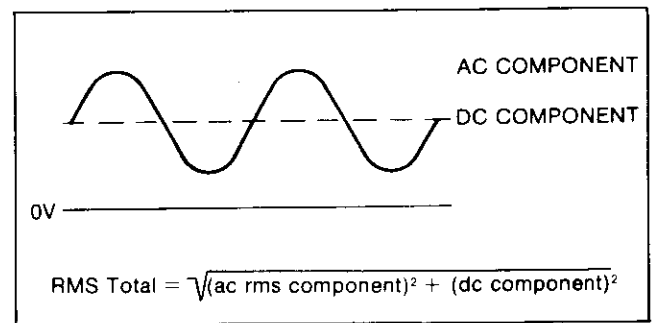


Figure 4-8. Combined AC and DC Measurement

4-22. Zero-Input VAC Error

If the 8840A input terminals are shorted while the VAC function is selected, the 8840A displays a non-zero reading (typically less than 80 digits in the highest four ranges, and less than 300 digits in the 200 mV range). Such readings are due to random noise combined with the inherent nonlinear response of computing-type rms converters to very small input signals.

The zero-input error is quickly reduced when the input is increased. The rms converter error (a dc error) and the internally generated noise (a random ac error) are both uncorrelated with the input signal. Therefore, when a signal is applied, the resulting reading is not the simple addition of the signal and the zero-input error, but the square root of the sum of their squares. This reduces the effect of the error, as shown in the example in Figure 4-9.

As long as the 8840A reading is 1,000 counts or more, readings will still be within specified accuracy.

EXAMPLE

Given a zero-input reading of 300 digits (0.300 mV in the 200 mV range) and an input signal of 10 mV, the 8840A might read:

$$\sqrt{10^2 + 0.300^2} = \sqrt{100 + 0.090} = 10.004 \text{ mV}$$

The effect of the zero-input error is reduced from 0.300 mV to 0.004 mV.

Figure 4-9. Reduction of Zero-Input Error

Section 5

Theory of Operation

5-1. INTRODUCTION

This section presents an overall functional description of the 8840A, followed by a detailed circuit description. The descriptions are supported by simplified schematics in text and by the complete schematics in Section 10.

5-2. OVERALL FUNCTIONAL DESCRIPTION

A functional block diagram of the 8840A is shown in Figure 5-1. The basic signal path flows from left to right across the center of the page. The input is sensed at the input terminals, scaled, directed through the Track/ Hold circuit, converted into digital representation by the Analog-to-Digital (A/D) Converter, processed by the Digital Controller, and sent to the display.

The DC Scaling circuit, which constitutes the "front end" of the instrument, has two major functions. First, it senses the input and produces an equivalent dc voltage for all functions except VAC and mA AC. (AC inputs are converted to a dc voltage by the True RMS AC Option.) Resistances are sensed as a dc voltage using a known test current from the Ohms Current Source. A dc current input is converted to a dc voltage by a precision current shunt.

Second, the DC Scaling circuit scales the equivalent dc voltages (for in-range inputs) to within the input range of the A/D Converter ($\pm 2V$). In addition, the DC Scaling circuit provides input protection and provides analog filtering for certain ranges and reading rates. (AC inputs are scaled by the True RMS AC Option.)

The Track/ Hold (T/H) circuit samples the scaled dc voltage and presents the A/D Converter with a voltage that is constant for the input portion of each A/D conversion cycle. The T/H circuit also provides additional scaling for certain ranges.

The Digital Controller controls the operation of virtually every part of the 8840A. It reads the front panel keyboard, configures the instrument for each function and range, triggers the A/D Converter, calculates the result of each A/D conversion cycle, averages A/D samples, controls the display, and communicates with the IEEE-488 Interface Option via the Guard Crossing circuit. The heart of the Digital Controller is the In-Guard Microcomputer (μC).

The Guard Crossing circuit permits serial asynchronous communication between the Digital Controller and the IEEE-488 Interface Option, while isolating the two circuits electrically. Whereas the in-guard power supply floats with the voltage at the INPUT LO terminal, the IEEE-488 Interface Option operates with reference to earth ground. The "guard" is the isolation between the in-guard and out-guard circuits.

The Power Supply provides supply voltages to all parts of the instrument. The Precision Voltage Reference provides precise reference voltages for the A/D Converter and the Ohms Current Source.

5-3. DETAILED CIRCUIT DESCRIPTION

The following paragraphs give a detailed circuit description of each of the functional blocks in Figure 5-1. For clarity, measurement ranges are referred to as r1, r2, r3, etc., where r1 is the lowest possible range, r2 the next higher range, and so on. Pins are designated by the respective integrated circuit (e.g., U101-7 for U101 pin 7).

5-4. DC SCALING

The DC Scaling circuit scales all in-range dc inputs so that the output of the Track/ Hold (T/H) amplifier (U307) is within $\pm 2V$. In addition, the DC Scaling circuit provides input protection and analog filtering. Additional scaling is provided by the the T/H Amplifier.

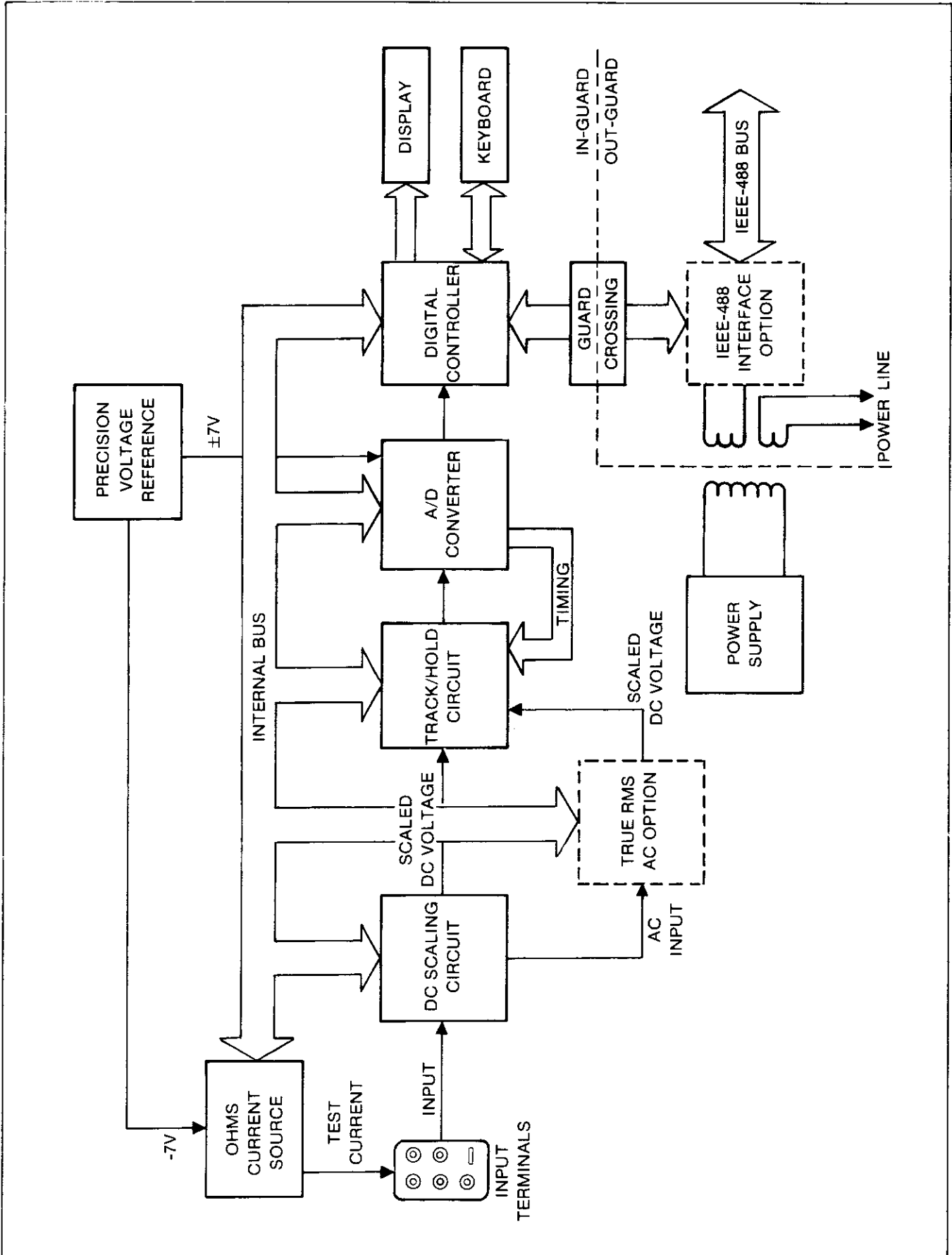


Figure 5-1. Overall Functional Block Diagram

The following paragraphs describe the configuration of the DC Scaling circuit in the DCV and mA DC functions and also describe the analog filter. The ohms functions are described under a later heading because the T/H Amplifier provides additional input switching for these functions.

5-5. VDC Scaling

Scaling is performed in the VDC function by two precision resistors networks (Z301 and Z302). These components are configured by relay K301, switching

transistor Q311, and quad analog switches U302A and U301B to provide the correct scaling for each range. Voltage follower U306 provides high input impedance for the 20V dc range. A simplified schematic and a switch state table for the VDC function are shown in Figure 5-2.

In the 200 mV and 2V ranges, the input voltage is applied directly to the T/H Amplifier via Q310, Q311, and U301B. In the 200 mV range, the T/H Amplifier has a gain of 10; in all other dc voltage ranges, the T/H Amplifier has a gain of 1.

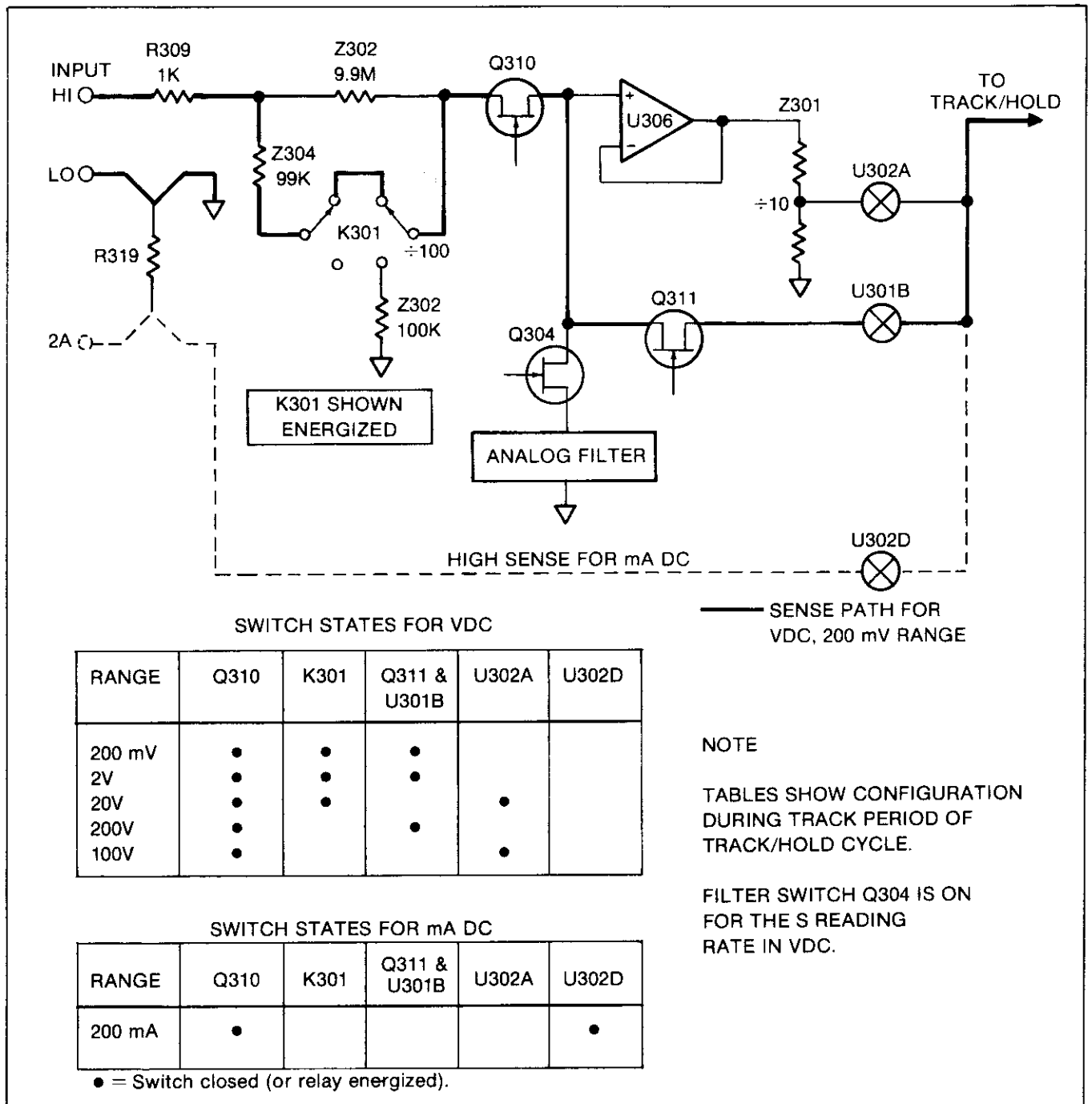


Figure 5-2. DC Scaling (VDC and mA DC)

In the 20V range, the input voltage is buffered by unity-gain amplifier U306, and divided by 10 by Z301. To allow U306 to handle $\pm 20V$ inputs, its power supplies are "bootstrapped" by Q305 and Q306, so that the output voltage of U306 determines the midpoint of its supply voltages. The positive supply is approximately 6.2V above the input and the negative supply is approximately 6.2V below.

In the 200V and 1000V ranges, K301 is de-energized and the input voltage is divided by 100 by Z302. In the 200V range, the reduced input voltage is then applied directly to the T/H Amplifier as in the 2V range. In the 1000V range, the reduced input voltage is buffered by U306 and divided by 10 as in the 20V range.

5-6. VDC Protection

Input protection for the VDC function is provided by a 1K, 2W fusible resistor (R309), four metal-oxide varistors (MOVs) (RV301, RV402, RV403, and RV404), and additional protection resistors and clamp circuits.

WARNING

TO AVOID INJURY OR EQUIPMENT DAMAGE, USE EXACT REPLACEMENT PARTS FOR ALL PROTECTION COMPONENTS.

In all dc voltage ranges, voltage transients greater than 1560V are clamped by the MOVs. Extreme overvoltage conditions cause R309 to fail open-circuit.

R309 is followed either by a 99 k Ω , 10W resistor network (Z304) in the 200 mV, 2V, and 20V ranges, or by 10 M Ω (Z302) to ground in the 200V and 1000V ranges. Z304 provides current limiting in extreme overvoltage conditions in the 200 mV, 2V, and 20V ranges. The non-inverting input of U306 is clamped to $\pm 25V$ by Q307 and Q308.

5-7. mA DC Scaling

In the mA DC function, the unknown current causes a voltage drop across current shunt R319. This voltage drop is then measured as in the VDC function. The DC Scaling circuit is configured as shown by the simplified switch table in Figure 5-2.

5-8. Analog Filter

The three-pole, low-pass analog filter (U304) has a Butterworth response with corner frequency at 7 Hz, giving approximately 50 dB of rejection at 50 Hz. The filter is used only for the slow reading rate and is used only in the VDC ranges and lowest three ohms ranges. The

filter is switched into the input signal path by Q304 (Figure 5-2). In some ranges and functions, additional filtering is provided by U302B and C314.

5-9. TRACK/HOLD CIRCUIT

The Track/ Hold (T/H) circuit presents a stable voltage to the A/D Converter during the input period of the A/D conversion cycle. The circuit also provides a gain of 10 in the 200 mV dc, 200 Ω , and 2000 mA dc ranges.

The T/H circuit consists of the T/H Amplifier (Figure 5-3), T/H capacitor C308, quad analog switches U301, U302, and U303, and associated components. As shown in Figure 5-3, the T/H Amplifier functions as an op amp, with Q314 supplying additional gain. In subsequent figures, the T/H Amplifier is represented as a single op amp.

The circuit operates by cycling between the track, settling, hold, and precharge configurations shown in Figure 5-4. The In-Guard μC selects a particular settling and hold configuration for each function and range, and suppresses the precharge configuration for certain ranges. This control is achieved by latching function and range information in U301, U302, and U303.

Basic timing for the T/H circuit is provided by the A/D Converter over clock lines PC, HD1, TR1, and TR2. (See the timing diagram in Figure 5-5, top.) The T/H cycle is initiated when the In-Guard μC pulls line TR low.

5-10. Track Configuration

In the track configuration (Figure 5-4A), the T/H circuit functions as a non-inverting buffer. The voltage on C308 tracks the scaled dc input voltage.

5-11. Settling Configuration

The circuit assumes a settling configuration between the track and hold configurations. The circuit assumes the configuration in Figure 5-4B for unity gain and the configuration in Figure 5-4C for gain of 10.

During this time the DC Scaling circuit is still connected to the T/H amp. However, changes in the input do not affect the value to be measured, which is stored on C308.

5-12. Hold Configuration

The X1 hold configuration (Figure 5-4D) is used for all VDC ranges except r1 and for all ohms ranges except r1. The output of U307 is the negative of the input voltage.

The X10 hold configuration (Figure 5-4E) is used for the mA DC function, the 200 mV dc range, and the 200 Ω range, and provides a gain of 10.

5-13. Pre-Charge Configuration

The pre-charge configuration (Figure 5-4F) occurs after the hold configuration in VDC ranges r1, r2, and r4, and ohms ranges r1, r2, r3, and r4. U306 is connected as a buffer to charge stray capacitance at the non-inverting input of the T/H Amplifier. The pre-charge configuration is not used in any other ranges.

5-14. PRECISION VOLTAGE REFERENCE

The Precision Voltage Reference (Figure 5-6) provides precise reference voltages of -7.00000 and $+7.00000$. The reference element is a reference amplifier (ref amp). The nominal ref amp voltage is $6.5V$.

Resistor R701, precision resistor network Z701, and transistor/zener diode combination U701 are produced as a matched set so that the output of U702A is precisely $-7.00000V$. This output is remotely sensed at the pins of the custom A/D IC (U101). Diode CR701 prevents the output from going positive at power-up.

U702B functions as an inverter to provide the $+7.00000V$ output and to supply the reference amplifier. The gain of U702B is set by the two $20\text{ k}\Omega$ resistors in the resistor network Z702.

5-15. OHMS CURRENT SOURCE

The Ohms Current Source (Figure 5-7) provides a precise test current for the ohms functions. The first stage (U401, R401, and Q401) produces a precise reference current, using precision resistor R401 and a $-7.00000V$ reference voltage from the Precision Voltage Reference.

The second stage (U404, precision resistor network Z401, and analog switches U402 and U403) is a current amplifier whose gain is controlled by the In-Guard μC . The In-Guard μC sets the output current for each range by controlling U402 and U403. (See switch state table in Figure 5-7.)

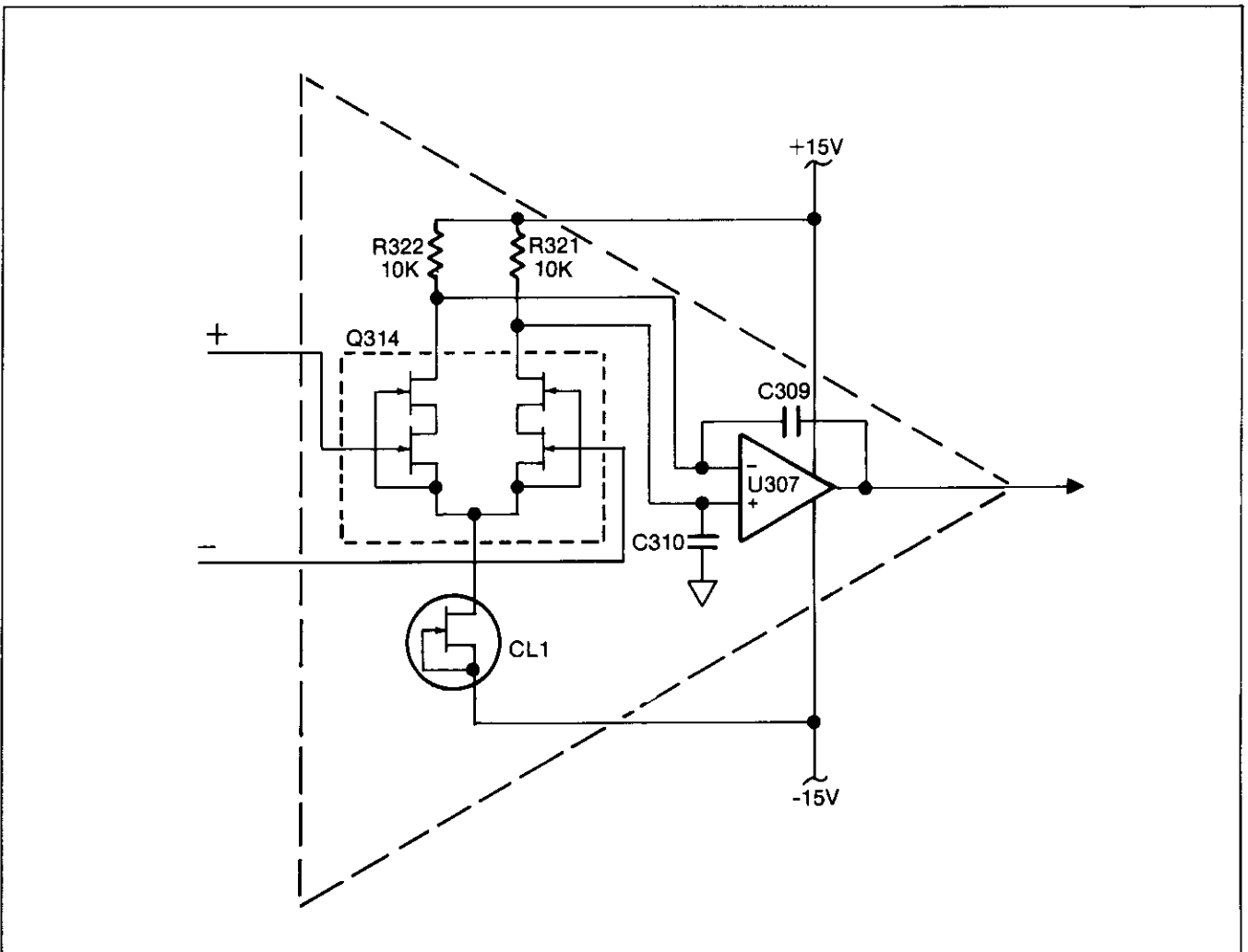


Figure 5-3. Track/Hold Amplifier

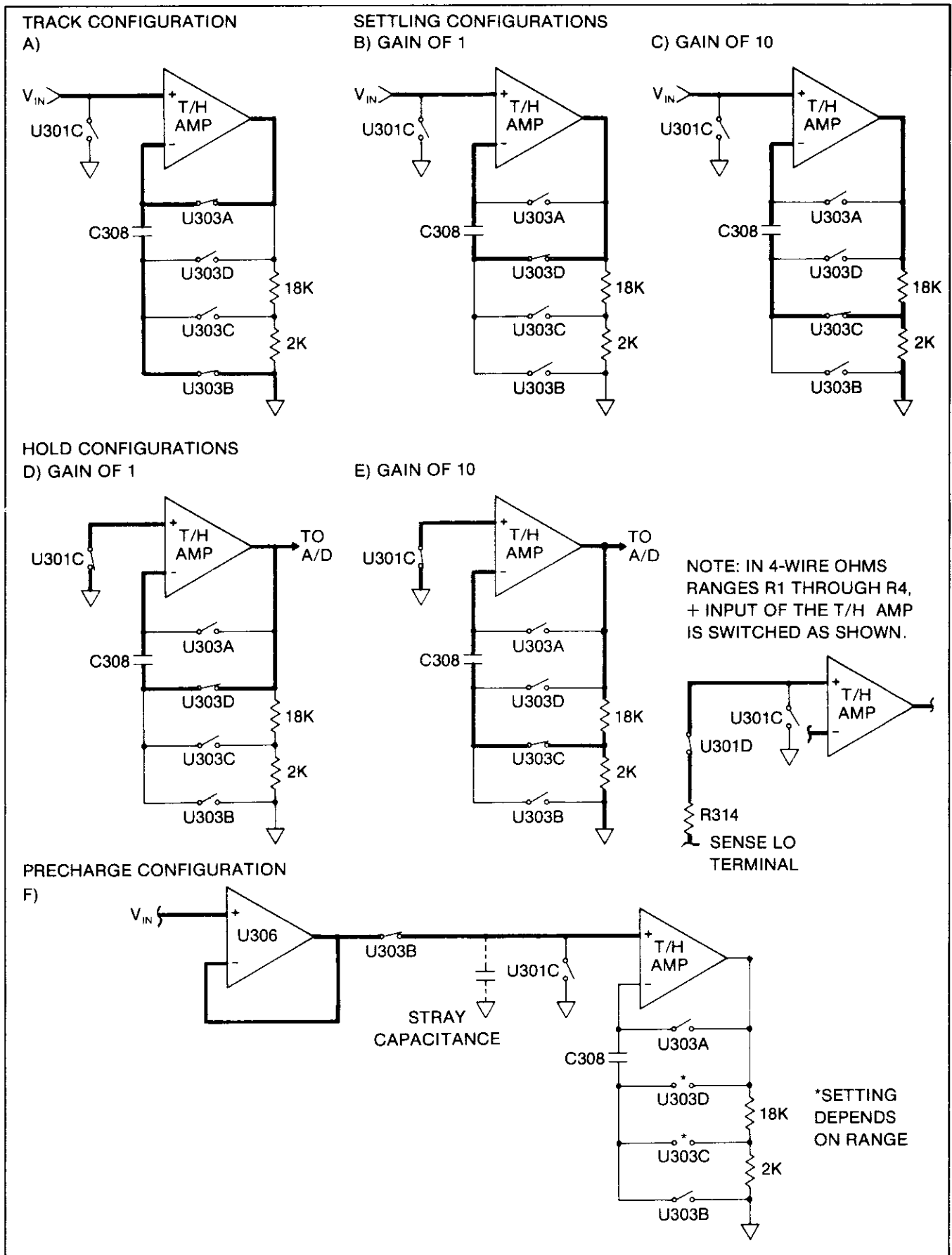


Figure 5-4. Track/Hold Circuit Configurations

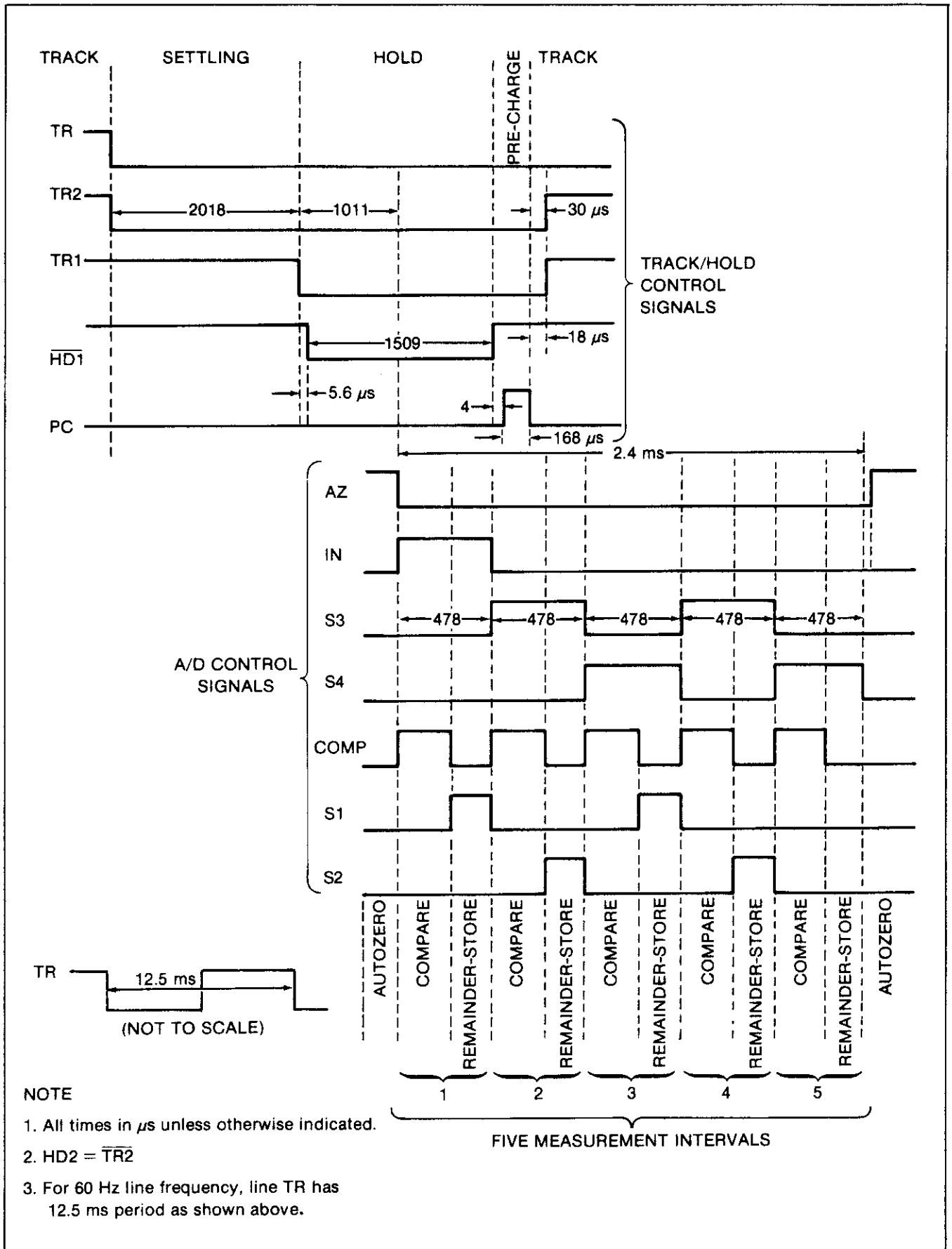


Figure 5-5. Timing Diagram for One A/D Cycle

5-16. OHMS PROTECTION

The Ohms Protection circuit (Q402, Q403, Q404, Q405, Q406, and Q407) clamps the open circuit voltage of the Ohms Current Source and provides protection for the Ohms Current Source. The circuit protects the Ohms Current Source from up to $\pm 300V$ across the INPUT terminals. The circuit also clamps voltage transients larger than 1560V with four MOVs (RV401, RV402, RV403, and RV404). In addition, a 1 k Ω , 2W fusible wire-wound resistor (R410) in series with the output current path fails open-circuit under extreme overvoltage conditions.

Large positive input voltages are blocked by CR402. Large negative input voltages are dropped equally across three high-voltage transistors (Q402, Q403, and Q404). If -300V is present at the collector of Q404, the voltage drops equally across Z402 so that large negative voltages never reach the current source.

The circuitry associated with Q408 (R406, R407, R408, R409, Q406, Q408, and CR403) clamps the open-circuit voltage of the Ohms Current Source below +6.5V in the lower four ranges and below +13V dc in the higher two ranges. The in-guard μC turns Q408 on or off depending on range. In the lower four ohms ranges, Q408 is on,

effectively shorting R409; R406 and R409 then form a voltage divider which clamps the output of the ohms current source below +6.5V. In the higher two ohms ranges, Q408 is off, including R409 in the voltage divider and clamping the output below +13V.

5-17. OHMS FUNCTIONS

5-18. 2-Wire Ohms

In the 2-wire ohms function, the Ohms Current Source is connected to the INPUT HI terminal by ohms relay K401 (Figure 5-8). The Ohms Current Source applies a known current to the resistance under test, and the resulting voltage drop across the resistor is measured ("sensed") as in the VDC function.

The voltage sensed at the INPUT terminals is scaled as shown by the simplified switch table in Figure 5-8. (Refer to the track period of the track/hold cycle, during which the scaled input voltage is sampled.)

In the lower four ranges, the full scale input voltage to the A/D Converter is 2V. However, in the 2000 k Ω and 20 M Ω ranges, the full-scale input voltage to the A/D Converter is +1V; the in-guard μC completes the scaling by multiplying the A/D result by 2.

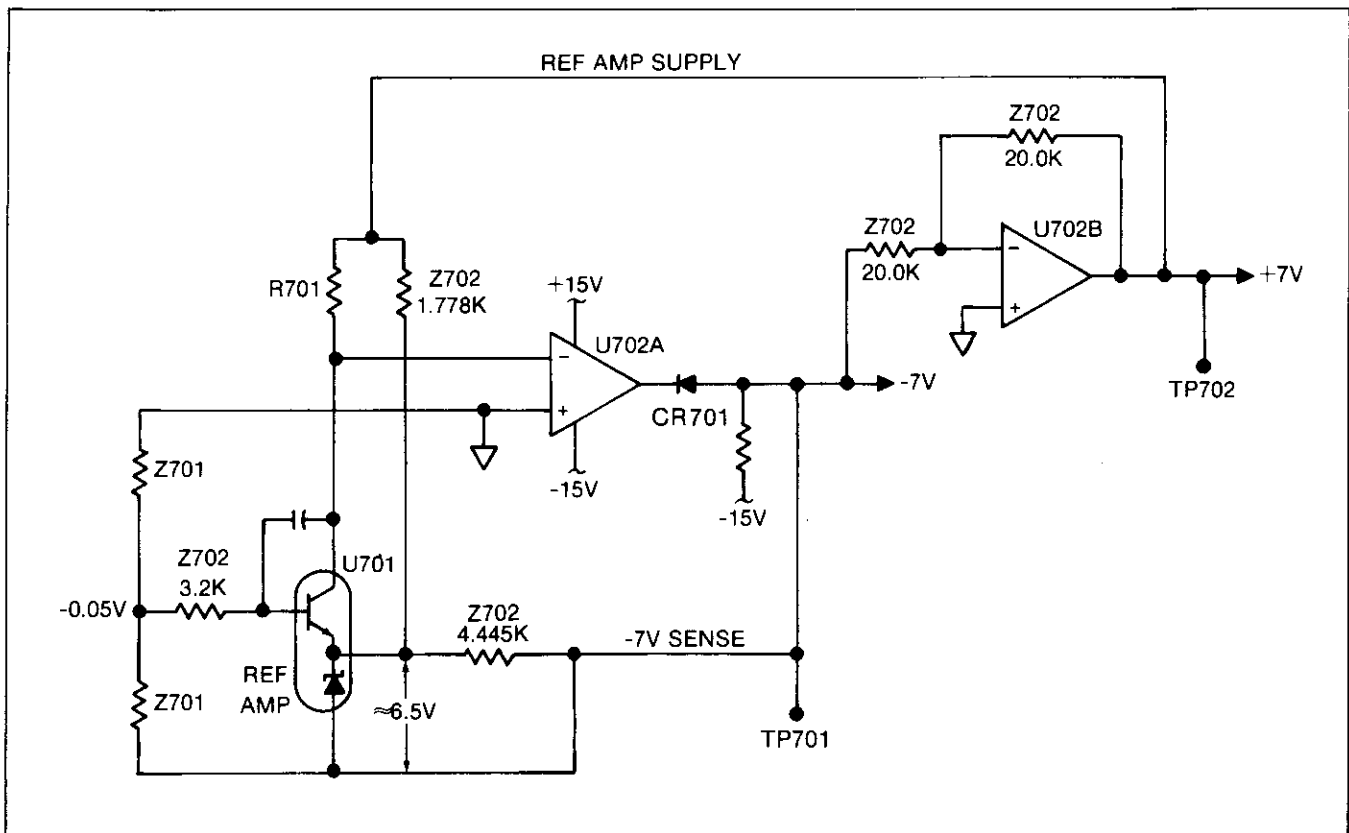


Figure 5-6. Precision Voltage Reference

5-19. 4-Wire Ohms

In the 4-wire ohms function, the Ohms Current Source is connected to the INPUT HI terminal by ohms relay K401 as in 2-wire ohms (Figure 5-8). The Ohms Current Source applies a known current to the resistance under test through the INPUT HI and INPUT LO leads. The resulting voltage drop across the resistor is measured by the SENSE HI and SENSE LO leads.

The voltage at the SENSE HI terminal is connected to the DC Scaling circuit by Q303 (Figure 5-8). The voltage is then scaled exactly as in the 2-wire ohms function. (Refer to the track period in the switch table in Figure 5-8.) Q310 is turned off to isolate the SENSE HI terminal from the INPUT HI terminal.

Additional input switching occurs during the hold period of the track/hold cycle. (Refer to the hold period in the switch table in Figure 5-8.) In ranges r1 through r4, the SENSE LO terminal is switched into the dc input path by U301D, and the INPUT LO terminal is switched out of the dc input path by U301C. This has the effect of measuring the SENSE HI terminal with respect to the SENSE LO terminal.

In ranges r5 and r6, the SENSE LO and INPUT LO terminals are both switched into the dc input path by U301C and U301D during the hold period. This has the effect of measuring the SENSE HI terminal with respect to INPUT LO terminal rather than SENSE LO. Although the resistance of the INPUT LO lead is in series with the unknown resistance, accuracy is not affected as long as the resistance of the lead is less than 10Ω in the 2 MΩ range and less than 100Ω in the 20 MΩ range.

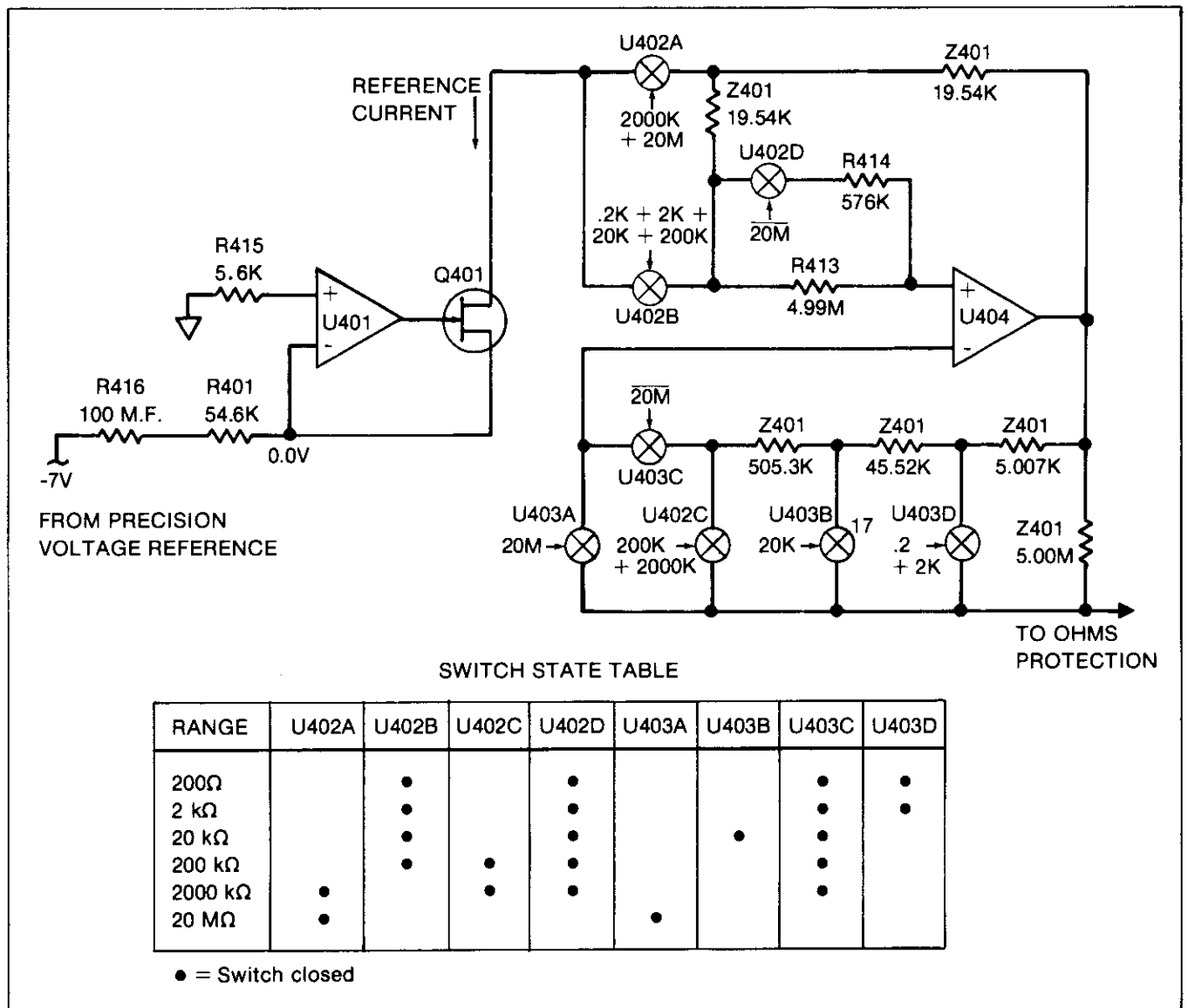


Figure 5-7. Ohms Current Source

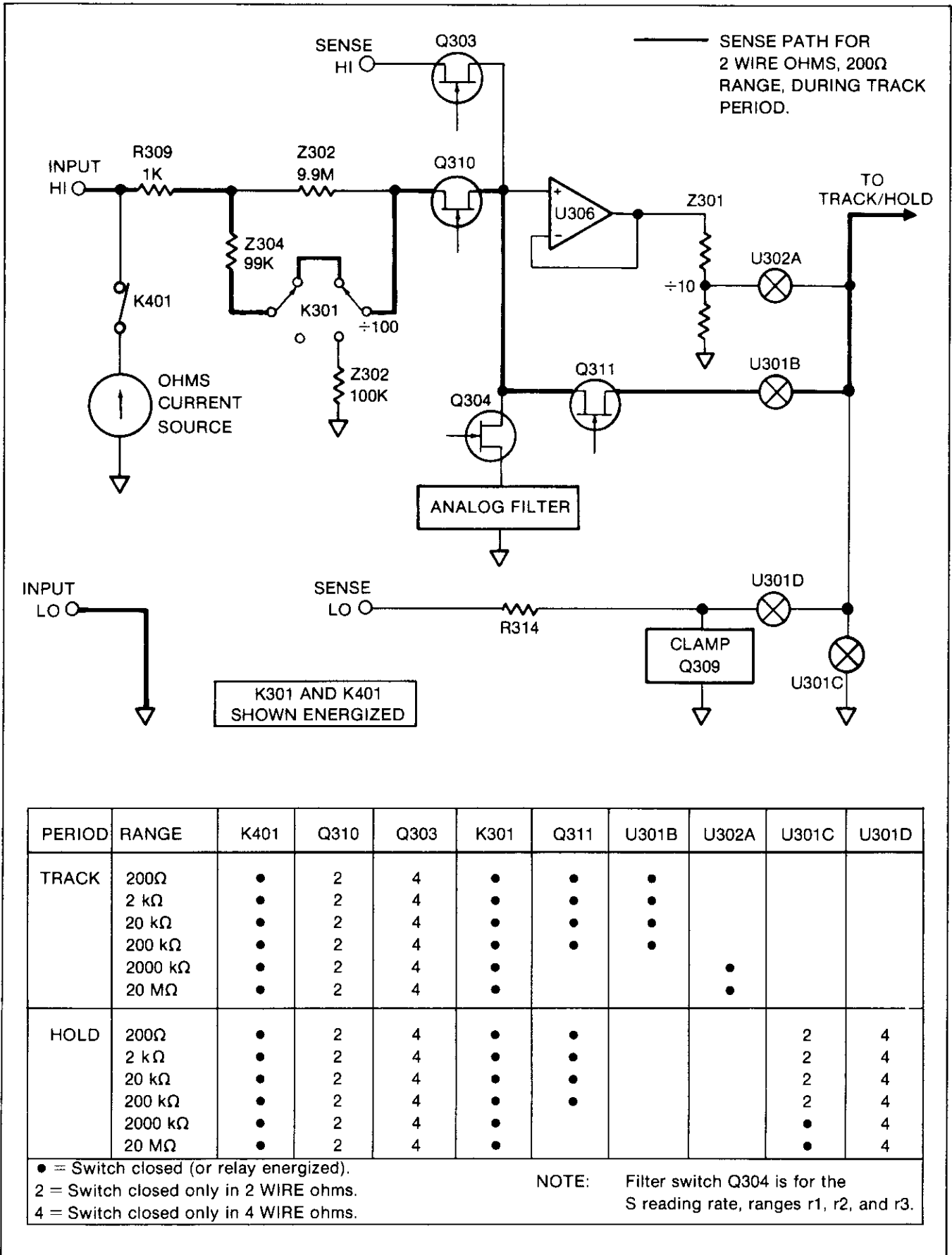


Figure 5-8. Ohms Scaling

5-20. A/D CONVERTER

The Analog-to-Digital (A/D) Converter (Figure 5-9) uses Fluke's patented recirculating remainder technique. An input voltage (V_{in}) is compared to the output of the precision Digital-to-Analog Converter (DAC). The output of the A/D Amplifier, connected as a comparator, is monitored to indicate when the DAC output is larger than the input voltage.

The conversion process is broken up into an autozero period followed by five measurement intervals. (A timing diagram is shown in Figure 5-5.) Six bits of the final A/D sample are obtained during each interval.

During the first compare period (shown in Figure 5-9), the A/D Converter determines the value of the scaled input voltage (V_{in}) by comparing V_{in} to the output of the DAC. Each of the DAC bit-switches is tried in sequence and kept or rejected (left closed or reopened) depending on the output polarity of the A/D Amplifier, which is configured as a comparator. This process produces a string of six bits which is stored in the Timing/Data Control circuit (the digital portion of U101).

During the following remainder-store period (Figure 5-10), the difference between the V_{in} and the DAC output is multiplied by 16 by the A/D Amplifier and stored on capacitor C102. During subsequent compare and remainder-store periods, the remainder voltage is connected to the input of U103 and is resolved to six bits; the remainder voltage (multiplied by 16) is stored alternately on capacitor C102 and C103. Each of the five compare periods thus produces a six-bit nibble which is stored in the Timing/Data Control circuit.

This five-interval process thus generates five nibbles which are processed by the In-Guard μC to produce one A/D sample. After the fifth nibble is generated, U101 interrupts the In-Guard μC over line INT. The In-Guard μC then pulls line CS7 low five times, causing U101 to send the μC the five (six-bit) nibbles one-at-a-time over lines AD0-AD5. The In-Guard μC then weights each nibble $1/16$ of the value of the previous number and calculates the input voltage.

The hardware for the A/D Converter has four major sections: Timing/Data Control, Precision DAC, A/D Amplifier, and bootstrap supplies.

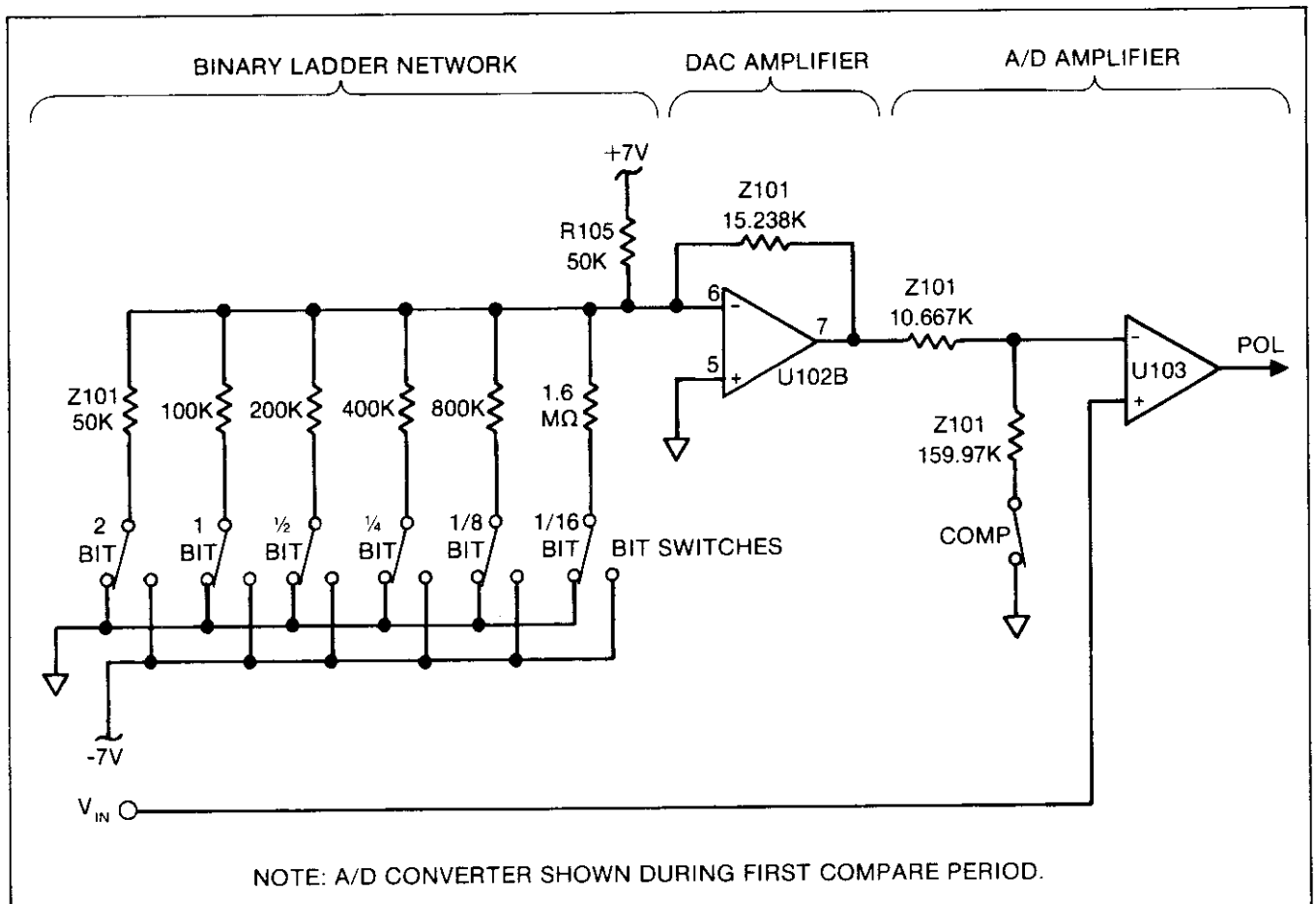


Figure 5-9. Analog-to-Digital Converter

5-21. Timing/Data Control

The Timing/Data Control circuit (the digital portion of U101) times and controls the A/D Converter by manipulating the switches in the A/D Amplifier and the bit-switches in the Precision DAC. An A/D conversion cycle is triggered by the falling edge of line TR from the In-Guard μ C. Once triggered, the A/D Converter (under control by U101) generates the five 6-bit nibbles without further interaction with the In-Guard μ C.

The Timing/Data Control circuit also provides a watchdog timer (line RES) which resets the In-Guard μ C in case normal program execution is interrupted. If the timer senses inactivity on line CS7 for longer than 1.5 seconds, it resets the In-Guard μ C by pulling RES low.

The Timing/Data Control circuit is supplied with a fixed-rate 8 MHz clock and provides a 1 MHz output clock for the Keyboard/Display Interface (U212). In addition, four output lines (PC, HDI, TR1, and TR2) provide control signals for the Track/Hold circuit.

5-22. Precision DAC

The Precision Digital-to-Analog Converter (DAC) is composed of DAC Amplifier U102B and a binary ladder

network, which consists of resistors in Z101 and digitally controlled analog bit-switches contained in U101.

The bit-switches determine the output voltage of U102B by controlling the binary ladder network. The gain of U102B is set by the ratio of a precision feedback resistor (Z101-7,-8) and the equivalent output resistance of the ladder network.

5-23. A/D Amplifier

The A/D Amplifier is composed of a comparator/amplifier (U103), two remainder-storage capacitors (C103 and C102), an autozero storage capacitor (C101), and several digitally controlled analog switches contained in U101.

The A/D Amplifier has three modes of operation: autozero mode, where any offsets in the A/D input are stored on C101 so as to be cancelled later; compare mode, where the A/D input is compared to the DAC output; and remainder-store mode, where U103 amplifies and stores the difference between the A/D input and the DAC output on one of the two remainder-storage capacitors (C102 or C103). The autozero mode is shown in Figure 5-11. The other modes are shown in Figures 5-9 and 5-10.

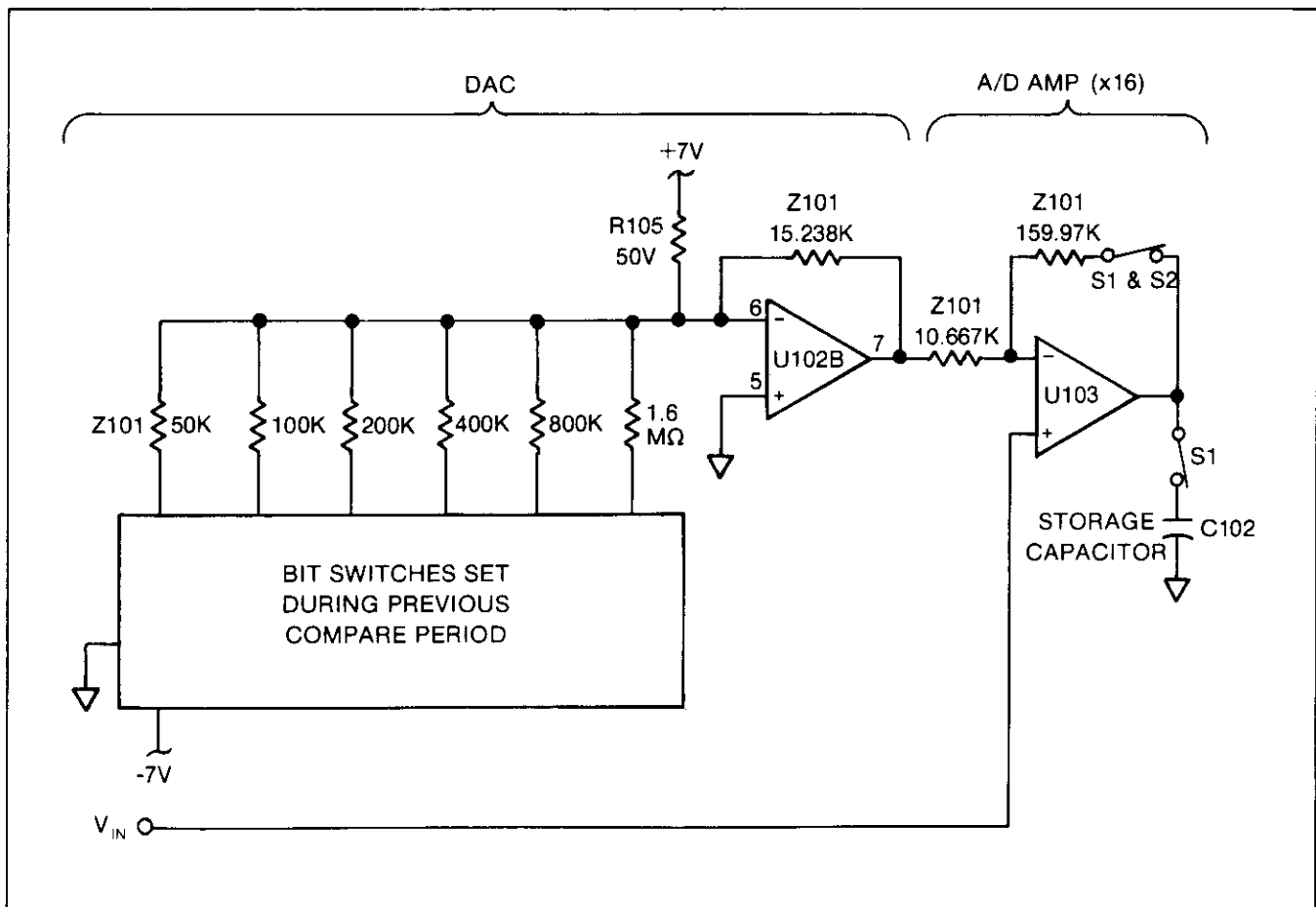


Figure 5-10. First Remainder-Store Period

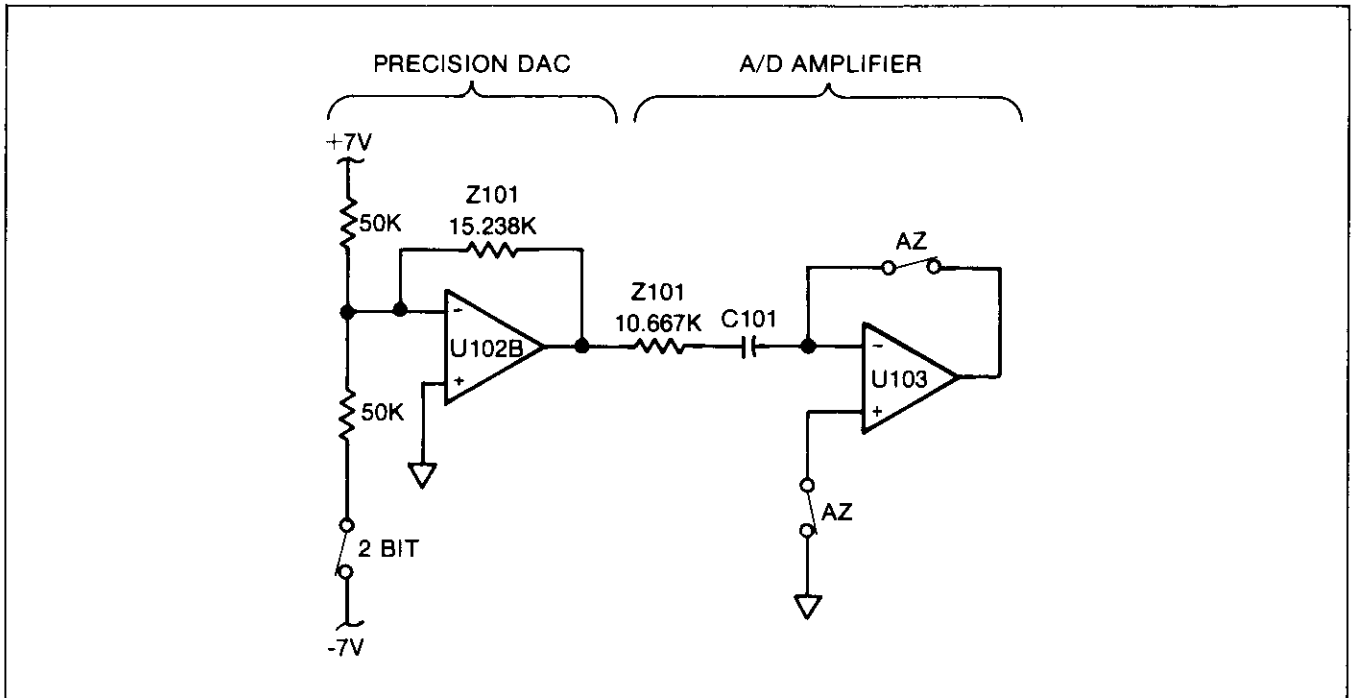


Figure 5-11. Autozero Period

5-24. Bootstrap Supplies

The bootstrap supplies are composed of U102A, Q101, Q102, CR103, CR104, and associated components. The Bootstrap Supplies enhance the gain accuracy of U103. During compare periods, the bootstrap supplies limit the output of U103 to minimize the time it takes to recover from being driven to a supply rail. Both functions are achieved by manipulating the supplies of U103 (BS1 and BS2).

5-25. DISPLAY

The vacuum fluorescent display is similar to a vacuum tube, containing eight control grids and 69 phosphor-coated plates which form the display segments and annunciators. (See Figure 5-12.) The filament voltage is 4.5V ac, with a +5V dc bias. Each plate is controlled by a G line and a P line. The G lines go to the control grids, and the P lines go to the plates.

The Digital Controller sequentially enables the G lines by applying +30V dc (nominal). When a G line is enabled, electrons flow from the filament to the enabled grid. If a P line is enabled (i.e., raised to a nominal +30V dc by the Digital Controller), the electrons continue past the grid and strike the respective plate, causing it to glow.

5-26. KEYBOARD

The keyboard consists of a silicone-rubber switch matrix located over metalized epoxy contacts on the printed wire board. Each button contains a conductive pad that shorts two contacts when pressed.

5-27. DIGITAL CONTROLLER

The Digital Controller (Figure 5-13) consists of the In-Guard μ C (U202), External Program Memory (U222), Calibration Memory (U220), Keyboard/Display Interface, and associated components.

5-28. In-Guard Microcomputer

The In-Guard Microcomputer (μ C) is a single-chip Z8 microcomputer containing 4K bytes of ROM, 144 bytes of RAM, a UART, and four 8-bit I/O ports. It communicates with the rest of the instrument via the internal bus and dedicated I/O lines. The In-Guard μ C is reset when pin 6 is pulled low either by C204 at power-up or by the watch-dog timer in the custom A/D IC (U101). Pin 6 is tied to +5V through a 100 k Ω resistor inside the μ C.

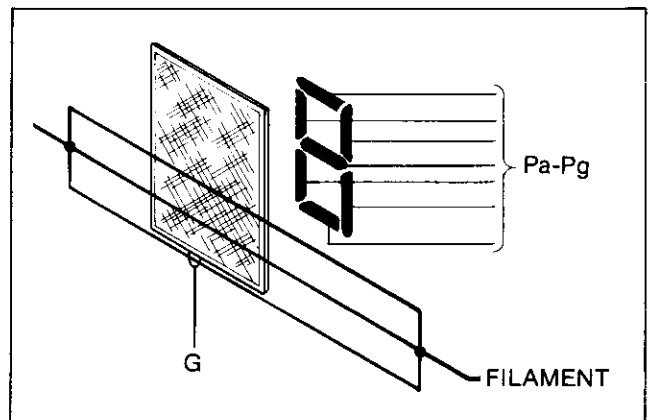


Figure 5-12. Vacuum Fluorescent Display

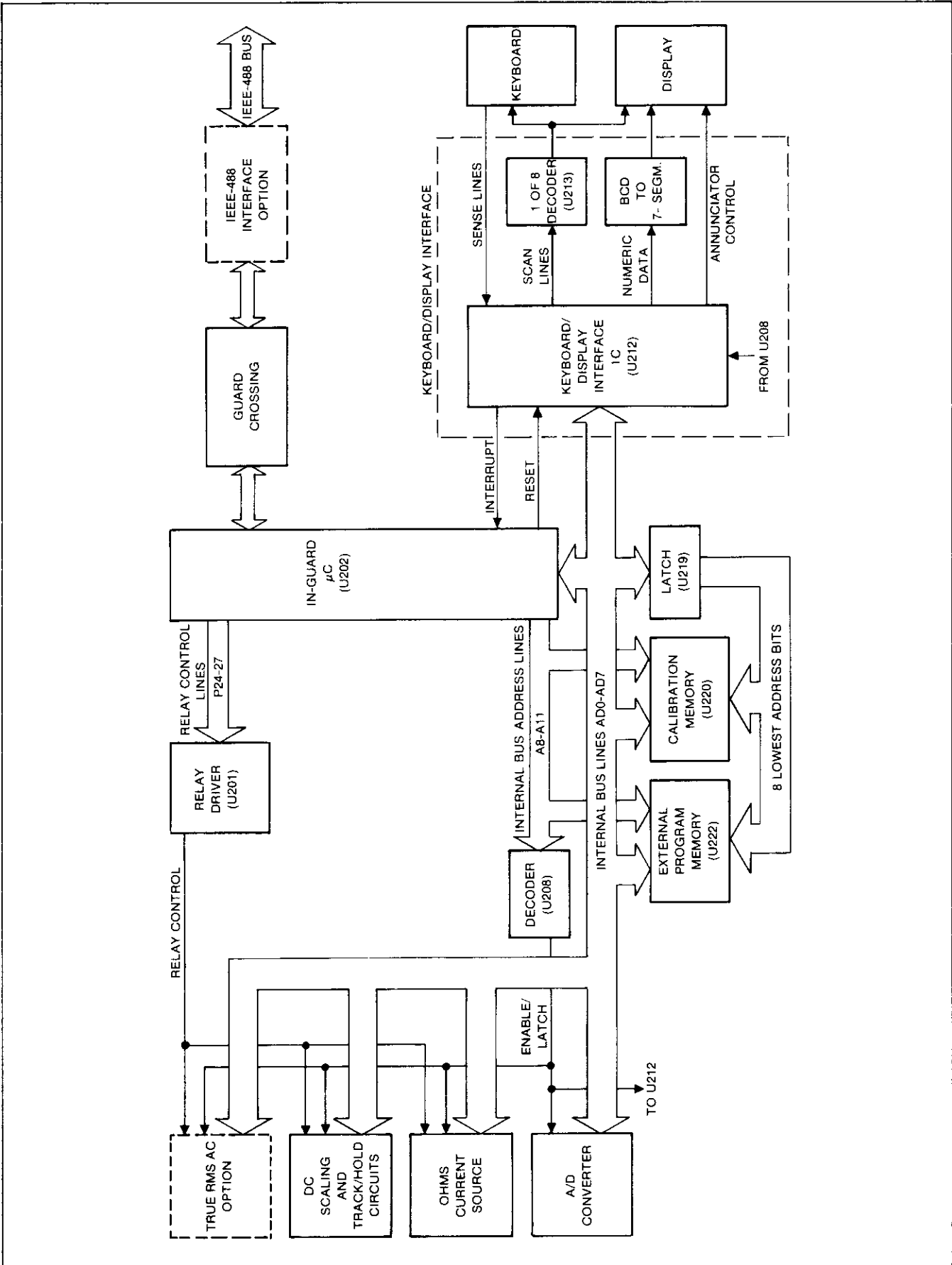


Figure 5-13. Digital Controller Block Diagram

All internal bus communication is memory-mapped. Each component that sends or receives data on the bus has a unique address or range of addresses. The internal bus consists of lines AD0-AD7 and A8-A11. Lines AD0-AD7 are time-multiplexed to carry both the least-significant address byte and the data. Lines A8-A11 carry the most-significant bits of the address. The μC writes to and reads from the internal bus according to the read and write cycles shown in Figure 5-14. During either cycle, the address strobe (AS) changes from low to high when an address is valid, and the data strobe (DS) changes from low to high when the data is valid.

The address strobe latches the address on AD0-AD7 into U219 which then provides static address inputs for those devices that need it while data is on the bus. The data memory line (DM) divides the address space between program memory (U222) and data memory (all other devices on the bus). The data memory address space is further divided between the calibration memory (U220) and the remaining devices by A11. The addresses of the remaining devices are decoded from A8-A10 by U208, which combines the address with the data strobe (DS) to provide a chip select (CS0, CS2, CS3, CS4, or CS7) for each device.

The In-Guard μC performs the following functions: range and function control; A/D control and computation; calibration corrections; keyboard/display control; serial communication with the IEEE-488 Interface; and diagnostic self-testing and troubleshooting.

5-29. Function and Range Control

The In-Guard μC configures the DC Scaling circuit, the Track/Hold circuit, and the Ohms Current Source to provide the proper input switching, scaling, and filtering for each function, range, and reading rate. It does this by controlling dedicated output lines which control relays and FET switches, and by sending configuration codes out on the bus. The quad analog switches (U301, U302, U303, U402, and U403) latch the configuration codes and perform any level-shifting needed to control their internal MOSFET switches. Some of the switches require dynamic timing signals from the custom A/D IC (U101); these signals are combined appropriately in the quad analog switches with the configuration codes.

5-30. A/D Control and Computation

The In-Guard μC initiates each A/D sample by pulling line TR low. When the μC is reset, it senses the power line frequency on line FREQ REF. The μC then sets its internal timer so that the A/D sample rate is as shown in Table 5-1.

The number of readings per second for the slow and medium rates are chosen to provide rejection of input signals that are at the line frequencies.

The custom A/D IC (U101) generates five 6-bit numbers after each trigger from the μC and then pulls INT low, telling the μC that data is ready. The μC reads the five 6-bit numbers over the bus (CS7 pulses low five times for five read cycles) and computes the value of the A/D sample using calibration constants. The μC averages the appropriate number of samples for one reading, which is then sent to the keyboard/display interface for display.

For example, with a 60-Hz power-line frequency, an externally triggered reading in the slow reading rate would cause the μC to send 32 pulses on TR at an 80 Hz rate. The 32 A/D samples would be calibrated and averaged by the μC and sent for display. With internal triggering, the A/D runs continuously at 80 samples per second with a reading being sent to the display every 32 samples.

5-31. Calibration Correction

The calibration constants used by the In-Guard μC in computing each reading are stored in the EEROM (electronically erasable read-only memory) Calibration Memory (U220). The front panel CAL ENABLE switch protects the EEROM from accidental writes.

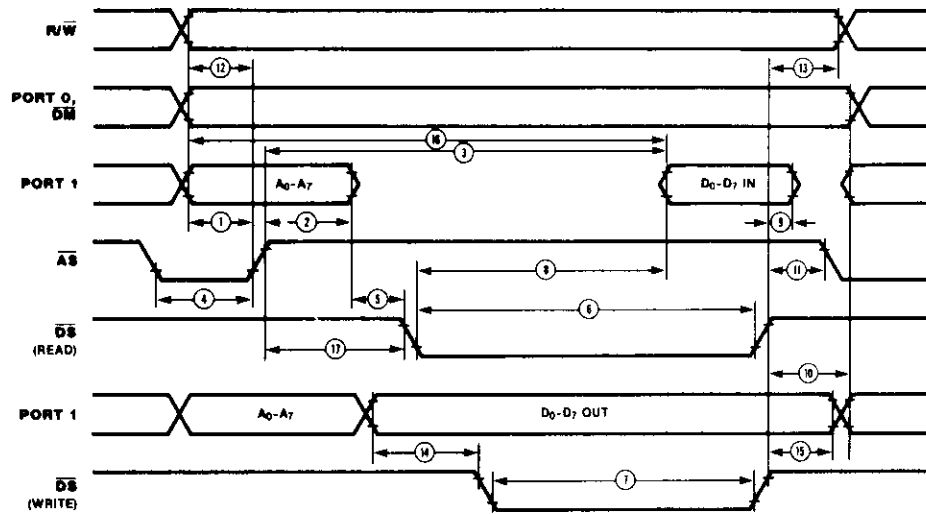
5-32. Keyboard/Display Control

Keyboard/Display Controller U212 communicates with the In-Guard μC over the internal bus. During a μC write cycle, address line A0 tells U212 whether to consider data being sent by the μC as configuration commands or as display data. Display data is stored in the Keyboard/Display Controller, which automatically scans the display. The Keyboard/Display Controller selects one of eight grids using decoder U213 and buffer U215. The numeric display data is decoded from BCD to 7-segment by decoder U216 and buffered by U217. Additional annunciator data is buffered by U218.

The Keyboard/Display Controller is reset by the μC whenever the μC is reset. It receives a 1-MHz clock signal from the custom A/D IC (U101), which uses the μC 8 MHz crystal for its clock input.

The Keyboard/Display Controller scans the keyboard, sensing pressed buttons on lines RL0-RL7. It sends an interrupt to the μC via line KEYINT whenever a front panel button is pressed. The μC then reads the keycode from the Keyboard/Display Controller. (The status of the FRONT/REAR switch is sensed separately by line F/R SENSE.)

**External I/O
or Memory
Read and
Write Timing**



Z8681/82 8 MHz					
No.	Symbol	Parameter	Min	Max	Notes*†
1	TdA(AS)	Address Valid to \overline{AS} † Delay	50		1,2,3
2	TdAS(A)	\overline{AS} † to Address Float Delay	70		1,2,3
3	TdAS(DR)	\overline{AS} † to Read Data Required Valid		360	1,2,3,4
4	TwAS	\overline{AS} Low Width	80		1,2,3
5	TdAz(DS)	Address Float to \overline{DS} †	0		1
6	TwDSR	\overline{DS} (Read) Low Width	250		1,2,3,4
7	TwDSW	\overline{DS} (Write) Low Width	160		1,2,3,4
8	TdDSR(DR)	\overline{DS} † to Read Data Required Valid		200	1,2,3,4
9	ThDR(DS)	Read Data to \overline{DS} † Hold Time	0		1
10	TdDS(A)	\overline{DS} † to Address Active Delay	70		1,2,3
11	TdDS(AS)	\overline{DS} † to \overline{AS} † Delay	70		1,2,3
12	TdR/W(AS)	R/ \overline{W} Valid to \overline{AS} † Delay	50		1,2,3
13	TdDS(R/W)	\overline{DS} † to R/ \overline{W} Not Valid	60		1,2,3
14	TdDW(DSW)	Write Data Valid to \overline{DS} (Write) † Delay	50		1,2,3
15	TdDS(DW)	\overline{DS} † to Write Data Not Valid Delay	70		1,2,3
16	TdA(DR)	Address Valid to Read Data Required Valid		410	1,2,3,4
17	TdAS(DS)	\overline{AS} † to \overline{DS} † Delay	80		1,2,3

NOTES:

- 1. Test Load 1
- 2. Timing numbers given are for minimum TpC.
- 3. Also see clock cycle time dependent characteristics table.
- 4. When using extended memory timing add 2 TpC.
- 5. All timing references use 2.0 V for a logic "1" and 0.8 V for a logic "0".
- * All units in nanoseconds (ns).
- † Timings are preliminary and subject to change.

Zilog and Z8® are trademarks of Zilog, Inc., with whom John Fluke Mfg. Co., Inc. is not associated.

Reproduced by permission ©1983 Zilog, Inc. This material shall not be reproduced without the written consent of Zilog, Inc.

Figure 5-14. Read/Write Timing Diagrams for Internal Bus

5-33. Troubleshooting Modes

In addition to running the diagnostic self-tests, the In-Guard μ C has a troubleshooting mode which aids in finding digital hardware problems. After the μ C is reset, it senses the relay control lines (U202-35 through U202-38) as inputs. If line U202-38 (TP205) is shorted to ground, the μ C goes into the troubleshooting mode. (U201 provides internal pull-up.) The troubleshooting mode is described in detail in the Maintenance section.

5-34. Guard-Crossing Communication

The In-Guard μ C contains a UART (universal asynchronous receiver transmitter) which it uses to communicate across the guard to the IEEE-488 Interface. The transmission speed is 62,500 bits per second.

5-35 GUARD CROSSING

The Guard Crossing consists of two identical circuits, each of which transmits data in one direction across the guard isolation between the Main Pinned Circuit Assembly and the IEEE-488 Interface. One circuit is shown in Figure 5-15; the other circuit works identically. A portion of each circuit is contained in the IEEE-488 Interface.

The circuit in Figure 5-15 has two stable states, corresponding to output high (+5V) and output low (0V). If the output is high, the voltage present at the non-inverting input of op amp A is approximately +140 mV.

Since the inputs to op amps A and B are inverted, their outputs are always in opposite states. If the output of A is high, the output of B is low, forcing the inverting input of A (and the non-inverting input of B) to ground, hence reinforcing the existing state. The situation is analogous if the output of A is low.

A positive-going transition at the input causes a positive pulse at the non-inverting input of A, and a corresponding negative pulse at the inverting input of A. If the output is high to start with (with the non-inverting input of A raised 140 mV above its inverting input), these pulses reinforce the existing state (raising the non-inverting input and lowering the inverting input). If, however, the output is low to start with, the positive pulse (which is greater than 140 mV) raises the non-inverting input of A above its inverting input, switching the output to the high state. The situation is analogous for a negative-going input transition.

Table 5-1. Sample Rates and Reading Rates

POWER LINE FREQUENCY	SLOW		MEDIUM		FAST	
	Samples per Sec	Samples per Reading	Samples per Sec	Samples per Reading	Samples per Sec	Samples per Reading
50 Hz	66.67	32	66.67	4	100	1
60 Hz	80	32	80	4	100	1
400 Hz	76.19	32	76.19	4	100	1

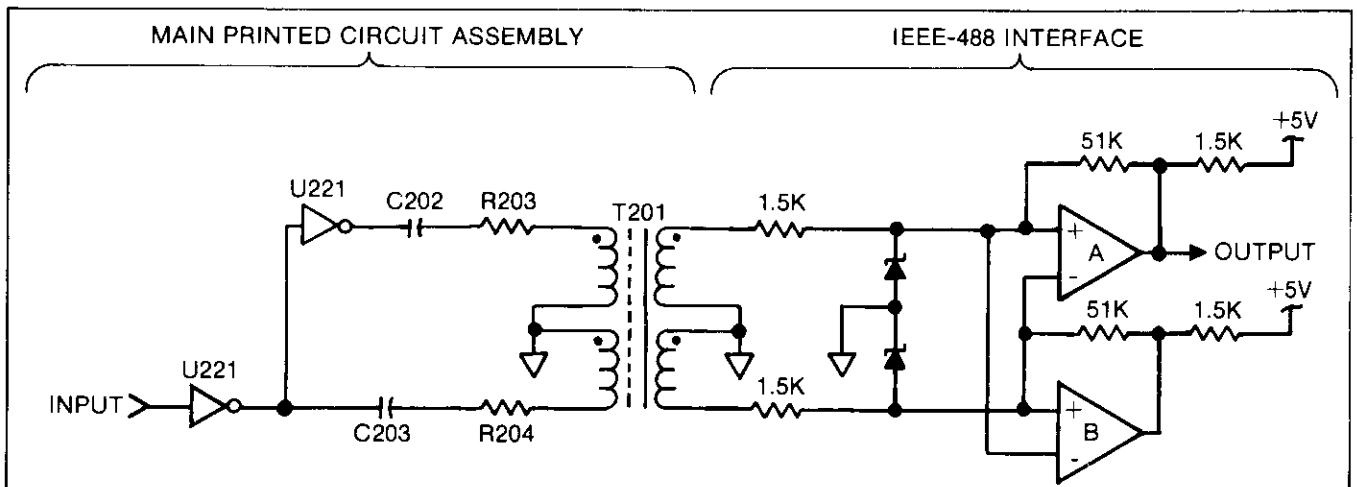


Figure 5-15. Guard Crossing Circuit

5-36. POWER SUPPLY

The Power Supply provides the following in-guard outputs: $\pm 30V$, $\pm 15V$, $-6.2V$, $+7.5V$, $+5V$, $-5V$, and $-8.2V$ dc; and $4.5V$ ac. The Power Supply also provides a $16V$ ac center-tapped out-guard output.

Input line voltage is directed to the primary transformer winding through fuse F601, the front panel POWER switch, and the rear panel LINE SET switches. Metal oxide varistor RV601 clamps line transients at about $390V$. The LINE SET switches configure the Power Supply to accept line power of 100 , 120 , 220 , or $240V$ ac ($\pm 10\%$ with a maximum of $250V$) at 50 , 60 , or 400 Hz.

AC voltage for the $+5V$ supply is rectified by CR601 and CR602 and regulated by VR601. The $+5V$ output supplies mostly logic circuits. The ac input to the $+5V$ supply is sensed by the In-Guard μC (via R604, CR615, and U221-12,13) to measure the line frequency.

AC voltage for the $+30V$ and $-30V$ supplies is rectified by bridge network CR603, CR604, CR605, and CR606 and regulated by VR602 and VR605. The $+30V$ and $-30V$ outputs supply front-end buffer amp U306. In addition, the $+30V$ output supplies the anodes of the vacuum fluorescent display. Zener diode CR612 supplies $-6.2V$ to the A/D Converter clamps.

AC voltage for the $+15V$ and $-15V$ supplies is rectified by bridge network CR608, CR609, CR610, and CR611 and regulated by VR603 and VR604. The $+15V$ and $-15V$ supply analog circuitry throughout the 8840A. Zener diodes CR613 and CR614 supply $+7.5V$ and $-8.2V$ to the A/D Converter, analog filter, and DC Scaling circuit.

Secondary T601-14,15,16 supplies the vacuum fluorescent display filament with $4.5V$ ac. The center tap is connected to the in-guard $+5V$ supply in order to correctly bias the display. An isolated secondary supplies $16V$ ac to the power supply on the IEEE-488 Interface.

5-37. IEEE-488 INTERFACE (OPTION -05)

The IEEE-488 Interface has five major parts, as shown in the block diagram in Figure 5-16. All components are contained in a single printed circuit assembly (PCA). Reference designations are numbered in the 900 series.

5-38. Out-Guard Microcomputer

The Out-Guard Microcomputer (μC) (U901) performs all of the functions necessary to communicate with the IEEE-488 bus: handshaking, checking of syntax, interpretation of device-dependent commands, generation of error messages, etc. The Out-Guard μC also communicates with the In-Guard μC (U202) over the guard crossing.

The Out-Guard μC is identical to the In-Guard Z8 μC except for the contents of the internal ROM. For further description of the Z8 μC , refer to the heading "In-Guard Microcomputer," above.

5-39. Guard Crossing

The guard crossing circuit permits serial asynchronous communication between U901 and U202 while isolating the two electrically. One-half of the guard crossing circuit is contained on the Main PCA; the other half is on the IEEE-488 Interface PCA. Operation of the guard crossing circuit is described in an earlier heading.

5-40. Bus Transceiver

Bus transceivers U902 and U903 buffer U901 from the IEEE-488 bus. They provide the bus with the required output drive capability and receiver impedance. While ATN is true, the Out-Guard μC controls U905-9 to configure U902 and U903 either as bus drivers or receivers depending on whether the 8840A is addressed as a talker or a listener. (U905-9 is high when driving and low when receiving.) When ATN goes true, gates U904-3,-6 configure U902 and U903 as receivers in order to meet the IEEE-488 requirement that the 8840A stop driving the bus within 200 ns.

5-41. Signal Conditioning

The SAMPLE COMPLETE and EXT TRIG signals (J903 and J904) are conditioned by U906. Diodes CR903, CR904, CR905, and CR906 and resistors R917 and R918 provide protection from excessive voltages. Jumpers E902 and E903 allow selection of the polarity of the EXT TRIG signal. (A polarity selection procedure is given in the Maintenance section.) The 8840A is configured in the factory so that it is triggered on the falling edge of the EXT TRIG signal.

5-42. IEEE-488 Interface Power Supply

The IEEE-488 Interface power supply circuit provides the IEEE-488 Interface PCA with $+5V$. The circuit consists of rectifying diodes CR908 and CR909, filter capacitor C910, and voltage regulator VR901. Power comes from transformer T605 on the Main PCA. U908 and associated circuitry resets the Out-Guard μC at power-up and following power-line voltage dropouts.

5-43. TRUE RMS AC (OPTION -09)

The True RMS AC circuit (Figure 5-17) performs two primary functions. First, it scales ac input voltages and ac current sense voltages to a range of $0V$ to $2V$ ac rms. Second, it converts the scaled ac voltages to an equivalent dc voltage which is then directed to the A/D Converter via the Track/Hold Amplifier. The True RMS AC circuit is trimmed for flat high-frequency response using a variable filter which is set by the High-Frequency AC Calibration procedure.

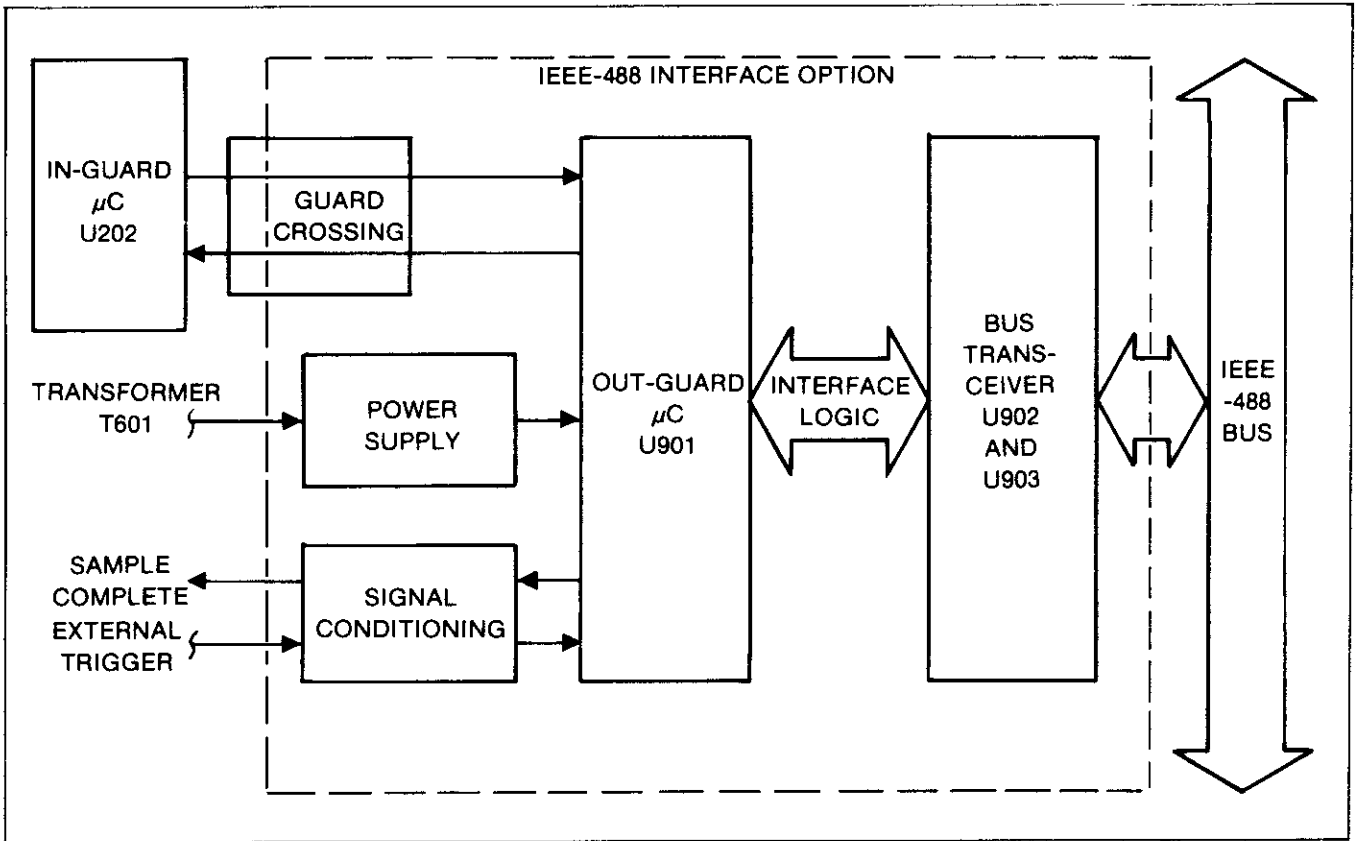


Figure 5-16. IEEE-488 Interface Block Diagram

The following paragraphs describe how these functions are performed. Components are laid out on a single printed circuit assembly (PCA). Component reference designators are numbered in the 800 series.

5-44. VAC Scaling

AC voltage inputs are directed from the HI INPUT terminal to the True RMS AC PCA through protection resistor R309 on the Main PCA. In this way, voltage transients greater than 1560V are clamped by MOVs (RV301, RV402, RV403, and RV404) as in the VDC function. With the VAC function selected, K801 is closed.

The input voltage is thus applied to C801, which blocks dc inputs.

U807 and resistor network Z801 provide selectable attenuation and 1 MΩ input impedance. In the upper two ranges, K802 is closed and Q806 is off, providing a gain of -1/500. In the lower three ranges, K802 is open and Q806 is on, shorting Z801-4 to ground; this configuration provides a gain of -1/5. CR801 and CR802 provide protection by clamping the inverting input of U807 to approximately ±0.6V. Q805 shifts logic levels to control Q806.

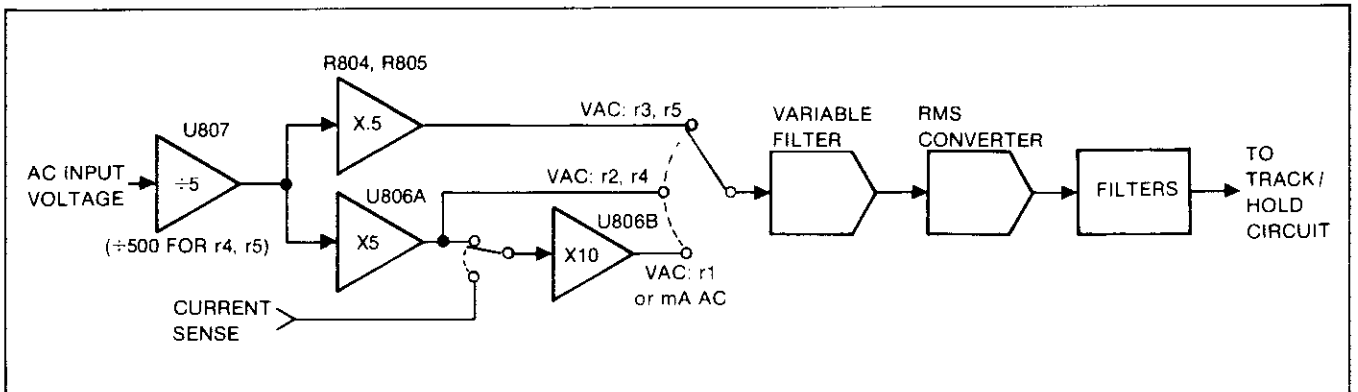


Figure 5-17. True RMS AC Option Block Diagram

U806A, U806B, and a voltage divider (R804 and R805) provide gain which is selected for each range by the analog switches in U804. The configuration for each range is shown in Figure 5-17. (In this figure, the CMOS analog switches are represented by mechanical switches.) When U806A is not used, its non-inverting input is grounded by Q804. When U806B is not used, its non-inverting input is connected to the CURRENT SENSE line.

5-45. mA AC Scaling

The mA AC function uses the same current shunt and protection network which is used for dc current. In the mA AC function, Q802 switches the CURRENT SENSE line to the non-inverting input of U806B, which provides a gain of 10.

5-46. Frequency Response Trimming

The frequency response is trimmed by software calibration using a digitally controlled one-pole low-pass filter (R832 and a combination of C826, C827, C828, and C829). The analog switches in U808 configure the four

capacitors to select one of 16 possible RC constants. The input of the digitally controlled filter is buffered by voltage follower U801A. The individual gain stages are also provided with fixed frequency compensation.

5-47. True RMS AC-to-DC Conversion

U801B buffers the input to rms converter U802. U802 computes the rms value of the scaled input voltage as shown in Figure 5-18. Rather than explicitly squaring and averaging the input, U802 uses an implicit method in which feedback is used to perform an equivalent analog computation.

The filter averages the divider output signal. This filter consists of U809A, C813, R815, and the internal 25 kΩ resistor and op amp between pins 8 and 9 of U802. The output is further filtered by a three-pole post-filter comprised of U809B and associated resistors and capacitors. This output is then switched into the Track/Hold Amplifier of the dc front end via U302 pins 15 and 14. The Track/Hold Amplifier is set up for unity gain on all ac ranges.

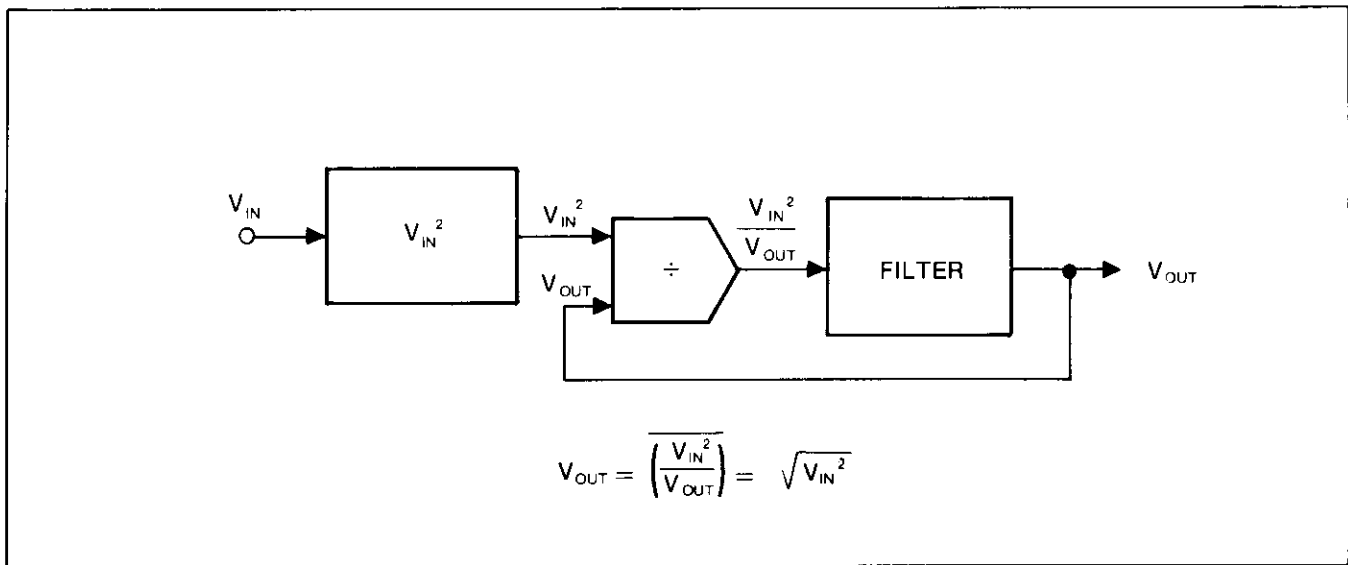


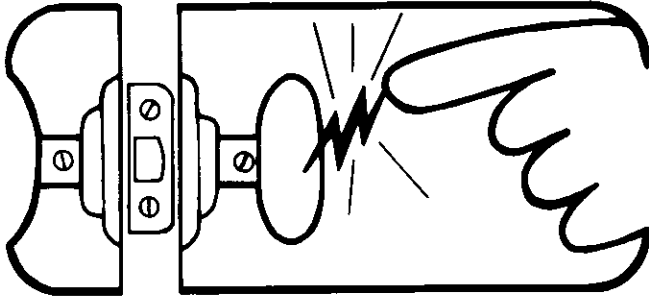
Figure 5-18. True RMS AC-to-DC Converter



static awareness



A Message From
John Fluke Mfg. Co., Inc.



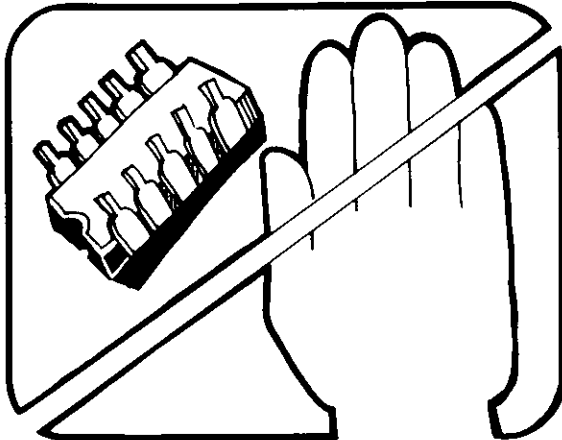
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

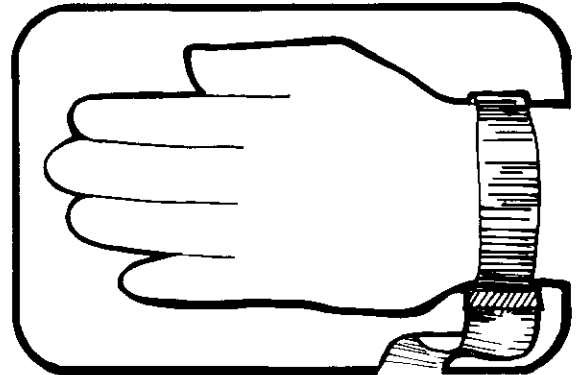
The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol



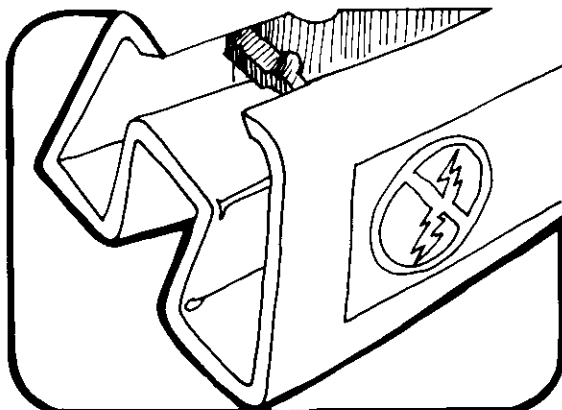
The following practices should be followed to minimize damage to S.S. devices.



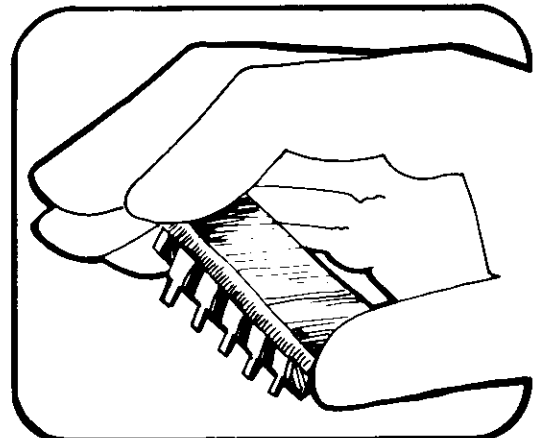
1. MINIMIZE HANDLING



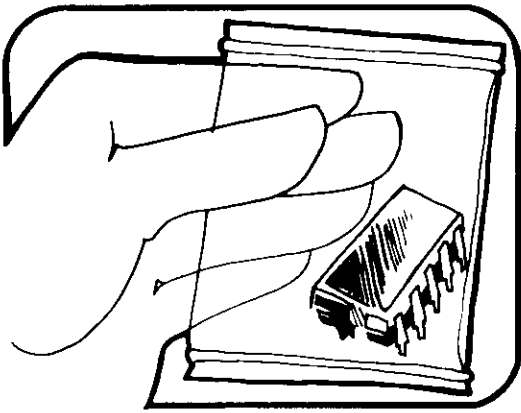
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES



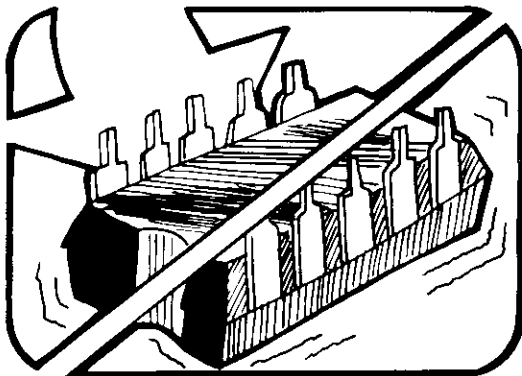
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



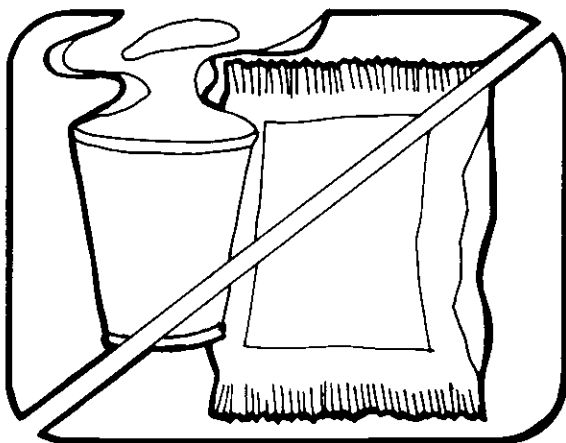
4. HANDLE S.S. DEVICES BY THE BODY



5. USE ANTI-STATIC CONTAINERS FOR HANDLING AND TRANSPORT

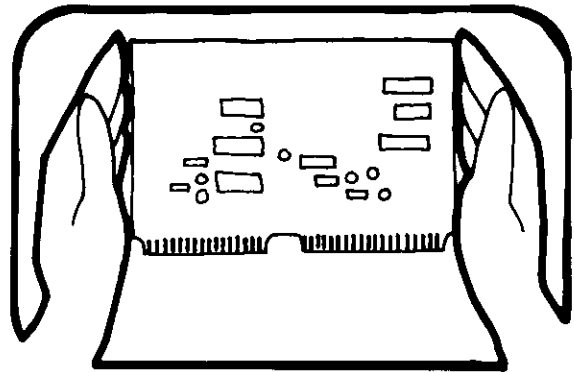


6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE

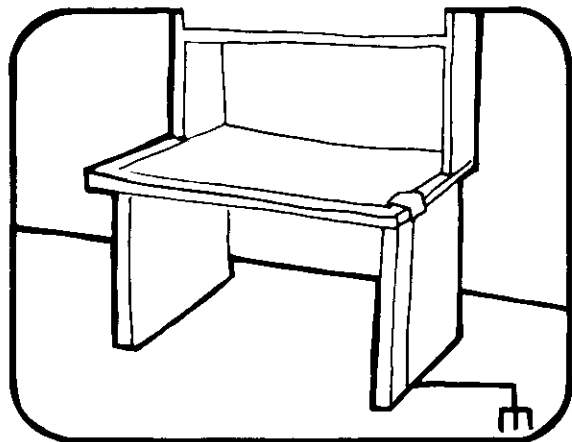


7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA

PORTIONS REPRINTED
WITH PERMISSION FROM TEKTRONIX, INC.
AND GENERAL DYNAMICS, POMONA DIV.



8. WHEN REMOVING PLUG-IN ASSEMBLIES, HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR USUALLY PROVIDES COMPLETE PROTECTION TO INSTALLED SS DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION
10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.
11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

Anti-static bags, for storing S.S. devices or pcbs with these devices on them, can be ordered from the John Fluke Mfg. Co., Inc.. See section 5 in any Fluke technical manual for ordering instructions. Use the following part numbers when ordering these special bags.

John Fluke Part No.	Description
453522	6" X 8" Bag
453530	8" X 12" Bag
453548	16" X 24" Bag
454025	12" X 15" Bag
Pink Poly Sheet	Wrist Strap
30"x60"x60 Mil	P/N TL6-60
P/N RC-AS-1200	\$7.00
\$20.00	

Section 6 Maintenance

WARNING

THESE SERVICE INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY PROCEDURES IN THIS SECTION UNLESS YOU ARE QUALIFIED TO DO SO.

6-1. INTRODUCTION

This section presents maintenance information for the 8840A. The section includes a performance test, a calibration procedure, troubleshooting information, and other general service information.

Test equipment recommended for the performance test and calibration procedure is listed in Table 6-1. If the recommended equipment is not available, equipment that meets the indicated minimum specifications may be substituted.

6-2. PERFORMANCE TEST

This test compares the performance of the 8840A with the specifications given in Section 1. The test is recommended as an acceptance test when the instrument is first received, and as a verification test after performing the calibration procedure. If the instrument does not meet the performance test, calibration or repair is needed.

To ensure optimum performance, the test must be performed at an ambient temperature of 18°C to 28°C, with a relative humidity of less than 75%. Also, the 8840A should be allowed to warm up for one hour prior to beginning any test other than the self-test.

6-3. Diagnostic Self-Tests

The diagnostic self-tests check the analog and digital circuitry in the 8840A. There are 21 analog tests followed by the power-up self-test, which consists of five digital tests. Each test is described in detail under the heading Troubleshooting.

NOTE

The inputs must be left open-circuited while the self-tests are performed. Otherwise, the 8840A may indicate errors are present. Errors may also be caused by inductive or capacitive pick-up from long test leads.

If the FRONT/REAR switch is in the REAR position, the 8840A skips tests 3 and 4. Also, if Option -09 is not installed, the 8840A skips tests 1, 2, and 3.

To initiate the self-tests, press the SRQ button for 3 seconds. The TEST annunciator will then light up, and the 8840A will run through the analog tests in sequence. Each test number is displayed for about 1 second. The instrument can be stopped in any of the test configurations by pressing the SRQ button while the test number is displayed. Pressing any button continues the tests.

After the last analog test is performed, all display segments light up while the instrument performs the power-up self-test. The instrument then assumes the power-up configuration: VDC, autorange, slow reading rate, offset off, local control.

If the 8840A detects an error during one of the tests, it displays the ERROR annunciator and the test number for about 2-1/2 seconds, and then proceeds to the next test. The test number thus becomes an error code. (Error codes are listed in Table 2-1, Section 2.)

Passing all diagnostic self-tests does not necessarily mean the 8840A is 100% functional. The test, for example, cannot check the accuracy of the analog circuitry. If one or more errors are displayed, the 8840A probably requires service.

6-4. DC Voltage Test

The following procedure may be used to verify the accuracy of the VDC function:

1. Ensure the 8840A is on and has warmed up for at least 1 hour.

Table 6-1. Recommended Test Equipment

INSTRUMENT TYPE	MINIMUM SPECIFICATIONS	RECOMMENDED MODEL	
DC Calibrator	PREFERRED: Voltage Range: 0-1000V dc Voltage Accuracy: 10 ppm Absolute Linearity: ±1.0 ppm	Fluke 5440A	
	ALTERNATIVE: (Must be used with Kelvin-Varley Voltage Divider) Voltage Range: 0-1000V dc Voltage Accuracy: 20 ppm + 20 ppm of range Kelvin-Varley Voltage Divider: Ratio Range: 0-1.0 Absolute Linearity: ±1 ppm of input at dial setting	Fluke 343A Fluke 720A	
Resistor Decade	Resistance Accuracy: 0.005%	Fluke 5450A, ESI DB62	
DC Current Source	Accuracy: ±0.025%	Fluke 5100B or Fluke 382	
Oscilloscope	General purpose, 60 MHz, with 10 MΩ probe	Tektronix 2213, 2215, 465A, 465B, or 475	
Digital Multimeter	Voltage Accuracy: 0.01% in V dc 1.0% for 1V in V ac @ 100 kHz Input Impedance: 10 MΩ or greater in V dc; 1 MΩ or greater in parallel with <100 pF in V ac	Fluke 8840A (with AC Option -09), Fluke 8860A, or Fluke 8810A (with AC Option -08 or -09)	
AC Calibrator		Fluke 5200A and Fluke 5205A	
Minimum Required Accuracy (By Range)			
Frequency Range	1, 10, 100 mV¹	1, 10, 100V²	1000V²
20 Hz-30 Hz	.1 + .005	.1 + .005	.12 + .005
30 Hz-20 kHz	.02 + 10	.02 + .002	.04 + .004
20 kHz-50 kHz	.05 + 20	.05 + .005	.08 + .005
50 kHz-100 kHz	.05 + 20	.05 + .005	.1 + .01
1. ±(% of setting + μV 2. ±(% of setting + % of range)			
AC Current Source		Fluke 5100A or Fluke 5220A	
	Frequency Range	Minimum Required Accuracy (All Ranges)	
	30 Hz-1 kHz	±(.07% + 1 mA)	
	1 kHz-5 kHz	±(.07% + 1 mA) X frequency in kHz	
Shorting Bar	Resistance: <1.5 mΩ Construction: Soldered (not rivetted)	Pomona MDP-S-0	
6-Inch Jumper	--	E-Z-Hook 204-6W-S or equivalent	

2. Select the VDC function.
3. Connect the DC Calibrator (see Table 6-1) to provide a voltage input to the HI and LO INPUT terminals. If using the Fluke 343A and the Kelvin-Varley Voltage Divider instead of the Fluke 5440A, connect the test leads as shown in Figure 6-1.
4. For each step in Table 6-2, select the indicated range, set the DC Calibrator for the specified input, and verify that the displayed reading is within the limits shown for each reading rate. (For step A, connect a short across the HI and LO INPUT terminals and press OFFSET. The measurement in step C should be relative to this offset.)

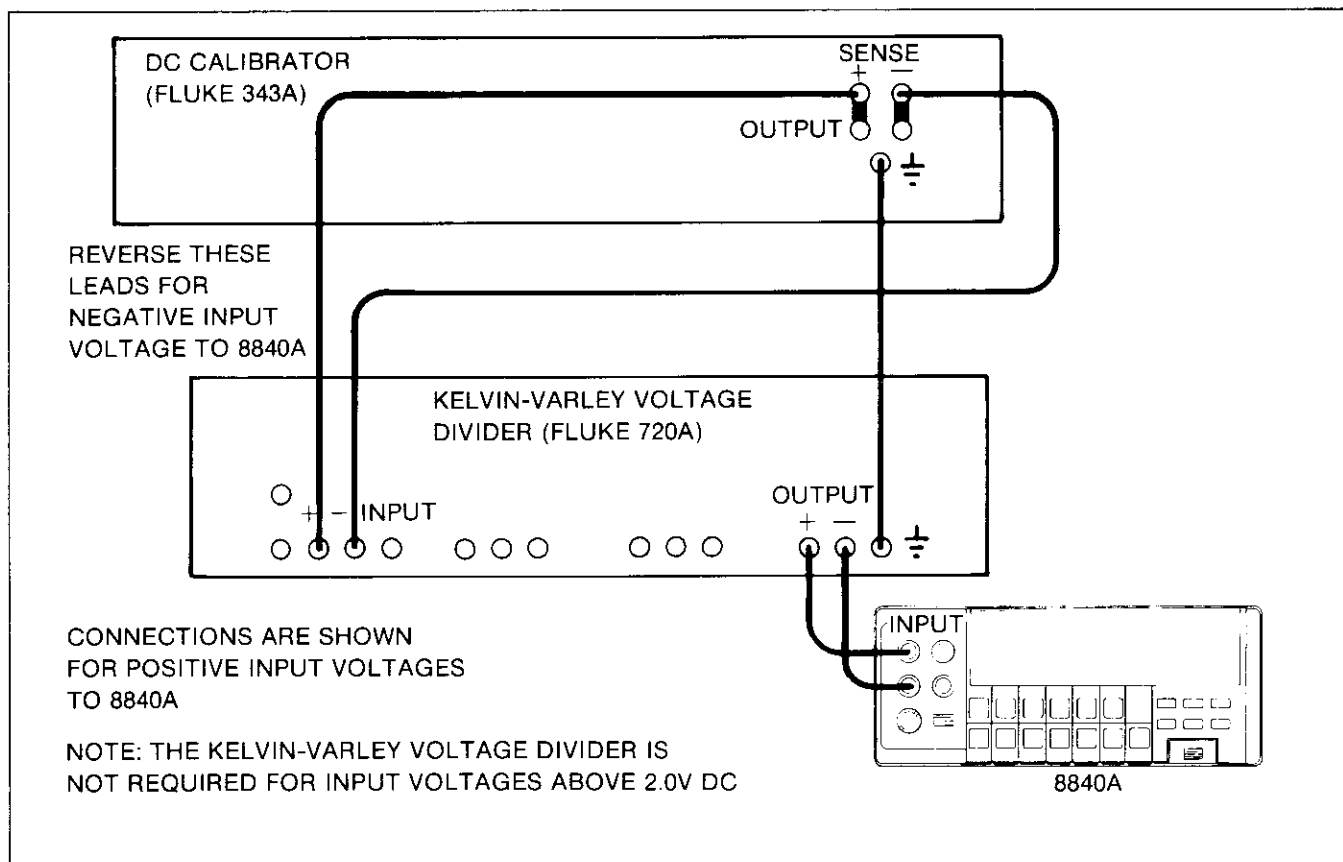


Figure 6-1. Connections for Kelvin-Varley Voltage Divider

Table 6-2. DC Voltage Test

STEP	RANGE	INPUT (V dc)	DISPLAYED READING					
			SLOW		MEDIUM		FAST	
			MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
A ¹	200 mV	0V (short)	-00.004	+00.004	-00.006	+00.006	-00.02	+00.02
B	2V, 20V, 200V, 1000V	0V (short)	-3 counts	+3 counts	-5 counts	+5 counts	-2 counts	+2 counts
C ¹	200 mV	100 mV	+99.989	+100.011	+99.987	+100.013	+99.97	+100.03
D	2V	1V	+99993	+1.00007	+99991	+1.00009	+9997	+1.0003
E	20V	10V	+9.9992	+1.00008	+9.9990	+10.0010	+9.997	+10.003
F	200V	100V	+99.992	+100.008	+99.990	+100.010	+99.97	+100.03
G	1000V	1000V	+999.92	+1000.08	+999.90	+1000.10	+999.7	+1000.3

1. Relative to high-quality short stored using OFFSET feature.

- Set the DC Calibrator for zero volts and disconnect it from the 8840A.

6-5. AC Voltage Test (Option -09 Only)

The following procedure may be used to verify the accuracy of the VAC function:

- Perform the Initial Procedure, above.
- Select the VAC function and the slow (S) reading rate.
- Connect the AC Calibrator to provide a voltage input to the HI and LO INPUT terminals.
- (Low- and Mid-Frequency Test.) For each step in Table 6-3, select the indicated range, set the AC Calibrator for the specified input, and verify that the displayed reading is within the limits shown for each reading rate.

NOTE

This procedure tests the extremes of each range. You may shorten the procedure by testing only the "quick test points" indicated in Table 6-3 with asterisks.

- (High-Frequency Test.) For each step in Table 6-4, select the indicated range, set the AC Calibrator for the specified input, and verify that the displayed reading is within the limits shown for each reading rate.

NOTE

This procedure tests the extremes of each range. You may shorten the procedure by testing only the "quick test points" indicated in Table 6-4 with asterisks.

- Disconnect the AC Calibrator from the 8840A.

Table 6-3. Low- and Mid-Frequency AC Voltage Test

STEP NUMBER	RANGE	INPUT		ERROR IN COUNTS	TEST LIMITS (IN VOLTS)	
		VOLTAGE	FREQUENCY		MINIMUM	MAXIMUM
1	2V	0.01000V	100 Hz	201	0.00799	0.01201
2	2V	0.10000V	100 Hz	114	0.09886	0.10114
3*	2V	0.30000V	100 Hz	142	0.29858	0.30142
4	2V	1.00000V	100 Hz	240	0.99760	1.00240
5*	2V	1.90000V	100 Hz	366	1.89634	1.90366
6	2V	0.10000V	20 Hz	220	0.09780	0.10220
7	2V	1.90000V	20 Hz	2380	1.87620	1.92380
8	2V	0.10000V	45 Hz	135	0.09865	0.10135
9	2V	1.90000V	45 Hz	765	1.89235	1.90765
10 *	200 mV	0.001000V	100 Hz	201	0.000799	0.001201
11	200 mV	0.190000V	20 kHz	366	0.189634	0.190366

*Quick test points.

Table 6-4. High-Frequency AC Voltage Test

STEP NUMBER	RANGE	INPUT		ERROR IN COUNTS	TEST LIMITS (IN VOLTS)	
		VOLTAGE	FREQUENCY		MINIMUM	MAXIMUM
1	200 mV	0.010000V	50 kHz	169	0.009831	0.010169
2*	200 mV	0.010000V	100 kHz	350	0.009650	0.010350
3*	2V	0.10000V	100 kHz	350	0.09650	0.10350
4*	20V	1.0000V	100 kHz	350	0.9650	1.0350
5*	200V	10.000V	100 kHz	350	9.650	10.350
6*	700V	100.00V	100 kHz	350	96.50	103.50
7	20V	19.0000V	100 kHz	1250	18.8750	19.1250
8	200 mV	0.190000V	100 kHz	1250	0.188750	0.191250

*Quick test points.

6-6. Resistance Test

The following procedure may be used to verify the accuracy of the 2-wire and 4-wire ohms functions.

1. Ensure the 8840A is on and has warmed up for at least 1 hour.
2. Connect the Resistor Decade to the 8840A for 4-wire ohms.
3. For each step in Table 6-5, select the indicated range, set the Resistor Decade for the specified nominal input, and proceed as follows:
 - A. Test the 4-wire ohms function:
 1. Select the 4-wire ohms function.
 2. Verify that the displayed reading is within the limits shown for each reading rate.
 - B. Test the 2-wire ohms function:
 1. Select the 2-wire ohms function. (The SENSE test leads need not be disconnected.)
 2. Zero the test lead resistance by pressing the OFFSET switch while shorting the HI and LO INPUT test leads together.
 3. Verify that the displayed reading is within the limits shown for each reading rate.

Table 6-5. Resistance Test

STEP	RANGE	INPUT (Nominal)	ERROR FROM INPUT (In Counts)		
			SLOW	MEDIUM	FAST
1	200Ω	0Ω (short)	±4	±6	±3
2	2 kΩ	0Ω (short)	±3	±5	±2
3	20 kΩ	0Ω (short)	±3	±5	±2
4	200 kΩ	0Ω (short)	±3	±5	±2
5	2000 kΩ	0Ω (short)	±3	±6	±2
6	20 MΩ	0Ω (short)	±3	±6	±2
7	200Ω	100Ω	±15	±17	±4
8	2 kΩ	1 kΩ	±13	±15	±3
9	20 kΩ	10 kΩ	±13	±15	±3
10	200 kΩ	100 kΩ	±13	±15	±3
11	2000 kΩ	1 MΩ	±30	±33	±5
12	20 MΩ	10 MΩ	±47	±50	±6

6-7. DC Current Test

The following procedure may be used to test the mA DC function:

1. Ensure the 8840A is on and has warmed up for at least 1 hour.
2. Select the mA DC function.
3. Connect the Current Source to the 2A and LO INPUT terminals.
5. For each step in Table 6-6, set the Current Source for the indicated input and verify that the displayed reading is within the limits shown for each reading rate.
6. Set the Current Source for zero mA and disconnect it from the 8840A.

6-8. AC Current Test (Option -09 Only)

The following procedure may be used to test the mA AC function:

1. Perform the Initial Procedure, above.
2. Select the mA AC function.
4. Connect the AC Current Source to provide a current input to the 2A and LO INPUT terminals. If an ac current source is not available, the functionality of the 8840A can be checked at 10 mA by using a Fluke 5200A set at 100V and connected to the 8840A 2A terminal through a 10 kΩ, 2W, 1% resistor.
5. For each step in Table 6-7, set the AC Current Source for the indicated input and verify that the displayed reading is within the limits shown for each reading rate.
6. Disconnect the Current Source from the 8840A.

6-9. CALIBRATION**CAUTION**

To avoid uncalibrating the 8840A, never toggle power on or off while the CAL ENABLE switch is on.

The 8840A features closed-case calibration using known reference sources. The 8840A automatically prompts you for the required reference sources, measures them, calculates correction factors, and stores the correction factors in the nonvolatile calibration memory.

Closed-case calibration has many advantages. There are no parts to disassemble, no mechanical adjustments to make, and if the IEEE-488 Interface is installed, the 8840A can be calibrated by an automated instrumentation system.

The 8840A should normally be calibrated on a regular cycle, typically every 90 days or 1 year. The frequency of the calibration cycle depends on the accuracy specification you wish to maintain. The 8840A should also be calibrated if it fails the performance test or has undergone repair. To meet the specifications in Section 1, the 8840A should be calibrated with equipment meeting the minimum specifications given in Table 6-1.

The following paragraphs first present a basic calibration procedure. This is followed by a description of advanced features and special considerations, and by a description of remote calibration using the IEEE-488 Interface.

6-10. Basic Calibration Procedure

The basic calibration procedure consists of the following four parts. These parts must be performed in the order shown.

1. Initial Procedure.
2. A/D Calibration.
3. Offset and Gain Calibration for each function and range.

4. High-Frequency AC Calibration (True RMS AC option only).

Normally, it is recommended that the entire calibration procedure be performed. However, under some circumstances the earlier parts may be omitted. For example, if installing the True RMS AC option, it may be necessary only to perform Offset and Gain Calibration for the ac functions, followed by High-Frequency AC Calibration. But if the A/D Calibration is performed, it must be followed by a complete Offset and Gain Calibration for all functions and then by High-Frequency AC Calibration.

Some of the calibration calculations are complex and take the 8840A some time to execute. For example, when you store the zero input during the Offset and Gain Calibration for the VDC function, it takes around 22 seconds before the next prompt appears. (The 8840A automatically uses this input to calibrate the offset for all ranges.) While the 8840A is executing a calibration step, it ignores all of the front panel buttons.

6-11. INITIAL PROCEDURE

Always begin the calibration procedure as follows:

1. Allow the 8840A to stabilize in an environment with ambient temperature of 18°C to 28°C and relative humidity less than 75%.
2. Turn the 8840A on and allow it to warm up for at least 1 hour.

Table 6-6. DC Current Test

STEP NUMBER	INPUT	DISPLAYED READING					
		SLOW		MEDIUM		FAST	
		MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
1	0 mA	-000.04	+000.04	-000.06	+000.06	-000.2	+000.2
2	1000 mA dc	-999.56	+1000.44	-999.54	+1000.46	-999.4	+1000.6

Table 6-7. AC Current Test

STEP NUMBER	RANGE	INPUT		TEST LIMITS	
		CURRENT	FREQUENCY	MINIMUM	MAXIMUM
1	2000 mA	1900.00 mA	1 kHz	1890.40	1909.60
2	2000 mA	100.00 mA	1 kHz	97.60	102.40

3. Enable the calibration mode by pressing the CAL ENABLE switch with a small screwdriver or other suitable instrument. (The CAL ENABLE switch is located on the right side of the display and is normally covered by a calibration seal.)

When the calibration mode is enabled, the CAL annunciator lights up, and the 8840A displays the first prompt for the A/D Calibration procedure (Figure 6-2). To exit the calibration mode, press the CAL ENABLE switch again.

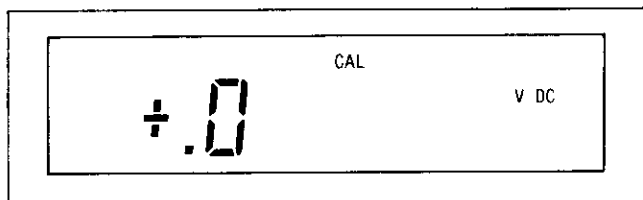


Figure 6-2. First A/D Calibration Prompt

In the calibration mode, the front panel controls assume the functions described in Figure 6-3. Some of these functions are advanced features and are not required for the basic calibration procedure. The display blanks briefly when a button is pressed.

The following functions are inappropriate during calibration, and are therefore unavailable:

- Offset
- Autoranging
- External Trigger
- Front Panel Trigger
- Front panel SRQ (Under local control)
- Diagnostic self-tests

Function Buttons	Each button selects the Offset and Gain Calibration procedure for the respective function.
Range Buttons	These buttons have two functions. Normally, pressing a range button selects the Offset and Gain Calibration procedure for that range in the presently selected function. When using the variable input feature, these buttons are used to increment the digits of the displayed prompt. The range buttons are ignored during the A/D Calibration procedure.
STORE	Tells the 8840A that the input it is requesting is now present at the input terminals. Pressing the STORE button causes the 8840A to compute and store calibration constants.
A/D	Selects the A/D Calibration procedure.
HF AC	Selects the High-Frequency AC Calibration procedure.
ERASE	Used to erase calibration constants from calibration memory. To complete an erasure of all or part of calibration memory, you must press another button within 1½-seconds of pressing this button.
CAUTION	
If any part of calibration memory is erased, all or part of the calibration procedure must be performed.	
RATE	Changes the reading rate. Valid only when the 8840A is taking verification readings. Ignored at other times.
VAR IN	Allows the use of reference sources that differ from the prompted values. After pressing VAR IN (variable input), the range buttons can be used to change the displayed prompt. The variable input feature is not available during the A/D Calibration procedure.

Figure 6-3. Calibration Functions

6-12. A/D CALIBRATION

The A/D Calibration procedure calibrates the analog-to-digital converter for offset, gain and linearity. The 8840A automatically selects the A/D calibration procedure when the CAL ENABLE switch is first pressed. The procedure must be performed in its entirety, and may not be performed in part.

To perform A/D Calibration, proceed as follows:

1. Ensure the Initial Procedure has been completed. The 8840A then displays the prompt for the first reference source, zero volts (i.e., a short).
2. Each time the 8840A prompts you for a reference source, apply the requested source to the HI and LO INPUT terminals, and press the STORE button. When STORE is pressed, the numeric display field blanks while the 8840A performs the necessary calculations. (Do not change the reference source while the display is blank.) The 8840A then displays the next prompt. For reference, all prompts are shown in Table 6-8.

Table 6-8. A/D Calibration

STEP	DISPLAYED PROMPT
A	.0 V DC (short)
B	- .03 V DC
C	- 1.01 V DC
D	+ .99 V DC
E	+ .51 V DC
F	- .51 V DC
G	- .26 V DC
H	+ .26 V DC
I	+ .135 V DC
J	- .135 V DC
K	- .0725 V DC
L	+ .0725 V DC

NOTE

The 8840A automatically checks that the reference input is near the value prompted, and displays ERROR 41 if it exceeds a specific tolerance. (See Advanced Features and Special Considerations, later in this section.)

3. After the last input is stored, the 8840A begins taking readings in the 2V range of the VDC function. (The CAL annunciator remains on.) Verify the A/D calibration using the test points in Table 6-9. If you wish to repeat the A/D Calibration procedure, press the A/D button.

The A/D Calibration procedure is an iterative process. Each pass through the procedure uses the constants stored previously and improves them. Normally, one pass is adequate. However, if the calibration memory has been erased or replaced, or the A/D Converter has undergone repair, the A/D Calibration procedure must be performed twice.

Because the A/D Calibration procedure is iterative, the instrument's performance can be slightly enhanced by going through the procedure more than twice. However, this is not necessary to meet the published specifications.

Table 6-9. A/D Calibration Test

STEP	INPUT	ALLOWABLE ERROR
A	0V (short)	±2 counts
B	-0.03V	±2 counts
C	+0.03V	±2 counts
D	-0.660V	±3 counts
E	+0.660V	±3 counts
F	-1.970V	±4 counts
G	+1.970V	±4 counts

6-13. OFFSET AND GAIN CALIBRATION

This procedure calibrates the instrument's offsets and gains by applying a high and low input for every range of each function. To save time, the 8840A uses each input for as many ranges as possible.

A function is calibrated by pressing the corresponding function button. Once a function is selected, the 8840A automatically steps through each range of that function, prompting you for the necessary reference sources. (The prompts are shown in Table 6-10.) The 8840A does not automatically select another function after one function has been completely calibrated; therefore, the functions may be calibrated in any order.

To perform Offset and Gain Calibration, proceed as follows:

1. Ensure the A/D Calibration procedure has been completed.

2. Select the desired function by pressing the corresponding function button. The 8840A will display the first prompt for that function.
3. Each time the 8840A prompts you for a reference source, apply this source to the appropriate terminals, and press the STORE button. When STORE is pressed, the numeric display field blanks while the 8840A performs the necessary calculations. (Do not change the reference source while the display is blank.) The 8840A then displays the next prompt. For reference, all prompts are shown in Table 6-10.

NOTE

To use reference sources that differ from the prompted values, see *Storing Variable Inputs* later in this section.

4. After the last range is calibrated, the 8840A begins taking readings in the highest range so that you may verify its calibration. (The CAL annunciator remains on.) To verify the calibration for the other ranges, press the corresponding range button. (Pressing a function button begins the Offset and Gain Calibration procedure for that function.)
5. Repeat steps 2, 3, and 4 for the remaining functions. Note that both 2-wire and 4-wire ohms functions must be calibrated. (The VAC and mA AC functions require calibration only if the True RMS AC option is installed.)

NOTE

(True RMS AC option only.) The VAC and mA AC functions should normally be calibrated using reference sources at 1 kHz ($\pm 10\%$). For special applications, performance may be optimized at other frequencies. See *Optimizing AC Calibration at Other Frequencies*, later in this section.

6. When all functions have been calibrated, exit the calibration mode by pressing the CAL ENABLE switch and attach a calibration certification sticker over the CAL ENABLE switch. (If the True RMS AC option is installed, instead proceed to the High-Frequency AC Calibration procedure which follows.)

6-14. HIGH-FREQUENCY AC CALIBRATION

The High-Frequency AC Calibration procedure calibrates the response of the VAC function from 20 kHz to 100 kHz. If the True RMS AC option is not installed, selecting this procedure results in an error message.

The reference sources used in this procedure should normally be between 90 kHz and 100 kHz. 100 kHz (nominal) is recommended. For special applications, performance may be optimized at other frequencies. See *Optimizing AC Calibration at Other Frequencies*, later in this section.

Table 6-10. Offset and Gain Calibration

STEP	DISPLAYED PROMPT				
	VDC	VAC ¹	2 WIRE k Ω 4 WIRE k Ω	mA DC	mA AC ¹
A	+00.0 mV DC (short)	10.0 mV AC	0.00 Ω (short)	00.0 mA DC (open)	100. mA AC
B	+190.0 mV DC	100.0 mV AC	100.0 Ω	1000. mA DC	1000 mA AC
C	+1.900 V DC	1.000 V AC	1.000 k Ω	Steps C-G not applicable for these functions.	
D	+19.00 V DC	10.00 V AC	10.00 k Ω		
E	+190.0 V DC	100.0 V AC	100.0 k Ω		
F	+1000. V DC	500. V AC	1000. k Ω		
G	Step G not applicable for these functions.		10.00 M Ω		

1. Inputs should be at 1 kHz $\pm 10\%$. Performance may be enhanced for specific frequencies (see text).

To perform High-Frequency AC Calibration, proceed as follows:

1. Ensure Offset and Gain Calibration has been completed for the VAC function.
2. Select the High-Frequency AC Calibration procedure by pressing the HF AC button. The 8840A will display the first prompt (100 mV AC). The "U" in the display indicates the High-Frequency AC Calibration procedure has been selected.
3. Each time the 8840A prompts you for a reference amplitude, apply this amplitude to the HI and LO INPUT terminals, and press the STORE button. When STORE is pressed, the numeric display field blanks while the 8840A performs the necessary calculations. (Do not change the reference source while the display is blank.) The 8840A then displays the next prompt. For reference, all prompts are shown in Table 6-11.

NOTE

To use reference amplitudes that differ from the prompted values, see Storing Variable Inputs later in this section.

4. After the last range is calibrated, the 8840A begins taking readings in the highest range so that you may verify its calibration. To verify the calibration for the other ranges, push the corresponding range button. The CAL annunciator remains on.
5. The calibration procedure is now completed. Exit the calibration mode by pressing the CAL ENABLE switch, and attach a calibration certification sticker over the CAL ENABLE switch.

Table 6-11. High-Frequency AC Calibration

STEP	DISPLAYED PROMPT ^{1 2}
A	100.0 mV AC
B	1.000 V AC
C	10.00 V AC
D	100.0 V AC
E	200.0 V AC

NOTES:

1. The display also indicates "U" to show that HF AC cal is selected.
2. Inputs should be between 90 kHz and 100 kHz. 100 kHz (nominal) is recommended.

6-15. Advanced Features and Special Considerations

The 8840A has several advanced calibration features which are not necessary for the basic calibration procedure, but which can make calibration easier. The following paragraphs describe these features and also discuss special considerations for optimizing the performance of the 8840A in special situations.

6-16. STORING VARIABLE INPUTS

As a convenience, the VAR IN (variable input) feature lets you calibrate the 8840A using reference source values which differ from the values prompted by the 8840A. For example, you may want to calibrate the 200Ω range using a reference resistor with a precisely known value of 99.875Ω, rather than 100Ω as prompted. This feature is not available during A/D Calibration.

To use the variable input feature, proceed as follows:

1. When the 8840A prompts you for an input, press the VAR IN button. The blank digits will be replaced with zeroes. You can then increment each digit of the display by pressing the range buttons. The 200Ω/mV button toggles the displayed sign.
2. Change the displayed prompt to correspond to the desired reference source by pressing the appropriate range buttons.
3. Connect the desired reference source to the appropriate input terminals of the 8840A.
4. Press the STORE button.

To meet the specifications over all ranges, the reference source for the high prompts must be between half and full scale. (The high prompts are those prompts that are between 50% and 100% of full scale.) The reference source for the low prompts must be equal to or greater than the prompted value, but not more than that value plus 4000 counts. (The low prompts are those prompts that are zero or 5% of full scale.)

For special applications, the 8840A can be calibrated at values outside the recommended range. This can enhance the performance at the calibration value. However, performance at other values may be degraded.

6-17. CALIBRATING INDIVIDUAL RANGES

During Offset and Gain and High-Frequency AC Calibration, it is possible to calibrate individually selected ranges. This feature does not apply to the mA DC and mA AC functions and is not permitted during A/D Calibration.

To calibrate an individual range, proceed as follows:

1. Select the desired calibration procedure by pressing the appropriate function button (or press the HF AC button if High-Frequency AC Calibration is desired).
2. Press the range button for the range to be calibrated. The 8840A then prompts for a low reference source for that range. (See Table 6-12.) (During High-Frequency AC Calibration, the 8840A prompts only for a high reference source. In this case, proceed to step 4.)
3. Apply the requested reference source and press STORE. The display will blank briefly and then prompt for a high reference source. (See Table 6-12.)
4. Apply the requested reference source and press STORE. The display will blank briefly, and the 8840A will then begin taking readings in the selected range so that you may verify the calibration. The CAL annunciator remains on.
5. To continue, select another range. You may restart any of the calibration procedures by pressing the appropriate function button, the A/D button, or the HF AC button.

Specifically, the 8840A begins taking verification readings after:

1. Completing A/D Calibration.
2. Completing Offset and Gain or High-Frequency AC Calibration.
3. Completing the calibration of an individually selected range.

While the 8840A is taking verification readings, certain buttons are active or function differently:

1. If you just completed the Offset and Gain or High-Frequency AC Calibration for an entire function (not just one range), the range buttons can be used to change ranges in order to verify all ranges were calibrated correctly.
2. If you just calibrated an individually selected range, pressing another range button begins the Offset and Gain Calibration procedure for the new range.
3. You can use the RATE button to verify the calibration at other reading rates.

CAUTION

It is still possible to erase the calibration memory while the 8840A is taking verification readings.

6-18. VERIFYING CALIBRATION

When you complete certain parts of the calibration procedure, the 8840A automatically begins taking readings so that you can verify the calibration is correct. (It is recommended that you do so.) The CAL annunciator remains lit. The 8840A continues to take readings until you select another calibration procedure or exit the calibration mode.

6-19. ERASING CALIBRATION MEMORY

The 8840A allows you to erase some or all of the correction constants stored in calibration memory (U220). It is recommended that you erase the entire calibration memory before beginning calibration if the calibration memory is replaced or accidentally altered. The capability of erasing particular parts of the memory is mainly intended as a troubleshooting aid to the technician.

Table 6-12. Prompts When Calibrating Individual Ranges

PROCEDURE	FUNCTION	LOW PROMPT	HIGH PROMPT
Offset and Gain Calibration	VDC	Zero	95% of full scale ¹
	kΩ	Zero	50% of full scale
	VAC	5% of full scale ²	50% of full scale ²
High-Frequency AC Calibration	(Not applicable)	(No low prompt)	50% of full scale ³

1. Exception: The 1000V dc range has a high prompt of 1000V dc.
2. Exception: The 700V ac range has a low prompt of 100V ac and a high prompt of 500V ac.
3. Exception: The 700V ac range has a prompt of 200V ac.

CAUTION

Once the calibration memory is erased, the 8840A must be recalibrated.

To erase all or part of the calibration memory, proceed as follows:

1. Press the front panel ERASE button. The display should show the erase prompt "C1" (for "clear"). If you do not press another button within 1-1/2 seconds, the 8840A returns to its previous state.
2. To complete an erasure, press one of the following buttons within 1-1/2 seconds of pressing the ERASE button:
 - a. STORE -- Erases the entire memory.
 - b. A/D -- Erases the A/D Calibration constants
 - c. Any function button -- Erases the Offset and Gain Calibration constants for all ranges of that function.
 - d. HF AC -- Erases the High-Frequency AC Calibration constants.

After an erasure is finished (a complete erasure takes about 3 seconds), the 8840A returns to one of the following states:

- a. After complete erasure: Begins A/D Calibration.
- b. After A/D erasure: Begins A/D Calibration.
- c. After Offset and Gain erasure: Begins Offset and Gain Calibration for erased function.
- d. After High-Frequency AC erasure: Begins High-Frequency AC Calibration.

6-20. TOLERANCE CHECK

The 8840A automatically checks that the reference input is near the value prompted. This minimizes common errors such as applying a reference source with the wrong sign. If the reference input exceeds the tolerances shown in Table 6-13, the 8840A displays ERROR 41.

If ERROR 41 occurs, the most likely cause is that the reference input is incorrect (e.g., has the wrong polarity).

If the input is in fact correct, refer to the Troubleshooting heading in this section.

6-21. AC CALIBRATION AT OTHER FREQUENCIES

For special applications where the 8840A is to be used to measure ac voltages or currents exclusively at a single frequency or narrow range of frequencies, accuracy may be enhanced at that frequency (or range of frequencies) by performing calibration according to the following procedure. Note that this may degrade the accuracy at frequencies significantly removed from the frequency of optimization.

To optimize performance at a frequency less than 1 kHz, perform the offset and gain calibration procedure, above, using the frequency at which measurements will be made rather than 1 kHz. This technique may be used for both the VAC and mA AC functions. At the calibration frequency, the 8840A will yield accuracy closely approaching the specified mid-band performance.

To optimize performance at a frequency greater than 1 kHz, perform calibration as follows:

1. Perform the Offset and Gain Calibration procedure using inputs at 1 kHz.
2. Perform the High-Frequency AC Calibration procedure using inputs at the desired frequency of optimization rather than at 100 kHz. Skip step 5 in that procedure.
3. Again perform the Offset and Gain Calibration procedure, this time using inputs at the desired frequency of optimization rather than at 1 kHz.

Table 6-13. Tolerance Limits

CALIBRATION	TOLERANCE
1. A/D Calibration	±100 counts from prompt
2. Offset and Gain Calibration	
VDC, mA DC	±500 counts from prompt
Ohms	±3000 counts from prompt
VAC, mA AC	±3000 counts from prompt
3. HF AC Calibration	±10000 counts from prompt

6-22. OPTIMIZING USE OF THE 5450A

If the Fluke 5450A Resistance Calibrator is used to calibrate the 2-wire ohms function, the following procedure is recommended to optimize the calibration of the lowest two ranges. (The 5450A has a 25 m Ω "floor" which would otherwise result in 25 digits of error in the 200 Ω range of the 8840.) In this procedure, the 8840A is referred to as the unit under test (UUT).

1. Complete Offset and Gain Calibration for the UUT's 4-wire ohms function. The UUT will then be taking verification readings.
2. Connect the UUT to the 5450A as shown in Figure 6-4.
3. Select the "SHORT" from the 5450A, and measure this value at the 5450A OUTPUT terminals using the UUT in 4-wire ohms. If in remote, take the average of four readings. (In remote calibration, the averaged value can be stored in the controller.) Record the value.
4. Select the "100 Ω " output from the 5450A, and measure this value as in step 3.
5. Find and record the numerical difference between the values measured in steps 3 and 4. This value will be used as the variable input for calibrating the 200 Ω range in 2-wire ohms.
6. Repeat steps 4 and 5 using the "1 k Ω " output from the 5450A; find and record the numerical difference between this and the "SHORT" measured in step 3. This value will be used as the the variable input for calibrating the 2 k Ω range in 2-wire ohms.
7. Press the UUT's 2 WIRE k Ω button (this selects the Offset and Gain calibration procedure for the 2-wire ohms function), select the "SHORT" from the 5450A.
8. Select the "100 Ω " output from the 5450A and calibrate the high point for the 200 Ω range, entering the value computed in step 5 as a variable input.
9. Select the "1 k Ω " output from the 5450A and calibrate the high point for the 2 k Ω range, entering the value computed in step 6 as a variable input.
10. Calibrate the remaining ranges (steps D-G of Table 6-10) using the 5450A outputs.
11. Recalibrate the low point for each 2-wire ohms range using a shorting link (Pomona MDP-S-0 or equivalent) across the UUT's HI and LO INPUT terminals.
12. Exit the calibration mode by pressing the CAL ENABLE switch.
13. Using the same configuration shown in Figure 6-4, verify that the UUT measures the same value (within 1 digit) in 2-wire ohms (using the offset feature to correct for 5450A floor error) as in 4-wire ohms. If the readings differ by more than 1 digit, reenable the calibration mode and repeat steps 2 through 8.
14. Cover the CAL ENABLE switch with a calibration certification sticker.

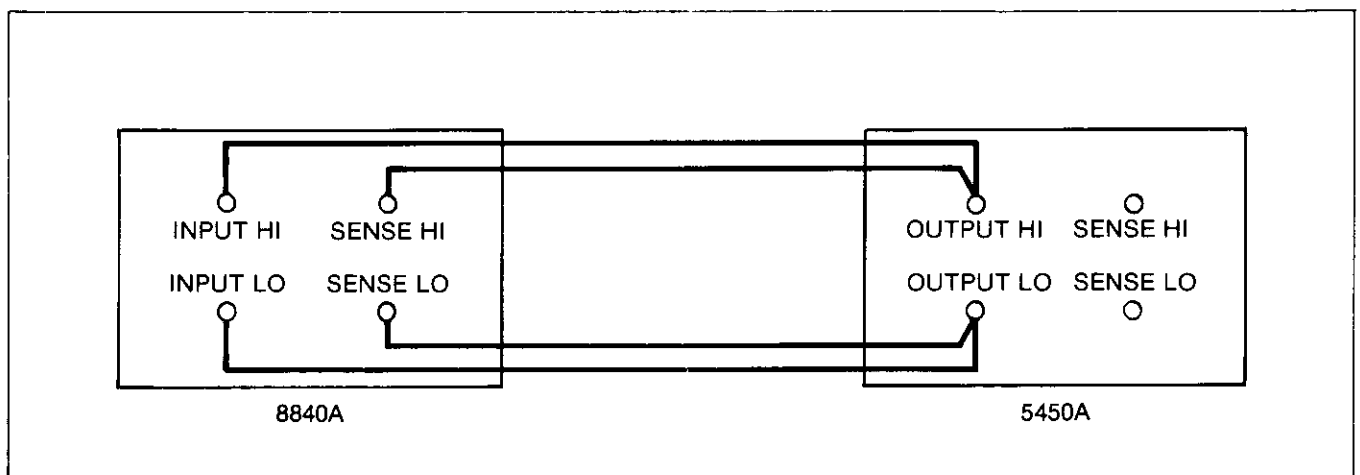


Figure 6-4. Optimizing Use of the 5450A

6-23. Remote Calibration

If the IEEE-488 Interface is installed, the 8840A can be calibrated under remote control. Remote calibration is very similar to local (front-panel controlled) calibration. Table 6-14 shows the remote commands which correspond to the front panel features.

To facilitate remote calibration, there are some differences from local calibration:

1. In remote calibration, you can store a 16-character message in the calibration memory which can be read by the system controller. Possible uses include storing the calibration date, instrument ID, etc.
2. Although some buttons are ignored in local calibration (e.g., the AUTO button), the corresponding commands (e.g., R0) load the output buffer with an error message.
3. The calibration memory is erased differently. (This is explained later.)
4. The rear panel SAMPLE COMPLETE signal acts slightly differently. During calibration, the signal is pulsed only when all of the readings for a particular calibration input are taken. Thus the 8840A might take several readings before pulsing the SAMPLE COMPLETE signal. This allows the SAMPLE COMPLETE signal to control the input to the 8840A during calibration. (When the 8840A is taking verification readings, the SAMPLE COMPLETE signal acts the same as in normal operation.)

Note that a command may be valid in some parts of the calibration procedure but not in others. The Get Input Prompt (G2) command, for instance, is not valid when the 8840A is taking verification readings. The Rate (Sn) commands, for instance, are valid when the 8840A is taking verification readings, but they are not valid at any other time during calibration. Table 6-15 shows when commands are invalid.

6-24. TIMING CONSIDERATIONS

The C0 command can take up to 22 seconds to execute. If during this time the controller continues to send the 8840A more commands, the commands may fill up the 8840A's input buffer and start to overwrite previous commands. If this happens, errors will probably occur.

You can avoid this problem by knowing when these commands are completed. There are three ways to determine this:

1. Monitoring the Cal Step Complete bit in the serial poll status register. This status bit is set false every time the remote processor sends a command to the in guard processor. It is then set true when the in guard processor completes the command and is ready to accept more. So you can send a command and loop on a check of the status, until the command is complete.
2. Setting the SRQ mask to generate an SRQ on Cal Step Complete. The Cal Step Complete bit in the serial poll status response indicates when a cal command in progress. This approach depends on capabilities of the controller being used.
3. Executing a delay in controller software after sending each command. (Not recommended.)

Although not usually necessary, these methods can be used for other commands as well.

6-25. REMOTE ERASURE

The C3 command allows you to erase the entire calibration memory. The erasure is executed by sending the string "C3 C0" (equivalent to pressing ERASE and then STORE). To facilitate remote calibration, the C0 command does not timeout as does the front panel ERASE button. The selective erasure that is possible from the front panel is intended as a troubleshooting aid, and is not available over the IEEE-488 Interface.

Note that the erase command can take up to 3 seconds to execute. To prevent timeout problems with the controller, you must determine when the command is completed before continuing. Several methods are presented in Timing Considerations, above.

NOTE

When erasing calibration memory, it is good practice to send the commands C3 and C0 in the same command string. Sending C3 by itself could lead to accidentally erasing calibration memory, since the C3 command does not time out as does the ERASE button.

6-26. EXAMPLE CALIBRATION PROGRAM

An example A/D calibration program is shown in Figure 6-5. The program is written in Fluke BASIC for the Fluke 1720A Instrument Controller. It uses the Fluke 5440A Direct Voltage Calibrator to perform and then verify the A/D Calibration procedure. In this program, the 8840A is at bus address 1, and the 5440A is at bus address 7.

Table 6-14. Commands Used During Remote Calibration

FRONT PANEL FEATURE	CORRESPONDING COMMAND	COMMENTS
Display	G2	Loads the calibration prompt into the output buffer. Not valid when the 8840A is taking verification readings.
Function Buttons	F1 through F6	In the calibration mode, these select the Offset and Gain Calibration procedure for the corresponding function.
Range	R1 through R6	In the calibration mode, these select the Offset and Gain Calibration procedure for the corresponding range in the presently selected function. (For entering variable inputs, see VAR IN below.)
STORE	C0	Tells the 8840A that the requested calibration input is valid. This command causes the 8840A to take readings, and compute and store calibration constants. NOTE The C0 command can take up to 22 seconds to execute. You must determine when this command is complete before sending more commands. See Timing Considerations in text.
A/D	C1	Selects the A/D Calibration procedure.
HF AC	C2	Selects the High-Frequency AC Calibration procedure.
ERASE	C3	After receiving this command the display shows the erase mode prompt ('C1'). (The prompt is not loaded into the output buffer.) To complete the erasure you must then send C0. Sending any other command after the C3 command causes the 8840A to return to its previous state. There is no timeout as with the front panel ERASE button. CAUTION The command string 'C3 C0' erases the entire calibration memory. A complete calibration must then be performed.
RATE	S0 through S2	Changes the reading rate while the 8840A is taking verification readings. Causes an error at any other time during calibration.
VAR IN	N(value)P2	Enters (value) as a variable input. (See Entering Variable Inputs, in text.) Causes an error if sent during A/D Calibration or when the 8840A is taking verification readings. You can check the command was successful by checking the error status, by sending the Get Calibration Input command (G2).
--	P3(string)	Puts the (string) into calibration memory. The string may contain up to 16 ASCII characters, and can be recalled with the G3 command.
NOTE: Other commands that may be used during calibration are: P1 (Put SRQ mask); the remaining Get commands; and X0 (Clear Error Register).		

Table 6-15. Times at Which Commands are Invalid

COMMAND	NORMAL OPERATING MODE (Calibration mode disabled)	CALIBRATION MODE			
		A/D CAL	OFFSET & GAIN CAL	HF AC CAL	VERIFICATION READINGS
Bn C0 C1 C2 C3	• • • •	•	•	•	• •
Dn Fn G0 G1 G2	•	•	•	•	• •
G3 G4 G5 G6 G7					
N P0 P1 P2 P3	• •	•	•	•	• •
Rn Sn Tn Wn X0		• • •	• •	• •	•
Yn Z0 * ?		• •	• •	• •	• •
• Command causes error					

6-27. DISASSEMBLY PROCEDURE

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE THE POWER CORD AND TEST LEADS BEFORE DISASSEMBLING THE INSTRUMENT.

CAUTION

To avoid contaminating the printed circuit assemblies (PCAs), handle the PCAs by their

edges. Do not handle the nonsoldermasked areas of the PCAs unless absolutely necessary. These areas must be cleaned if contaminated.

The following paragraphs present a disassembly procedure for the 8840A. The procedure must be performed in the order presented. Disassemble the case first, and then remove the True RMS AC PCA (Option -09 only), IEEE-488 Interface PCA (Option -05 only), Main PCA, and front panel. For reference, see the final assembly drawing in Section 7.

This program performs the A/D Calibration procedure and then verifies the A/D Calibration is correct. The program uses the Fluke 1722A Instrument Controller and the Fluke 5440A Direct Voltage Calibrator. The 8840A is at bus address 1, and the 5440A is at bus address 7.

```

10 DIM V(6)
20 DIM W(6)
30 DATA 0.0, 2, 0.03, 2, -0.03, 2, 0.66, 3, -0.66, 3, 1.97, 4, -1.97, 4
40 FOR A=0 TO 6 STEP 1 : LOOP TO READ IN VERIFICATION VALUES.
50 READ V(A),W(A)
60 NEXT A
70 INIT PORT 0          ! INITIALIZE SYSTEM. (THIS AND NEXT LINE.)

90 REMOTE @1
100 !GOTO 290           ! PROVIDES MEANS TO DO VERIFICATION ONLY.
110 PRINT "PUT 8840 IN CAL MODE, THEN HIT <RETURN>." ! INSTRUCTION NOTE.
120 INPUT Z$           ! STOP PROGRAM UNTIL <RETURN> IS HIT.
130 FOR M=1 TO 2       ! LOOP FOR NO. OF PASSES.
140 PRINT @7, "SOUT 0.0;OPER" ! SET 5440A OUTPUT TO 0.0
150 WAIT 1000
160 PRINT @1, "C1"      ! PUT 8840A IN A/D CAL.
170 FOR N=0 TO 11 STEP 1 ! CALIBRATION LOOP.
180 PRINT @1, "Q2"
190 INPUT @1,C          ! GET 8840A CAL PROMPTS.
200 IF C > 1000 GOTO 180 ! CLEARS POSSIBLE ERROR MESSAGE IN BUFFER.
210 PRINT "PASS", "STEP", "INPUT" ! LABELS.
220 PRINT M,N,C         ! DISPLAY PASS, STEP, INPUT VALUE.
230 PRINT @7, "SOUT";C ! SET OUTPUT OF 5440A.
240 WAIT 7500          ! SETTLING TIME FOR 5440A.
250 PRINT @1, "CO "    ! STORE CAL.
260 IF (SPL(1%) AND 8%) < > 8% GOTO 260 ! TEST 8840A FOR CAL STEP COMPLETE.
270 NEXT N
280 NEXT M
290 PRINT "VERIFICATION"
300 WAIT 3000
310 FOR T=0 TO 6 STEP 1 ! VERIFICATION LOOP.
320 PRINT @7, "SOUT";V(T) ! SET 5440A OUTPUT.
330 WAIT 7500          ! SETTLING TIME FOR 5440A.
340 INPUT @1,R         ! GET READING FROM 8840A.
350 R$ = NUM$(R, "S#. *****") ! THIS AND NEXT 3 LINES FORMATS DISPLAY.
360 IF MID(R$, 2, 1) = "0" THEN R$ = LEFT(R$, 1) + " " + RIGHT(R$, 3)
370 IF LEFT(R$, 1) = " " THEN R$ = " " + RIGHT(R$, 2)
380 PRINT R$           ! PRINTS DISPLAY.
390 IF ABS(R-V(T)) <= W(T)*1E-5+1E-6 THEN PRINT "PASS" ELSE PRINT "FAIL"
400 NEXT T
410 END

```

Figure 6-5. Example A/D Calibration Program

6-28. Case Disassembly

1. Remove the grounding screw from the bottom of the case. (See Figure 6-6.)
2. Remove the two rear panel mounting screws.
3. Holding the front panel, slide the case and rear bezel off of the chassis. (At this point, the rear bezel is not secured to the case.)

6-29. True RMS AC PCA Removal (Option -09 Only)

The True RMS AC PCA should be removed by reversing the last three steps in Figure 809-1 (see Section 8).

1. Release the True RMS AC PCA from the chassis by pulling the four nylon latches upward (Figure 809-1E).
2. Raising the True RMS AC PCA slightly, disconnect the red lead from the stud located on the Main PCA (Figure 809-1C).

3. Disconnect the ribbon cable from the Main PCA by releasing the ribbon connector latches outwards (Figure 809-1D) and pulling the ribbon cable directly outward from the connectors (Figure 809-1C).
4. Lift the True RMS AC PCA directly out of the chassis.

6-30. IEEE-488 Interface PCA Removal (Option -05 Only)

The IEEE-488 Interface PCA should be removed by reversing the last four steps in Figure 805-1 (see Section 8):

1. Remove the two screws and washers from the rear panel IEEE-488 connector (Figure 805-1H).
2. Release the IEEE-488 Interface PCA from the chassis by pulling the two nylon latches upward (Figure 805-1H).

5. Replace the push rod for the POWER switch as follows:
 - a. Insert the straight end of the push rod into the rear of the front panel.
 - b. Snap the other end of the push rod onto the POWER switch plunger. The rear of edge of the push rod should fit in the groove nearest the rear panel (Figure 6-10).
6. Turn the chassis so that the top side is facing upward.
7. Insert the FRONT/REAR switch push rod through the front panel and snap it into place.
8. Reinstall the CAL ENABLE switch push rod as follows:
 - a. Insert the straight end of the push rod into the rear of the front panel.
 - b. Rotate the push rod 90 degrees downwards and and snap it onto the CAL ENABLE switch plunger.
9. Position the Line Voltage Selection Switch PCA against the rear panel, secure it with the single mounting screw, and plug the ribbon cable into the Main PCA.

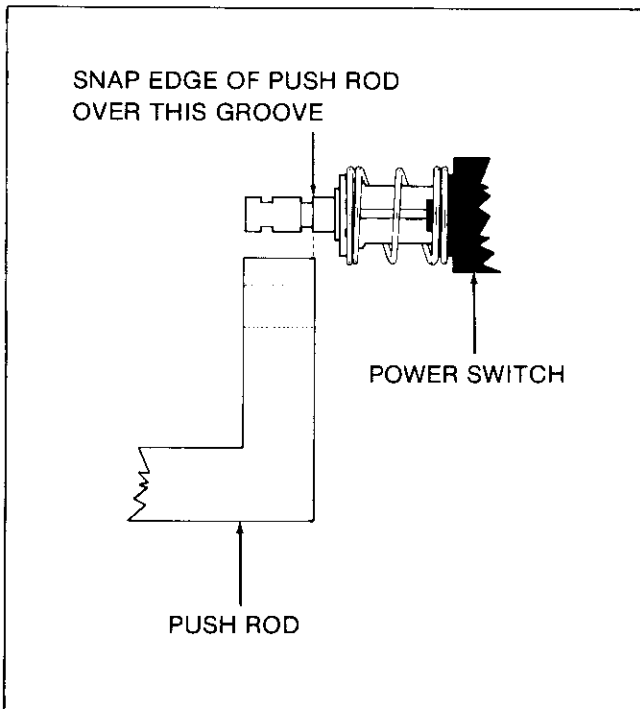


Figure 6-10. Installing The POWER Switch Push Rod

10. Connect the power supply ground lead to the rear panel mounting stud. (The stud is located near the rear panel power receptacle as shown in Figure 6-7.)

WARNING

TO AVOID ELECTRIC SHOCK, ENSURE THE POWER SUPPLY GROUND LEAD IS FIRMLY ATTACHED TO THE REAR PANEL MOUNTING STUD.

11. Attach the two mounting screws on either side of the rear panel power receptacle.
12. Connect the two ribbon cables to the Display PCA to the connectors. Push the cables straight in to avoid damage.
13. Reinstall the harness in the side-wall cable guide and fasten the harness to the cable clamps.
14. Connect the leads to the four front panel input terminals according to the color codes marked on the rear side of the Display PCA.
15. Connect the leads to the four rear panel input terminals following the color codes as shown in Figure 6-7.
16. Reinstall the front panel fuse and fuse cap in the front panel, rotating the fuse cap 1/4-turn counterclockwise.
17. (Option -05 only) Install the IEEE-488 Interface PCA according to the instructions in Section 8.
18. (Option -09 only) Install the True RMS AC PCA according to the instructions in Section 8.
19. Slide the case and rear bezel onto the chassis.
20. Attach the two rear panel mounting screws.
21. Attach the grounding screw to the bottom of the case.

WARNING

TO AVOID ELECTRIC SHOCK, ENSURE THE GROUNDING SCREW IS FIRMLY ATTACHED TO THE CASE BOTTOM.

6-34. INTERNAL FUSE REPLACEMENT**CAUTION**

For fire protection, use exact fuse replacements only.

The 8840A has an internal 3A 600V slow-blow fuse (F301) in series with the 2A input terminal. To replace this fuse, remove the case according to the disassembly instructions. The fuse is held in fuse clips on the Main PCA.

6-35. EXTERNAL TRIGGER POLARITY SELECTION (Option -05 Only)

The EXT TRIG input is factory-configured with negative polarity (trigger on falling-edge). This polarity is set by jumper E902 on the IEEE-488 Interface PCA. To select positive polarity (trigger on rising-edge), remove jumper E902 and add jumper E903.

6-36. TROUBLESHOOTING

The 8840A is designed to be easily maintained and repaired. Both the analog and digital circuits have built-in diagnostic self-tests and troubleshooting modes to facilitate troubleshooting and repair. The instrument's circuits allow troubleshooting and repair with basic electronic troubleshooting equipment such as a multimeter and oscilloscope. The troubleshooting mode in the digital controller circuitry generates special test signals to allow troubleshooting and repair without a special test signal generator or complex logic analyzer. Using the information in this section, a technician should be able to troubleshoot and repair the 8840A very efficiently.

6-37. Initial Troubleshooting Procedure**WARNING**

TO AVOID INJURY OR EQUIPMENT DAMAGE, USE EXACT REPLACEMENT PARTS FOR ALL PROTECTION COMPONENTS.

When a problem occurs in the 8840A, first verify the problem is actually in the instrument. If the problem occurs when the instrument is in a system, check to see if the same problem exists when under local control. Watch the display as the instrument is turned on to see if any of the digital self-test error codes appear indicating a digital failure. If the malfunction does not involve the True RMS AC or IEEE-488 options, remove the option(s) from the instrument before proceeding.

If the display lights up, perform the self-test by pressing the SRQ button for 3 seconds. (Remember, the input terminals must be disconnected from the test leads during the self-tests. Otherwise, the 8840A may indicate errors are present.) The test numbers will appear consecutively. "ERROR" will appear on the display if a test should fail. The 8840A can be held in each of the test configurations by momentarily pressing the SRQ button. (Press any button to continue the tests.) With the description of the self-tests given below, the section causing the failure can be isolated. For reference, the states of various switches and logic lines are shown in Table 6-16 for each function, range, and reading rate.

If only one or a few failures appear in the self-tests, the problem is usually in the DC Scaling circuit. By carefully analyzing which failure(s) occurred, the fault can be located to within a few components. (Table 6-17 shows which components are exercised by each of the analog tests.) The heading DC Scaling Troubleshooting provides detailed instructions on locating and repairing DC Scaling circuit problems. However, before troubleshooting the DC Scaling circuit, all of the power supply levels should be measured to verify they are within the limits specified in Table 6-23 under Power Supply Troubleshooting, later in this section.

Some failures will cause many self-tests to fail. If this occurs, the fault is usually in the Track/Hold circuit, the A/D Converter, the Digital Controller circuit, or the Power Supply. Again, measure all of the power supply levels according to the limits specified in Table 6-23. The next step is to isolate the problem to a specific section.

If the self-tests display a large number of errors or if readings are noisy and/or in error, the problem is usually in the A/D Converter or Track/Hold circuit. (A large number of errors can also be caused by a problem in the Ohms Current Source.) To isolate the problem, connect a jumper between TP103 and Reference Low (TP306, or the L-shaped shield around U202). The display should typically read less than approximately 35 counts (i.e., $\pm .000XX$ where XX is less than 35) on the 2V dc range. If a good reading can be obtained (less than approximately 35 counts), the A/D Converter and Precision Voltage Reference circuits are most likely good. A more conclusive test can be made by connecting a low-impedance dc source between Reference Low and TP103 with an output voltage between -2.0V and +2.0V. The reading on the display will be of opposite polarity to the voltage applied to TP103. (Disconnecting one end of R318 will usually make it possible to display readings within 0.1% to 0.5% of the actual input.) After it has been determined that the A/D Converter or the Track/Hold circuit is not functioning properly, proceed to the corresponding heading for detailed troubleshooting instructions and guidelines.

● TEST 3: mA AC, Zero

Configures the 8840A exactly as in the mA AC function and takes a reading of the voltage across the $0.1\ \Omega$ current shunt at the slow reading rate.

● TEST 4: mA DC, Zero

Configures the 8840A in the mA DC function and the slow reading rate, and measures the reading across the $0.1\ \Omega$ current shunt. This test should be fairly immune to outside noise because the total driving impedance is typically less than $1\ \text{k}\Omega$. The reading is not a perfect zero because of the offsets generated by charge injection of U302 and the T/H Amplifier (X10 configuration).

● TEST 5: 200 VDC, Zero

Configures the 8840A in the 200V dc range and slow reading rate. Input noise is divided by 100. Assuming no input of any kind, the T/H Amplifier is essentially shorted to ground by $100\ \text{k}\Omega$ and filtered by the 3-pole analog filter. Any non-zero reading under quiet input conditions is due to the offset of the T/H Amplifier (X1 configuration).

● TEST 6: 1000 VDC, Zero

Configures the 8840A exactly as in the 1000V dc range and slow reading rate, with input noise being divided by 1000. The reading is very close to zero because of the inherent $2\ \text{k}\Omega$ driving impedance to the T/H Amplifier (X1 configuration).

● TEST 7: 1000 VDC + 20 M Ω

Couples the 1000V dc range and $20\ \text{M}\Omega$ current source together. The result is nominally $500\ \text{nA}$ through the $10\ \text{M}\Omega$ input divider. Since the 1000V dc range senses this voltage at the divide-by-1000 point of the scaling circuit, the reading should be $5\ \text{mV}$, or 500 counts at the A/D Converter. This test could indicate an error if input capacitance is greater than $1000\ \text{pF}$.

● TEST 8: 20 VDC + 20 M Ω

Puts the DC Scaling circuit into the 20V dc range and the Ohms Current Source into the $20\ \text{M}\Omega$ range. The infinite input impedance of the 20V dc range causes the $20\ \text{M}\Omega$ current source to be clamped at its maximum open circuit voltage, typically 12V. The 20V dc range scales this voltage and presents the A/D Converter with 1.15V, or 115,000 counts. This is a good test to ensure that the maximum open-circuit voltage of the Ohms Current Source is less than 13V. This test is susceptible to capacitance greater than $0.01\ \mu\text{F}$ at the input terminals.

● TEST 9: 20 VDC + 2000 k Ω

Puts the DC Scaling circuit in the 20V dc range and the Ohms Current Source in the $2000\ \text{k}\Omega$ range. The infinite input impedance of the 20V dc range causes the $2000\ \text{k}\Omega$ current source to be clamped at typically 11.5V. The reading at the A/D Converter should be 1.15V. Again tests that the maximum open-circuit voltage of the Ohms Current Source is less than 13V. Capacitances greater than $0.1\ \mu\text{F}$ at the input terminals can cause an error.

● TEST 10: 2 VDC + 2000 k Ω

Puts the DC Scaling circuit in the 2V dc range and the Ohms Current Source in the $2000\ \text{k}\Omega$ range, except that its maximum open-circuit voltage is limited to less than 6.5V in this configuration. This test, as well as tests 11-13, checks clamps Q312 and Q313 and the analog filter. The reading at the A/D Converter should be an overload. Capacitances greater than $0.5\ \mu\text{F}$ at the input terminals can cause an error.

● TEST 11: 200 Ω , Overrange

● TEST 12: 2 k Ω , Overrange

● TEST 13: 20 k Ω , Overrange

● TEST 14: 200 k Ω , Overrange

These tests put the 8840A in the respective range of the 2-wire ohms function. They check that each range of the Ohms Current Source has enough compliance voltage to overload the dc front end.

● TEST 15: 1000 VDC + X10 T/H + 20 M Ω

Puts the Ohms Current Source in the $500\ \text{nA}$ range. The resulting current through Z302 (the $10\ \text{M}\Omega$ input divider) causes a nominal divider output voltage of $50\ \text{mV}$. The T/H Amplifier is in X10; thus the A/D Converter sees $50\ \text{mV}$, or 5000 counts. This test can be susceptible to input capacitances above $1000\ \text{pF}$.

● TEST 16: 200 VDC + 200 k Ω

● TEST 17: 200 VDC + 20 k Ω

● TEST 18: 200 VDC + 2 k Ω

These three tests put the DC Scaling circuit in the 200V dc range and the Ohms Current Source in the respective current range. The $10\ \text{M}\Omega$ input divider (Z302) senses the maximum open-circuit voltage of each range of the current source, and the T/H Amplifier (X1) presents the compliance voltage divided by 100 to the A/D Converter.

Nominal readings should be 49 mV for Test 16, 53 mV for Test 17, and 59 mV for Test 18. All three tests have a pass limit of 65 mV, insuring that no more than 6.5 volts appears at the input terminals.

- TEST 19: 200 VDC, Filter On

Test 18 (above) ties the 1 mA range of the Ohms Current Source into the 200V dc range, with the three-pole analog filter on, such that the A/D reads 59 mV nominal. Test 19 decouples the DC Scaling circuit from the Ohms Current Source; the In-Guard μC waits 28 ms and determines if the voltage at Z302-3 (the divide-by-100 point of the 10 M Ω input divider) has not discharged to zero volts, due to the long time constant of the filter.

- TEST 20: 200 VDC + 2 k Ω , Filter Off

- TEST 21: 200 VDC, Filter Off

Test 20 ties the 1 mA range of the Ohms Current Source into the 200V dc range, with the 3-pole analog filter off, such that the A/D Converter reads 59 mV nominal. Test 21 then decouples the DC Scaling circuit from the ohms current source; the In-Guard μC waits 28 ms and determines if the voltage at Z302-3 is at zero volts.

- TEST 25: In-Guard μC Internal RAM (U202)

A GALPAT test is performed on the internal RAM of the In-Guard μC . If there are any error, ERROR 25 is displayed.

- TEST 26: Display RAM (U212)

A pattern is written to the Display RAM and read back for comparison. If there are any differences ERROR 26 is displayed.

- TEST 27: In-Guard μC Program Memory (U202)

A two-byte check sum is calculated over the entire 4K Internal Program Memory and compared with the checksum bytes at the end of that memory. A special add and shift algorithm minimizes the possibility of double errors cancelling. If something is wrong with the Internal Program Memory, ERROR 27 is displayed.

- TEST 28: External Program Memory (U222)

A two-byte check sum is calculated over the entire 4K External Program Memory and compared with the checksum bytes at the end of that memory. A special add and shift algorithm minimizes the possibility of double errors cancelling. If something is wrong with the External Program Memory, ERROR 28 is displayed.

- TEST 29: Calibration Memory (U220)

Numerous single-byte checksums are placed in the Calibration Memory, one at the end of each group of calibration constants. They are calculated in such a way that the single-byte sum of all bytes in the Calibration Memory add to zero (all carries discarded) and the single-byte sums of each group also add to zero. A new checksum is calculated and written to Calibration Memory each time a full or partial calibration is performed. If the Calibration Memory is not properly configured or not working correctly, ERROR 29 is displayed.

6-40. Digital Controller Troubleshooting

The basic strategy in troubleshooting the Digital Controller circuit is to check first whether the In-Guard Microcomputer (μC) system is functional, starting with the In-Guard μC itself (U202). Most of this circuitry is tested using the specially provided In-Guard Troubleshooting Mode.

If the In-Guard μC system proves to be functional, then basic instrument control is assured and troubleshooting efforts can proceed in one of two directions. If the display and keyboard appear to be malfunctioning, then they should be checked next. (See Display System, below.) If the display and keyboard are functioning correctly, you can omit Display System troubleshooting and proceed to verify that signals are arriving correctly at the inputs of the analog control devices. (See Analog Control Signals, below.) If these are also correct, the digital controller is functioning correctly, and you can proceed to the appropriate analog troubleshooting procedure.

NOTE

For the convenience of the following tests, Options -05 and -09 should be removed if present. They should only be removed in the power-off condition.

6-41. IN-GUARD MICROCOMPUTER SYSTEM

This procedure is performed entirely in the In-Guard Troubleshooting Mode. This mode is established by shorting TP205 (U202-38) to Reference Low (TP306, or the L-shaped shield around U202) prior to turning on the instrument. To maintain this mode, the short must remain in effect after the instrument is turned on. When this is done, the μC programs U202-38 as an input (it is normally an output) to preclude any possibility of damage due to the short.

CAUTION

To avoid damaging the μC , the short must be initiated before the instrument is turned on, not after.

The In-Guard Troubleshooting Mode also programs all the normal port outputs to display a 1 kHz square wave except that the IEEE-488 output (U202-4) sends the word "55" repeatedly at a rate of 2,000 words/second and the A/D trigger (U202-40) is a square wave at its normal frequency of 80 Hz, and DM and P23 stay high. (The data received at U202-5 is meaningless.) Adjacent port outputs display opposite phases of the 1 kHz square wave. All μ C pins that are normally only programmed as inputs are also programmed as inputs to prevent contentions between them and the outputs from other ICs which drive them. Data coming into all μ C inputs (except pin 38) is ignored.

NOTE

If the A/D IC (U101) is working properly, its watchdog timer briefly interrupts all of the In-Guard Troubleshooting Mode signals every 1.5 sec for a period of about 0.2 sec. (The signals are then re-established.) If this occurs, the main counter in U101 and its watchdog timer are operating correctly. (See step 6, below.)

When the test is complete, turn off the 8840A and remove the short from TP205.

6-42. In-Guard Microcomputer

While the 8840A is in the In-Guard Troubleshooting Mode, check the following in the order shown:

1. Power supplies: +5V dc at U202-1; 0V dc U202-11.
2. μ C clock output: 8 MHz at U202-2,-3.
3. Trigger line U202-40 (TP201): Square wave, 50% duty, low 0V, high 3.8V (nominal). The period of the trigger signal should be 12.500 ms for 60 Hz line.
4. Interrupt from A/D (U202-39): Normally low, duration 48 μ s occurs approximately 5450 us after falling edge of trigger signal on TP201 (U202-40).
5. Guard-crossing test pattern (U202-4): Waveform C (see Figure 6-11).
6. Interrupts from watchdog timer (U202-6): Pulsed low for 0.2 sec every 1.5 sec, exponential rise between pulses.

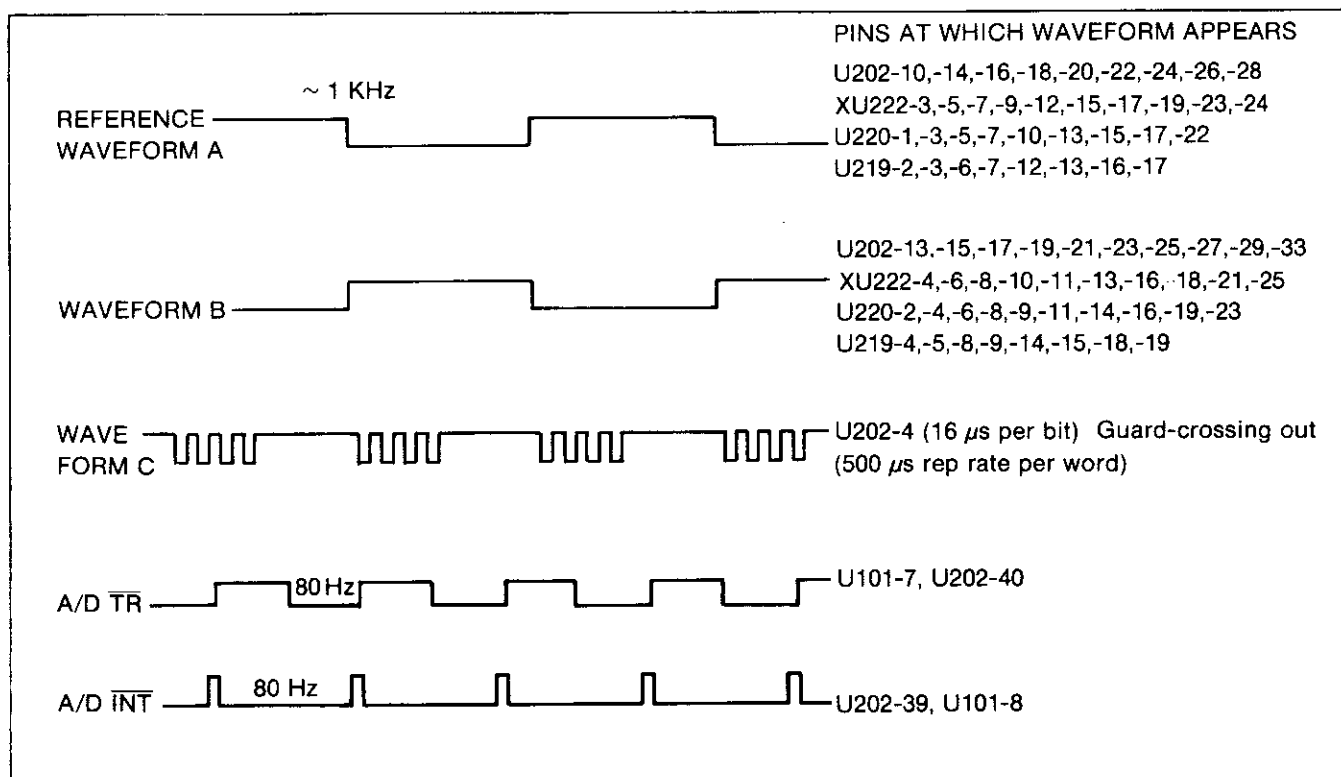


Figure 6-11. Waveforms for In-Guard Troubleshooting Mode

7. Output test patterns (see Waveforms A and B in Figure 6-11): 1 kHz square wave on indicated pins, 50% duty cycle, low 0V, high 3.8V nominal. (The waveforms are interrupted every 1.5 sec for 0.2 sec due to interrupts from the watchdog timer.) To observe these patterns, remove U220, attach a logic clip to address latch U219 and sync on U219-3 for Reference Waveform A on channel 1 of a dual trace scope. Compare channel 1 with waveforms at U202-10,-14,-16,-18,-20,-22,-24,-26,-28. These should all be the same as reference Waveform A (including phase). Then compare channel 1 with waveforms at U202-13,-15,-17,-19,-21,-23,-25,-27,-29,-33. These should be the same as Waveform B, which is simply the opposite phase of Waveform A.

6-43. Address Latch (U219)

Verify that U219-2,-6,-7,-12,-13,-16,-17 are the same as Waveform A (see Figure 6-11) on U219-3. Verify that U219-4,-5,-8,-9,-14,-15,-18,-19 are the same as Waveform B. The waveforms should be interrupted every 1.5 sec for 0.2 sec due to interrupts from the watchdog timer.

6-44. External Program Memory (XU222)

Sync on U219-3. Verify that XU222-3,-5,-9,-12,-15,-17,-19,-23,-24 are the same as Waveform A (see Figure 6-11) on U219-3. Verify that XU222-4,-6,-8,-10,-11,-13,-16,-18,-21,-25 are the same as Waveform B. The waveforms should be interrupted every 1.5 sec for 0.2 sec due to interrupts from the watchdog timer. (Note: XU222 pins refer to a 28-pin socket.)

6-45. Calibration Memory (U220)

Sync on U219-3. Verify that U220-1,-3,-5,-7,-10,-13,-15,-17,-22 are the same as Waveform A (U219-3). Verify that U220-2,-4,-6,-8,-9,-11,-14,-16,-19,-23 are the same as Waveform B. The waveforms should be interrupted every 1.5 sec for 0.2 sec due to interrupts from the watchdog timer.

6-46. Relay Buffer (U201)

At this point it is necessary to return the 8840A to the normal operating mode by turning the power switch off, removing the short from TP205 (U202-38), and installing the True RMS AC option, if present, so that U201 -14, -15 may be checked. Power up the instrument. Unlike the previous checks, outputs are steady state and therefore do not require a sync signal. Logic "1" is approximately 4.3V dc.

Check that U201-14 is high (4.3V) for mA AC and all ranges of VAC, and low for all other functions.

Check that U201-15 is high (4.3V) for mA AC and 200V ac and 700V ac ranges, and low for all other functions.

Check that U201-16 is high (4.3V) for all 2-wire and 4-wire ohms ranges, and low for all other functions.

Check that U201-17 is high (4.3V) for the lowest three VDC ranges and all 2-wire and 4-wire ohms ranges, and low for all other functions.

6-47. 3-to-8 Chip Select Decoder (U208)

Make the following checks in the normal operating mode using the fast reading rate and any function and range. These sequences begin 5.5 ms after the A/D trigger, which is the falling edge at U202-40.

Check U208-13 for 0.2 us pulses, normally high, groups of 1, pulse spacing: 10 ms.

Check U208-12 for 0.2 us pulses, normally high, groups of 1, pulse spacing: 10 ms (10 us after pin 13).

Check U208-11 for 0.2 us pulses, normally high, groups of 1, pulse spacing: 10 ms (46 us after pin 13).

Check U208-15 for 0.2 us pulses, normally high, groups of 13, group width: 100 us, group spacing: 10 ms (230 us after pin 13).

Check U208-7 for 0.6 us pulses, normally high, groups of 5, group width: 50 us, group spacing: 10 ms (380 us after pin 13).

This concludes testing of the basic μ C system. If the keyboard or display is still suspect at this point, proceed to Display System, below. Otherwise proceed to Analog Control Signals, below.

6-48. DISPLAY SYSTEM

The display/keyboard system is operated by a complex LSI IC (U212). Generally, this IC is checked indirectly by observing behavior of the simpler logic devices which it drives.

If the keyboard is working at all, the 8840A display should be "frozen" to make the following tests. This places the 8840A in a special display test configuration. If it is not possible to freeze the display, it should still be possible to observe the waveforms at U215, U213, U221, and U211 as described in the following paragraphs.

To freeze the display, turn off the instrument, press the POWER switch and within 1 second press the SRQ button. If all is well, all display segments will light and remain lit. Do not press any other buttons as that will release the display, allowing the instrument to resume its normal power-up sequence. This state should remain in effect for all of the following tests.

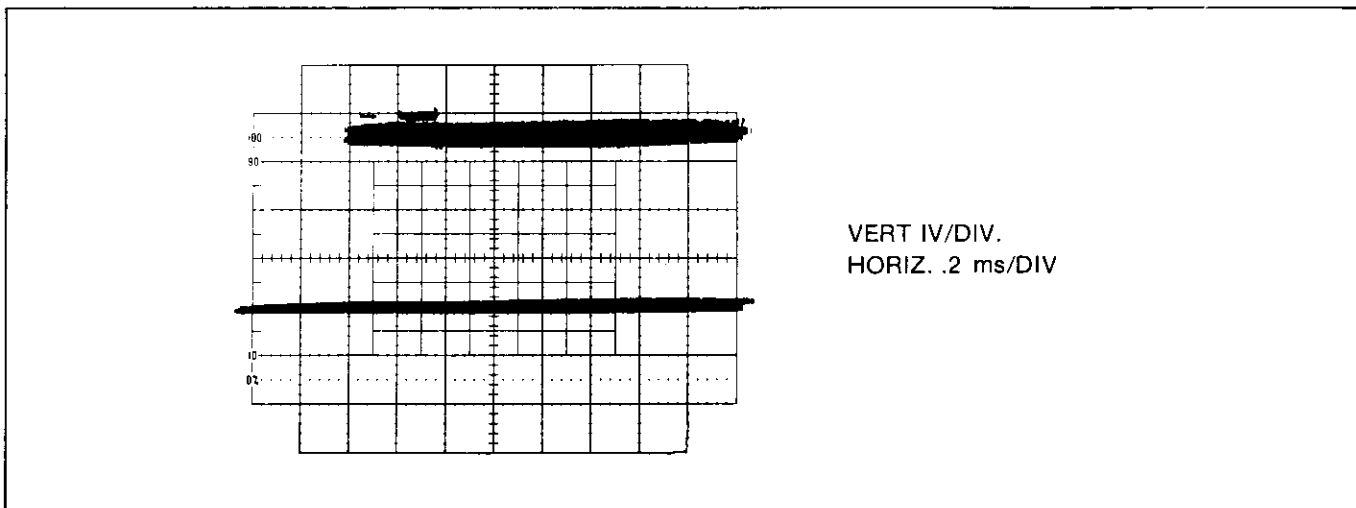


Figure 6-17. Typical Bus Data Line Waveform

One technique of finding an overloaded or shorted data line is to remove the In-Guard μC and drive one data line at a time through a $1\text{ k}\Omega$ resistor, measuring the voltage drop across a length of the line. Normally the voltage drop across the line is zero volts (less than $5\ \mu\text{V}$). Voltage drops larger than $5\ \mu\text{V}$ indicate a short. (The voltage drop is caused by excessive current flowing through the line.)

When troubleshooting the A/D Converter it may be desirable to determine what the reading is at the A/D Converter when the display is definitely incorrect. A digital problem between the A/D Converter and the In-Guard μC can cause erroneous or noisy readings or offsets. Similar problems may be caused by a failure of the Calibration Memory (U220) or by bad A/D calibration constants. (To check for bad A/D calibration constants, clear the calibration memory.)

Readings at the A/D Converter can be determined by interpreting the waveform at the DAC output (TP102). Waveforms at TP102 for several input levels are shown in Figure 6-18. The A/D reading can be calculated by knowing the weight of each bit and by weighting each nibble correctly. (The first nibble is weighted 1, the second $1/16$, the third $1/16^2$, the fourth $1/16^3$, etc.) Figure 6-19 shows how to read the A/D output for an input of 0.66V by interpreting the waveform at TP102 using the first three nibbles.

Troubleshooting the A/D Converter for defective components can be simplified by setting the circuit in a quiescent state. This can be done by selecting EX TRIG, which causes all A/D activity to stop. The A/D Converter is then in the autozero configuration, and the offset of the amplifiers and the various levels in the bootstrap circuits can be easily measured with a voltmeter. Oscillations at the outputs of the amplifiers and other abnormal signals can easily be identified with an oscilloscope.

6-67. Power Supply Troubleshooting

If the display does not light up, first check the following:

1. Is the instrument plugged in to an energized outlet providing alternating current at a frequency of 47 Hz to 440 Hz and a voltage within $\pm 10\%$ of that selected by the rear panel line voltage selection switches?
2. Is the POWER switch ON (pushed in)?
3. Is the rear panel fuse blown?

CAUTION

For fire protection, use exact fuse replacement only.

If the rear panel fuse is blown, replace it with a 250V fuse of the proper rating for the line voltage selected. Use $1/4\text{A}$ fast-blo for 100V and 120V power-line voltage and $1/8\text{A}$ slo-blo for 200V and 240V power-line voltage. If the fuse keeps blowing, measure the resistances of the power transformer (T601) windings. They should be within 10% of the values shown on the schematic. If not, the transformer is probably shorted. Also inspect the area around the transformer POWER switch and power-cord connector to make sure there isn't something shorting out the traces. If the IEEE-488 Interface board is suspected of causing the problem, it can easily be unplugged.

If everything looks OK but the fuse keeps blowing, troubleshooting may be performed by powering the instrument through a variac, applying only enough line voltage to find the problem without blowing the fuse. NEVER USE A LARGER FUSE. To do so will only turn a small problem into a big one.

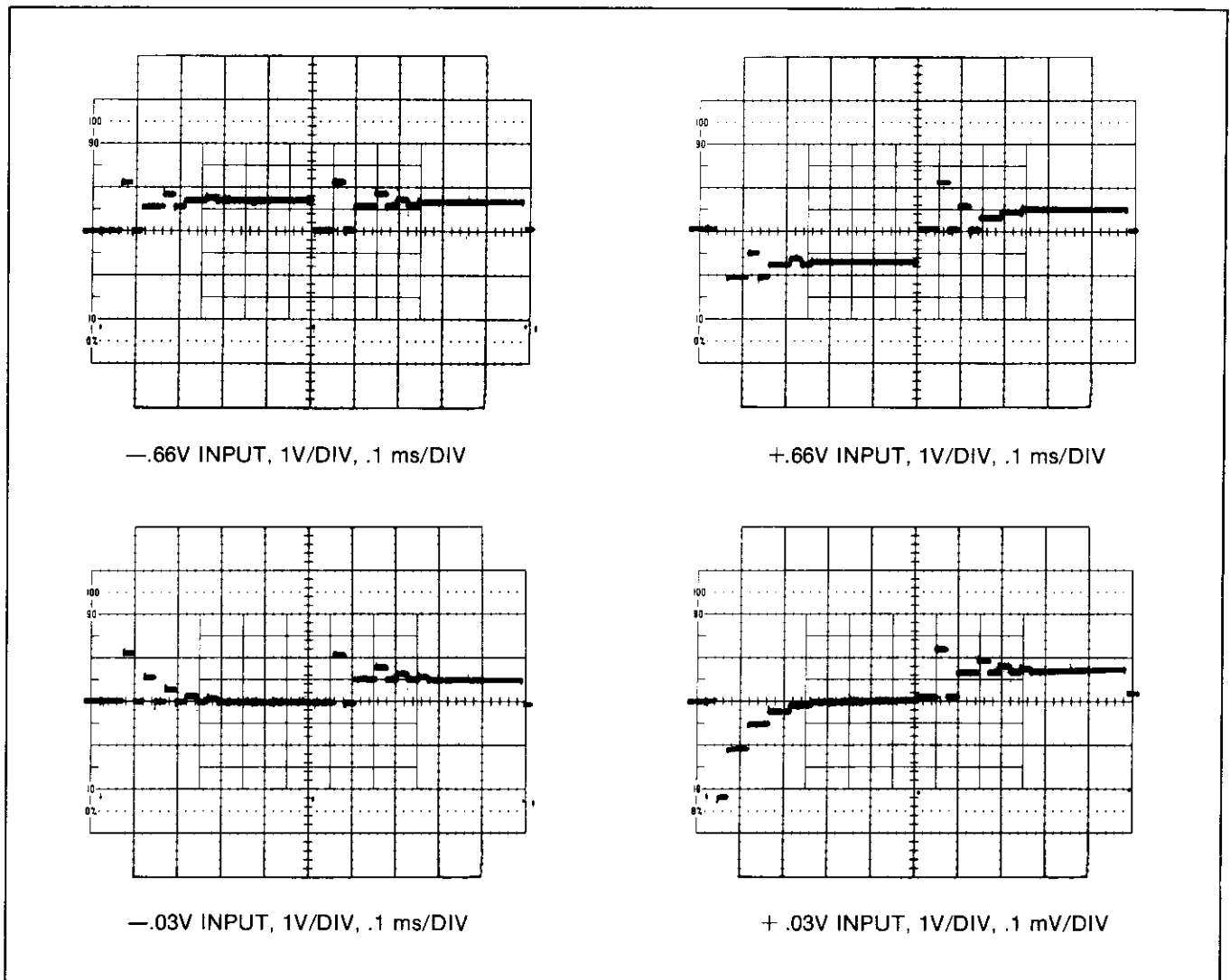


Figure 6-18. Waveforms at TP102 for Several Inputs on 2V DC Range

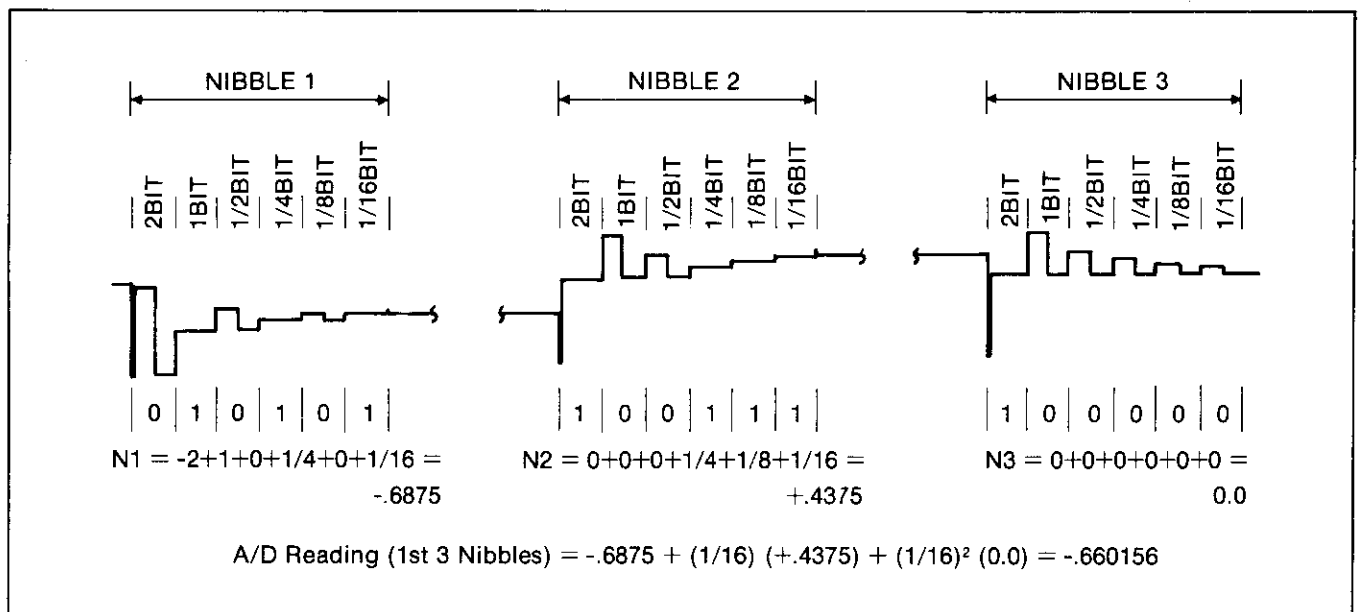


Figure 6-19. Calculating the A/D Reading From TP102 Waveform

Since power supply problems can produce symptoms in many different sections of the instrument, the first step in troubleshooting any problem should usually be a quick check of the power supplies. For each power supply (TP801-TP806), check the level with a voltmeter and check for ripple with an ac-coupled oscilloscope. The dc voltages should be within the limits given in Table 6-23.

Table 6-23. Power Supply Voltages

TEST POINT	LIMITS (In volts)	
	MINIMUM	MAXIMUM
+5V	4.75	5.25
+7.5V	7.12	7.87
+15V	14.25	15.75
+30V	28.45	31.55
-8.2	-8.61	-7.79
-15V	-15.75	-14.25
-30V	-31.55	-28.45

If a supply is too high, either its three-terminal regulator has failed or a fault elsewhere in the instrument has shorted two supplies together. After repairing such a problem, make certain that nothing else was damaged by the overvoltage.

If a supply is too low, there are a number of possible causes. First check the input to the affected regulator. If it is not at least 1V above the maximum output given in Table 6-23, the cause may be a bad transformer winding (check the resistance), open or shorted rectifiers, a shorted filter capacitor, or a shorted regulator. The latter two failures will usually blow the line fuse.

All regulators incorporate current-limiting which allows them to shut down in the event of a load failure. Therefore if the power supply output is too low, the first step should be to determine if it is due to a high load caused by a failure elsewhere in the instrument. Frequently the faulty component can be found by using a multimeter with at least 5 digits resolution to check the supply pins of all components powered from that supply. Connect one lead of the voltmeter to the appropriate test point for the power supply under test and use the other lead to probe the loads. Small voltage drops across the PCA traces can be detected in this way, and the fault isolated. If any component other than one of the regulators is too hot to touch, there is something wrong with it or with something connected to it.

The True RMS AC PCA, if installed, uses +5V and $\pm 15V$. If there is a problem with one of those supplies, first disconnect the True RMS AC PCA. If the problem goes away, troubleshoot the True RMS AC PCA using the procedure given later in this section.

With most power supply problems, the output voltage is too low or too high. More subtle problems that may be encountered include high ripple or oscillation. If more than 10 mV of line-frequency ripple exists on one of the power supply outputs, it is usually caused by the input being too low, causing the regulator to drop out of regulation. It is also possible (but not likely) that the regulator itself is defective. High-frequency oscillation (frequently synchronized with the 1 Mhz or 8 Mhz clock) is usually the result of a bad regulator or output bypass capacitor. A fair amount of high-frequency noise is generally present on all the supplies, particularly +5V, and should not cause any concern unless the instrument behaves erratically or the reading is noisy.

6-68. IEEE-488 Interface Troubleshooting (Option -05)

6-69. SERVICE POSITION

To provide easy access to the IEEE-488 Interface PCA and the Main PCA, the IEEE-488 Interface PCA can be placed in the specially provided service position as follows:

1. Remove the case from the chassis according to the Case Disassembly procedure provided earlier in this section.
2. Release the two nylon latches that hold the IEEE-488 Interface PCA in place by pulling the latches upward.
3. Position the IEEE-488 Interface PCA vertically as shown in Figure 6-20 and latch it in place by pressing the two nylon latches into the mounting supports specially provided on the chassis.

6-70. DIAGNOSTIC PROGRAM

To facilitate troubleshooting, the IEEE-488 Interface provides a diagnostic program which places the instrument in known configurations. To initiate the diagnostic program, proceed as follows:

CAUTION

To avoid damage to the 8840A or other equipment, the 8840A must be disconnected from all other IEEE-488 interface instruments while the diagnostic program is running.

1. Ensure the 8840A POWER switch is OFF.
2. Disconnect all cables from the rear panel IEEE-488 connector.
3. Short TP904 to TP905.

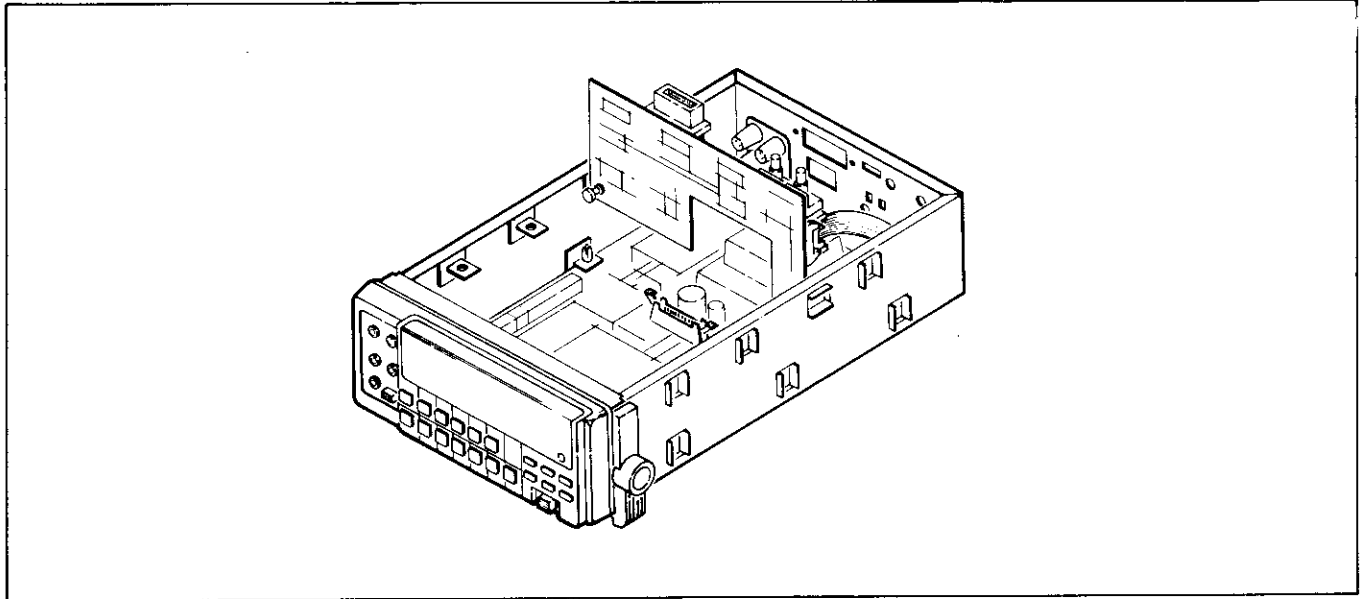


Figure 6-20. Option -05 Service Position

4. Power up the 8840A. The 8840A should display ERROR 50. To exit the troubleshooting mode, open the jumper and cycle the POWER switch from off to on.
5. Connect the Main PCA ac take-off point (stud connector W301) to the True RMS AC PCA input (the stud connector labeled AC IN) with a 6-inch jumper (E-Z-Hook 204-6W-S or equivalent).

Once the diagnostic program is started, rear-panel IEEE-488 address switches A3, A2, and A1 can be used to select one of six diagnostic modes, as shown in Table 6-24. In this table, Configuration A and Configuration B indicate which Out-Guard μ C I/O port bits are programmed as outputs and driven with a signal, as shown in Table 6-24.

6-71. True RMS AC Troubleshooting (Option -09)

6-72. SERVICE POSITION

To provide easy access to the True RMS AC PCA and the Main PCA, the True RMS AC PCA can be placed in the specially provided service position as follows:

1. Remove the case from the chassis using the Case Disassembly procedure provided earlier in this section.
2. Release the four nylon latches that hold the True RMS AC PCA in place by pulling the latches upward. (See Figure 809-1E in Section 8.)
3. Disconnect the red ac input lead from both the True RMS AC PCA and the Main PCA.
4. Position the True RMS AC PCA vertically as shown in Figure 6-21 and latch it in place by pressing the bottom two nylon latches into the specially provided mounting supports on the chassis.

6-73. MAJOR PROBLEMS

The signal flow through the True RMS AC option is straightforward, with no feedback paths between individual stages. This simplifies troubleshooting and often makes it possible to isolate a single defective stage without removing the instrument cover.

Test the mid-frequency response of the VAC function around 1 kHz. If an accurate reading can be obtained on at least one range, the rms converter (U802) is working properly. Test the high-frequency response around 100 kHz. If, after calibration, an accurate reading can be obtained on at least one range, the digitally controlled filter (U801, U808, R832, and C826-829) is OK. If some ranges are good and others are bad, the defective stage may be isolated using Table 6-26. If this table is used, the bad ranges must correspond exactly to the ranges listed in the first column and all other ranges must be good.

Most ac troubleshooting can be performed with the shields removed. To remove both shields, unscrew the Phillips screw on the back of the True RMS AC PCA. The only time it should be necessary to work on the PCA with the shields in place is when there is subtle high-frequency (>20 kHz) or low-level (<10 mV) error. In that case, the PCA should be left in its operating position, and the test points probed from the foil side of the PCA. Test points are labeled on both sides to facilitate such troubleshooting.

ranges or as an overrange in all ranges. First isolate faults in the buffer amplifier (U802A) by ascertaining that the signal at U802-13 is the same as that at TP802 when each is observed with an ac-coupled oscilloscope, and that the dc offset at U802-13 is less than 4 mV. It is possible that a component in the loop filter (U809A and associated passive components) or the post-filter (U809B and associated passive components) is defective. The dc voltage at U802-6 should be the same as that at TP803 for frequencies above 500 Hz, and should be equal to the rms value of the input signal.

6-74. MORE OBSCURE PROBLEM

Slow settling time or excessive jitter for low-frequency inputs is caused by rms converter loop errors. The cause may be a fault in the rms converter or loop filter.

If the output voltage is stuck at the supply rails, the cause is probably a fault in the rms converter. A less common cause is op amp oscillation; this can be checked with a scope at TP802.

If one or more ranges are functional but cannot be calibrated at high frequencies, then either the digitally controlled filter (U801B, R832, and C826-C829) is defective, or a defective component elsewhere in the circuit has rendered the response out of calibration range. (The high-frequency calibration is designed to cover the range of error expected due to op amp variations, input dividers, PCA tolerances, shielding, etc.). A sweep generator is useful in troubleshooting difficult frequency response problems.

The calibration control lines to U808 are set by software to store a high-frequency correction factor for each range. A state table cannot be given for these signals, but common sense will indicate if they are reasonable. For example, if all lines are at logic 0 for all ranges, something is probably wrong. Suspect U803, U808, or digital hardware on the Main PCA. If the control signals do indeed change with range, U808 or some part of the digitally controlled filter (U801B, R832, and C826-C829) may be defective. Even with the worst possible error in the high-frequency calibration code, the reading should be within 10% of the correct value at frequencies up to 100 kHz. If the error is larger, there are analog problems.

It is safe to force one control line at a time high (+5V) or low (0V) to test the individual switches in U808. (The on resistance of switches in U808 should be less than 500Ω; the off resistance should be greater than 10 MΩ.) Forcing the control lines high or low should cause the reading to change when the voltages in Table 6-27 are applied to the input terminals at 100 kHz. If only certain ranges cannot be calibrated, refer to Table 6-26 to find the suspected stage.

6-75. Guard Crossing Troubleshooting

To troubleshoot the Guard Crossing circuit, place the 8840A in the In-Guard Troubleshooting Mode as described under Digital Controller Troubleshooting, earlier in this section. This causes the In-Guard μC to send a test pattern to the IEEE-488 Interface PCA via one-half of the Guard Crossing circuit. You should be able to observe the waveforms shown in Figure 6-22.

To troubleshoot the other half of the circuit, run the diagnostic program as described under IEEE-488 Interface Troubleshooting earlier in this section. The program causes the IEEE-488 Interface PCA to send the same test pattern to the In-Guard μC. You should be able to observe the waveforms shown in Figure 6-22 at the corresponding points in this half of the circuit.

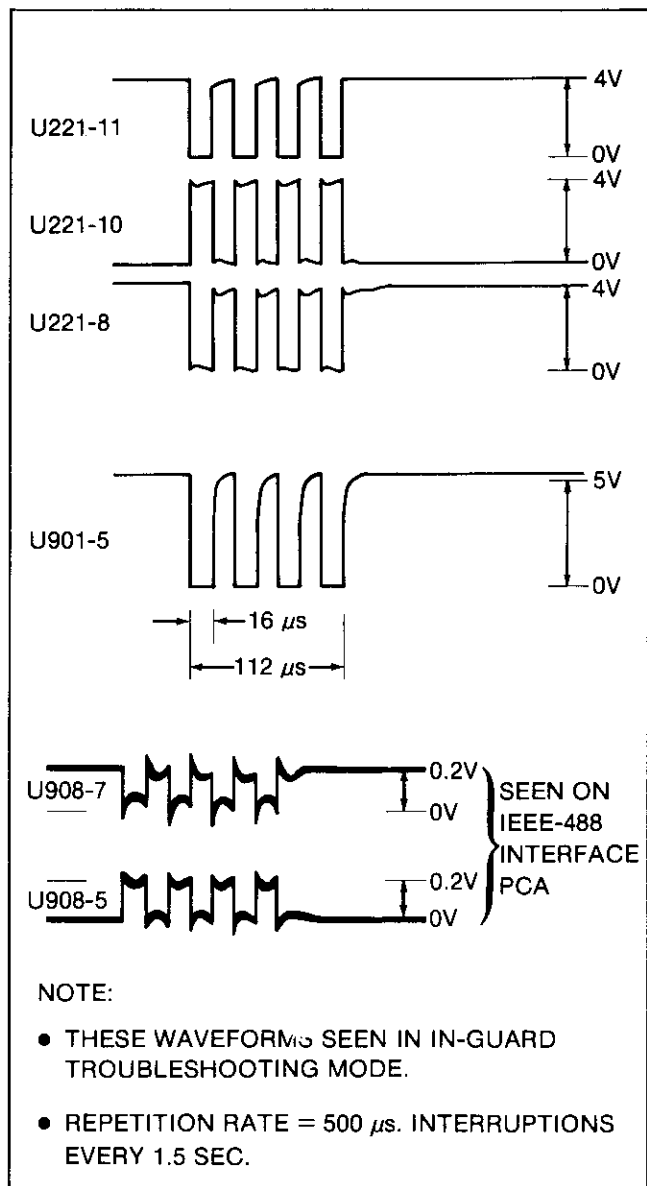


Figure 6-22. Guard Crossing Test Waveforms

6-76. INTERNAL CLEANING**CAUTION**

Failures due to electrostatic discharge can be caused by improper handling of the PCAs and by the use of a vacuum cleaner with static-inducing brushes. To prevent damage by electrostatic discharge, observe the precautions described on the Static Awareness sheet in front of this section.

If visual inspection of the instrument shows excessive dirt build-up in the instrument, clean the appropriate section using clean, oil-free, low-pressure air (less than 20 psi). If necessary, remove the option PCAs first.

6-77. Cleaning Printed Circuit Assemblies

If conditions warrant, individual printed circuit assemblies (PCAs) can be cleaned with water-based commercial cleaning systems such as dishwashers. If such systems are used, observe the following precautions:

1. Remove all shield covers (applies to the True RMS AC PCA) and socketed ICs.
2. Use Reagent Grade 2 or better water (de-ionized or distilled water) for the final rinse in geographic areas with exceptionally hard water. During the final rinse, spray or run the water so that the surface is thoroughly covered to remove all ionized material.

3. Thoroughly dry all PCAs using one of the following methods:

- a. Preferably, the PCA should be dried in a low-temperature drying chamber or infrared drying rack with a temperature range of 49°C to 72°C (120°F to 160°F).
- b. If neither a drying chamber nor a drying rack is available, air dry the PCA at ambient room temperature for at least two days.

A satisfactory cleaning method consists of holding the PCAs under hot running water until they are clean. Follow this wash with a final rinse. (See consideration 2, above.)

6-78. Cleaning After Soldering**CAUTION**

T.M.C. Cleaner and similar products can attack the nylon latches and other plastic pieces.

If a PCA has been soldered, it should first be cleaned with SPRAYON T.M.C. Cleaner* (rosin flux remover) or equivalent. The PCA should then be cleaned with water as described above.

*Trademark of E.E. DuPont De Nemours & Co.

Section 7

List of Replaceable Parts

7-1. INTRODUCTION

This section contains an illustrated parts list for the 8840A. Similar parts lists for the options are found in Section 8. Components are listed alphanumerically by assembly and reference designation. Most listed parts are shown in an accompanying illustration.

The parts lists include the following information for each part:

1. Reference Designation.
2. Description.
3. Fluke Stock Number.
4. Federal Supply Code for Manufacturers. (See Table 7-2 for a list of names and codes.)
5. Typical Manufacturer's Part Number.
6. Total Quantity per assembly.
7. Recommended Quantity.

The REC QTY entry indicates the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of each assembly in the instrument be stocked.

7-2. HOW TO OBTAIN PARTS

Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. or its authorized representatives by using the FLUKE STOCK NUMBER.

In the event that the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

To ensure prompt and efficient handling of your order, include the following information:

1. Quantity.
2. Fluke stock number.
3. Description.
4. Reference designation.
5. Printed wire board part number and revision letter.
6. Instrument model and serial number.

A Recommended Spare Parts Kit for the 8840A is available from the factory. The Kit contains those items listed in the REC QTY column of the parts list in the quantities recommended.

Parts price information is available from the John Fluke Mfg. Co., Inc. and its authorized representatives. Prices are also available in a Fluke Replacement Parts Catalog, which is available on request.

CAUTION

*

**DEVICES INDICATED BY THE ABOVE
SYMBOL ARE SUBJECT TO DAMAGE BY
STATIC DISCHARGE.**

LIST OF REPLACEABLE PARTS

SECTION 7

TABLE 7-1. 8840A DIGITAL MULTIMETER
(SEE FIGURE 7-1.) 8840A

REFERENCE DESIGNATOR A->NUMERICS-->	S	DESCRIPTION	FLUKE STOCK NO	MFRS SPLY CODE	MANUFACTURERS PART NUMBER OR GENERIC TYPE	TOT QTY	R S T	N O E
		PCA, MAIN	728857	89536	728857	1		
		PCA, DISPLAY	728873	89536	728837	1		
AK 701	*	REF AMP SET	684209	89536	684209	1		
C 101-103, 311		CAP, POLYPR, 0.1UF, +-10%, 100V	446781	55112	1.71	4		
C 104, 105, 205-		CAP, CER, 0.22UF, +80-20%, 50V, Z5U	649939	71590	CZ20	14	1	
C 209, 304, 305,			649939					
C 404, 604, 606,			649939					
C 609, 610			649939					
C 201		CAP, CER, 10 PF +/-2% 50V	713875	71590	CN20	1		
C 202, 203, 617,		CAP, CER, 0.01UF, +80-20%, 50V, Z5V	697284	71590	2DDH61	4		
C 618			697284					
C 204, 602, 608,		CAP, TA, 1UF, +-20%, 35V	697417	05571	199D	4		
C 612			697417					
C 210		CAP, CER, 1000PF, +-20%, 50V, X7R	697458	71590	CW20	1		
C 301, 302, 306		CAP, POLYPR, 0.22UF, +-10%, 100V	446799	55112	1.71	3		
C 303		CAP, POLYES, 0.22UF, +-20%, 50V	706028	60935	185	1		
C 307		CAP, POLYCA, 4700PF, +-10%, 63V	721662	89536	721662	1		
C 308		CAP, POLYPR, 0.47UF, +-10%, 100V	446807	55112	1.71	1		
C 309, 310		CAP, CER, 120PF, +-5%, 50V, COG	721142	71590	CN20	2		
C 312		CAP, POLYES, 0.001UF, +-10%, 50V	720938	60935	185	1		
C 314		CAP, POLYPR, 0.047UF, +-10%, 100V	446773	55112	1.71	1		
C 401, 402		CAP, CER, 330PF, +-5%, 50V, COG	697441	71590	CN20	2		
C 403		CAP, POLYES, 0.47UF, +-10%, 50V	697409	60935	185	1		
C 601		CAP, AL, 6800UF, +30-20%, 16V	478784	80031	314AS752V015	1		
C 603		CAP, AL, 330UF, +50-20%, 100V	484436	89536	484436	1		
C 605, 607		CAP, AL, 470UF, +50-20%, 50V	478792	89536	478792	2		
C 611		CAP, AL, 100UF, +50-20%, 50V	649731	89536	649731	1		
C 701		CAP, CER, 270PF, +-5%, 50V, COG	658898	71590	CN20	1		
CL 301	*	DIODE, SI, N-JFET, CURRENT REG, 20%, T&R	707836	89536	707836	1	1	
CR 101, 102, 201,	*	ZENER, UNCOMP, 3.9V, 10%, 20.0MA, 0.4W	698654	22767	1N748A	10	1	
CR 202, 306, 307,	*		698654					
CR 309, 311-313	*		698654					
CR 103, 104, 613	*	ZENER, UNCOMP, 7.5V, 5%, 20.0MA, 0.4W	698688	22767	1N755A	3	2	
CR 105, 106, 203-	*	DIODE, SI, BV= 75.0V, IO=150MA, 500MW	698720	57668	1N4448	12	1	
CR 206, 301, 302,	*		698720					
CR 401, 404, 615,	*		698720					
CR 701	*		698720					
CR 303	*	ZENER, UNCOMP, 10.0V, 5%, 12.5MA, 0.4W	698696	22767	1N961B	1	1	
CR 304, 305	*	ZENER, UNCOMP, 6.2V, 5%, 20.0MA, 0.4W	698670	22767	1N754A	2	1	
CR 308, 310	*	ZENER, UNCOMP, 24.0V, 5%, 5.2MA, 0.4W	698902	22767	1N970B	2	1	
CR 402, 403	*	DIODE, SI, 1K PIV, 1.0 AMP	707075	57668	1N4007	2	1	
CR 405	*	ZENER, UNCOMP, 5.1V, 5%, 20MA, 0.4W	722926	22767	1N751A	1	1	
CR 601-606, 608-	*	DIODE, SI, 100 PIV, 1.0 AMP	707067	57668	1N4002	10	1	
CR 611	*		707067					
CR 607, 612	*	ZENER, UNCOMP, 6.2V, 5%, 20.0MA, 0.4W	698662	22767	1N753A	2	1	
CR 614	*	ZENER, UNCOMP, 8.2V, 5%, 20.0MA, 0.4W	707539	22767	1N756A	1	1	
DS 1		DISPLAY	680843	89536	680843	1		
F 301		FUSE, 1/32 X 1-3/8, FAST, 3A, 600V	475004	71400	BBS-3	1	5	
F 302		FUSE, 1/4 X 1, FAST, 2A, 250V	376582	71400	AGX2-	1	10	
F 601		FUSE, 1/4 X 1-1/4, FAST, 0.25A, 250V	109314	71400	AGC1-4	1	5	
F 601		FUSE, 1/4 X 1-1/4, SLOW, 1/8A, 250V	166488	89536	166488	1		
H 1		RIVET, PLATED STEEL, .1205X5/32	103424	12014	R3647X5-32	2		
H 2		RIVET, STEEL, 7/32"HD	529941	12014	R-3479	2		
H 3		P-NUT, 4-40	380196	24347	KF2-440	1		
H 4		SCREW, PHP, STEEL, 4-40X1/4	129890	73734	19022	1		
H 5		NUT, HEX, DOUBLE CHAMFER, 4-40	184044	73734	8002A-NP	1		
H 6		SCREW, MACHINE, PHP SEMS, STEEL, 6-32X3/8	177022	89536	177022	3		
H 7		GROMMET LATCH	682898	83014	HN4G-44-5	6		
H 8		PLUNGER LATCH	682906	83014	HN4P-44-4-1	6		
H 9		SCREW, SHOULDER, DELRIN, 4-40	735373	89536	735373	1		
H 10		SPACER, HEX, THRD, BRASS, 6-32X3/8	203075	89536	203075	1		
H 11		SCREW, MACHINE, PHP, STEEL, 4-40X5/16	152116	89536	152116	1		
H 12		SCREW, MACHINE, PHP, STEEL, 4-40X1/4	129890	73734	19022	1		
H 13		SCREW, MACHINE, THP, 5 STEEL, 4-40X3/16	721118	89536	721118	2		
H 14		SCREW, MACHINE, FIHP, STEEL, 8-32X1/2	721134	89536	721134	2		
H 15		SCREW, THD FORM, PHP, STEEL, 4-20X1/2	721449	89536	721449	5		
H 16		SCREW, MACHINE, FHUP, STEEL, 4-40X5/16	268193	89536	268193	2		
H 17		SCREW, MACHINE, FHUP, S STEEL, 6-32X1/4	320093	89536	320093	1		
H 18		SCREW, MACHINE, FHP, STEEL, 8-32X3/8	114116	89536	114116	2		
H 19		SCREW, MACHINE, PHP, S STEEL, 6-32 X 5/16	424713	89536	424713	3		
H 20		SCREW, MACHINE, PHP SEMS, STEEL, 4-40X3/8	281196	89536	281196	1		
H 21		SCREW, MACHINE, FHS, NYLON, 6-32X3/8	474783	95987	N-632-3/8	1		
H 22		NUT, 6-32 SELF-LOCKING HEX, STEEL	152819	89536	152819	1		
H 23		SCREW, MACHINE, RHS, NYLON, 4-40X1/4	574780	27440	1020-004-4B	2		

SECTION 7

LIST OF REPLACEABLE PARTS

TABLE 7-1. 8840A DIGITAL MULTIMETER
(SEE FIGURE 7-1.) 8840A

REFERENCE DESIGNATOR A->NUMERICS----	S-----DESCRIPTION-----	FLUKE STOCK --NO--	MFRS SPLY CODE--	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S	N T E
J 201	CONNECTOR, PWB HEADER W/LATCHES 20PIN	706986	28213	3428-6302	1		
J 202	CABLE ASSY, 10 COND FLAT, 6"L IDC/DRB	714022	30146	1002645-C	1		
J 203, 204	CABLE, DISPLAY	684167	89536	684167	2		
J 601	CONNECTOR, 3 CONTACT, MALE RECEPTACLE	461806	82389	EAC-303	1		
J 602	PIN, CONTACT, 6 PIN, #09-65-1061	380378	27264	09-65-1061	1		
JFK 1, 2	JUMPER WIRE, COPPER, NO INSULATION	643452	89536	643452	2		
K 301	RELAY, ARMATURE, 2 FORM C, 5VDC	615575	26806	AZ7-2C-5DE	1	1	
K 401	RELAY, REED, 1 FORM A, 5V, HIGH VOLTAGE	714352	71707	3400-0087	1	1	
MP 1	BRACKET, CONNECTOR MTG	534446	89536	534446	2	1	
MP 2	SPACER, MOUNT, NYLON	152207	07047	10123-DAF	1		
MP 3	CASE, METAL	656389	89536	656389	1		
MP 4	FRONT PANEL	656397	89536	656397	1		
MP 5	PUSHROD, POWER	656413	89536	656413	1		
MP 6	PUSH ROD RAI	656488	89536	656488	1		
MP 7	PUSH ROD CAL ENABLE SWITCH	684142	89536	684142	1		
MP 8	MOUNTING PLATE, HANDLE (LEFT)	729004	89536	729004	1		
MP 9	MOUNTING PLATE, HANDLE (RIGHT)	660472	89536	660472	1		
MP 10	HANDLE	656496	89536	656496	1		
MP 11	BEZEL, REAR	660480	89536	660480	1		
MP 12	SPACER, MATRIX	684126	89536	684126	1		
MP 13	FOOT, CASE	684183	89536	684183	2		
MP 14	INSERT, REAR PANEL	684191	89536	684191	1		
MP 15	TERMINAL BLOCK, RAI	656504	89536	656504	1		
MP 16	SEAL, CALIBRATION	735274	89536	735274	1	5	
MP 17	SUPPORT, PWB	683987	89536	683987	14		
MP 18	LENS, FRONT PANEL	656405	89536	656405	1	2	
MP 19	DECAL, FRONT	685081	89536	685081	1		
MP 20	DECAL, REAR	698431	89536	698431	1		
MP 21	COVER, AC SWITCH	475681	89536	475681	1		
MP 22	IEEE CABLE GUIDE	728956	89536	728956	1		
MP 23	CLAMP, CABLE, 2-PIECE ASSY, 201-25	631507	89536	631507	2		
MP 24	SPACER, RND, NYLON, 6-32X0.400	733790	89536	733790	1		
MP 25	SPACER, HEX	735357	89536	735357	2		
MP 26	SHIELD, SUPPORT	735308	89536	735308	4		
MP 27	FUSE HLDR, CAP, 1/4 X 1-1/4 FUSE	460238	61935	031.1663	1		
MP 29	FUSE HLDR, CLIP, 13/32, DIA, FUSE	516880	71400	1A1360-03	2	1	
MP 30	SHIELD, A/D	728907	89536	728907	1		
MP 31	PCA, SHIELD MAIN BOTTOM	728998	89536	728998	1		
MP 32	FUSE HOLDER ASSEMBLY	516039	89536	516039	1		
MP 33	HEATSINK	414128	13103	6030B-TT	1		
MP 34	CHASSIS ASSEMBLY	684134	89536	684134	1		
MP 35	FUSE HLDR, BODY, PCB	602763	82389	FAU031.3573	1	1	
Q 101, 408	* TRANSISTOR, SI, NPN, SMALL SIGNAL	698225	04713	2N3904RLRA2	2	1	
Q 102	* TRANSISTOR, SI, PNP, T092	698233	04713	2N3906RLRA2	1	1	
Q 301, 302, 307,	* TRANSISTOR, SI, N-JFET, LOW IGSS, RAD T&R	707703	89536	707703	6	1	
Q 308, 312, 313	*	707703					
Q 303, 304, 310,	* TRANSISTOR, SI, N-JFET, REMOTE CUTOFF	697987	89536	697987	5	1	
Q 311, 315	*	697987					
Q 305	* TRANSISTOR, SI, NPN, HI-VOLTAGE	722934	04713	MPSA42	1	1	
Q 306, 402-404	* TRANSISTOR, SI, PNP, SM SIG, SELECTED HFE	650846	89536	650846	4	2	
Q 309	* TRANSISTOR, SI, NPN, SELECTD IEBO, SM SIG	685404	89536	685404	1	1	
Q 314	* TRANSISTOR, SI, N-JFET, DUAL, T0-71	478172	32293	IT502P	1	1	
Q 316, 401, 405-	* TRANSISTOR, SI, N-JFET, IGSS SELECTED	698266	89536	698266	5	1	
Q 407	*	698266					
R 101, 601-603	RES, CF, 1K, +-5%, 0.25W	573170	80031	CR251-4-5P1K	4		
R 102, 203, 204	RES, CF, 470, +-5%, 0.25W	573121	80031	CR251-4-5P470E	3		
R 103, 104	RES, CF, 27K, +-5%, 0.25W	573477	80031	CR251-4-5P27K	2		
R 105	RES, MF, 50K, +-0.1%, 0.125W, 25PPM	706184	09021	MF	1		
R 106	RES, CF, 560, +-5%, 0.25W	573147	09021	CF1/4	1		
R 201, 215, 217	RES, CF, 20K, +-5%, 0.25W	573444	80031	CR251-4-2P20K	3		
R 202, 315	RES, CF, 100, +-5%, 0.25W	573014	80031	CR251-4-5P100E	2		
R 205, 207, 208,	RES, CF, 1.5K, +-5%, 0.25W	573212	80031	CR251-4-5P1K5	5		
R 210, 412		573212					
R 206, 209	RES, CF, 51K, +-5%, 0.25W	573535	09021	CF1/4	2		
R 216	RES, CF, 2.7K, +-5%, 0.25W	573261	80031	CR251-4-5P2K7	1		
R 301	RES, CC, 100K, +-5%, 2W	285056	01121	HB1045	1		
R 302, 303	RES, CF, 100K, +-5%, 0.25W	573584	80031	CR251-4-5P100K	2		
R 304	RES, CF, 1.5M 5%, 1/4W	714931	09021	CF1/4	1		
R 305-307	RES, CF, 15K, +-5%, 0.25W	573428	80031	CR251-4-5P15K	3		
R 308, 316, 317	RES, CF, 1M, +-5%, 0.25W	573691	80031	CR251-4-5P1M	3		
R 309, 410, 415	RES, WW, 1K, +-10%, 2W	474080	89536	474080	3		
R 310, 409	RES, CF, 5.6K, +-5%, 0.25W	573337	80031	CR251-4-5P5K6	2		
R 312, 313, 408	RES, CF, 33K, +-5%, 0.25W	573485	09021	CF1/4	3		
R 314	RES, CC, 22K, +-10%, 2W	109975	01121	HB	1		

LIST OF REPLACEABLE PARTS

SECTION 7

TABLE 7-1. 8840A DIGITAL MULTIMETER
(SEE FIGURE 7-1.) 8840A

REFERENCE DESIGNATOR A->NUMERICS-----)	S	DESCRIPTION-----	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S	O T
							-Q	-E
R 318		RES,CF,620,+/-5%,0.25W	641092	09021	CF1/4	1		
R 319		RES, WW, 0.1	731950	89536	731950	1	1	
R 321,322		RES,MF,10K,+/-1%,0.125W,50PPM	706937	09021	MF	2		
R 401		RES, WW, 54.6K	730945	89536	730945	1	1	
R 402		RES,CF,4.3M,+/-5%,0.25W	697136	09021	CF1/4	1		
R 406		RES,CF,2.4K,+/-5%,0.25W	573253	09021	CF1/4	1		
R 407		RES,CF,910,+/-5%,0.25W	696948	09021	CF1/4	1		
R 413		RES, MF, 4.99M,1/8W,0+/-100PPM	715060	09021	MF	1		
R 414		RES, MF, 576K 1X, 1/8W, 100PPM	714949	09021	MF	1		
R 416		RES,MF,100,+/-1%,0.125W,25PPM	714410	09021	MF	1		
R 604		RES,CF,10K,+/-5%,0.25W	573394	80031	CR251-4-5P10K	1		
RV 301,401-404	*	VARISTOR 390V 10% RADIAL INSERTION	697383	89536	697383	6	6	
RV 601		VARISTOR,430V,20%,1.0MA	519355	09214	V275LA15AS14K275	1	1	
S 1		SWITCH,CONDUCTIVE ELASTOMERIC	680769	89536	680769	1		
S 201		SW, 2 POLE, DOUBLE THROW	473736	82389	EAC-303	1		
S 301		SW 16 POLE DOUBLE THROW	696773	71590	PRS	1		
S 601		SWITCH, ON-OFF	453605	89536	453605	1		
S 602,603		PCA, LINE VOLTAGE SELECTION SWITCH	735258	89536	735258	1		
T 201,202		TRANSFORMER, PULSE	660589	89536	660589	2		
T 601		TRANSFORMER, POWER	660548	89536	660548	1	1	
TM 1		OPERATOR MANUAL	684365	89536	684365	1	1	
TM 2		GETTING STARTED MANUAL	684373	89536	684373	1	1	
U 101		IC,CMOS,RR A/D CONVERTER	715680	89536	715680	1	1	
U 102,702	*	IC,OP AMP,DUAL,LO OFFST,VOLT,LO-DRIFT	685164	12040	LF412CN	2	1	
U 103	*	IC,OP AMP,LO-OFF VOLTAGE,LO-DRIFT	685156	12040	LF411CN	1	1	
U 201	*	IC,BIPLR,8CHNL DRIVER	685412	56289	UDN2585A	1	1	
U 202	*	IC,NMOS,8 BIT MICROCOMPUTR,8840A-9002	685438	56708	Z8611PS	1	1	
U 203	*	IC,LSTTL,HEX INVERTER	393058	01295	SN74LS04N	1	1	
U 204,305	*	IC,COMPARATOR,QUAD,14 PIN DIP	387233	12040	LM339N	2	1	
U 208	*	IC,LSTTL,3-8 LINE DCDR W/ENABLE	407585	01295	SN74LS138N	1	1	
U 211	*	IC,LSTTL,QUAD 2 INPUT OR GATE	393108	01295	SN74LS32N	1	1	
U 212	*	IC,NMOS,PROGRAMBL KEYBRD/DSPLY INTRFC	685560	34649	P8279-5	1	1	
U 213	*	IC,LSTTL,8BIT ADDR SABLE LATCH,W/CLR	419242	01295	SN74LS259N	1	1	
U 215,217,218	*	IC,BIPLR,8CHNL FLOURS CNT DISPLY DRIVR	685537	56289	UND6118A-2	3	1	
U 216	*	BCD TO 7 SEGMENT DECODER/DRIVER	697730	01295	SN74LS248N	1	1	
U 219	*	IC,CMOS,OCTL D F/F W/3-STATE,+EDG TRG	585364	36665	74SC374A	1	1	
U 220	*	IC,512 X 8 EEPROM	723411	60395	X2804AD-35	1	1	
U 221	*	IC,LSTTL,HEX INVERTER W/SCHMT TRIG	483180	01295	SN74LS14N	1	1	
U 222	*	IC, 4KX8, EPROM, 8840A-4510	728964	89536	728964	1	1	
U 301-303,402,	*	IC,CMOS,QUAD ANALOG SW, PLASTIC, HI.	700013	89536	700013	5	10	
U 403	*		700013					
U 304	*	IC,OP AMP,SELECTED LO-NOISE,JFET IN	385450	12040	LH0042	1	1	
U 306	*	IC,OP AMP, LO BIAS, LOW VDS	650713	89536	650713	1	1	
U 307	*	IC,OP AMP,JFET IN,COMPENSTD,8 PIN DIP	418780	12040	LF351	1	1	
U 401,404	*	IC,OP AMP,GENERAL PURPOSE,8 PIN DIP	478107	12040	308AN	2	1	
VR 601	*	IC,VOLT REG,FIXED,+5 VOLTS,1.5 AMPS	428847	04713	MC7805CT	1	1	
VR 602	*	IC,VOLT REG,FIXED,+24 VOLTS,1.5 AMPS	604074	04713	MC7824CT	1	1	
VR 603	*	IC,VOLT REG,FIXED,+15 VOLTS,1.5 AMPS	413187	04713	MC7815CT	1	1	
VR 604	*	IC,VOLT REG,FIXED,-15 VOLTS,1.5 AMPS	413179	04713	MC7915CP	1	1	
VR 605	*	IC,VOLT REG,FIXED,-24 VOLTS,1.5 AMPS	418251	04713	MC7924CP	1	1	
W 1		WIRE ASSY, GUARD CROSSING	684399	89536	684399	2		
W 2		WIRE ASSY, GUARD CROSSING	728840	89536	728840	2		
W 3		WIRE ASSY, GROUND	728949	89536	728949	1		
W 4		LINE CORD,3COND.FEMALE PLUG ATR.ANGLE	707018	89536	707018	1	1	
W 5		HARNESS, ANALOG FRONT	684159	89536	684159	1		
W 6		HARNESS, ANALOG REAR	684175	89536	684175	1		
W 7		TEST LEADS	642033	89536	642033	1	1	
XDS 1		SOCKET,DIP,0.100 CTR,16 PIN	291534	91506	216AG-39D	2		
XU 101		SOCKET,DIP,0.100 CTR,40 PIN	429282	09922	DILB40P-10B	1		
XU 203,208,212		SOCKET,SIP,0.100 CTR,20 PIN	443077	00779	583773-9	4		
XU 211,222		SOCKET,SIP,0.100CTR,14PIN	733261	00779	583773-6	2		
XU 219,220		SOCKET,SIP,0.100 CTR,12 PIN	478610	00779	583773-4	2		
Y 201	*	CRYSTAL,8.00MHZ QUARTZ HC-18U	707133	89536	707133	1	1	
Z 101	*	RESISTOR NETWORK RR LADDER	646828	89536	646828	1	1	
Z 301,303	*	RESISTOR NETWORK OUTPUT DIVIDER	655811	89536	655811	2	1	
Z 302	*	RESISTOR NETWORK DC INPUT DIVIDER	655852	89536	655852	1	1	
Z 304,402	*	RESISTOR NETWORK INPUT PROTECTION	715789	89536	715789	2	1	
Z 401	*	RESISTOR NETWORK OHMS	652867	89536	652867	1	1	
Z 702	*	RESISTOR NETWORK, REF AMP II	683110	89536	683110	1	1	

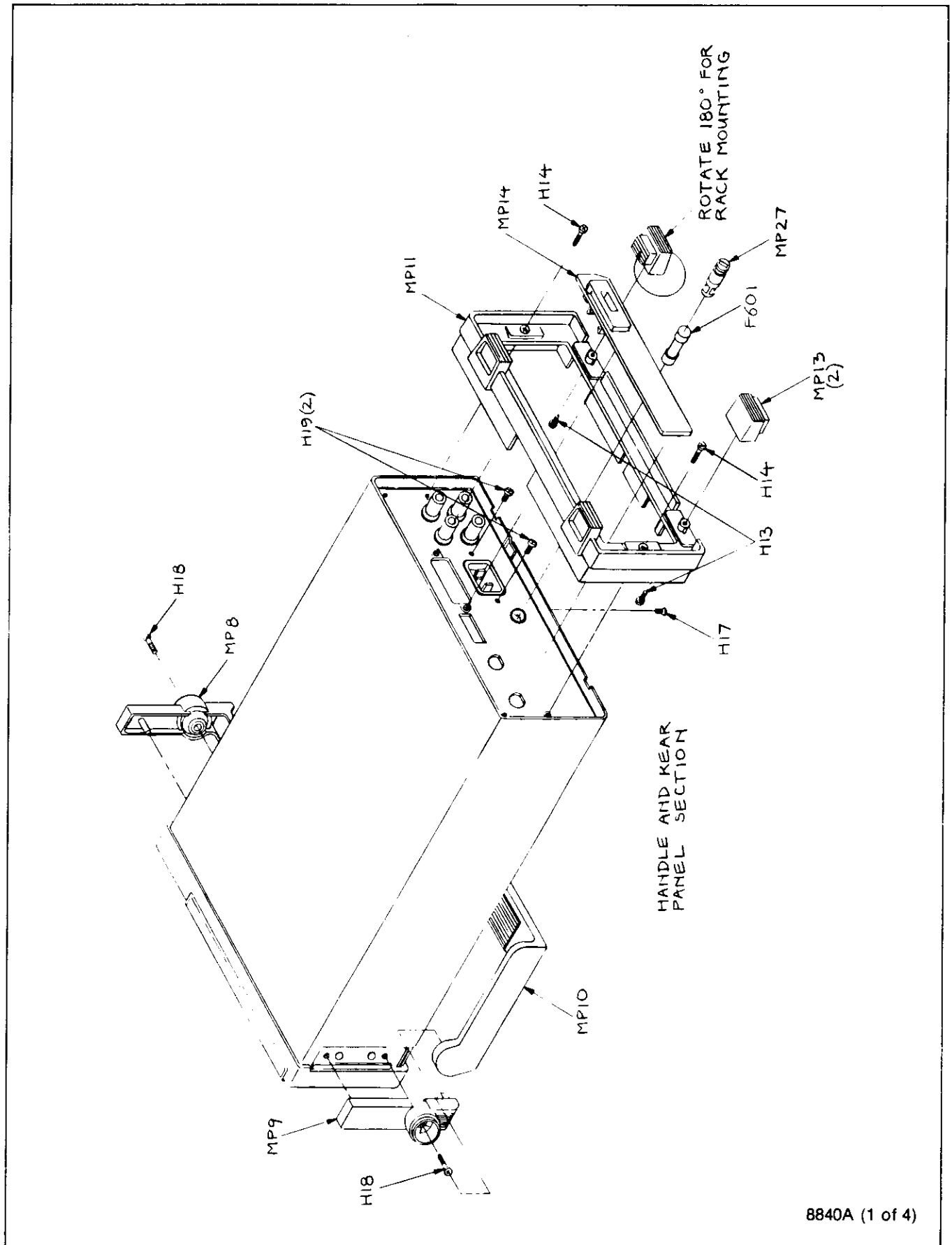
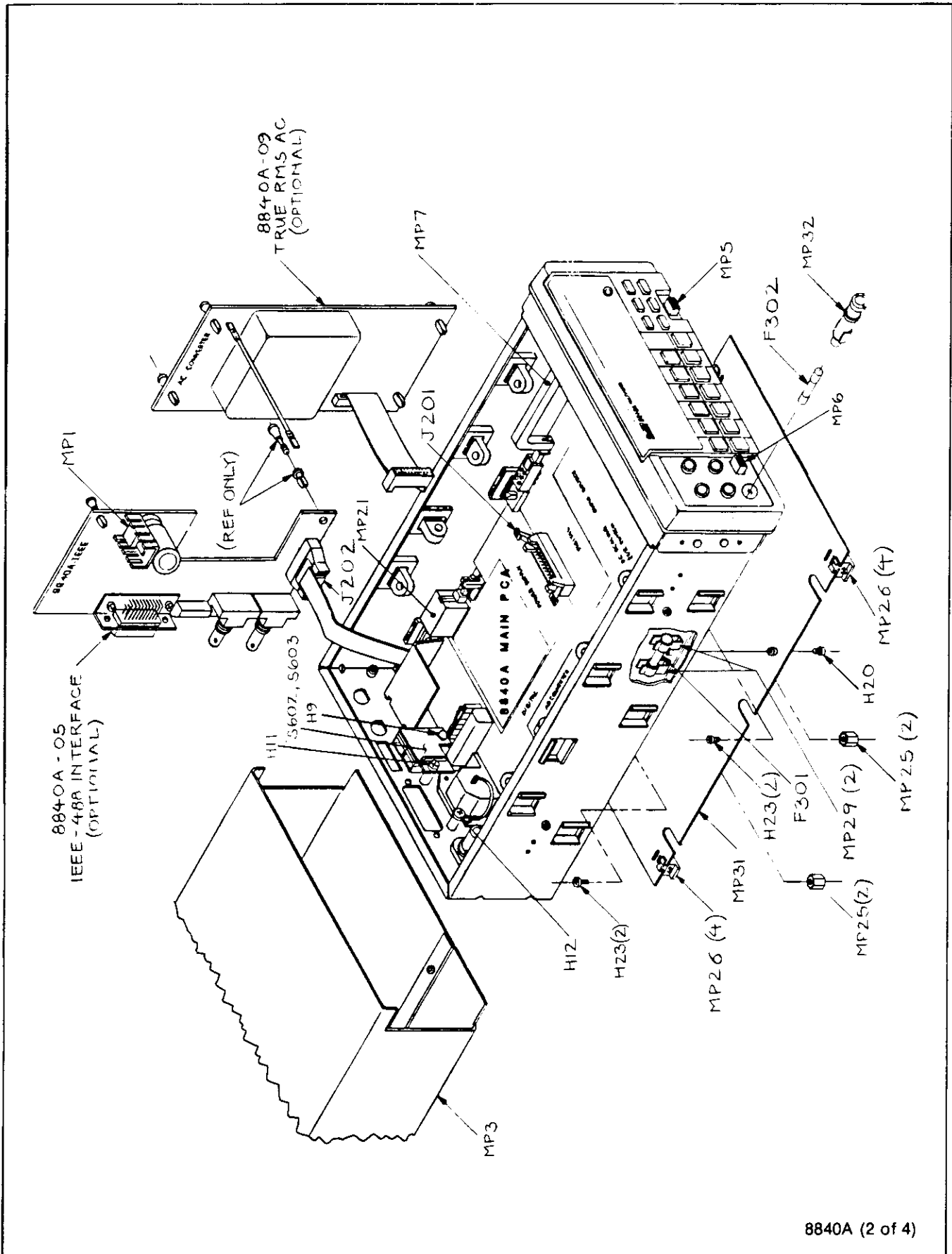
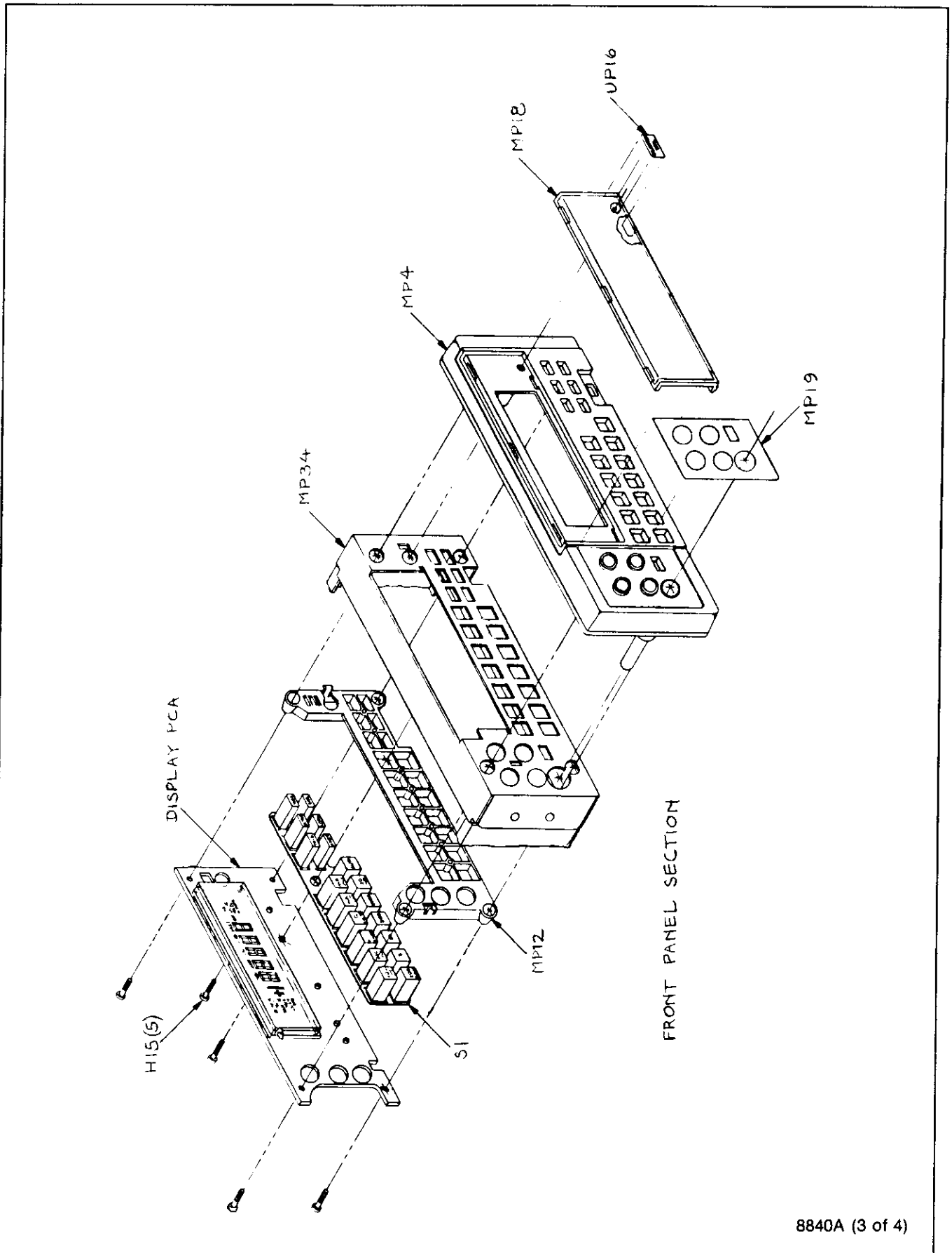


Figure 7-1. 8840A Digital Multimeter



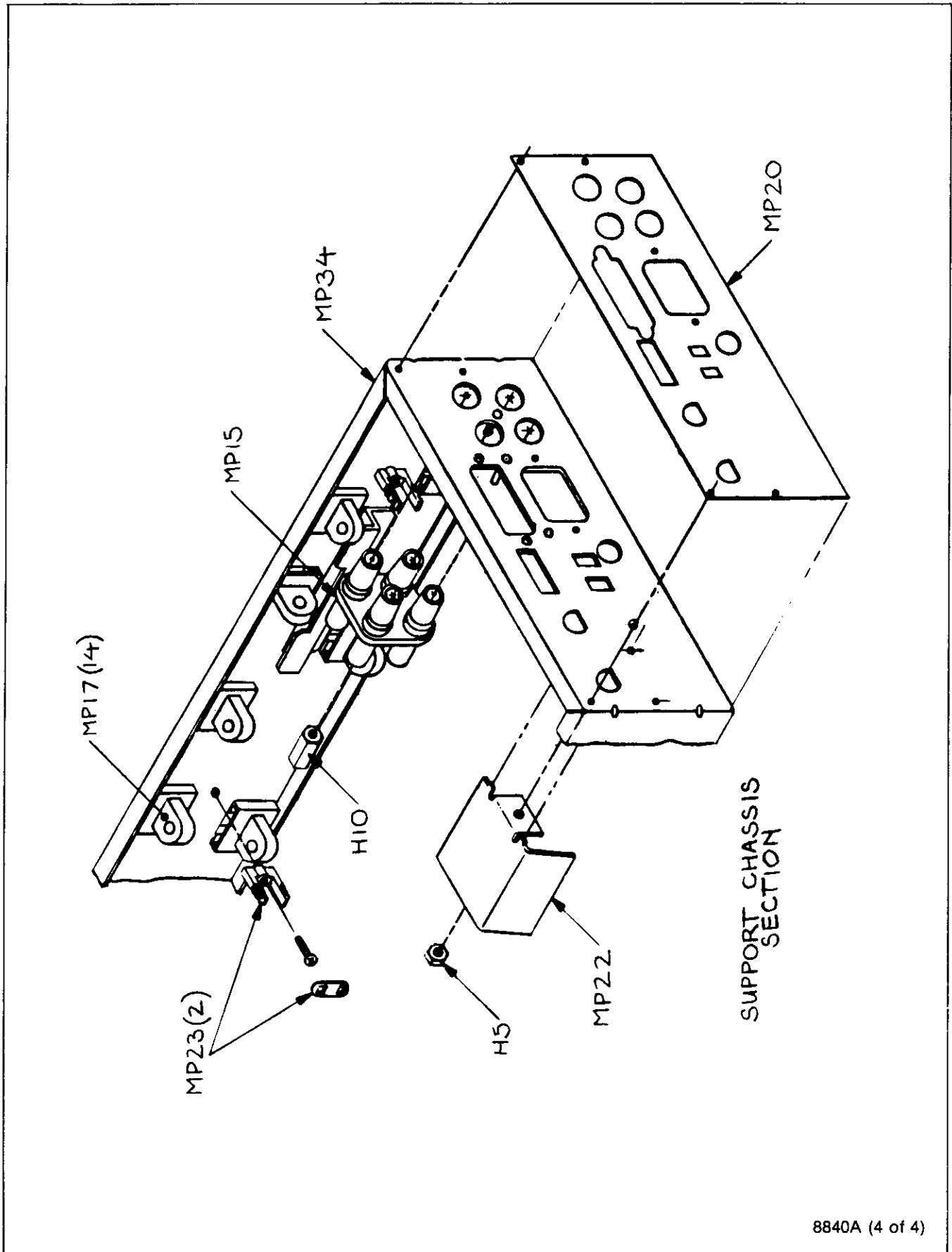
8840A (2 of 4)

Figure 7-1. 8840A Digital Multimeter (cont)



8840A (3 of 4)

Figure 7-1. 8840A Digital Multimeter (cont)



8840A (4 of 4)

Figure 7-1. 8840A Digital Multimeter (cont)

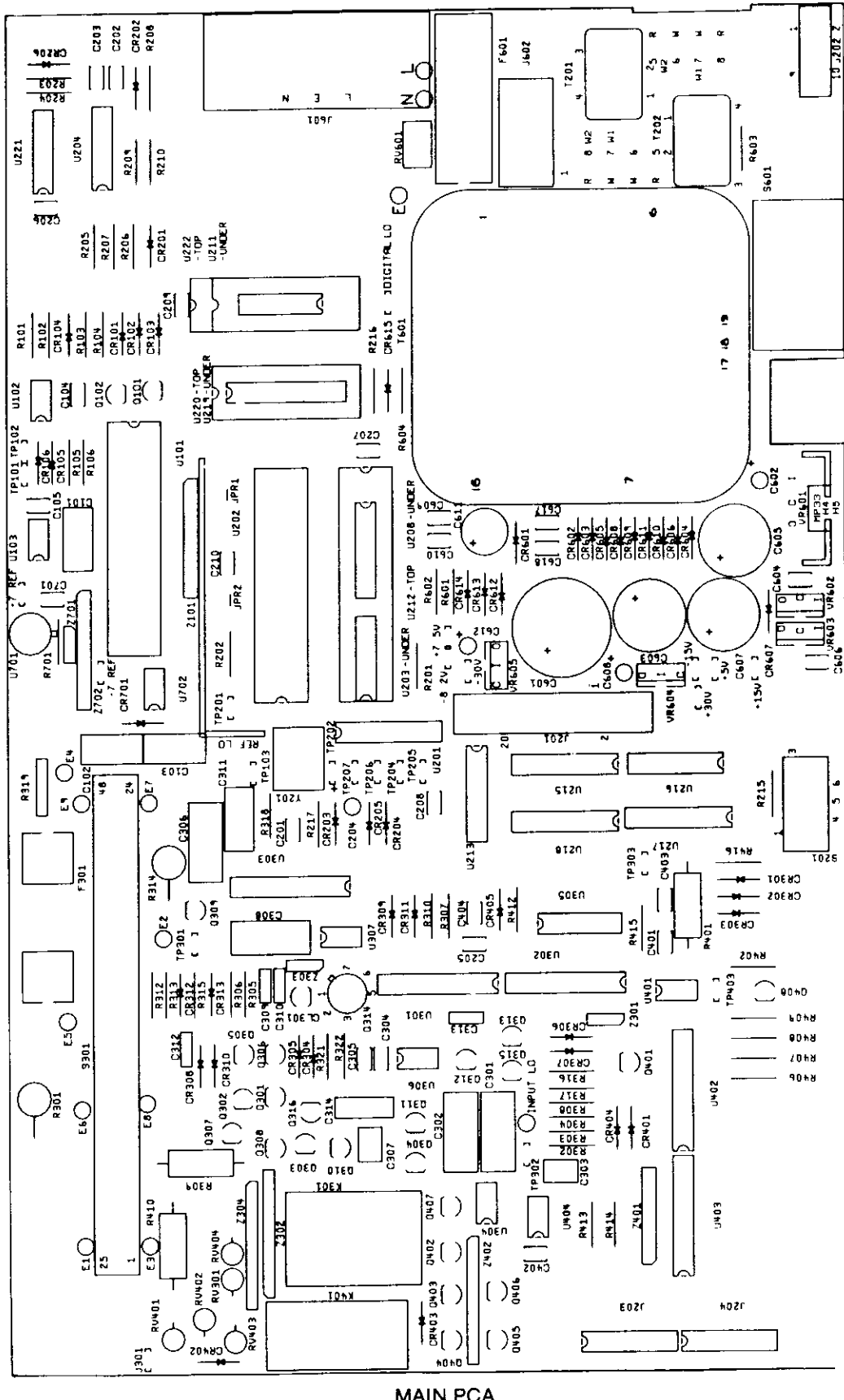


Figure 7-1. 8840A Digital Multimeter (cont)

Table 7-2. Federal Supply Codes for Manufacturers

00213 Nytronics Comp. Group Inc. Subsidiary of Nytronics Inc. Formerly Sage Electronics Rochester, New York	02660 Bunker Ramo Corp., Conn Div. Formerly Amphenol-Borg Electric Corp. Broadview, Illinois	04946 Standard Wire & Cable Los Angeles, California	06751 Components, Inc. Semcor Div. Phoenix, Arizona
00327 Welwyn International, Inc. Westlake, Ohio	02799 Areo Capacitors, Inc. Chatsworth, California	05082 Replaced by 94988	06860 Gould Automotive Div. City of Industry, California
00656 Aerovox Corp. New Bedford, Massachusetts	03508 General Electric Co. Semiconductor Products Syracuse, New York	05236 Jonathan Mfg. Co. Fullerton, California	06961 Vernitron Corp., Piezo Electric Div. Formerly Clevite Corp., Piezo Electric Div. Bedford, Ohio
00686 Film Capacitors, Inc. Passaic, New Jersey	03614 Replaced by 71400	05245 Components Corp. now Corcom, Inc. Chicago, Illinois	06980 Eimac Div. Varian Associates San Carlos, California
00779 AMP Inc. Harrisburg, Pennsylvania	03651 Replaced by 44655	05277 Westinghouse Electric Corp. Semiconductor Div. Youngwood, Pennsylvania	07047 The Ross Milton Co. South Hampton, Pennsylvania
01121 Allen-Bradley Co. Milwaukee, Wisconsin	03797 Eldema Div. Genisco Technology Corp. Compton, California	05278 Replaced by 43543	07115 Replaced by 14674
01281 TRW Electronic Comp. Semiconductor Operations Lawndale, California	03877 Transistron Electronic Corp. Wakefield, Massachusetts	05279 Southwest Machine & Plastic Co. Glendora, California	07138 Westinghouse Electric Corp., Electronic Tube Div. Horsehead, New York
01295 Texas Instruments, Inc. Semiconductor Group Dallas, Texas	03888 KDI Pyrofilm Corp. Whippany, New Jersey	05397 Union Carbide Corp. Materials Systems Div. New York, New York	07233 TRW Electronic Components Cinch Graphic City of Industry, California
01537 Motorola Communications & Electronics Inc. Franklin Park, Illinois	03911 Clairex Electronics Div. Clairex Corp. Mt. Vernon, New York	05571 Use 56289 Sprague Electric Co. Pacific Div. Los Angeles, California	07256 Silicon Transistor Corp. Div. of BBF Group Inc. Chelmsford, Massachusetts
01686 RCL Electronics Inc. Manchester, New Hampshire	03980 Muirhead Inc. Mountainside, New Jersey	05574 Viking Industries Chatsworth, California	07261 Aumet Corp. Culver City, California
01730 Replaced by 73586	04009 Arrow Hart Inc. Hartford, Connecticut	05704 Replaced by 16258	07263 Fairchild Semiconductor Div. of Fairchild Camera & Instrument Corp. Mountain View, California
01884 Use 56289 Sprague Electric Co. Dearborn Electronic Div. Lockwood, Florida	04062 Replaced by 72136	05820 Wakefield Engineering Inc. Wakefield, Massachusetts	07344 Bircher Co., Inc. Rochester, New York
02114 Ferroxcube Corp. Saugerties, New York	04202 Replaced by 81312	06001 General Electric Co. Electronic Capacitor & Battery Products Dept. Columbia, South Carolina	07597 Burndy Corp. Tape/Cable Div. Rochester, New York
02131 General Instrument Corp. Harris ASW Div. Westwood, Maine	04217 Essex International Inc. Wire & Cable Div. Anaheim, California	06136 Replaced by 63743	07792 Lerma Engineering Corp. Northampton, Massachusetts
02395 Rason Mfg. Co. Brooklyn, New York	04221 Aemco, Div. of Midtex Inc. Mankato, Minnesota	06383 Panduit Corp. Tinley Park, Illinois	07910 Teledyne Semiconductor Formerly Continental Device Hawthorne, California
02533 Snelgrove, C.R. Co., Ltd. Don Mills, Ontario, Canada M3B 1M2	04222 AVX Ceramics Div. AVX Corp. Myrtle Beach, Florida	06473 Bunker Ramo Corp. Amphenol SAMS Div. Chatsworth, California	07933 Use 49956 Raytheon Co. Semiconductor Div. HQ Mountain View, California
02606 Fenwal Labs Div. of Travenal Labs. Morton Grove, Illinois	04423 Telonic Industries Laguna Beach, California	06555 Beede Electrical Instrument Co. Penacook, New Hampshire	08225 Industro Transistor Corp. Long Island City, New York
	04645 Replaced by 75376	06739 Electron Corp. Littleton, Colorado	
	04713 Motorola Inc. Semiconductor Products Phoenix, Arizona	06743 Clevite Corp. Cleveland, Ohio	

Table 7-2. Federal Supply Codes for Manufacturers (cont)

08261 Spectra Strip Corp. Garden Grove, California	11726 Qualidyne Corp. Santa Clara, California	13606 Use 56289 Sprague Electric Co. Transistor Div. Concord, New Hampshire	16299 Corning Glass Electronic Components Div. Raleigh, North Carolina
08530 Reliance Mica Corp. Brooklyn, New York	12014 Chicago Rivet & Machine Co. Bellwood, Illinois	13839 Replaced by 23732	16332 Replaced by 28478
08806 General Electric Co. Miniature Lamp Products Dept Cleveland, Ohio	12040 National Semiconductor Corp. Danbury, Connecticut	14099 Semtech Corp. Newbury Park, California	16473 Cambridge Scientific Ind. Div. of Chemed Corporation Cambridge, Maryland
08863 Nylomatic Corp. Norrisville, Pennsylvania	12060 Diodes, Inc. Chatsworth, California	14140 Edison Electronic Div. Mc Gray-Edison Co. Manchester, New Hampshire	16742 Paramount Plastics Fabricators, Inc. Downey, California
08988 Use 53085 Skottie Electronics Inc. Archbald, Pennsylvania	12136 Philadelphia Handle Co. Camden, New Jersey	14193 Cal-R-Inc. formerly California Resistor, Corp. Santa Monica, California	16758 Delco Electronics Div. of General Motors Corp. Kokomo, Indiana
09214 G.E. Co. Semi-Conductor Products Dept. Power Semi-Conductor Products OPN Sec. Auburn, New York	12300 Potter-Brumfield Div. AMF Canada LTD. Guelph, Ontario, Canada	14298 American Components, Inc. an Insilco Co. Conshohocken, Pennsylvania	17001 Replaced by 71468
09353 C and K Components Watertown, Massachusetts	12323 Presin Co., Inc. Shelton, Connecticut	14655 Cornell-Dubier Electronics Division of Federal Pacific Electric Co. Govt. Control Dept. Newark, New Jersey	17069 Circuit Structures Lab. Burbank, California
09423 Scientific Components, Inc. Santa Barbara, California	12327 Freeway Corp. formerly Freeway Washer & Stamping Co. Cleveland, Ohio	14752 Electro Cube Inc. San Gabriel, California	17338 High Pressure Eng. Co., Inc. Oklahoma City, Oklahoma
09922 Burndy Corp. Norwalk, Connecticut	12443 The Budd Co. Polychem Products Plastic Products Div. Bridgeport, Pennsylvania	14869 Replaced by 96853	17545 Atlantic Semiconductors, Inc. Asbury Park, New Jersey
09969 Dale Electronics Inc. Yankton, S. Dakota	12615 U.S. Terminals Inc. Cincinnati, Ohio	14936 General Instrument Corp. Semi Conductor Products Group Hicksville, New York	17856 Siliconix, Inc. Santa Clara, California
10059 Barker Engineering Corp. Formerly Amerace, Amerace ESNA Corp. Kenilworth, New Jersey	12617 Hamlin Inc. Lake Mills, Wisconsin	15636 Elec-Trol Inc. Saugus, California	17870 Replaced by 14140
11236 CTS of Berne Berne, Indiana	12697 Clarostat Mfg. Co. Dover, New Hampshire	15801 Fenwal Electronics Inc. Div. of Kidde Walter and Co., Inc. Framingham, Massachusetts	18178 Vactec Inc. Maryland Heights, Missouri
11237 CTS Keene Inc. Paso Robles, California	12749 James Electronics Chicago, Illinois	15818 Teledyne Semiconductors, formerly Amelco Semiconductor Mountain View, California	18324 Signetics Corp. Sunnyvale, California
11358 CBS Electronic Div. Columbia Broadcasting System Newburyport, Minnesota	12856 Micrometals Sierra Madre, California	15849 Litton Systems Inc. Useco Div. formerly Useco Inc. Van Nuys, California	18612 Vishay Resistor Products Div. Vishay Intertechnology Inc. Malvern, Pennsylvania
11403 Best Products Co. Chicago, Illinois	12954 Dickson Electronics Corp. Scottsdale, Arizona	15898 International Business Machines Corp. Essex Junction, Vermont	18736 Voltronics Corp. Hanover, New Jersey
11503 Keystone Columbia Inc. Warren, Michigan	12969 Unitrode Corp. Watertown, Massachusetts	15909 Replaced by 14140	18927 GTE Sylvania Inc. Precision Material Group Parts Division Titusville, Pennsylvania
11532 Teledyne Relays Hawthorne, California	13103 Thermalloy Co., Inc. Dallas, Texas	16258 Space-Lok Inc. Burbank, California	19451 Perine Machinery & Supply Co. Seattle, Washington
11711 General Instrument Corp. Rectifier Division Hicksville, New York	13327 Solitron Devices Inc. Tappan, New York	20584 Enochs Mfg. Inc. Indianapolis, Indiana	19701 Electro-Midland Corp. Mepco-Electra Inc. Mineral Wells, Texas

Table 7-2. Federal Supply Codes for Manufacturers (cont)

20891 Self-Organizing Systems, Inc. Dallas, Texas	28480 Hewlett Packard Co. Corporate HQ Palo Alto, California	43543 Nytronics Inc. Transformer Co. Div. Geneva, New York	70903 Belden Corp. Geneva, Illinois
21604 Bucheys Stamping Co. Columbus, Ohio	28520 Heyman Mfg. Co. Kenilworth, New Jersey	44655 Ohmite Mfg. Co. Skokie, Illinois	71002 Birnback Radio Co., Inc. Freeport, New York
21845 Solitron Devices Inc. Transistor Division Riveria Beach, Florida	29083 Monsanto, Co., Inc. Santa Clara, California	49671 RCA Corp. New York, New York	71400 Bussmann Mfg. Div. of McGraw-Edison Co. Saint Louis, Missouri
22767 ITT Semiconductors Palo Alto, California	29604 Stackpole Components Co. Raleigh, North Carolina	49956 Raytheon Company Lexington, Massachusetts	71450 CTS Corp. Elkhart, Indiana
23050 Product Comp. Corp. Mount Vernon, New York	30148 AB Enterprise Inc. Ahoskie, North Carolina	50088 Mostek Corp. Carrollton, Texas	71468 ITT Cannon Electric Inc. Santa Ana, California
23732 Tracor Inc. Rockville, Maryland	30323 Illinois Tool Works, Inc. Chicago, Illinois	50579 Litronix Inc. Cupertino, California	71482 Clare, C.P. & Co. Chicago, Illinois
23880 Stanford Applied Engrng. Santa Clara, California	31091 Optimax Inc. Colmar, Pennsylvania	51605 Scientific Components Inc. Linden, New Jersey	71590 Centrelab Electronics Div. of Globe Union Inc. Milwaukee, Wisconsin
23936 Pamotor Div., Wm. J. Purdy Co. Burlingame, California	32539 Mura Corp. Great Neck, New York	53021 Sangamo Electric Co. Springfield, Illinois	71707 Coto Coil Co., Inc. Providence, Rhode Island
24248 Replaced by 94222	32767 Griffith Plastic Corp. Burlingame, California	54294 Cutler-Hammer Inc. formerly Shallcross, A Cutter-Hammer Co. Selma, North Carolina	71744 Chicago Miniature Lamp Works Chicago, Illinois
24355 Analog Devices Inc. Norwood, Massachusetts	32879 Advanced Mechanical Components Northridge, California	55026 Simpson Electric Co. Div. of Am. Gage and Mach. Co. Elgin, Illinois	71785 TRW Electronics Components Cinch Connector Operations Div. Elk Grove Village Chicago, Illinois
24655 General Radio Concord, Massachusetts	32897 Erie Technological Products, Inc. Frequency Control Div. Carlisle, Pennsylvania	56289 Sprague Electric Co. North Adams, Massachusetts	72005 Wilber B. Driver Co. Newark, New Jersey
24759 Lenox-Fugle Electronics Inc. South Plainfield, New Jersey	32997 Bourns Inc. Trimpot Products Division Riverside, California	58474 Superior Electric Co. Bristol, Connecticut	72092 Replaced by 06980
25088 Siemen Corp. Isilen, New Jersey	33173 General Electric Co. Products Dept. Owensboro, Kentucky	60399 Torin Corp. formerly Torrington Mfg. Co. Torrington, Connecticut	72136 Electro Motive Mfg. Co. Williamantic, Connecticut
25403 Amperex Electronic Corp. Semiconductor & Micro-Circuits Div. Slatersville, Rhode Island	34333 Silicon General Westminister, California	63743 Ward Leonard Electric Co., Inc. Mount Vernon, New York	72259 Nytronics Inc. Pelham Manor, New Jersey
27014 National Semiconductor Corp. Santa Clara, California	34335 Advanced Micro Devices Sunnyvale, California	64834 West Mfg. Co. San Francisco, California	72619 Dialight Div. Amperex Electronic Corp. Brooklyn, New York
27264 Molex Products Downers Grove, Illinois	34802 Electromotive Inc. Kenilworth, New Jersey	65092 Weston Instruments Inc. Newark, New Jersey	72653 G.C. Electronics Div. of Hydrometals, Inc. Brooklyn, New York
28213 Minnesota Mining & Mfg. Co. Consumer Products Div. St. Paul, Minnesota	37942 P.R. Mallory & Co., Inc. Indianapolis, Indiana	66150 Winslow Tele-Tronics Inc. Eaton Town, New Jersey	72665 Replaced by 90303
28425 Serv-/Link formerly Bohannon Industries Fort Worth, Texas	42498 National Radio Melrose, Massachusetts	70485 Atlantic India Rubber Works Chicago, Illinois	72794 Dzus Fastener Co., Inc. West Islip, New York
28478 Deltrol Controls Div. Deltrol Corporation Milwaukee, Wisconsin		70563 Amperite Company Union City, New Jersey	72928 Gulton Ind. Inc. Gudeman Div. Chicago, Illinois

Table 7-2. Federal Supply Codes for Manufacturers (cont)

72982 Erie Tech. Products Inc. Erie, Pennsylvania	75382 Kulka Electric Corp. Mount Vernon, New York	80583 Hammarlund Mfg. Co., Inc. Red Bank, New Jersey	83594 Burrhoughs Corp. Electronic Components Div. Plainfield, New Jersey
73138 Bechman Instrument Inc. Helipot Division Fullerton, California	75915 Littlefuse Inc. Des Plaines, Illinois	80640 Arnold Stevens, Inc. South Boston, Massachusetts	83740 Union Carbide Corp. Battery Products Div. formerly Consumer Products Div. New York, New York
73293 Hughes Aircraft Co. Electron Dynamics Div. Torrance, California	76854 Oak Industries Inc. Switch Div. Crystal Lake, Illinois	81073 Grayhill, Inc. La Grange, Illinois	84171 Arco Electronics Great Neck, New York
73445 Amperex Electronic Corp. Hicksville, New York	77342 AMF Inc. Potter & Brumfield Div. Princeton, Indiana	81312 Winchester Electronics Div. of Litton Industries Inc. Oakville, Connecticut	84411 TRW Electronic Components TRW Capacitors Ogallala, Nebraska
73559 Carling Electric Inc. West Hartford, Connecticut	77638 General Instrument Corp. Rectifier Division Brooklyn, New York	81483 Therm-O-Disc Inc. Mansfield, Ohio	84613 Fuse Indicator Corp. Rockville, Maryland
73586 Circle F Industries Trenton, New Jersey	77969 Rubbercraft Corp. of CA. LTD. Torrance, California	81483 International Rectifier Corp. Los Angeles, California	84682 Essex International Inc. Industrial Wire Div. Peabody, Massachusetts
73734 Federal Screw Products, Inc. Chicago, Illinois	78189 Shakeproof Div. of Illinois Tool Works Inc. Elgin, Illinois	81590 Korry Mfg. Co. Seattle, Washington	85777 Precision Metal Products of Malden Inc. Stoneham, Massachusetts
73743 Fischer Special Mfg. Co. Cincinnati, Ohio	78277 Sigma Instruments, Inc. South Braintree, Massachusetts	81741 Chicago Lock Co. Chicago, Illinois	86684 Radio Corp. of America Electronic Components Div. Harrison, New Jersey
73899 JFD Electronics Co. Components Corp. Brooklyn, New York	78488 Stackpole Carbon Co. Saint Marys, Pennsylvania	82305 Palmer Electronics Corp. South Gate, California	86928 Seastrom Mfg. Co., Inc. Glendale, California
73949 Guardian Electric Mfg. Co. Chicago, Illinois	78553 Eaton Corp. Engineered Fastener Div. Tinnerman Plant Cleveland, Ohio	82389 Switchcraft Inc. Chicago, Illinois	87034 Illuminated Products Inc. Subsidiary of Oak Industries Inc. Anaheim, California
74199 Quan Nichols Co. Chicago, Illinois	79136 Waldes Kohinoor Inc. Long Island City, New York	82415 North American Phillips Controls Corp. Frederick, Maryland	88219 Gould Inc. Industrial Div. Trenton, New Jersey
74217 Radio Switch Corp. Marlboro, New Jersey	79497 Western Rubber Company Goshen, Indiana	82872 Roanwell Corp. New York, New York	88245 Litton Systems Inc. Useco Div. Van Nuys, California
74276 Signalite Div. General Instrument Corp. Neptune, New Jersey	79963 Zierick Mfg. Corp. Mt. Kisko, New York	82877 Rotron Inc. Woodstock, New York	88419 Cornell-Dubilier Electronic Div. Federal Pacific Co. Fuquay-Varian, North Carolina
74306 Piezo Crystal Co. Carlisle, Pennsylvania	80031 Electro-Midland Corp. Mepco Div. A North American Phillips Co. Norristown, New Jersey	82879 ITT Royal Electric Div. Pawtucket, Rhode Island	88486 Plastic Wire & Cable Jewett City, Connecticut
74542 Hoyt Elect. Instr. Works Penacook, New Hampshire	80145 LFE Corp., Process Control Div. formerly API Instrument Co. Chesterland, Ohio	83003 Varo Inc. Garland, Texas	88690 Replaced by 04217
74970 Johnson E.F., Co. Waseca, Minnesota	80183 Use 56289 Sprague Products North Adams, Massachusetts	83058 The Carr Co., United Can Div. of TRW Cambridge, Massachusetts	89536 John Fluke Mfg. Co., Inc. Seattle, Washington
75042 TRW Electronics Components IRC Fixed Resistors Philadelphia, Pennsylvania	80294 Bourns Inc., Instrument Div. Riverside, California	83298 Bendix Corp. Electric Power Div. Eatontown, New Jersey	89730 G.E. Co., Newark Lamp Works Newark, New Jersey
75376 Kurz-Kasch Inc. Dayton, Ohio		83330 Herman H. Smith, Inc. Brooklyn, New York	
75378 CTS Knights Inc. Sandwich, Illinois		83478 Rubbercraft Corp. of America, Inc. West Haven, Connecticut	

Table 7-2. Federal Supply Codes for Manufacturers (cont)

90201 Mallory Capacitor Co. Div. of P.R. Mallory Co., Inc. Indianapolis, Indiana	91836 King's Electronics Co., Inc. Tuckahoe, New York	95354 Methode Mfg. Corp. Rolling Meadows, Illinois	98291 Sealectro Corp. Mamaroneck, New York
90211 Use 56365 Square D Co. Chicago, Illinois	91929 Honeywell Inc. Micro Switch Div. Freeport, Illinois	95712 Bendix Corp. Electrical Components Div. Microwave Devices Plant Franklin, Indiana	98388 Royal Industries Products Div. San Diego, California
90215 Best Stamp & Mfg. Co. Kansas City, Missouri	91934 Miller Electric Co., Inc. Div. of Anunet Woonsocket, Rhode Island	95987 Weckesser Co. Inc. Chicago, Illinois	98743 Replaced by 12749
90303 Mallory Battery Co. Div. of Mallory Co., Inc. Tarrytown, New York	92194 Alpha Wire Corp. Elizabeth, New Jersey	96733 San Fernando Electric Mfg. Co. San Fernando, California	98925 Replaced by 14433
91094 Essex International Inc. Suglex/IWP Div. Newmarket, New Hampshire	93332 Sylvania Electric Products Semiconductor Products Div. Woburn, Massachusetts	96853 Gulton Industries Inc. Measurement and Controls Div. formerly Rustrak Instruments Co. Manchester, New Hampshire	99120 Plastic Capacitors, Inc. Chicago, Illinois
91293 Johanson Mfg. Co. Boonton, New Jersey	94145 Replaced by 49956	96881 Thomson Industries, Inc. Manhasset, New York	99217 Bell Industries Elect. Comp. Div. formerly Southern Elect. Div. Burbank, California
91407 Replaced by 58474	94154 Use 94988 Wagner Electric Corp. Tung-Sol Div. Newark, New Jersey	97540 Master Mobile Mounts, Div. of Whitehall Electronics Corp. Ft. Meyers, Florida	99392 STM Oakland, California
91502 Associated Machine Santa Clara, California	94222 Southco Inc. formerly South Chester Corp. Lester, Pennsylvania	97913 Industrial Electronic Hardware Corp. New York, New York	99515 ITT Jennings Monrovia Plant Div. of ITT Jennings formerly Marshall Industries Capacitor Div. Monrovia, California
91506 Augat Inc. Attleboro, Massachusetts	95146 Alco Electronic Products Inc. Lawrence, Massachusetts	97945 Penwalt Corp. SS White Industrial Products Div. Piscataway, New Jersey	99779 Use 29587 Bunker-Ramo Corp. Barnes Div. Landsdowne, Pennsylvania
91637 Dale Electronics Inc. Columbus, Nebraska	95263 Leecraft Mfg. Co. Long Island City, New York	97966 Replaced by 11358	99800 American Precision Industries Inc. Delevan Division East Aurora, New York
91662 Elco Corp. Willow Grove, Pennsylvania	95264 Replaced by 98278	98094 Replaced by 49956	99942 Centrelab Semiconductor Centrelab Electronics Div. of Globe-Union Inc. El Monte, California
91737 Use 71468 Gremar Mfg. Co., Inc. ITT Cannon/Gremar Santa Ana, California	95275 Vitramon Inc. Bridgeport, Connecticut	98159 Rubber-Teck, Inc. Gardena, California	Toyo Electronics (R-Ohm Corp.) Irvine, California
91802 Industrial Devices, Inc. Edgewater, New Jersey	95303 RCA Corp. Receiving Tube Div. Cincinnati, Ohio	98278 Malco A Microdot Co., Inc. Connector & Cable Div. Pasadena, California	National Connector Minneapolis, Minnesota
91833 Keystone Electronics Corp. New York, New York	95348 Gordo's Corp. Bloomfield, New Jersey		

U.S. SALES AREAS for all Fluke products

AL, Huntsville

John Fluke Mfg. Co., Inc.
3322 S. Memorial Parkway
Suite 96
Huntsville, AL 35801
(205) 881-6220

AZ, Tempe

John Fluke Mfg. Co., Inc.
2211 S. 48th Street
Suite B
Tempe, AZ 85282
(602) 438-8314

Tucson

(602) 790-9881

CA, Los Angeles

John Fluke Mfg. Co., Inc.
20902 South Bonita St.
Carson, CA 90746
(213) 538-3900

San Diego

John Fluke Mfg. Co., Inc.
4540 Kearny Villa Rd., Suite 115
San Diego, CA 92123
(619) 292-7656

Santa Clara

John Fluke Mfg. Co., Inc.
2300 Walsh Ave., Bldg. K
Santa Clara, CA 95051
(408) 727-0513

Tustin

John Fluke Mfg. Co., Inc.
15445 Red Hill Ave., Suite F
Tustin, CA 92680
(714) 838-8863

CO, Denver

John Fluke Mfg. Co., Inc.
1980 South Quebec St. #4
Denver, CO 80231
(303) 750-1222

CT, Hartford

John Fluke Mfg. Co., Inc.
Glen Lochen East
41-C New London Turnpike
Glastonbury, CT 06033
(203) 659-3541

FL, Orlando

John Fluke Mfg. Co., Inc.
940 N. Fern Creek Ave.
Orlando, FL 32803
(305) 896-4881

GA, Atlanta

John Fluke Mfg. Co., Inc.
2700 Delk Rd., Suite 250
Marietta, GA 30067
(404) 953-4747

IA, Iowa City

(319) 354-2811

IL, Chicago

John Fluke Mfg. Co., Inc.
3740 Industrial Ave.
Rolling Meadows, IL 60008
(312) 398-0850

IN, Indianapolis

John Fluke Mfg. Co., Inc.
8777 Purdue Road
Suite 101
Indianapolis, IN 46268
(317) 875-7870

KS, Kansas City

(913) 381-9800

LA, New Orleans

(504) 455-0814

MA, Burlington

John Fluke Mfg. Co., Inc.
25 "B" Street
Burlington MA 01803
(617) 273-4674

MD, Baltimore

(301) 792-7060

Rockville

John Fluke Mfg. Co., Inc.
5640 Fishers Lane
Rockville, MD 20852
(301) 770-1570

MI, Detroit

John Fluke Mfg. Co., Inc.
33031 Schoolcraft
Livonia, MI 48150
(313) 522-9140

MN, Bloomington

John Fluke Mfg. Co., Inc.
1801 E. 79th St., Suite 9
Bloomington, MN 55420
(612) 854-5526

MO, St. Louis

John Fluke Mfg. Co., Inc.
2029 Woodland Parkway
Suite 105
St. Louis, MO 63141
(314) 993-3805

NC, Greensboro

John Fluke Mfg. Co., Inc.
1310 Beaman Place
Greensboro, NC 27408
(919) 273-1918

NJ, Paramus

John Fluke Mfg. Co., Inc.
P.O. Box 930
West 75 Century Road
Paramus, NJ 07652
(201) 262-9550

NM, Albuquerque

John Fluke Mfg. Co., Inc.
1108 Alvarado Drive N.E.
Albuquerque, NM 87110
(505) 881-3550

NY, Rochester

John Fluke Mfg. Co., Inc.
4515 Culver Road
Rochester, NY 14622
(716) 323-1400

OH, Cleveland

John Fluke Mfg. Co., Inc.
7830 Freeway Circle
Middleburg Heights, OH 44130
(216) 234-4540

Columbus

(614) 889-5715

Dayton

John Fluke Mfg. Co., Inc.
4756 Fishburg Rd.
Dayton, OH 45424
(513) 233-2238

OR, Portland

John Fluke Mfg. Co., Inc.
2700 NW 185th
Suite 2080
Portland, OR 97229
(503) 629-5928

PA, Philadelphia

John Fluke Mfg. Co., Inc.
1010 West 8th Ave., Suite H
King of Prussia, PA 19406
(215) 265-4040

Pittsburgh

(412) 261-5171

TX, Dallas

John Fluke Mfg. Co., Inc.
14400 Midway Road
Dallas, TX 75234
(214) 233-9990

Houston

John Fluke Mfg. Co., Inc.
4240 Blue Bonnet Dr.
Stafford, TX 77477
(713) 491-5995

San Antonio

John Fluke Mfg. Co., Inc.
10417 Gulfdale
San Antonio, TX 78216
(512) 340-2621

UT, Salt Lake City

(801) 268-9331

WA, Seattle

John Fluke Mfg. Co., Inc.
5020 148th Ave. N.E.
Suite 110
Redmond, WA 98052
(206) 881-6966

Service Center Areas

CA, Burbank (213) 849-4641

CA, Santa Clara (408) 727-8121

CO, Denver (303) 750-1228

FL, Orlando (305) 896-2296

IL, Chicago (312) 398-5880

MA, Burlington (617) 273-4678

MD, Rockville (301) 770-1576

NJ, Paramus (201) 262-9550

TX, Dallas (214) 233-9945

WA, Everett (206) 356-5560

For more information on Fluke products or Sales Offices you may dial (800) 426-0361 toll-free in most of the U.S.A. From Alaska, Hawaii, or Washington phone (206) 356-5400. From Canada and other countries phone (206) 356-5500.



John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, WA 98206

Fluke (Holland) B.V., P.O. Box 5053, 5004 EB, Tilburg, The Netherlands. Phone (013) 673973

Litho in U.S.A. 4/84

INTERNATIONAL SALES OFFICES

Argentina •

Coasin, S.A.
Virrey del Pino 4071
Buenos Aires, Argentina
Tel: 552-5248, TLX: 22284

Australia •

Elmeasco Instruments Pty Ltd.
P.O. Box 30, Concord, N.S.W.
Australia 2137
Tel: (2) 736-2888, TLX: (790) 25887

Elmeasco Instruments Pty Ltd.
21-23 Anthony Drive
Mt. Waverly, VIC 3149
Australia
Tel: 233-4044, TLX: (790) 36206

Elmeasco Instruments Pty Ltd.
Professional Suites Bldg.
G.P.O. Box 2360
Brisbane, 4001, Australia
Tel: (07) 229-3161

Elmeasco Instruments Pty Ltd.
G.P.O. Box 1240, Adelaide
South Australia 5001
Tel: (08) 271-1839

Elmeasco Instruments Pty. Ltd.
P.O. Box 95, Gosnells
West Australia 6110
Tel: (09) 398-3362

Austria •

Walter Rekersch
Elektronische Gerate GmbH & Co.
Vertrieb KG
Obachgasse 28
Vienna, Austria
Tel: (0222) 235555, TLX: 134759

Bangladesh •

Motherland Corporation
24 Hatkhola Rd., Tikatuli
Dacca 3, Bangladesh
Tel: 257249 or 255776

Belgium •

Fluke (Belgium) S.A./N.V.
6, Rue de Geneve
1140 Brussels, Belgium
Tel: (2) 2164090, TLX: 26312

Bolivia •

Coasin Bolivia S.R.L.
Casilla 7295, La Paz, Bolivia
Tel: 40962, TLX: 3233

Brazil •

Fluke Brasil-Industria E
Commercio LTDA
Al. Amazonas 422,
Alphaville, Barueri,
CEP 06400 Sao Paulo, Brazil
Tel: (011) 421-5477, TLX: 01135589

Fluke Brasil-Industria E
Commercio LTDA
Av. Henrique Valadares, 23/401
Rio de Janeiro, Brazil
Tel: 252-1297

Brunei •

Rank O'Connor's (PTE) Limited
No. 8, BK.D
Surfri Shop House Complex
Mile 1, Jalong Tutong
Bandar Seri Begawan, Brunei
Tel: 26680

Bulgaria •

Amtest Associates Ltd.
Clarence House, 31, Clarence St.
Staines, Middlesex TW18 4SY
United Kingdom
Tel: (784) 63555, TLX: 928855

Canada •

Allan Crawford Assoc., Ltd.
#14 1935 30th Ave. N.E.
Calgary, Alberta T2E 6Z5
Tel: (403) 230-1341, TLX: 03-821186

Allan Crawford Assoc., Ltd.
P.O. Bag 3967
Postal Station "D"
Edmonton, Alberta T5L 4K1
Tel: (403) 451-4893

Allan Crawford Assoc., Ltd.
3795 William Street
Burnaby, British Columbia V5C 3H3
Tel: (604) 294-1326, TLX: 04-54247

Allan Crawford Assoc., Ltd.
881 Lady Ellen Place
Ottawa, Ontario K1Z 5L3
Tel: (613) 722-7682, TLX: 0533600

Allan Crawford Assoc., Ltd.
6503 Northam Drive
Mississauga, Ontario L4V 1J2
Tel: (416) 678-1500, TLX: 06968769

Allan Crawford Assoc., Ltd.
7918 cote de Liesse
St. Laurent, Quebec H4T 1E7
Tel: (514) 731-8564, TLX: 05824944

Chad •

Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB Tilburg
Zevenheuvelenweg 53, 5048 AN Tilburg
The Netherlands
Tel: (013) 673973, TLX: 52237

Chile •

Intronica Chile Ltda.
Manuel Montt 024 - Of. D
Casilla 16228, Santiago 9, Chile
Tel: 44940, TLX: 240301
Attn: Intronica Chile

China, People's Republic of •

Fluke International Corporation
P.O. Box C9090
Everett, WA 98206, U.S.A.
Tel: (206) 356-5511
TLX: 152662 JOHN FLUKE EVT

Colombia •

Sistemas E Instrumentacion, Ltda.
Carrera 13, No. 37-43, Of. 401
Ap. Aereo 29583
Bogota DE, Colombia SA
Tel: 232-45-32, TLX: 45787

Cyprus •

Chris Radiovision Ltd.
P.O. Box 1989, Nicosia, Cyprus
Tel: 66121, TLX: 8262395

Czechoslovakia •

Amtest Associates Ltd.
Clarence House, 31, Clarence St.
Staines, Middlesex TW18 4SY
United Kingdom
Tel: (784) 63555, TLX: 928855

Denmark •

Tage Olsen A/S
Ballerup Byvej 222
DK - 2750 Ballerup, Denmark
Tel: (2) 658111, TLX: (855) 35293

Ecuador •

Protoco Coasin Cia., Ltda.
Edificio "Jerico"
Ave. 12 de Octubre #2285 y
Ave. Orellana (Planta Baja)
Quito, Ecuador
Tel: 529684, TLX: (393) 2865
Protoco Coasin Cia., Ltda.
Calderon 103 y Malecon
Casilla #9733
Guayaquil, Ecuador
Tel: 526093

Egypt and Sudan •

Electronic Engineering Liaison Office
P.O. Box 2891 Horreya
Heliopolis, Cairo, Egypt
Tel: 691588, TLX: (927) 92502

England •

Fluke (Great Britain) LTD.
Colonial Way
Watford, Herts, WD2 4TT
United Kingdom
Tel: (0923) 40511, TLX: (851) 934583
Rapifax: (0923) 25067

Ethiopia •

Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB Tilburg
Zevenheuvelenweg 53, 5048 AN Tilburg
The Netherlands
Tel: (013) 673973, TLX: 52237

Fiji •

AWA Fiji
47 Forster Road, Waiu Bay
Suva, Fiji
Tel: 312079, TLX: FJ2347

Finland •

Oy Findip AB, Teollisuustie 7
02700 Kauniainen, Finland
Puh: (0) 5052255, TLX: (857) 123129

France •

M.B. Electronique S.A.
Rue Fourny 606, Z1 Centre
78530 BUC
B.P. No. 31
78530 BUC, France
Tel: (3) 9568131, TLX: (842) 695414

German Democratic Republic •

Amtest Associates Ltd.
Clarence House, 31, Clarence St.
Staines, Middlesex TW18 4SY
United Kingdom
Tel: (784) 63555, TLX: 928855

German Federal Republic •

Fluke (Deutschland) GmbH
Max-Hueber Straße 8
8045 Ismaning, West Germany
Tel: (089) 96050, TLX: 522472
Rapifax: (089) 9605166
Fluke (Deutschland) GmbH
Meinekestrasse 53
4000 Dusseldorf 30, West Germany
Tel: (0211) 450831, TLX: (841) 8585576

Greece •

Hellenic Scientific Representations Ltd.
11, Vrasside Street
Athens 612, Greece
Tel: (1) 711140, TLX: (863) 219330

Hong Kong •

Schmidt & Co. (H.K.) Ltd.
28th Fl. Wing on Centre
111 Connaught Road
Central Hong Kong
Tel: 5-455644
TLX: 74766

Hungary •

Amtest Associates Ltd.
Clarence House, 31, Clarence St.
Staines, Middlesex TW18 4SY
United Kingdom
Tel: (784) 63555, TLX: 928855

Iceland •

Kristjan O. Skagfjord Ltd.
P.O. Box 906
Reykjavik, Iceland
Tel: 24120, TLX: 2133

India •

Hinditron Services Pvt. Ltd.
69/A.L. Jagmohandas Marg
Bombay 400 006, India
Tel: 811316, TLX: 112326
Hinditron Services Pvt. Ltd.
8th Main Road
33/44-A Raj Mahi Vilas Extension
Bangalore 560 080, India
Tel: 33139, TLX: (953) 0845741

Hinditron Services Pvt. Ltd.
Shantiniketan, Office No.8
6th Floor, 8 Camac Street
Calcutta 700 017, India
Tel: 434032, 447541

Hinditron Services Pvt. Ltd.
204-206 Henkunt Tower
98 Nehri Place
New Delhi, 110019, India
Tel: 640380, TLX: (95) 314890

Hinditron Services Pvt. Ltd.
Srinath Complex, 5th Floor
1-1-58/1 to 1-1-58/11
Sarajini Devi Road
Secunderabad 500 003, India
Tel: 821117, TLX: (953) 0155 575

Indonesia •

P.T. Dwi Tunggal Jaya Sakti
Kebayoran Baru
Jakarta Selatan, Indonesia
Tel: 716374, TLX: 45305

Iraq •

Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB Tilburg
Zevenheuvelenweg 53, 5048 AN Tilburg
The Netherlands
Tel: (013) 673973, TLX: 52237

Ireland •

Euro Electronics
32 Brews Hill
Naven County Meath, Ireland
Tel: (46) 23577, TLX: (851) 3182

Israel •

R.D.T. Electronics Engineering Ltd.
P.O. Box 75
46, Sokolov Street
Ramat Hasharon 47235, Israel
Tel: (3) 483216, TLX: (922) 32143

Italy •

Sistrel S.p.A.
Via Pelizza da Volpedo 59
20092 Cinisello Balsamo
Milan, Italy
Tel: (2) 6181893, TLX: (843) 334643

Sistrel S.p.A.
Via Giuseppe Armellini No. 39
00143 Rome, Italy
Tel: (6) 5915551, TLX: (843) 68356

Sistrel S.p.A.
Via Cinto
Parco S. Paolo
80126 Naples, Italy
Tel: (81) 7679700

Japan •

John Fluke Mfg. Co., Inc.
Japan Branch
Sumitomo Higashi
Shinbashi Bldg.
1-1-11 Hamamatsucho
Minato-ku, Tokyo, Japan
Tel: (03) 434-0181, TLX: 2424331



John Fluke Mfg. Co., Inc. / PO Box C9090 / Everett, WA 98206 / (206) 356 5400

Litho in U.S.A. 1/83

TECHNICAL SERVICE CENTERS

U.S.A.

CA, Burbank

John Fluke Mfg. Co., Inc.
Tel: (213) 849-4641

CA, Santa Clara

John Fluke Mfg. Co., Inc.
Tel: (408) 727-8121

CO, Denver

John Fluke Mfg. Co., Inc.
Tel: (303) 750-1228

FL, Orlando

John Fluke Mfg. Co., Inc.
Tel: (305) 896-2296

IL, Rolling Meadows

John Fluke Mfg. Co., Inc.
Tel: (312) 398-5800

MA, Burlington

John Fluke Mfg. Co., Inc.
Tel: (617) 273-4678

MD, Rockville

John Fluke Mfg. Co., Inc.
Tel: (301) 770-1576

NJ, Paramus

John Fluke Mfg. Co., Inc.
Tel: (201) 262-9550

TX, Dallas

John Fluke Mfg. Co., Inc.
Tel: (214) 233-9945

WA, Everett

John Fluke Mfg. Co., Inc.
Tel: (206) 356-5560

Other Countries

Argentina, Buenos Aires

Coasin S.A.
Tel: 552-5248/3485
TLX: 122284 COASN AR

Australia, Concord

Eimeasco Instruments Pty Ltd.
Tel: (02) 736-2888
TLX: (790) 25887

Australia, Mount Waverley

Eimeasco Instruments Pty Ltd.
Tel: 03-233-4044
TLX: 36206

Australia, Brisbane

Eimeasco Instruments Pty Ltd.
Tel: (07) 229-3161

Austria, Vienna

Walter Rekirsch Electronische Gerate
GmbH & Co.
Tel: (0222) 235555
TLX: 134759

Belgium, Brussels

Fluke (Belgium) SA/NA
Tel: (02) 2164090
TLX: 26312

Brazil, Sao Paulo

Fluke Brasil-Industria E Comercio Ltda.
Tel: (011) 421-3603
TLX: 01135589 FLKE BR

Canada, Calgary, AB

Allan Crawford Associates Ltd.
Tel: (403) 230-1341

Canada, Burnaby, BC

Allan Crawford Associates Ltd.
Tel: (604) 294-1326

Canada, Mississauga, ON

Allan Crawford Associates Ltd.
Tel: (416) 678-1500

Canada, St. Laurent, PQ

Allan Crawford Associates Ltd.
Tel: (514) 731-8564

Chile, Santiago

Intronica Chile Ltda.
Tel: 44940
TLX: 240301

China, Beijing

Beijing Radio Research Institute
Tel: 445612

Colombia, Bogota

Sistemas E Instrumentacion, Ltda.
Tel: 232-45-32
TLX: 45787 COASN CO

Denmark, Bellerup

Tage Olsen A/S
Tel: (02) 658111
TLX: 35293 TOAS SK

Ecuador, Quito

Edificio "Jerico"
Tel: 529684, 526759
TLX: 2865 Protec Ed

Egypt, Cairo

Electronic Engineering Liaison Office
Tel: 691588
TLX: (927) 92502

England, Watford, Herts

Fluke (Great Britain) LTD
Tel: 44-923-40511
TLX: 934583

Finland, Kaunialainen

Oy Findip AB
Tel: (0) 5052255
TLX: 123129

France, BUC

M.B. Electronique S.A.
Tel: (01) 9568131
TLX: 695414

Greece, Athens

Hellenic Scientific Representations
Tel: (01) 711140
TLX: 219330

Hong Kong, Hong Kong

Schmidt & Co. (H.K.) Ltd.
Tel: 5-455644
TLX: 74766 SCHMC HX

India, Bombay

Hinditron Services Pvt. Ltd.
Tel: 811316, 815344
TLX: 953-112326 HSPL IN

India, Bangalore

Hinditron Services Pvt. Ltd.
Tel: 33139
TLX: 0845741

India, New Delhi

Hinditron Services Pvt. Ltd.
Tel: 619118
TLX: 031 4890 SRMP IN

Indonesia, Jakarta Selatan

P.T. Dwi Tunggal Jaya Sakti
Tel: 716374
TLX: 47308 DIJS IA

Israel, Ramat Hasharon

R.D.T. Electronics Engineering Ltd.
Tel: (03) 483216
TLX: 32143

Italy, Milan

Sistrel S.p.A.
Tel: (02) 6181893
TLX: 334643

Italy, Rome

Sistrel S.p.A.
Tel: (06) 5915551
TLX: 68356

Japan, Tokyo

John Fluke Mfg. Co., Inc.
Japan Branch
Tel: (03) 434-0181
TLX: (781) 2424331 (FLUKJJP)

Korea, Seoul

Electro-Science Korea Co.
Tel: 261-7702, 260-1908
TLX: K25381

Malaysia, Petaling Jaya

Mecomb Malaysia SDN BHD
Tel: 573455
TLX: MA37605

Mexico, Mexico D.F.

Electronica y Tecnologia
Avanzada S.A. de C.V. (ETA)
Tel: 393 09 02 or 393 57 62
TLX: 0172697 BLOSME

Netherlands, Mearssen

Fluke (Nederland) B.V.
Tel: (030) 436514
TLX: 47128

Netherlands, Tilburg

Fluke (Holland) B.V.
Tel: (013) 673973
TLX: 52237

New Zealand, Auckland

McLean Information Technology, Ltd.
Tel: 501-801, 501-219, 587-037
TLX: NZ21570 THERMAL

Norway, Oslo

Morgenstjerne & Co A/S
Tel: (02) 356110
TLX: 71719

Pakistan, Karachi

Pak International Operations
Tel: 221127, 239052
TLX: 24494 PIO PK

Peru, Lima

Importaciones Y Representaciones
Electronicas S.A.
Tel: 288650
TLX: 37425663

Philippines, Metro Manila

Spark Radio & Electronics Corp.
Tel: 78-78-16
TLX: 27901 RLA PH

Portugal, Lisboa

Decada-Equipamentos de
Electronica, Lda.
Tel: (19) 574984
TLX: 18469

Republic of Singapore, Singapore

Rank O'Connor's (PTE) Limited
Tel: 637944, 239052
TLX: OCONSIN RS21023

Republic of South Africa, Bramley

Fluke S.A. (Pty) Ltd.
Tel: (011) 786-3170
TLX: 424328

Spain, Alcorcon (Madrid)

Hispano Electronics S.A.
Tel: (01) 6194108
TLX: 22404/42634

Sweden, Vallingby

Teleinstrument AB
Tel: (08) 380370
TLX: 15770

Switzerland, Zurich

Traco Electronic AG
Tel: (01) 2010711
TLX: 54318

Taiwan, Taipei

Schmidt Scientific Far East Ltd.
Tel: 5414600
TLX: 11111 Schmidt

Thailand, Bangkok

Measuretronix Ltd.
Tel: 3143369, 3143430
TLX: 81143 DEJOBKK TH

Turkey, Istanbul

Erkman Elektronik Aletler
Tel: (01) 5461
TLX: 23353

Uruguay, Montevideo

Coasin Uruguay S.R.L.
Tel: 29-31-952
TLX: UY 6571 OROCUER

Venezuela, Caracas

Coasin, C.A.
Tel: 38-78-42, 38-78-86
TLX: 21027 EMVEN VE

West Germany, Ismaning

Fluke (Deutschland) GmbH
Tel: (089) 96050
TLX: 0522472



John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, WA 98206

Fluke (Holland) B.V., P.O. Box 5053, 5004 EB, Tilburg, The Netherlands. Phone (013) 673973

Litho in U.S.A. 4/84

Kenya •

ADCOM Ltd.
P.O. Box 30070
Nairobi, Kenya, East Africa
Tel: 331955, TLX: 22639

Korea •

Electro Science
201 Hyunjin Bldg
251-19 Bangbae
Gangnam-Ku
Seoul, Korea
Tel: 583-7703, TLX: K25381

Kuwait ■

Al-Bahar Int. Group
P.O. Box 26672 Safat
Kuwait, Arabian Gulf
Tel: 450108, TLX: 44822

Lebanon and Jordan ■

Mabek (Electronics Division)
P.O. Box 11-3823
Beirut, Lebanon
Tel: 812523, TLX: (923) 22889

Libya ■

Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB Tilburg
Zevenheuvelenweg 53, 5048 AN Tilburg
The Netherlands
Tel: (013) 673973, TLX: 52237

Malaysia •

Mecomb Malaysia SDN BHD
Lot 20, Jalan 225
Petaling Jaya, Malaysia
Tel: 743422, TLX: MA37764

Mexico •

Electronica y Tecnologia
Avanzada S.A. de C.V.
Pafnucio Padilla 53
Circuito Comercial Satellite
Naucalpan Edo. De Mexico
Tel: 393 0902, TLX: (383) 017 2697

Nepal •

Associated Enterprises
GPO Box 790, Pyaphal Tole
Kathmandu, Nepal
Tel: 13868

Netherlands ■

Fluke (Nederland) B.V.
Gasthuisring 14
5041 DS Tilburg
The Netherlands
P.O. Box 115
5000 AC Tilburg
The Netherlands
Tel: (013) 352455, TLX: 52683

New Zealand •

McLean Information Technology, Ltd.
P.O. Box 9464, Newmarket
Auckland 1, New Zealand
Tel: 501-801; TLX: (791) NZ 215 70

McLean Information Technology, Ltd.
P.O. Box 496
Wellington, New Zealand
Tel: 851-450 or 844-424

Nigeria •

Mofat Engineering Co., Ltd.
P.O. Box 6369
Lagos, Nigeria
Tel: 21353,
Cable: MOFATENG LAGOS

Norway ■

Morgenstjerne & Co A/S
P.O. Box 6688, Rodelokka
Oslo 5, Norway
Tel: (2) 356110, TLX: (856) 71719

Oman ■

OHi Telecommunications
P.O. Box 889
Muscat
Sultanate of Oman
Tel: 702666 or 703862
TLX: 3180

Pakistan •

International Operations (PAK)
505 Muhammadi House
i.I. Chundrigar Road
P.O. Box 5323, Karachi, Pakistan
Tel: 221127, TLX: (952) 24494

PDR Yemen ■

Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB Tilburg
Zevenheuvelenweg 53, 5048 AN Tilburg
The Netherlands
Tel: (013) 673973, TLX: 52237

Peru •

Importaciones Y Representaciones
Electronicas S.A.
Avda. Franklin D. Roosevelt 105
Lima 1, Peru
Tel: 288650, TLX: (394) 25663

Philippines •

Spark Radio & Electronics, Inc.
Greenhills P.O. Box 610
Metro-Manila, Philippines 3113
Tel: 704096, TLX: 27901

Poland ■

Amtest Associates Ltd.
Clarence House, 31, Clarence St.
Staines, Middlesex TW18 4SY
United Kingdom
Tel: (784) 63555, TLX: 928855

Portugal ■

Decada Espectral
Equipamentos de Electronica e
Cientificos, Sarl
Av. Bombeiros Voluntarios
Lote 102, B
Miraflores/Aiges
1495 Lisboa, Portugal
Tel: (01) 2103420, TLX: 15515

Qatar ■

Technology Organisation
P.O. Box 5549, Doha, Qatar
Tel: 321431, TLX: (957) 4581

Romania ■

Amtest Associates Ltd.
Clarence House, 31, Clarence St.
Staines, Middlesex TW18 4SY
United Kingdom
Tel: (784) 63555, TLX: 928855

Saudi Arabia ■

Electronic Equipment Marketing Co.
P.O. Box 3750
Riyadh, Saudi Arabia
Tel: (1) 477-165001
TLX: 201120

Singapore •

Rank O'Connor's (PTE) Ltd.
98 Pasir Panjang Road
Singapore 0511
Republic of Singapore
Tel: 637944
TLX: RS21023

Somalia ■

Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB Tilburg
Zevenheuvelenweg 53, 5048 AN Tilburg
The Netherlands
Tel: (013) 673973, TLX: 52237

South Africa •

Fluke S.A. (Pty) Ltd.
P.O. Box 39797, Bramley 2018
Republic of South Africa
Tel: (011) 786-3170, TLX: 4-24328SA

Fluke S.A. (Pty) Ltd.

P.O. Box 7135
Roggebaai 8012
Cape Town
Republic of South Africa
Tel: (021) 21-1819, TLX: 57-21898

Spain ■

ESSA
(Equipos y Sistemas S.A.)
Apolonio Morales 13-b
Madrid 16 - Spain
Tel: 4580150

Sri Lanka •

Jay-Es Electronics
160 Poorvarama Mawatha
Colombo 5, Sri Lanka
Tel: 073-2393

Sweden ■

Teleinstrument AB
P.O. Box 4490
162 04 Vallingby, Sweden
Tel: (8) 380370, TLX: (854) 15770

Switzerland ■

Traco Electronic AG
Jenatschstrasse 1
8002 Zurich, Switzerland
Tel: (1) 2010711, TLX: (845) 54318

Syria ■

Mabek (Electronics Division)
P.O. Box 4238
Damascus, Syria

Taiwan •

Schmidt Electronics Corp.
6th Fl Cathay Min-Sheng
Commercial Bldg, 344
Min-Sheng East Road
Taipei 104, Taiwan
Tel: 501-3468, TLX: (785) 11111

Thailand •

Measuretronix Ltd.
2102/63 Ramkamhaeng Rd.
Huamark, Bangkok 24, Thailand
Tel: 3782516, TLX: 81143

Tunisia ■

Selep S.A.R.L.
6, Rue de Sparte
Tunis - 1000 RP, Tunisia
Tel: (1) 248093, TLX: (934) 13030

Turkey ■

Erkman Elektronik Aletler
Ticaret Anonim Sirketi
Necatib Cad 92/3
Karakoy, Istanbul, Turkey
Tel: 441546, TLX: (821) 23353

United Arab Emirates ■

Al Sanani Trad. Est.
P.O. Box 7187
Abu-Dhabi, United Arab Emirates
Tel: 821370 or 821371
TLX: 23966

United Kingdom ■

Fluke (Great Britain) Ltd.
Colonial Way
Watford, Herts, WD2 4TT
United Kingdom
Tel: (0923) 40511, TLX: 934583
Rapifax: (0923) 25067

Uruguay •

Coasin Uruguay S.R.L.
Casilla de Correo 1400
Correo Central
Montevideo, Uruguay
Tel: 29-31-95, TLX: UY6571

U.S.S.R. ■

Amtest Associates Ltd.
Clarence House, 31, Clarence St.
Staines, Middlesex TW18 4SY
United Kingdom
Tel: (784) 63555, TLX: 928855

Venezuela •

Coasin C.A.
Calle 9 Con Calle 4, Edif. Edinurbi
Apartado De Correos
NR-70.136 Los Ruices
Caracas 1070A, Venezuela
Tel: 239-0967, TLX: (395) 21027

Yemen ■

Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB Tilburg
Zevenheuvelenweg 53, 5048 AN Tilburg
The Netherlands
Tel: (013) 673973, TLX: 52237

Yugoslavia ■

Amtest Associates Ltd.
Clarence House, 31, Clarence St.
Staines, Middlesex TW18 4SY
United Kingdom
Tel: (784) 63555, TLX: 928855

■ Supplied and Supported by —

Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB Tilburg
Zevenheuvelenweg 53, 5048 AN Tilburg
The Netherlands
Tel: (013) 673973, TLX: 52237

• Supplied and Supported by —

Fluke International Corporation
P.O. Box C9090
Everett, WA 98206 U.S.A.
Tel: (208) 356-5500
TLX: 152662 JOHN FLUKE EVT



Section 8

Options and Accessories

8-1. INTRODUCTION

A number of options and accessories are available which can enhance the 8840A's capabilities and increase operator safety. The accessories are summarized in Table 8-1 and described in the following paragraphs. The options are summarized in Table 8-2 and described in the following subsections.

Table 8-1. Accessories

MODEL	DESCRIPTION
Y8021	IEEE-488 Interface Cable (1m)
Y8022	IEEE-488 Interface Cable (2m)
Y8023	IEEE-488 Interface Cable (4m)
Y8834	Single Rack-Mount Kit
Y8835	Dual Rack-Mount Kit
TL70	Replacement Test Leads
Y8134	Deluxe Test Lead Kit
Y8140	Slim-Flex Test Leads
80T-150C	Temperature Probe (Celsius)
80T-150F	Temperature Probe (Fahrenheit)
85RF	RF Probe (100 kHz to 500 MHz)
83RF	RF Probe (100 kHz to 100 MHz)
80J-10	Current Shunt
Y8100	Current Probe (200A ac/dc)
Y8101	Current Probe (10A ac)
Y801-600	Current Probe (600A ac)
80K-6	High Voltage Probe (6000V)
80K-40	High Voltage Probe (40,000V)

8-2. ACCESSORIES

Accessories include a variety of rack-mounting kits, cables, test leads, and probes. The accessories include installation and/or operating instructions.

Table 8-2. Options

NUMBER	OPTION
-05	IEEE-488 Interface
-09	True RMS AC

8-3. Rack-Mount Kits (Y8834 and Y8835)

The rack-mount kits allow the 8840A to be mounted in standard 19-inch rack panels. The Y8834 kit allows the 8840A to be mounted either on the left or the right. The Y8835 kit allows two 8840As to be mounted side-by-side. Installation instructions are given in Section 2, and are also included with each kit.

8-4. Shielded IEEE-488 Interface Cables (Y8021, Y8022, and Y8023)

Shielded IEEE-488 cables are available in three lengths (see Table 8-1). The cables attach the 8840A to any other IEEE-488 device. Each cable has double 24-pin connectors at both ends to allow stacking. Metric threaded mounting screws are provided with each connector.

8-5. Replacement Test Leads (TL70)

The TL70 replacement test leads feature safety-designed input connectors.

8-6. Deluxe Test Lead Kits (Y8134)

Each deluxe test lead kit includes two test-tip probes, two alligator clips, two large spade lug tips, and one spring-loaded hook tip and probe.

8-7. Slim-Flex Test Leads (Y8140)

The Y8140 has adjustable, flexible, and insulated leads, and can fit into small places. The sharp steel needle points will pierce varnish and thin insulation.

8-8. Temperature Probes (80T-150C and 80T-150F)

The 80T-150C and 80T-150F convert any DMM into a thermometer. The 80T-150C responds in degrees Celsius; the 80T-150F responds in degrees Fahrenheit.

8-9. RF Probes (85RF and 83RF)

The RF probes (85RF and 83RF) use the DMM dc volts function to measure radio frequency (RF) ac signals. The 83RF has a frequency range of 100 kHz to 100 MHz; the 85RF has a frequency range of 100 kHz to 500 MHz. The probes are calibrated so that the dc output is equivalent to the rms value of a sine wave input over a range of 0.25V to 30V rms.

For best accuracy, the probes should be used with DMMs having 10 M Ω input impedance. This condition is satisfied by the 8840A in the 200V and 1000V ranges. The probes can also be used with the 8840A in the 200 mV, 2V, and 20V ranges if a 10 M Ω resistor is connected in parallel across the 8840A input terminals.

8-10. Current Shunt (80J-10)

The 80J-10 current shunt extends ac or dc current measurement up to 10A continuous, or to 20A for one minute without overheating.

8-11. Current Probes (Y8100, Y8101, and Y80I-600)

The current probes extend the ac and dc current measurement range. The Y8100 current probe uses the Hall effect to measure dc or ac current up to 200A (in two ranges) without electrical contact. The Y8101 is a low-cost, compact current probe which uses a transformer to measure ac current from 2A to 10A. The Y80I-600 uses a transformer to measure ac current from 1A to 600A, and features a large jaw opening for industrial use. The Y8101 and Y80I-600 measure ac current only.

8-12. High Voltage Probes (80K-6 and 80K-40)

The high voltage probes extend the dc and ac voltage measurement range while minimizing shock hazard. The 80K-6 has a range of 0 to 6000V dc or peak ac, with frequency response to 1 kHz; the 80K-40 has a range of 0 to 40,000V dc or peak ac, with frequency response to 60 Hz. As the probes use 1000:1 dividers, the probes have a high input impedance and cause minimal circuit loading. The probes are impedance matched for both ac and dc measurements. A plastic body protects the operator from the voltage being measured.

For best accuracy, the probes should be used with DMMs having 10 M Ω input impedance. This condition is satisfied by the 8840A in the 200V dc and 1000V dc ranges. The probes can also be used with the 8840A in the 200 mV dc, 2V dc, and 20V dc ranges if a 10 M Ω resistor is connected in parallel across the input terminals.

Option -05 IEEE-488 Interface

805-1. INTRODUCTION

The IEEE-488 Interface turns the 8840A into a fully programmable instrument for use with the IEEE Standard 488-1978 interface bus (IEEE-488 bus). With the IEEE-488 Interface, the 8840A can become part of an automated instrumentation system. The 8840A can be under complete, interactive control from a remote bus controller, or it can be set to the talk-only mode, connected to a data logger or printer, and dedicated to a single task.

805-2. CAPABILITIES

The IEEE-488 Interface provides remote control of all front panel controls except for the POWER, CAL ENABLE, and FRONT/REAR switches. Other features include:

- A simple and predictable command set
- Fast measurement throughput
- Full talk/listen capability, including talk-only operation
- Full serial poll capability, with bit-maskable SRQ
- Full remote/local capability, including local lockout
- External Trigger and Sample Complete connectors
- Remote calibration
- Programmable trigger sources, including two bus triggers
- Informative output suffix (suppressible)

- Selectable output terminators

The 8840A supports the following interface function subsets: SH1, AH1, T5, L4, SR1, RL1, DC1, DT1, E1, PP0, and C0.

805-3. EXTERNAL CONTROLS

When the IEEE-488 Interface is installed, the rear panel contains EXT TRIG (External Trigger) and SAMPLE COMPLETE connectors. These controls can be used even when the 8840A is disconnected from the IEEE-488 bus. Refer to Section 2 for details.

805-4. INSTALLATION

The IEEE-488 Interface is contained on a single, easy-to-install printed circuit assembly (PCA). To install the option, proceed as follows:

WARNING

TO AVOID ELECTRIC SHOCK, DISCONNECT THE POWER CORD AND ANY INPUT LEADS BEFORE REMOVING THE INSTRUMENT CASE.

1. Remove the grounding screw from the bottom of the case and remove the two rear panel mounting screws (Figure 805-1A).
2. Holding the front panel, slide the case and rear bezel off of the chassis (Figure 805-1B). Note: At this point, the rear bezel is not secured to the case.

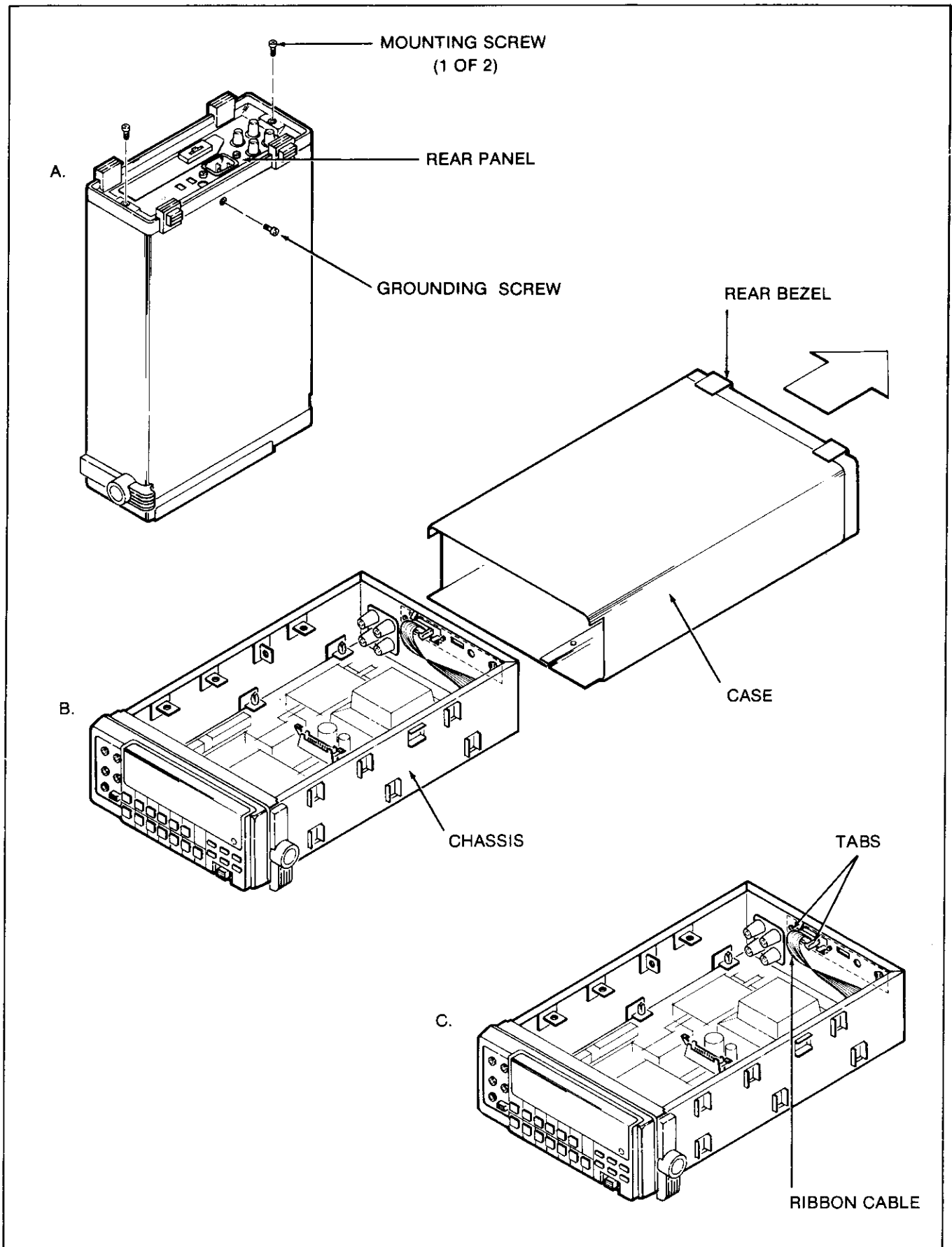


Figure 805-1. Installing Option -05

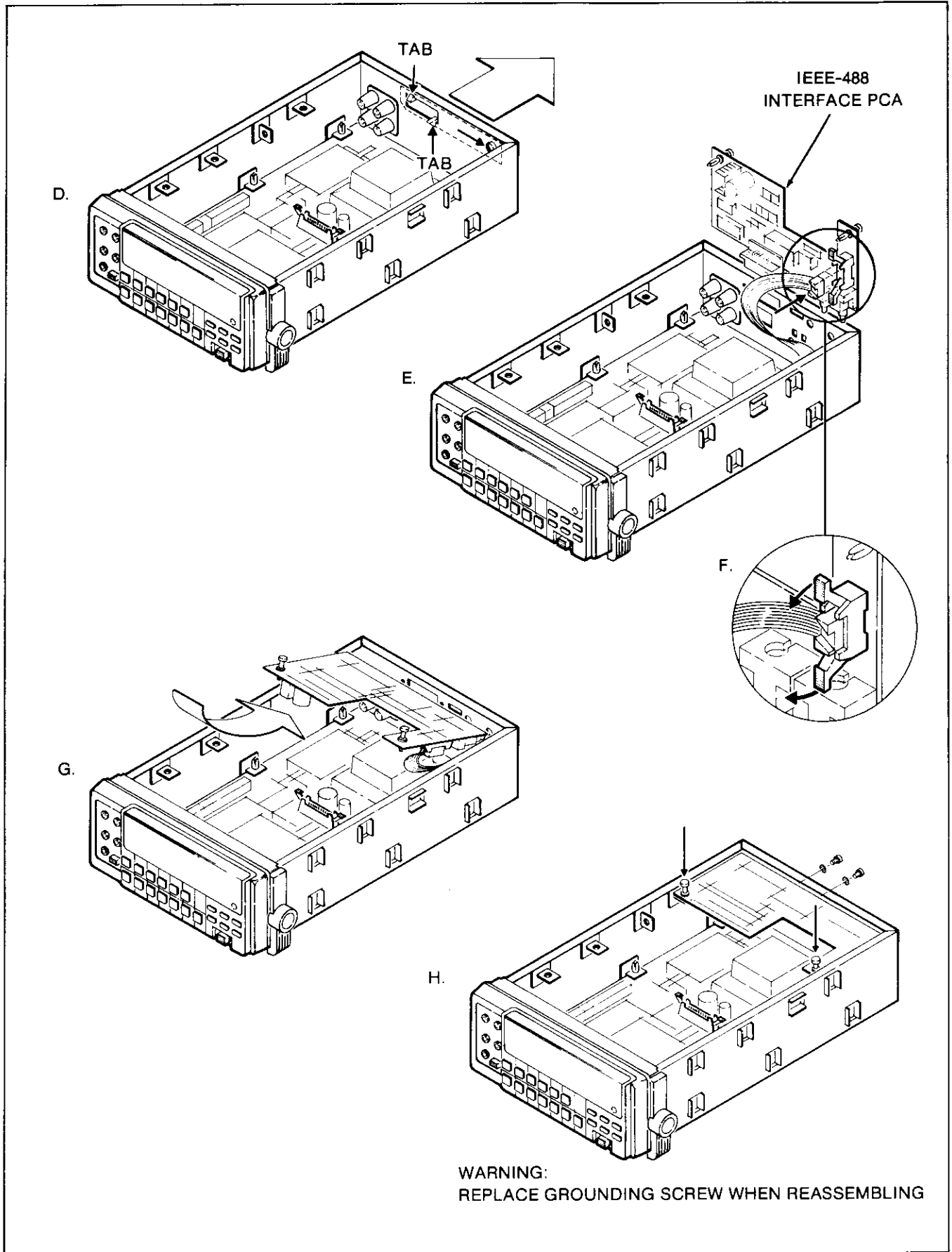


Figure 805-1. Installing Option -05 (cont)

3. Disconnect the ribbon cable from the plastic rear panel insert by pulling the tabs on either side of the ribbon cable connector outward. Pull the ribbon cable directly toward the front panel (Figure 805-1C).
4. Remove the rear panel insert by releasing the two snap tabs inside the instrument (Figure 805-1D).
5. Connect the the ribbon cable from the Main PCA to the connector on the IEEE-488 Interface PCA (Figure 805-1E).
6. Latch the ribbon cable in place as shown in Figure 805-1F.
7. With the component side down, guide the BNC and IEEE-488 connectors (located on the rear of the IEEE-488 Interface PCA) into the rear panel, and seat the IEEE-488 Interface PCA on the mounting supports on the chassis (Figure 805-1G).
8. Fasten the IEEE-488 Interface PCA to the chassis by pressing the two nylon latches into the mounting supports. (See Figure 805-1H.)
9. Secure the IEEE-488 connector to the rear panel with the two screws and washers supplied.

10. Replace the cover and rear bezel on the chassis and attach the two rear panel mounting screws.
11. Attach the grounding screw to the bottom of the case.

WARNING

TO AVOID ELECTRIC SHOCK, ENSURE THE GROUNDING SCREW IS FIRMLY ATTACHED TO THE CASE BOTTOM.

805-5. PROGRAMMING INSTRUCTIONS

Programming instructions are presented in Section 3. That section also explains how to set up the 8840A on the IEEE-488 bus.

805-6. MAINTENANCE

All service information regarding option -05 is contained in Section 6. The theory of operation is contained in Section 5.

805-7. LIST OF REPLACEABLE PARTS

A list of replaceable parts for the IEEE-488 Interface printed circuit assembly (PCA) is given in Table 805-1. Refer to Section 7 for ordering information.

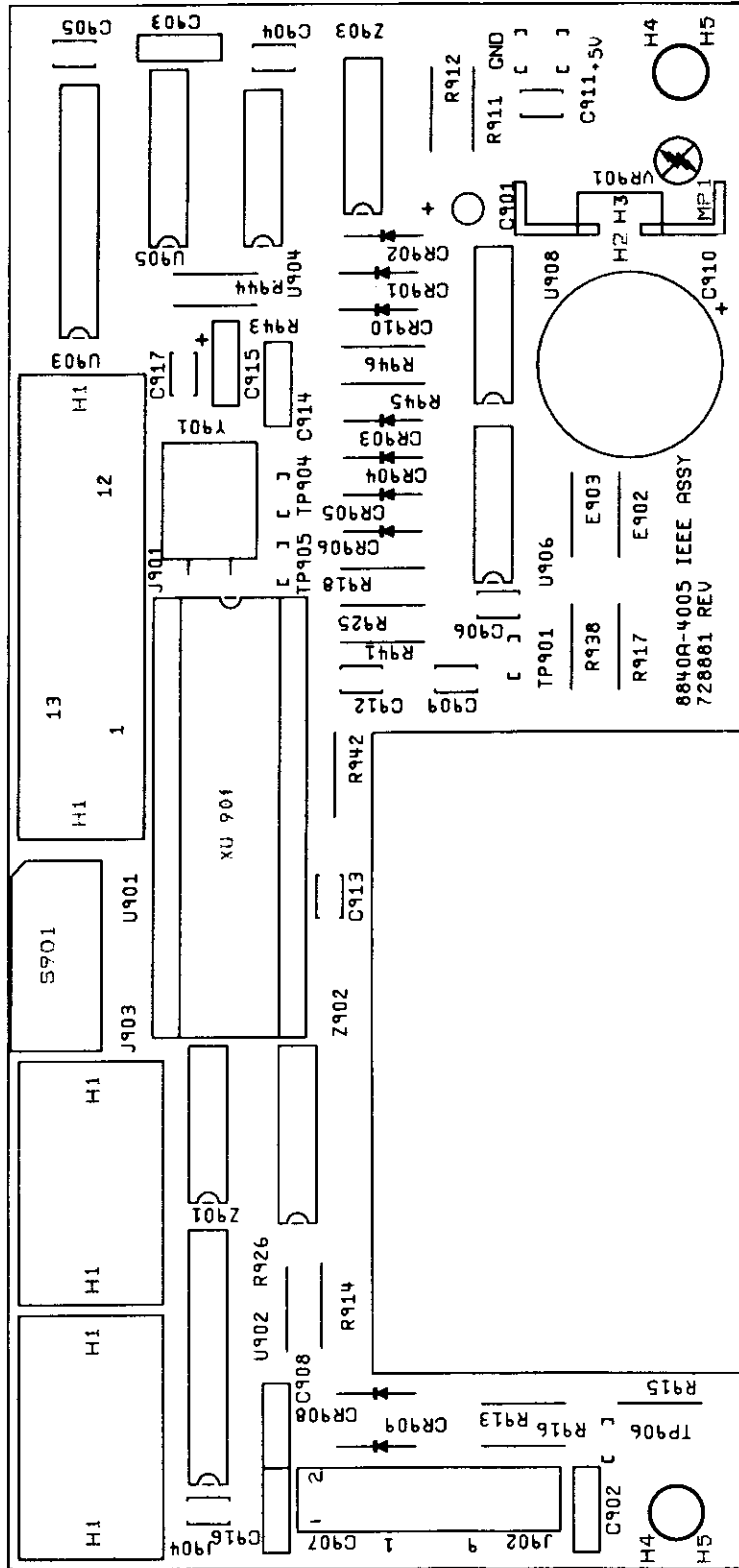
TABLE 805-1. IEEE-488 INTERFACE PCA
(SEE FIGURE 805-2.) 8840A-05

REFERENCE DESIGNATOR	DESCRIPTION	FLUKE STOCK --NO--	MFRS SFLY CODE	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S T	N O T
C 901	CAP, TA, 1UF, +-20%, 35V	697417	05571	199D	1		
C 902, 903, 907,	CAP, CER, 0.01UF, +80-20%, 50V, Z5V	697284	71590	2DDH61	4		
C 908		697284					
C 904-906, 911,	CAP, CER, 0.22UF, +80-20%, 50V, Z5U	649939	71590	CZ20	6		
C 916, 917		649939					
C 909, 912-914	CAP, CER, 1000PF, +-20%, 50V, X7R	697458	71590	CW20	4		
C 910	CAP, AL, 4700UF, +30-20%, 16V	460261	54473	ECE-T16R4700S	1		
C 915	CAP, TA, 47UF, +-20%, 10V	733246	56289	199D	1		
CR 901, 902	* ZENER, UNCOMP, 3.9V, 10%, 20.0MA, 0.4W	698654	22767	1N748	2	1	
CR 903-906, 910	* DIODE, SI, BV= 75.0V, IO=150MA, 500MW	698720	57668	1N4448	5	1	
CR 908, 909	* DIODE, SI, 100 PIV, 1.0 AMP	707067	57668	1N4002	2	1	
E 902	RES, CF, (0.02 OHMS	697060	09021	Z-25	1		
H 1	RIVET, .120 X .281	650283	12014	R3647X, 281	6		
H 2	NUT, HEX, DOUBLE CHAMFER, 4-40	184044	73734	8002A-NP	1		
H 3	SCREW, MACHINE, PHP, STEEL, 4-40X3/16	129882	73734	19022	1		
H 4	GROMMET LATCH	682898	83014	HN4G-44-5	2		
H 5	PLUNGER LATCH	682906	83014	HN4P-44-4-1	2		
J 901	CONN, PWB, RIBBON, 90, 24 POS, STD ORIENT	658039	02660	57-92245-12	1		
J 902	HEADER, VERTICAL L-LATCH W/KEYS 10POS	697359	28213	3446-6302	1		
J 903, 904	CONN, COAX, BNC, REC, 90, PWB	658542	00779	226978-1	2		
MP 1	HEATSINK	414128	13103	6030B-TT	1		
R 911, 912, 944	RES, CF, 51K, +-5%, 0.25W	573535	09021	CF1/4	3		
R 913, 914	RES, CF, 1.5K, +-5%, 0.25W	573212	80031	CR251-4-5P1K5	2		
R 915, 916	RES, CF, 470, +-5%, 0.25W	573121	80031	CR251-4-5P470E	2		
R 917, 918, 938,	RES, CF, 100, +-5%, 0.25W	573014	80031	CR251-4-5P100E	5		
R 941, 942		573014					
R 925, 926	RES, CF, 3.3K, +-5%, 0.25W	573287	80031	CR251-4-5P3K3	2		
R 943	RES, CF, 68K, +-5%, 0.25W	573550	80031	CR251-4-5P68K	1		
R 945, 946	RES, CF, 10K, +-5%, 0.25W	573394	80031	CR251-4-5P10K	2		
S 901	SWITCH, DIP	658567	00779	7900	1		
TM 3	IEEE 488 QUICK REFERENCE GUIDE	729012	89536	729012	1		
TP 901-906	CONN, TAB, FASTON, PRESS-IN, 0.110 WIDE	512889	02660	62395	6		
U 901	* IC, NMOS, 8 BIT MICROCOMPUTR, 8840A-90010	723122	56708	Z8611FS	1	1	
U 902, 903	* IC, LSTTL, OCTIL IEEE-488 BUS TRANSCVR	524835	04713	MC3447P	2	2	
U 904	* IC, LSTTL, QUAD 2 INPUT NAND GATE	394205	01295	SN74LS03N	1	1	
U 905	* IC, LSTTL, HEX INVERTER W/3-STATE OUT	654442	01295	SN74LS368AN	1	1	
U 906	* IC, LSTTL, QUAD 2 IN NAND W/SCHMT TRIG	504449	01295	SN74LS132N	1	1	
U 908	* IC, COMPARATOR, QUAD, 14 PIN DIP	387233	12040	LM339N	1	1	
VR 901	* IC, VOLT REG, FIXED, +5 VOLTS, 1.5 AMPS	428847	04713	MC7805CT	1	1	
XU 901	SOCKET, DIP, 0.100 CTR, 40 PIN	429282	09922	DILB40P-108	1		
Y 901	* CRYSTAL, 8.00MHZ QUARTZ HC-18U	707133	89536	707133	1	1	
Z 901	RES, NET, DIP, 14 PIN, 13 RES, 10K, +-5%	355313	01121	314	1		
Z 902	RES, NET, DIP, 16 PIN, 8 RES, 3.3K, +-5%	572073	01121	314	1		
Z 903	RES, NET, DIP, 14 PIN, 13 RES, 3.3K, +-5%	733402	01121	314	1		

CAUTION

*

DEVICES INDICATED BY THE ABOVE
SYMBOL ARE SUBJECT TO DAMAGE BY
STATIC DISCHARGE.



8840A-4005 IEEE ASSY
728861 REV

8840A-1605

Figure 805-2. IEEE-488 Interface, Option -05

Option -09 True AC RMS AC

809-1. INTRODUCTION

The True RMS AC option gives the 8840A the ability to make ac voltage and current measurements. The ac functions are selected with the front panel VAC and mA AC buttons, or by remote commands if the IEEE-488 Interface option is installed. Specifications for Option -09 are shown in Section 1, Table 1-1.

809-2. INSTALLATION

The True RMS AC option is contained on a single, easy-to-install printed circuited assembly (PCA). To install the option, proceed as follows:

WARNING

TO AVOID ELECTRIC SHOCK, DISCONNECT THE POWER CORD AND TEST LEADS BEFORE REMOVING THE INSTRUMENT CASE.

1. Remove the grounding screw from the bottom of the case and remove the two rear panel mounting screws (Figure 809-1A).
2. Holding the front panel, slide the case and rear bezel off of the chassis (Figure 809-1B). (At this point, the rear bezel is not secured to the case.)
3. Holding the True RMS AC PCA slightly above the chassis, component side down, connect the ribbon cable from the True RMS AC PCA to the Main PCA and latch it in place. (See Figure 809-1C and D.)
4. Connect the red lead from the True RMS AC PCA to stud J301 on the Main PCA. (See Figure 809-1C.) The stud is located next to the forward end of the FRONT/REAR switch.

5. Fasten the True RMS AC PCA to the chassis by pressing the four nylon latches into the mounting supports on the chassis. (See Figure 809-1E.)
6. Reinstall the cover and rear bezel on the chassis and attach the two rear panel mounting screws.
7. Attach the grounding screw to the bottom of the case.

WARNING

TO AVOID ELECTRIC SHOCK, ENSURE THE GROUNDING SCREW IS FIRMLY ATTACHED TO THE CASE BOTTOM.

8. Calibrate the VAC voltage and mA AC functions according to the calibration instructions given in the Maintenance section.

809-3. OPERATING INSTRUCTIONS

For operating instructions, refer to Section 2. For ac measurement considerations, refer to Section 4.

809-4. MAINTENANCE

All service information regarding Option -09 is contained in Section 6. The theory of operation is contained in Section 5.

809-5. LIST OF REPLACEABLE PARTS

A list of replaceable parts for the True RMS AC printed circuit assembly (PCA) is given in Table 809-1. Refer to Section 7 for ordering information.

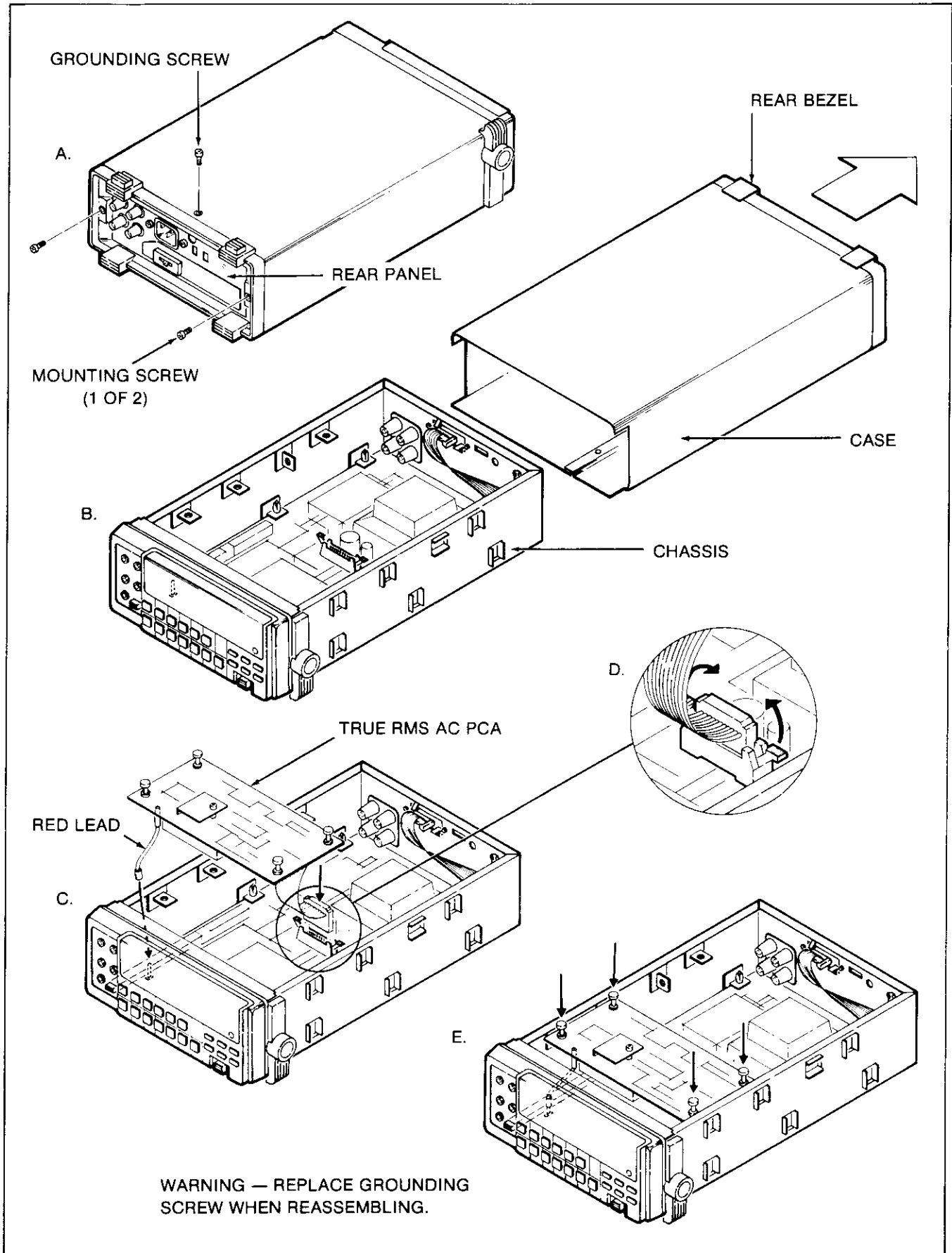


Figure 809-1. Installing Option -09

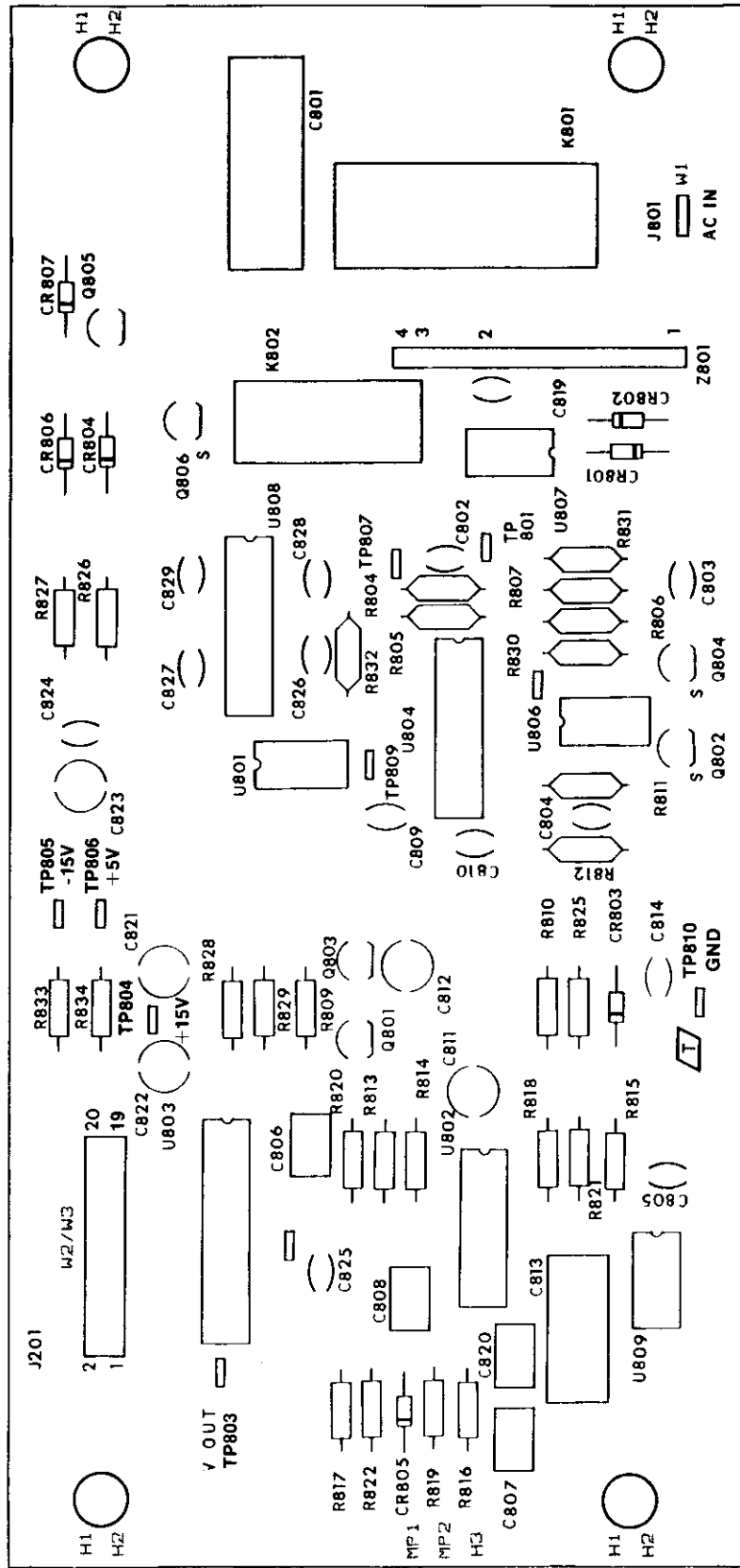
TABLE 809-1. TRUE RMS AC PCA
(SEE FIGURE 809-2.) 8840A-09

REFERENCE DESIGNATOR A->NUMERICS----->	S	-----DESCRIPTION-----	FLUKE STOCK --NO--	MFRS SPLY CODE--	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S	N O T -E
C 801		CAP, POLYES, 0.068UF, +-10%, 1000V	714816	60935	160	1		
C 802		CAP, CER, 56PF, +-2%, 50V, COG	714378	71590	CN20	1		
C 803		CAP, CER, 33PF, +-2%, 50V, COG	715292	71590	CN20	1		
C 804		CAP, CER, 6.8PF, +-0.25PF, 50V, M7J	715243	51406	RPE122	1		
C 805		CAP, CER, 470PF, +-10%, 50V, COG	733071	71590	CN20	1		
C 806-808, 820		CAP, POLYES, 0.47UF, +-10%, 50V	697409	60935	185	4		
C 809, 810, 824		CAP, CER, 0.22UF, +80-20%, 50V, Z5U	649939	71590	CZ20	3		
C 811, 812		CAP, TA, 1UF, +-20%, 35V	697417	05571	199D	2		
C 813		CAP, POLYES, 1.0UF, +-10%, 50V	733089	89536	733089	1		
C 814		CAP, CER, 1000PF, +-20%, 50V, X7R	697458	71590	CW20	1		
C 819		CAP, CER, 1.2PF, +-0.25PF, 50V, M7J	715235	51406	RPE122	1		
C 821		CAP, TA, 10UF, +-20%, 10V	714766	56289	199D	1		
C 822, 823		CAP, TA, 10UF, +-20%, 25V	714774	56289	199D	2		
C 825		CAP, CER, 0.01UF, +80-20%, 50V, Z5V	697284	71590	2DDH61	1		
C 826		CAP, CER, 39PF, +-2%, 50V, COG	714840	71590	CN20	1		
C 827		CAP, CER, 12PF, +-2%, 100V, COG	715169	71590	CN20	1		
C 828		CAP, CER, 68PF, +-2%, 50V, COG	715300	71590	CN20	1		
C 829		CAP, CER, 22PF, +-2%, 50V, COG	714832	71590	CN20	1		
CR 801, 802	*	DIODE, SI, BV= 20.0V, IO= 50MA, 250 MW	698738	07263	FD700	2	1	
CR 803-805	*	DIODE, SI, BV= 75.0V, IO=150MA, 500MW	698720	57668	1N4448	3	1	
H 1		GROMMET, LATCH	682898	83014	HN4G-44-5	4		
H 2		PLUNGER, LATCH	682906	83014	HN4F-44-4-1	4		
H 3		SCREW, MACHINE, PHF, STEEL, 6-32X1/2	152173	89536	152173	1		
K 801		RELAY, REED, 1 FORM A, 5V, HIGH VOLTAGE	714352	71707	3400-0087	1	1	
K 802		RELAY, REED, 1 FORM A, 4.5VDC	404590	71707	CR4503	1	1	
MF 1		SHIELD, AC BOTTOM	656421	89536	656421	1		
MF 2		SHIELD, AC	722223	89536	722223	1		
Q 801, 803, 805	*	TRANSISTOR, SI, PNP, T092	698233	07263	2N3906	3	1	
Q 802, 804, 806	*	TRANSISTOR, SI, N-JFET, REMOTE CUTOFF	707968	89536	707968	3	1	
R 804, 805, 830,		RES, MF, 10K, +-1%, 0.125W, 50PPM	706937	09021	MF	4		
R 831			706937					
R 806, 811		RES, MF, 20K, +-0.1%, 0.125W, 25PPM	706168	09021	MF	2		
R 807		RES, MF, 5K, +-0.1%, 0.125W, 25PPM	706135	09021	MF	1		
R 809		RES, CF, 8.2K, +-5%, 0.25W	573378	80031	CR251-4-5P8K2	1		
R 810, 820, 825-		RES, CF, 100K, +-5%, 0.25W	573584	80031	CR251-4-5P100K	5		
R 827			573584					
R 812		RES, MF, 2.222K, +-0.1%, 0.125W, 25PPM	706143	09021	MF	1		
R 813		RES, CF, 330K, +-5%, 0.25W	641159	80031	CR251-4-5P330K	1		
R 814		RES, CF, 20, +-5%, 0.25W	572958	80031	CR251-4-5P20E	1		
R 815, 818, 829		RES, CF, 15K, +-5%, 0.25W	573428	80031	CR251-4-5P15K	3		
R 816, 819		RES, CF, 75K, +-5%, 0.25W	641134	09021	CF1/4	2		
R 817		RES, CF, 91K, +-5%, 0.25W	573576	09021	CF1/4	1		
R 821		RES, CF, 7.5K, +-5%, 0.25W	573360	09021	CF1/4	1		
R 822		RES, CF, 2K, +-5%, 0.25W	573238	80031	CR251-4-5P2K	1		
R 828		RES, CF, 12K, +-5%, 0.25W	573402	80031	CR251-4-5P12K	1		
R 832		RES, MF, 4.99K 1%, 1/8W 500PPM	714923	09021	MF	1		
R 833, 834		RES, CF, 10, +-5%, 0.25W	572941	80031	CR251-4-5P10E	2		
U 609	*	IC, OP AMP, DUAL, JFET INPUT, 8 PIN DIP	495192	12040	LF353BN	1		
U 801, 806	*	IC, OP AMP, DUAL, HIGH SPEED	707976	18324	NE5532N	2	1	
U 802	*	IC, BPLR, TRUE RMS TO DC CONVERTER	707653	24355	AD637	1		
U 803	*	IC, TTL, OCTAL D F/F, +EDG TRG	473223	01295	SN74LS374N	1	1	
U 804, 808	*	IC, CMOS, QUAD BILATERAL SWITCH	586735	17856	DG211CJ	2	1	
U 807	*	IC, OP AMP, JFET INPUT, 8 PIN DIP	472779	12040	LF356N	1	1	
W 1		WIRE ASSY, AC CONNECT	684316	89536	684316	1		
W 3		CABLE ASSY, 20 COND. FLAT, 4.5L IDC/DRB	714014	30146	1003018-A	1		
Z 801	*	RESISTOR NETWORK AC INPUT DIVIDER	704478	89536	704478	1	1	

CAUTION

*

DEVICES INDICATED BY THE ABOVE
SYMBOL ARE SUBJECT TO DAMAGE BY
STATIC DISCHARGE.



8840A-1609

Figure 809-2. True RMS AC Converter, Option -09

Section 9

Manual Change Information

9-1. INTRODUCTION

Table 9-1 contains information necessary to backdate this manual to conform with earlier printed circuit assembly (PCA) configurations.

As changes and improvements are made to the instrument, they are identified by incrementing the revision letter marked on the affected PCA. These changes are documented on a supplemental change/errata sheet which, when applicable, is inserted at

the front of the manual. To identify the configuration of the PCAs used in your instrument, refer to the revision letter on the component side of each PCA.

9-2. BACKDATING INSTRUCTIONS

To backdate this manual to conform with an earlier assembly revision level, perform the changes indicated in Table 9-1. If this manual documents all PCAs at their original level, no changes are necessary, and no changes will be indicated in Table 9-1.

Table 9-1. Manual Status and Backdating Information

Ref Or Option No.	Assembly Name	Fluke Part No.	* To adapt manual to earlier rev configurations perform changes in descending order (by no.), ending with change under desired rev letter																	
			-	A	B	C	D	E	F	G	H	J	K	L	M	N	P			
	Main PCA	728857	●	●	●	X														
05	IEEE PCA	728881	●	●	X															
09	AC Converter TRMS PCA	728899	●	●	●	X														
			* X = The PCB revision levels documented in this manual. ● = These revision letters were never used in the instrument. -- = No revision letter on the PCB.																	

