NOTE

This manual documents the 5450A Resistance Calibrator and its assemblies at the revision levels shown in Section 8. If your instrument contains assemblies with different revision letters, it will be necessary for you to either update or backdate this manual. Refer to the supplemental change/errata sheet for newer assemblies, or to the backdating sheet in Section 8 for older assemblies.

5450A
Resistance Calibrator

Instruction Manual

P/N 713800
March 1984

FLUKE®

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

Rev. 6/81

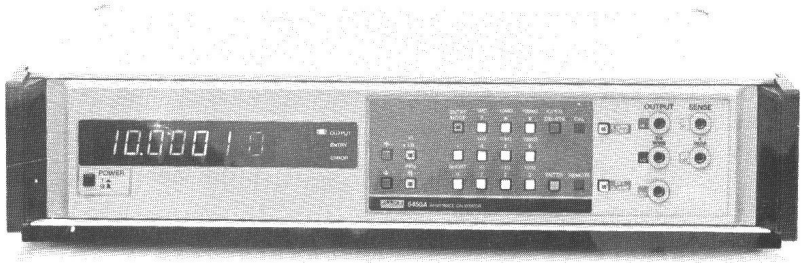
Table of Contents

(continued on page ii)

TABLE OF CONTENTS, *continued*

List of Tables

List of Illustrations



5450A Resistance Calibrator

Section 1
Introduction & Specifications

1-1. INTRODUCTION

The Fluke 5450A Resistance Calibrator is designed to facilitate manual or automated calibration of the resistance measuring circuitry of high-quality digital multimeters (DMMs). The 5450A provides cardinal point resistances in the range of 1Ω to 100 MΩ. Resistances may be selected either at decade points (e.g., 1Ω, 10Ω, 100Ω, etc.) or at x1.9 points (e.g., 1.9Ω, 19Ω, 190Ω, etc.).

The 5450A display indicates the value of the selected resistance and can also indicate the error of the instrument being calibrated (the unit under test, or UUT), expressed in percent or parts-per-million (ppm).

The 5450A may be controlled from the front panel or by remote control via the IEEE-488 interface bus. All functions available on the front panel are also available over the IEEE-488 bus.

The UUT may be connected directly to the 5450A front panel terminals using banana plugs, or to five-way low-thermal binding posts on the rear panel.

The 5450A is calibrated with its covers installed and may be calibrated remotely via the IEEE-488 bus. Calibration constants are stored in electrically alterable read-only memory (EAROM).

Accessories available for the 5450A include a rack mounting kit, rack mounting ears, and IEEE-488 interface bus cables.

1-2. SPECIFICATIONS

Specifications for the model 5450A are given in Table 1-1. An outline drawing is shown in Figure 1-1.

The accuracy specifications assume that the ambient temperature is held within the limits specified and that the relative humidity is held at or below 80% unless indicated. A minimum 2-hour warm-up time is also assumed.

Table 1-1. Specifications

FOUR-WIRE OPERATION

The four-wire specifications apply to the four-wire measurement configuration in which the OUTPUT terminals are used for test current and the SENSE terminals are used for sensing voltage.

FOUR-WIRE ACCURACY SPECIFICATIONS[1]

NOMINAL VALUE	NOMINAL[2] TOLERANCE (±ppm)	NORMAL I RANGE[4] $I_L < I < I_U$		ABSOLUTE UNCERTAINTY[2] (±ppm unless indicated)			
		Lower Limit I_L	Upper Limit I_U	23°C ±1°C, 70% RH		23°C ±5°C, 70% RH[3]	
				24 Hours	90 Days	90 Days	1 Year
SHORT		10 mA	500 mA	.1 mΩ	.1 mΩ	.1 mΩ	.1 mΩ
1Ω	1000	10 mA	100 mA	50	62	75	110
1.9Ω	1000	10 mA	75 mA	40	52	65	100
10Ω	500	10 mA	25 mA	18	20.5	25	33
19Ω	500	10 mA	25 mA	16	18.5	23	31
100Ω	175	10 mA	15 mA	7.5	9	11	16
190Ω	150	10 mA	15 mA	7	8.5	10.5	15.5
1 kΩ	100	700 μA	2.5 mA	5.5	7	8.5	13.5
1.9 kΩ	100	500 μA	2.5 mA	5	6.5	8	13
10 kΩ	60	50 μA	1 mA	5	6.5	8	13
19 kΩ	50	50 μA	1 mA	4.5	6	7.5	12.5
100 kΩ	50	5 μA	250 μA	6	7.5	9	14
190 kΩ	50	5 μA	250 μA	5.5	7	8.5	13.5
1 MΩ	50	5 μA	50 μA	7.5	10	11.5	19
1.9 MΩ	50	5 μA	25 μA	7.7	10	11.5	19
10 MΩ	100	.5 μA	5 μA	16	24	26	50
19 MΩ	100	.25 μA	2.5 μA	20	28	30	56
100 MΩ	500	.05 μA	.5 μA	65	90	120	200

Notes:

1. The above table assumes the 5450A was calibrated according to the procedure specified in Section 4-28.
2. The actual value of each resistance is determined to the accuracy given under ABSOLUTE UNCERTAINTY. These values can differ from the nominal values by the amount given under NOMINAL TOLERANCE.
3. Above 70% relative humidity the accuracy degrades for values above 190 kΩ. For these values use the following table for ABSOLUTE UNCERTAINTY to 80% RH:

Nominal Value	90 Days 23°C ±5°C	1 Year 23°C ±5°C
1 MΩ	12.5 ppm	20 ppm
1.9 MΩ	13.5 ppm	21 ppm
10 MΩ	36 ppm	60 ppm
19 MΩ	50 ppm	76 ppm
100 MΩ	140 ppm	220 ppm

4. The accuracy degrades for current outside the limits given under NORMAL I RANGE, which begins at the given lower limit (I_L) and ends at the given upper limit (I_U). For a description and derating factors, see FOUR-WIRE CURRENT DERATING FACTORS, below.

Table 1-1. Specifications (cont)

OTHER FOUR-WIRE SPECIFICATIONS

NOMINAL VALUE	STABILITY[1,2] (±ppm)				MAXIMUM CURRENT[4] (I_{MAX}) (direct current)	MAXIMUM VOLTAGE[4] (V_{MAX}) (direct voltage)	TEMPERATURE COEFFICIENT[5] 0°C-18°C & 28°C-50°C (±ppm/°C) (add to accuracy spec)
	23°C ±1°C, 70% RH		23°C ±5°C, 70% RH[3]				
	24 Hours	90 Days	90 Days	1 Year			
SHORT					500 mA	0.25V	
1Ω	30	42	55	90	400 mA	0.4V	6
1.9Ω	20	32	45	80	300 mA	0.57V	6
10Ω	7	9.5	14	22	100 mA	1V	2.5
19Ω	5	7.5	12	20	100 mA	1.9V	2.5
100Ω	2	3.5	5.5	10.5	25 mA	2.5V	1.5
190Ω	1.5	3	5	10	25 mA	4.75V	1.5
1 kΩ	2	3.5	5	10	10 mA	10V	1.5
1.9 kΩ	1.5	3	4.5	9.5	10 mA	19V	1.5
10 kΩ	2	3.5	5	10	2.5 mA	25V	1.5
19 kΩ	1.5	3	4.5	9.5	2.5 mA	47.5V	1.5
100 kΩ	2	3.5	5	10	500 μA	50V	1.5
190 kΩ	1.5	3	4.5	9.5	250 μA	50V	1.5
1 MΩ	2.5	5	6.5	14	50 μA	50V	1.5
1.9 MΩ	2.5	5	6.5	14	25 μA	50V	1.5
10 MΩ	10	18	20	44	5 μA	50V	3
19 MΩ	14	22	24	50	2.5 μA	50V	4
100 MΩ	40	65	95	175	.5 μA	50V	10

Notes:

1. This table can be used to determine the absolute uncertainty for four-wire operation when the 5450A is calibrated by means other than the procedure presented in Section 4-28. For each resistance value, add the uncertainty of the calibration technique used to the stability figure given above for the desired conditions.
2. The accuracy degrades for current outside the limits given under NORMAL I RANGE in the FOUR-WIRE ACCURACY SPECIFICATIONS, above. For a description and derating factors, see FOUR-WIRE DERATING FACTORS, below.
3. Above 70% relative humidity the accuracy degrades for values above 190 kΩ. For these values use the following table for STABILITY to 80% RH:

Nominal Value	90 Days 23°C ±5°C	1 Year 23°C ±5°C
1 MΩ	7.5 ppm	15 ppm
1.9 MΩ	8.5 ppm	16 ppm
10 MΩ	30 ppm	54 ppm
19 MΩ	44 ppm	70 ppm
100 MΩ	115 ppm	195 ppm

4. The maximum current and voltage given are the maximum that will not permanently change any resistance values. Operation above these limits may require recalibrating the instrument afterwards.
5. The temperature coefficient applies to both the ABSOLUTE UNCERTAINTY and the STABILITY, above.

Table 1-1. Specifications (cont)

FOUR-WIRE CURRENT DERATING FACTORS		
NOMINAL VALUE	OVER/UNDER I NORMALIZATION K	
	$I < I_L$ Note 1	$I_U < I < I_{MAX}$ Note 2
SHORT	$5x10^{-1}$	None
1Ω	$2x10^{2}$	$1x10^{-4}$
1.9Ω	$1x10^{2}$	$2x10^{-4}$
10Ω	$5x10^{1}$	$3x10^{-4}$
19Ω	$2.6x10^{1}$	$3x10^{-4}$
100Ω	$5x10^{0}$	$2x10^{-3}$
190Ω	$2.6x10^{0}$	$2x10^{-3}$
1 kΩ	$5x10^{-1}$	$2x10^{-2}$
1.9 kΩ	$2.6x10^{-1}$	$2x10^{-2}$
10 kΩ	$5x10^{1}$	$2x10^{-7}$
19 kΩ	$2.6x10^{1}$	$2x10^{-7}$
100 kΩ	$3x10^{0}$	$2x10^{-6}$
190 kΩ	$1.6x10^{0}$	$I_U = I_{MAX}$
1 MΩ	$5x10^{0}$	$I_U = I_{MAX}$
1.9 MΩ	$2.6x10^{0}$	$I_U = I_{MAX}$
10 MΩ	$1x10^{0}$	$I_U = I_{MAX}$
19 MΩ	$5.3x10^{-1}$	$I_U = I_{MAX}$
100 MΩ	$1x10^{-1}$	$I_U = I_{MAX}$

Notes:

1. For $I < I_L$, errors occur due to thermally generated voltages within the 5450A. Use the following equation to determine the error in ppm (or milliohms for the SHORT), and add this to the ABSOLUTE UNCERTAINTY or STABILITY, above.

   ppm (or milliohms for SHORT) = $K \times (I_L - I) / (I_L \times I)$

   where: K is the constant from the above table;
   I and I_L are expressed in mA for SHORT to 1.9 kΩ;
   I and I_L are expressed in μA for 10 kΩ to 100 MΩ.

2. For $I_U < I < I_{MAX}$, error occurs due to self-heating of the resistors in the 5450A. Use the following equation to determine the error (in ppm), and add this to the ABSOLUTE ACCURACY or STABILITY, above.

   ppm = $K \times (I^2 - I_U^2)$

   where: K is the constant from the above table;
   I and I_U are expressed in mA for SHORT to 1.9 kΩ;
   I and I_U are expressed in μA for 10 kΩ to 100 MΩ.

Table 1-1. Specifications (cont)

TWO-WIRE OPERATION

The two-wire specifications apply to the OUTPUT terminals and assume the use of the 2 WIRE COMPensation feature. The 2 WIRE COMPensation feature compensates for the connection resistance, which may include user cabling (such as test leads or system cabling). The compensation value can be calibrated at the time the instrument is calibrated, or for better accuracy, every 24 hours.

To find the two-wire accuracy specification, take the accuracy values from the TWO-WIRE SPECIFICATIONS table (below), add any error specified in notes 2 and 4 (below), convert the result to ppm, and add the result to the values given in the FOUR-WIRE ACCURACY SPECIFICATIONS and OTHER FOUR-WIRE SPECIFICATIONS tables, above. Above 190 kΩ the two-wire specifications are the same as the four-wire specifications.

TWO-WIRE SPECIFICATIONS [1, 2, 3, 4]			
NOMINAL VALUE	MINIMUM CURRENT	ADD TO 4-WIRE ACCURACY SPECIFICATION 23°C ±5°C 90 Days (±mΩ)	ADD TO 4-WIRE ACCURACY SPECIFICATION TOC ±5°C (18°C-28°C) 24 Hours (±mΩ)
1Ω	1 mA	25 mΩ	12 mΩ
1.9Ω	1 mA	25 mΩ	12 mΩ
10Ω	1 mA	20 mΩ	10 mΩ
19Ω	1 mA	20 mΩ	10 mΩ
100Ω	1 mA	25 mΩ	12 mΩ
190Ω	1 mA	25 mΩ	12 mΩ
1 kΩ	.1 mA	100 mΩ	35 mΩ
1.9 kΩ	.1 mA	100 mΩ	35 mΩ
10 kΩ	10 μA	200 mΩ	125 mΩ
19 kΩ	10 μA	200 mΩ	125 mΩ
100 kΩ	1 μA	1000 mΩ	1000 mΩ
190 kΩ	1 μA	1000 mΩ	1000 mΩ

Notes:

1. Specifications apply for both front and rear panel terminals regardless of which terminals were used during calibration.

2. If user cabling is included in the 2-wire compensation value, add to the specification the variations in cabling resistance for the appropriate time period and temperature.

3. The 2-wire compensation value may be calibrated every 24 hours as described in Section 2 (see "2-Wire Enhancement"). The ambient temperature at which this calibration is performed (called temperature of calibration, or TOC) may be between 18°C and 28°C. The 24-hour specification applies for the range TOC ±5°C, but does not apply above 28°C or below 18°C.

4. Add to the 24-hour specification the error (in milliohms) of the DMM used when measuring the short.

Table 1-1. Specifications (cont)

IEEE-488 INTERFACE FUNCTION SUBSETS		
SH1	Source handshake	Complete capability
AH1	Acceptor handshake	Complete capability
T8	Talker	Basic talker, unaddress if MLA
L4	Listener	Basic listener, unaddress if MTA
SRO	Service request	No capability
RL1	Remote/local	Complete capability
PPO	Parallel poll	No capability
DC1	Device clear	Complete capability
DTO	Device trigger	No capability
CO	Controller	No capability
E2	Electrical interface	Three-state drivers

GENERAL SPECIFICATIONS

Interface ..... IEEE Standard 488-1978 (IEEE-488)

Warm-up time ..... 2 hours from environment of 18°C to 28°C
4 hours from environment of 0°C to 40°C

Maximum Voltages:

Any terminal to ground: ..... 60V dc
Between HI & LO: ..... See V_{MAX} under OTHER FOUR-WIRE SPECIFICATIONS
Between LO & GD: ..... 60V dc if EXT GD selected,
2V dc otherwise.

Altitude ..... 0 to 10,000 feet (operating)
0 to 40,000 feet (storage)

Vibration ..... 3.1g maximum

Power Requirements ..... 100, 120, 220, or 240V ac ±10%
50 to 60 Hz ±5%, <50W

Weight ..... 9.3 kg (20.4 lbs)
15.9 kg (35 lbs) shipping weight

Dimensions ..... See Figure 1-1
8.89 cm H x 55.37 cm L x 43.18 cm W
(3.5 in H x 21.8 in L x 17.00 in W)

Shipping dimensions:
25.4 cm H x 67.3 cm L x 53.8 cm W
(10 in H x 26-1/2 in L x 21-3/16 in W)

Protection Class ..... Class 1 as defined in safety standards
IEC 348 and ANSI C39.5

Table 1-1. Specifications (cont)

TEMPERATURE AND HUMIDITY		
CONDITION	TEMPERATURE	RELATIVE HUMIDITY
Storage	-40°C to 0°C 0°C to 75°C	Not controlled ≤95% RH
Operating	0°C to 40°C 40°C to 50°C	≤80% RH ≤50% RH

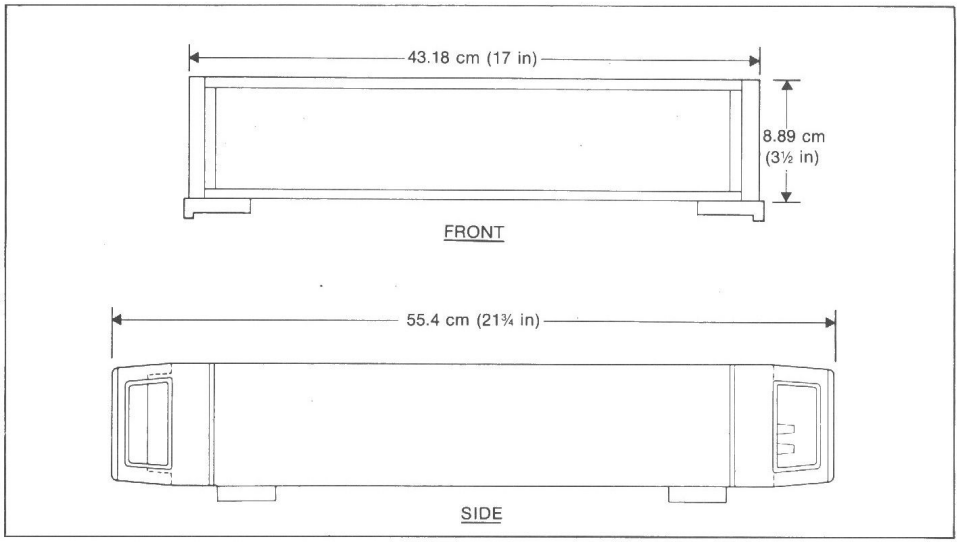


Figure 1-1. Outline Drawing

Section 2
Operating Instructions

2-1. INTRODUCTION

This section contains installation and operating instructions for the 5450A Resistance Calibrator. It is recommended this section be read and understood before any attempt is made to operate the instrument. Should any difficulties arise during operation, contact the nearest John Fluke sales representative. A list of sales offices is given in Section 7.

2-2. SHIPPING INFORMATION

The 5450A is packaged and shipped in a foam-packed container. Upon original delivery of the instrument, the purchaser should thoroughly inspect the product and check all materials in the container against the packing list. The manufacturer will not be responsible for shortages against the packing list unless notified immediately upon receipt. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation for repair of shipment damage, contact the nearest Fluke Technical Service Center. A list of Service Centers in given in Section 7.)

2-3. INPUT LINE POWER

The 5450A can be internally configured to operate from line voltages of 100, 120, 220, or 240V ac ±10% at frequencies of 50 to 60 Hz ±5%. The factory-selected line voltage setting is marked on the rear panel immediately to the left of the fuse. If the 5450A is set to a voltage that is incorrect for the application, refer to the instructions in Section 4 for changing the setting.

2-4. INSTALLATION

The 5450A is designed to be used either on the work bench or mounted in standard deep 24-inch equipment racks. For bench-top operation, the 5450A is equipped with tilt bails and non-marring feet. The tilt bails (located below the front panel) can be used to tilt the instrument to a convenient operating position. Rack mounting accessories available for the 5450A are listed in Table 2-1. The rack mounting accessories include installation instructions.

Table 2-1. Rack Mounting Accessories

NAME	MODEL NUMBER
3½" Rack Adapter with 22"-24" slides	Y8598
3½" Rack Adapter only	Y8599

2-5. IEEE-488 CONNECTION

The IEEE-488 connector on the rear panel allows the 5450A to be connected to an instrument controller (such as the Fluke 1722A) for remote-controlled operation. The IEEE-488 connector mates with standard 24-conductor IEEE-488 cables. The cables may be stacked at the connector.

IEEE-488 connections are confined to the following limits:

1. No more than 15 devices may be connected in a single IEEE-488 bus system.
2. The total length of cable used in one IEEE-488 bus system must not exceed 20 meters.
3. The total length of cable must also not exceed 2 meters times the number of devices in the system.

Combinations of 1-, 2-, and 4-meter IEEE-488 cables can be used, to meet the cable length restrictions. For example, when a system consists only of the 5450A and a controller, the number of devices is 2. Multiplying by 2 meters, the maximum length of the cable that can be used is 4 meters (2 devices x 2 meters/device = 4 meters).

Therefore, a 1-, 2-, or 4-meter cable could be used to connect the 5450A to the controller. When connecting more than 10 devices, the length of cables used should not total more than 20 meters. Available cables are listed in Table 2-2.

Table 2-2. IEEE-488 Cable Accessories

MODEL NUMBER	NAME
Y8021	IEEE Standard Cable, 1 Meter
Y8022	IEEE Standard Cable, 2 Meters
Y8023	IEEE Standard Cable, 4 Meters

2-6. CONTROLS AND INDICATORS

Front panel controls, indicators, and connectors are shown in Figure 2-1 and described in Table 2-3. Rear panel controls, indicators, and connectors are shown in Figure 2-2 and described in Table 2-4.

2-7. OPERATING NOTES

2-8. Rear Panel Settings

The rear panel switches provide for setting the IEEE-488 bus address, connecting the IEEE-488 cable shielding, enabling the calibration mode, and configuring the instrument for the type of calibration to be performed.

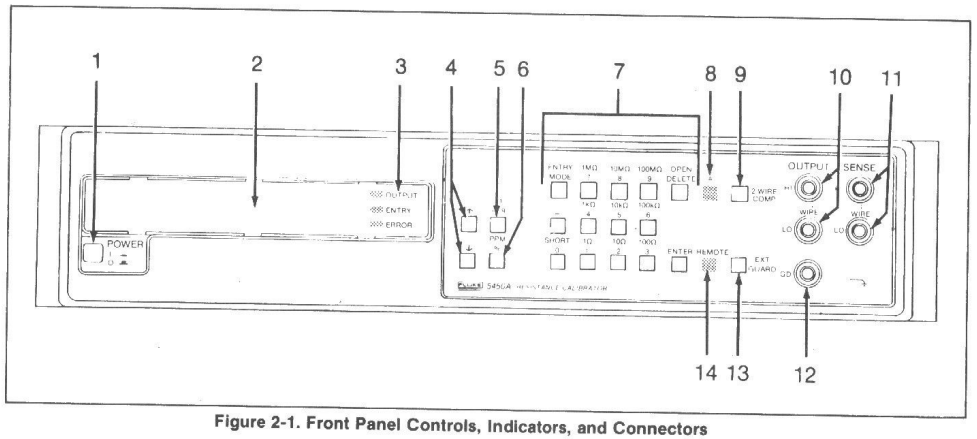


Figure 2-1. Front Panel Controls, Indicators, and Connectors

Table 2-3. Front Panel Controls, Indicators, and Connectors

ITEM NO.	NAME	FUNCTION
1	POWER switch	Turns the 5450A on (1) and off (0).
2	Display	Eight alphanumeric 14-segment LEDs. In the OUTPUT mode (OUTPUT light on), the display indicates the output resistance that the 5450A is actually sourcing. The last character is blank (for ohms), K (for kilohms), or M (for megohms). In the ENTRY mode (ENTRY light on), the display may indicate K (for kilohms), M (for megohms), or blank (for ohms), prompting the operator to enter the UUT reading via the 5450A keyboard, and indicating the units the 5450A expects the reading to be in. The display indicates the numbers as they are entered. In the ERROR mode (ERROR light on), the display indicates the error of the UUT in parts-per-million (PPM) or percent (PCT).

Table 2-3. Front Panel Controls, Indicators, and Connectors (cont)

ITEM NO.	NAME	FUNCTION
3	Mode annunciators	These indicate whether the 5450A is in the OUTPUT, ENTRY, or ERROR mode.
	OUTPUT light	When on, the OUTPUT mode is selected.
	ENTRY light	When on, the ENTRY mode is selected.
	ERROR light	When on, the ERROR mode is selected.
4	↑↓(up and down arrows)	Used in the OUTPUT mode. Pressing the up arrow selects the next higher decade of output resistance. If the output is presently 19 MΩ or 100 MΩ, pressing the up arrow selects an OPEN. Pressing the down arrow selects the next lower decade of output. If the output is presently 1Ω or 1.9Ω, pressing the down arrow selects a SHORT.
5	x1/x1.9 switch	Used in the OUTPUT mode. Toggles the output resistance between decade values (e.g., 10 kΩ, 100 kΩ, etc.) and x1.9 values (e.g., 19 kΩ, 190 kΩ, etc.). When the x1/x1.9 switch is lit, x1.9 values are selected.
6	PPM/% switch	Used in the ERROR mode. Toggles the displayed UUT error between percent (PCT) and parts-per-million (PPM). If the error is too large to display in PPM, the display indicates -----PPM. When the PPM/% switch is lit, PCT is selected.
7	Main Keyboard	14 pushbutton switches. White functions are enabled in the OUTPUT and ERROR modes; dark orange functions are enabled in the ENTRY mode.
	OUTPUT mode	In the OUTPUT mode, pressing a switch selects the nominal resistor value shown in white. If the x1.9 switch is lit, the output is the nominal value times 1.9. Pressing the ENTRY MODE switch selects the ENTRY mode.
	ENTRY mode	In the ENTRY mode, the keyboard is shifted for entering the UUT reading. The DELETE switch deletes displayed characters. After the UUT reading is keyed in, pressing the ENTER switch selects the ERROR mode.
	ERROR mode	In the ERROR mode, the 5450A computes and displays the UUT error. Pressing any switch except ENTRY MODE, EXT GUARD, or PPM/% selects the OUTPUT mode again.
8	CAL LED	The CALibration LED indicates that the rear panel CALIBRATION switch is enabled. **CAUTION** **Do not attempt to operate the 5450A while the CAL LED is lit unless you are calibrating the instrument, as the internal calibration constants may be inadvertently modified.**

Table 2-4. Front Panel Controls, Indicators, and Connectors (cont)

ITEM NO.	NAME	FUNCTION
9	2 WIRE COMP switch	The 2 WIRE COMPensation switch is used to compensate the characterized value of the internally stored resistance to accommodate UUTs that have a 2-wire resistance measuring circuit (i.e., that do not have separate source terminals). When the 2 WIRE COMP switch is lit, 2-wire compensation is in effect. **NOTE** *If set improperly, the 2 WIRE COMP switch can cause the 5450A display values to be incorrect.*
10	OUTPUT terminals	Connects the UUT to the 5450A's internal resistors in either 2-wire or 4-wire configurations. In the 4-wire configuration, the UUT source terminals are connected to the 5450A OUTPUT terminals. The front panel OUTPUT terminals are wired in parallel with the rear panel OUTPUT terminals.
11	SENSE terminals	Connects the sense terminals of the UUT to the 5450A's internal resistors when the UUT is in the 4-wire configuration. The front panel SENSE terminals are wired in parallel to the rear panel SENSE terminals.
12	GD (guard) terminal	Connects to the internal guard chassis. The GD terminal is connected to the OUTPUT LO terminal via a 100Ω resistor to reduce noise and leakage. If the EXT GUARD switch LED is on, the GD terminal is not tied to OUTPUT LO. The GD terminal is wired in parallel to the rear panel GUARD terminal.
13	EXT GUARD switch	The EXTernal GUARD switch toggles the 5450A between internal guard (LED off) and external guard (LED on). In internal guard, the GD and OUTPUT LO terminals are connected via a 100Ω resistor. In external guard, these terminals are not tied together. This switch is used for special configurations such as occur when calibrating the 5450A.
14	REMOTE LED	The REMOTE LED indicates that the 5450A has been addressed by the IEEE-488 bus. The instrument may be returned to local mode by pressing any front panel switch unless LOCAL LOCKOUT has been remotely programmed.

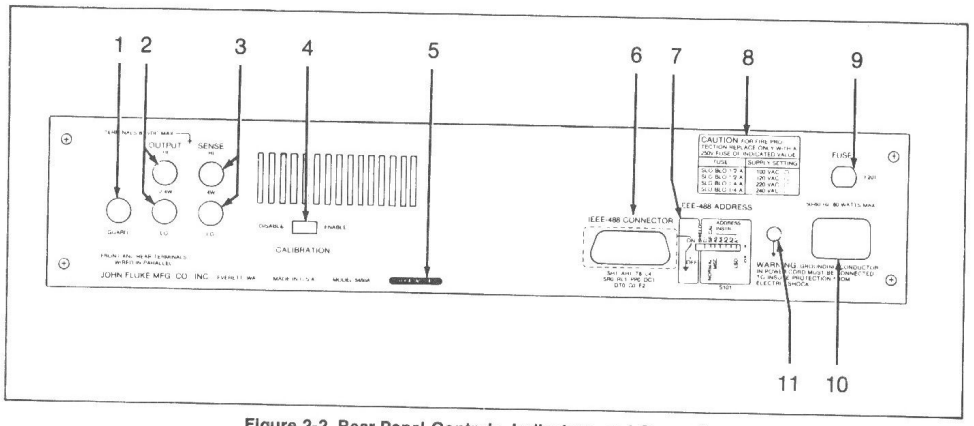


Figure 2-2. Rear Panel Controls, Indicators, and Connectors

Table 2-4. Rear Panel Controls, Indicators, and Connectors

ITEM NO.	NAME	FUNCTION
1	GUARD terminal	Connects to the internal guard chassis. The GUARD terminal is connected to the OUTPUT LO terminal via a 100Ω resistor to reduce noise and leakage. If the EXT GUARD switch LED is on, the GUARD terminal is not tied to OUTPUT LO. The GUARD terminal is wired in parallel to the front panel GD terminal.
2	OUTPUT terminals	Connects the UUT to the 5450A's internal resistors in either 2-wire or 4-wire configurations. In the 4-wire configuration, the UUT source terminals are connected to the 5450A OUTPUT terminals. The rear panel OUTPUT terminals are wired in parallel with the front panel OUTPUT terminals.
3	SENSE terminals	Connects the sense terminals of the UUT to the 5450A's internal resistors when the UUT is in the 4-wire configuration. The rear panel SENSE terminals are wired in parallel to the front panel SENSE terminals.
4	CALIBRATION switch	When in the ENABLE position, allows the 5450A's internal calibration constants to be modified. Normally covered by a calibration sticker.
5	Serial number	
6	IEEE-488 CONNECTOR	Standard 24-pin IEEE-488 receptacle used to connect the 5450A to an instrument controller.
7	IEEE-488 ADDRESS switches	Eight recessed toggle switches.
	A1-A5	Used to set the IEEE-488 instrument address of the 5450A.
	NORMAL/SP CAL	NORMAL (down): Used for normal ratio calibration method specified in Section 4 of this manual.

Table 2-4. Rear Panel Controls, Indicators, and Connectors (cont)

ITEM NO.	NAME	FUNCTION
		SP CAL (up): Allows calibration by general calibration methods such as in a standards calibration laboratory.
	D1	Not used.
	SHIELD	OFF (down): Disconnects IEEE-488 interface cable shield (pin 12) from 5450A ground.
		ON (up): Normal position. Connects IEEE-488 interface cable shield (pin 12) to 5450A ground.
8	FUSE/SUPPLY SETTING	Indicates the internally configured line-voltage selection and fuse sizes for the 5450A.
9	FUSE	Line power fuse.
10	Line power receptacle	Receptacle for line power cord.
11	Ground	Chassis ground.

2-9. IEEE-488 ADDRESS SWITCHES

The rear panel IEEE-488 address switches are used to set the 5450A to a known address so that the controller may talk and listen to the 5450A. In addition, one of the switches is used to specify the type of calibration to be performed. The switches operate as follows:

- SHIELD switch

Setting the SHIELD switch to the ON (up) position connects the shield on the IEEE-488 interface cable (pin 12) to the 5450A ground. Setting the switch to the OFF (down) position disconnects pin 12 from the 5450A ground. The SHIELD switch is typically ON to avoid instrument emissions and noise susceptibility.

- D1 switch

The D1 switch is not used.

- NORMAL/SP CAL switch

The NORMAL/SP CAL switch configures the 5450A for the type of calibration to be performed. The switch is placed in the down (NORMAL) position when the 5450A is to be calibrated using the procedure described in Section 4 of this manual. If the user wishes to calibrate the 5450A by alternate methods, the switch should be placed in the up (SPecial CALibration) position. For details, refer to Section 4. The switch is active only when the CALIBRATION switch is enabled.

- INSTR ADDRESS switches (A1-A5)

Switches A1-A5 are used to select the IEEE-488 address of the 5450A. A1 sets the "1-bit", A2 sets the "2-bit", A3 sets the "4-bit", and so on. A bit is set to 1 when the respective switch is in the up position, and is set to 0 when the switch is in the down position. Table 2-5 shows the switch positions for each possible address.

2-10. CALIBRATION SWITCH

The CALIBRATION switch places the 5450A in the calibration mode. The calibration mode should be enabled only when calibrating the 5450A. When the switch is in the DISABLE position, the calibration constants stored in the 5450A are protected from being changed. When the switch is in the ENABLE position, the front panel CAL LED illuminates and the internally stored calibration constants may be changed.

After the instrument has been calibrated and the switch has been set to the DISABLE position, it is important that the CALIBRATION switch be covered with a calibration sticker.

CAUTION

If the 5450A is operated with the CALIBRATION switch in the ENABLE position, the internal calibration constants may be inadvertently modified during normal operation. If this occurs, do not use the instrument; return it to the appropriate calibration facility for recalibration.

Table 2-5. IEEE-488 Addresses

DISPLAYED VALUE	INSTR ADDRESS				
	A5	A4	A3	A2	A1
00	DN	DN	DN	DN	DN
01	DN	DN	DN	DN	UP
02	DN	DN	DN	UP	DN
03	DN	DN	DN	UP	UP
04	DN	DN	UP	DN	DN
05	DN	DN	UP	DN	UP
06	DN	DN	UP	UP	DN
07	DN	DN	UP	UP	UP
08	DN	UP	DN	DN	DN
09	DN	UP	DN	DN	UP
10	DN	UP	DN	UP	DN
11	DN	UP	DN	UP	UP
12	DN	UP	UP	DN	DN
13	DN	UP	UP	DN	UP
14	DN	UP	UP	UP	DN
15	DN	UP	UP	UP	UP
16	UP	DN	DN	DN	DN
17	UP	DN	DN	DN	UP
18	UP	DN	DN	UP	DN
19	UP	DN	DN	UP	UP
20	UP	DN	UP	DN	DN
21	UP	DN	UP	DN	UP
22	UP	DN	UP	UP	DN
23	UP	DN	UP	UP	UP
24	UP	UP	DN	DN	DN
25	UP	UP	DN	DN	UP
26	UP	UP	DN	UP	DN
27	UP	UP	DN	UP	UP
28	UP	UP	UP	DN	DN
29	UP	UP	UP	DN	UP
30	UP	UP	UP	UP	DN

2-11. Connecting to a Unit under Test

2-12. SELECTING CABLES

Cables used to connect the 5450A to the unit under test (UUT) should be high-quality COAX or twisted pair shielded cables. Cables with a separate shield conductor are not necessary for typical bench applications, but can be advantageous in systems applications. Such cables are readily available in various lengths from manufacturers such as Pomona Electronics. The cables should generally be kept as short as possible.

2-13. FRONT AND REAR TERMINALS

CAUTION

To prevent instrument damage, input potentials must not exceed 60V dc to chassis from any terminal. In addition, the voltage from HI to LO terminals must not exceed the maximum voltage shown in the specifications for the selected resistor.

The 5450A provides both front and rear panel terminals. The front panel terminals are wired in parallel with the rear panel terminals.

All of the terminals are low-thermal alloy and accept standard banana plugs. The SENSE and OUTPUT terminals may be connected directly to twin banana plugs with 3/4-inch spacing. The rear panel terminals may also be connected to spade type connectors, which offer lower contact resistance than banana plugs.

It is generally inadvisable to connect cables to the front and rear terminals at the same time. The unused cables may degrade the specifications of the 5450A.

2-14. 4-WIRE CONNECTIONS

UUTs for the 5450A typically use a 4-wire circuit to measure resistance. Two leads from the UUT provide a constant current or a voltage source to the resistance being measured. Two other leads are used to measure (or sense) the voltage drop developed across the resistance. The advantage of the 4-wire technique is that it eliminates the effects of lead and contact resistance.

For UUTs that use the 4-wire measurement technique, the UUT source leads are connected to the 5450A OUTPUT terminals and the UUT sense leads are connected to the 5450A SENSE terminals.

2-15. 2-WIRE CONNECTIONS

Some UUTs, usually meters with lower accuracy, use a 2-wire circuit to measure resistance. The disadvantage of this type of measurement is that the lead and contact resistance of the leads and paths add directly to the resistance. (Consequently, some meters allow lead compensation.)

The 5450A features a 2 WIRE COMP switch which compensates for lead and contact resistance. The 2 WIRE COMP switch should normally be enabled (lit) when calibrating 2-wire UUTs. When the 2 WIRE COMP switch is enabled, the 5450A automatically adds the value of its internal lead and contact resistance to the value of the 4-wire resistance and displays this sum to the operator. For even higher accuracy, this internal compensation value may be updated daily. (For instructions, see the heading "2-Wire Enhancement" in this section.)

UUTs that use the 2-wire measurement technique are connected directly to the 5450A OUTPUT terminals.

2-16. GUARD CONNECTIONS

If the 5450A is used in a systems environment, it may be advantageous to use shielded cables for OUTPUT and SENSE connections. If shielded cables are used, the shields of the cables may be connected to the GD (or GUARD) terminal of the 5450A. This helps shield the measurement system from EMI and may also provide additional protection from ground current errors.

2-17. Powering Up the 5450A

CAUTION

Do not power up the 5450A while the CALIBRATION switch is in the ENABLE position, as the internal calibration constants may be inadvertently modified.

Before powering up the 5450A, ensure that the line voltage is properly selected and the line power cord is connected to a suitable outlet. To turn the 5450A on, press the front panel POWER switch.

When the 5450A is turned on, all display segments light briefly to test the display. If any segments are unlit, the 5450A should be repaired.

The display then indicates the instrument's IEEE-488 address for approximately 2 seconds. The address may be changed using the rear panel IEEE-488 ADDRESS switches. (For instructions, see the heading "IEEE-488 Address Switches" in this section.)

The display may then briefly indicate another message (such as "5450A"). If so, this message has been entered during a previous calibration. Contact the appropriate calibration facility if the instrument displays a message that you do not fully understand.

Once the preliminary messages have been displayed, the display should read OPEN and the OUTPUT light should turn on. This indicates that the 5450A is in the OUTPUT mode and is sourcing infinite resistance. The 5450A requires 2 hours of warm-up before meeting the specifications given in Section 1.

2-18. Selecting an Output

To select an output resistance, the 5450A must be in the OUTPUT mode (the OUTPUT light should be on). If the 5450A is in the ENTRY mode, it is possible to return it to the OUTPUT mode by pressing either the up arrow, down arrow, or x1/x1.9 switches, or by pressing the DELETE switch several times. If the 5450A is in the ERROR mode, it is possible to return it to the OUTPUT mode by pressing any front panel switch except ENTRY MODE, EXT GUARD or PPM/%.

If the UUT is a 2-wire device, it should be connected to the OUTPUT terminals only. In this case, ensure that the 2 WIRE COMP switch is lit. If the UUT is a 4-wire device, it should be connected to both the OUTPUT and SENSE terminals. In this case, ensure that the 2 WIRE COMP switch is unlit.

NOTE

When 2 WIRE COMP is selected, internal lead and contact resistance is added to the 4-wire resistance value to create the displayed resistance. Consequently, calibration errors will occur if the 2 WIRE COMP switch is set incorrectly.

In typical applications, the EXT GUARD switch should not be lit. The EXT GUARD switch is provided to allow for special configurations such as those that occur when calibrating the 5450A.

To select a decade value (i.e., 1Ω, 10Ω, etc.), ensure that the x1/x1.9 switch is unlit. To select a x1.9 value (i.e., 1.9Ω, 19Ω, etc.), ensure that the x1/x1.9 switch is lit.

To select an output range, press the switch on the main keyboard that has the desired resistance written above it in white characters. For example, press the 10 kΩ switch to cause the 5450A to source a nominal 10 kΩ. If the x1/x1.9 switch is lit, the output will be a nominal 19 kΩ.

To select a resistance that is one decade higher than that presently selected, press the up arrow switch. If the output is presently 100 MΩ or 19 MΩ, pressing the up arrow switch selects OPEN (infinite resistance).

To select a resistance that is one decade lower than that presently selected, press the down arrow switch. If the output is presently 1Ω or 1.9Ω, pressing the down arrow switch selects a SHORT (nominally zero resistance).

In the OUTPUT mode, the 5450A displays the actual, characterized value of its output resistance instead of the nominal value selected. For example, the 5450A might display 9.99987 when the nominal value 10.00000 is selected.

For 4-wire configurations (when the 2 WIRE COMP switch is unlit), the 5450A displays the resistance between the internal junction of the OUTPUT HI and SENSE HI terminals and the internal junction of the OUTPUT LO and SENSE LO terminals.

For 2-wire configurations (when the 2 WIRE COMP switch is lit), the 5450A displays the resistance between the OUTPUT HI and OUTPUT LO terminals at the front or rear panel. The 2 WIRE COMP offset may be characterized to include the resistance of a specific set of test leads. (See the heading "2-Wire Enhancement" in this section.)

2-19. Computing Error

The 5450A can automatically calculate and display the error of the UUT in percent or parts-per-million (ppm). The 5450A computes the UUT error by comparing the UUT reading (entered into the 5450A by the operator) to the characterized value of the resistance presently being sourced by the 5450A.

To enter the UUT reading, press the ENTRY MODE switch. The LED in the ENTRY MODE switch will light, and the ENTRY light will turn on, prompting the operator for an entry.

NOTE

Any computed error would be meaningless when the 5450A is sourcing an OPEN. Therefore, the ENTRY MODE switch is inactive when an OPEN is selected.

Then, using the main keyboard, enter the UUT reading. The rightmost digit of the display indicates the units for which the 5450A expects the entry: blank for ohms, K for kilohms, and M for megohms.

Use of the decimal point (.) is optional. If the decimal point is not explicitly entered, the 5450A assumes that the decimal point is in the same position as it was when the output resistance was displayed.

If an error is made while entering the UUT reading, press the DELETE switch to erase the last character entered. If the leftmost character is erased, the 5450A returns to the OUTPUT mode.

The entry is concluded by pressing the ENTER switch. If any of the rightmost digits are not entered prior to pressing the ENTER switch, they are assumed to be zeros.

Once the ENTER switch has been pressed, the 5450A changes to the ERROR mode. (This is indicated by the ERROR light turning on.)

The error may be displayed in percent or ppm. If the PPM/% switch is lit, the error is displayed in percent; otherwise, the error is displayed in ppm. The percent sign is shown in the display as PCT, and ppm is shown as PPM.

While in the ERROR mode, pressing the ENTRY MODE switch reselects the ENTRY mode. (This is useful if the UUT reading has changed.) In this case, the 5450A displays the UUT reading previously entered. The entry may be changed after using the DELETE switch. Then, pressing the ENTER switch causes the 5450A to recompute the UUT error.

To return to the OUTPUT mode, press any switch except ENTRY MODE, EXT GUARD, or PPM/%. Another output resistance may then be selected.

2-20. 2-Wire Enhancement

To decrease the uncertainty of the 5450A while calibrating 2-wire UUTs, the 5450A provides the capability of accommodating a short-term, user-performed calibration of the 5450A's lead and contact resistance. This short-term calibration updates the 2 WIRE COMP offset which is added to the 4-wire values of resistance. A selected test lead may be included in this characterization by making the measurement at the end of the test lead instead of directly at the 5450A OUTPUT terminals. If the measurement is made right at the terminals, it is valid for the other set of terminals as well.

Once characterized, the value may be used for 24 hours, or until the 5450A is turned off, whichever occurs first. For the specifications when using this optional capability, see Section 1.

To perform this characterization:

1. Connect a calibrated high-accuracy DMM (such as the Fluke 8505A or Fluke 8520A) to either the front or rear panel OUTPUT HI and LO terminals of the 5450A. Connect the DMM source HI and sense HI terminals together at the OUTPUT HI terminals of the 5450A. Connect the DMM source LO and sense LO terminals together at the OUTPUT LO terminal of the 5450A.
2. Select a SHORT from the 5450A.
3. Press 2 WIRE COMP. (The LED in the switch should light.)
4. Press ENTRY MODE.
5. After the external DMM is fully settled on the lowest resistance range, use the 5450A main keyboard to enter the value displayed by the external DMM.
6. Press ENTER.
7. The 5450A now displays the error of the new zero (in PPM or %) from the zero stored during the last complete calibration.
8. Press ENTRY MODE then press ENTER again. This stores the entered offset as the new offset to be used in subsequent 2-wire calculations.

The 5450A will use the new 2-wire compensation value until the 5450A is powered down. The improved specifications apply for 24 hours after enhancement. To erase the new compensation value and resume use of the offset value entered during the last complete calibration, cycle the POWER switch off and back on again.

2-21. REMOTE OPERATION

2-22. Introduction

The 5450A may be remotely controlled by an IEEE-488 controller, such as the Fluke Model 1722A Instrument Controller. A controller can facilitate the automated calibration of UUTs by operating the 5450A with a computer program.

Introductory literature about the IEEE-488 interface bus is available from local Fluke representatives, including "IEEE Standard 488-1978 Digital Interface for Programmable Instrumentation" (AB-36) and "Communication Over the IEEE-488 Bus" (B0079).

Remotely programming the 5450A involves a series of simple commands that correspond closely to front panel operation.

A typical automated sequence would begin by the controller programming the 5450A to provide a particular resistance. The controller would next request the characterized value of the 5450A resistance. The controller would then request the UUT to take a reading on the desired resistance range and transmit the reading back to the controller. Finally, the controller would compute the actual error and compare it to the error allowable for the particular UUT. The actual error could then be logged and the next range of the UUT could be verified.

A semi-automated sequence can be used for UUTs that are not remotely programmable. In this case, a typical sequence would be the same as above except that the UUT would be controlled manually, and the controller would solicit the UUT reading from the operator.

2-23. Capabilities

All functions available on the front panel (except for the POWER switch) are available using remote commands. The 5450A can become a listener for responding to remote commands. The 5450A can also become a talker in order to send the controller the instrument's status and the actual values of the programmed resistance.

The 5450A supports the ANSI/IEEE Standard 488-1978 function subsets listed in the specifications in Section 1 of this manual.

2-24. Device Clear

The universal bus command DCL (device clear) and the addressed bus command SDC (selective device clear) may be used to place the 5450A back to a known reset condition. The instrument is set back to the power-up conditions of OUTPUT MODE, OPEN, X1, PPM, EXT GUARD OFF, and 2 WIRE COMP OFF.

2-25. Local/Remote Operation

In typical operation, the 5450A front panel REMOTE light turns on when the 5450A is addressed as a listener or talker and data is being transferred. The REMOTE light remains on if the instrument is in REMS (REMote State). If the user presses any of the front panel switches, the instrument returns to local control and the REMOTE light turns off.

The universal bus command LLO (local lockout) may be used to disable the controls on the front panel of the 5450A. The bus command LOCAL reenables the 5450A controls. The front panel controls can also be reenabled by cycling the 5450A POWER switch.

2-26. Command Separators and Terminators

The individual commands sent to the 5450A must be separated by either a comma (,) or a semicolon (;). Each sequence of commands must be terminated by a carriage return (CR), line feed (LF), and/or an "end or identify" (EOI). If spaces (blanks) are sent to the 5450A, they are ignored. As the 5450A is case-insensitive, any command can be sent in either uppercase, lowercase, or a combination of the two.

When the 5450A is addressed as a talker, the string sent back to the controller is concluded by an LF and an EOI.

2-27. Remote Error Handling

If the 5450A receives a remote command containing an error, the remainder of the erroneous command is ignored. The 5450A responds to an error by setting two bits of the internal SPL byte: the least significant bit (with a binary weighting of 1), and RSV (bit 6, with a binary weighting of 64). When the SPL byte is read by the controller, the error bit is reset to zero.

2-28. Command Set

The set of device-dependent commands for the 5450A is shown in Tables 2-6 and 2-7. Table 2-6 shows the commands that correspond on a one-to-one basis with the front panel switches. Table 2-7 shows the additional commands that correspond to pushing several front panel switches in sequence. Note that most of the commands use the same nomenclature as the front panel.

Table 2-6. Simple IEEE-488 Commands

COMMAND	RESULT
UP;	Increments the decade of the selected resistance, just like the up arrow switch.
DN; or DOWN;	Decrements the decade of the selected resistance, just like the down arrow switch.
X1/X1.9;	Toggles the selected resistance between x1 and x1.9 values, just like the x1/x1.9 switch.
X1;	Selects decade values of resistance (e.g., 10 kΩ, 100 kΩ, etc). Equivalent to setting the x1/x1.9 switch to x1 (LED off).
X1.9;	Selects x1.9 values of resistance (e.g., 19 kΩ, 190 kΩ, etc.). Equivalent to setting the x1/x1.9 switch to x1.9 (LED on).
PPM/%;	Toggles the error display units between % and PPM (parts-per-million), just like the PPM/% switch.
PPM;	Selects display of UUT error in PPM (parts-per-million). Equivalent to setting the PPM/% switch to PPM (LED off).

Table 2-6. Simple IEEE-488 Commands (cont)

COMMAND	RESULT
%; or PCT;	Selects display of UUT error in percent. Equivalent to setting the PPM/% switch to % (LED on).
ENTRY MODE;	Selects the ENTRY mode. Conditions the 5450A to receive a following numeric value which represents the UUT display. Performs the same function as the ENTRY MODE switch.
SHORT;	Programs the 5450A to a SHORT (near 0 ohms).
OPEN;	Programs the 5450A to OPEN (infinite resistance).
0; - 9; and .;	The commands 0; 1; 2; 3; 4; 5; 6; 7; 8; 9; and .; perform the same function as the corresponding front panel switches: If the 5450A is in the OUTPUT or ERROR mode, the digits 0 through 9 select the corresponding decade of resistance to be sourced (i.e., 0 = short, 1 = 1Ω, 2 = 10Ω, 3 = 100Ω, 4 = 1 kΩ, 5 = 10 kΩ, 6 = 100 kΩ, 7 = 1 MΩ, 8 = 10 MΩ, 9 = 100 MΩ). The resistance actually sourced may be modified by the X1.9 command. If the 5450A is in the ENTRY mode (selected using the ENTRY MODE command), the digits 0 through 9 may be used in conjunction with the decimal point (.) to enter the UUT display for computation of UUT error. In this case, the digits are followed by the ENTER command to select the ERROR mode.
DELETE;	If the 5450A is in the ENTRY mode, the DELETE command causes the 5450A to delete the last numeric character entered. This command performs the same function as the DELETE switch.
ENTER;	Active in the ENTRY mode. Enters numbers programmed in the ENTRY mode, computes UUT error, and selects the ERROR mode. Performs the same function as the ENTER switch.
2 WIRE COMP;	Toggles the 2 WIRE COMP function on or off, depending on the previous state of this function. Performs the same function as the 2 WIRE COMP switch.
2 WIRE COMP ON;	Causes 2 WIRE COMP to be active.
2 WIRE COMP OFF;	Causes 2 WIRE COMP to be deactivated.
EXT GUARD;	Toggles the EXT GUARD function on or off, depending on the previous state of this function. This command performs the same function as the EXT GUARD switch.
EXT GUARD ON;	Causes EXT GUARD to become active.
EXT GUARD OFF;	Causes EXT GUARD to be deactivated.

Table 2-7. Extended IEEE-488 Commands

COMMAND	RESULT
OUTPUT ⟨number⟩;	Selects the OUTPUT mode, and programs the 5450A to source the resistance specified by ⟨number⟩. ⟨number⟩ is expressed in ohms and may consist of 0-9, ., + or E.
ENTRY ⟨number⟩;	Enters the ⟨number⟩ into the display and computes the resulting error. The instrument is left in the ERROR mode, displaying error in PPM or PCT. ⟨number⟩ is expressed in ohms and may consist of 0-9, ., + or E.
PERSONALITY ⟨string⟩;	The personality string is displayed to the operator for approximately 2 seconds during power-up and may also be read by the STAT or STATUS command. When the instrument is originally delivered, the string is set to "5450A". The string may be redefined using the PERSONALITY ⟨string⟩ command. ⟨string⟩ may consist of up to eight alphanumeric characters. Since the 5450A ignores spaces, spaces must be indicated by a % character in the string. The 5450A must be in the CALIBRATION ENABLE mode to successfully execute this command.
CLEAR;	Programs the 5450A to the power-up condition (OUTPUT MODE, OPEN, X1, PPM, 2 WIRE COMP OFF and EXT GUARD OFF). The CLEAR command works exactly like the interface messages DCL and SDC.
VALUE; or ?;	Requests the 5450A to return the characterized value of the resistance presently selected. The number returned is the value in ohms and may contain a decimal point and "E". The number is preceded by a space and is terminated by an LF and an EOI. If an OPEN is presently selected, the number returned is 1E50.
STAT; or STATUS;	Requests a 50-character message from the 5450A which describes the state of the instrument. The message is followed by an LF and an EOI. The character assignments are: 1-10 — 5450A display including decimal point (1st character is sign if negative) 11-16 — 5450A mode ("OUTPUT", "ENTRY " or "ERROR ") 17-20 — "X1 " or "X1.9" 21-23 — "PPM" or "% " 24-28 — "SPCAL", "CAL ", or " " (Blanks mean CALIBRATION DISABLED) 29-31 — "EXT" or " " 32-37 — "2 WIRE" or " " 38-45 — Personality message 46-47 — 00 if no error has occurred; 01 if an error has occurred 48-49 — "D1" or " " 50 — 50 Not used
ERR; or ERROR;	Requests a numeric value of the most recently computed UUT error in PPM. If an error has not been computed since power up, or the result of the last calculation resulted in an error greater than or equal to 2E6 PPM, 1E50 is returned.

2-29. Programming Examples

The following examples show programs for the Fluke 1722A Instrument Controller. For the purpose of these examples, it is assumed that the 5450A is set to the IEEE-488 address of 7.

Example 1: Initializing the 5450A to a power-up condition.

```
PRINT @7, "CLEAR;"
```

Example 2: Programming the 5450A to 10 kΩ.

```
PRINT @7, "5;"
```

or

```
PRINT @7, "OUTPUT 10000;"
```

Example 3: Determining the actual value of the 10 kΩ nominal resistance selected in Example 2.

```
PRINT @7, "VALUE;"
INPUT @7, A1
```

or

```
PRINT @7, "?;"
INPUT @7, A1
```

Example 4: Stringing the previous commands together.

```
PRINT @7, "CLEAR; OUTPUT 10000; ?;"
INPUT @7, A1
```


Section 3
Theory of Operation

3-1. INTRODUCTION

This section describes the internal operation of the 5450A Resistance Calibrator in two steps. First, a functional description describes the various functional blocks of the instrument and how they are related. Then, a circuit description examines each functional block in more detail, describing how each block works.

3-2. FUNCTIONAL DESCRIPTION

A functional block diagram for the 5450A is shown in Figure 3-1. As this figure shows, the 5450A consists of four functional blocks: the display circuit, the digital circuit, the analog circuit, and the power supply circuit.

The display circuit receives information from the digital circuit and displays this information via the front panel annunciators and alphanumeric display. The display circuit also sends signals to the digital circuit when the operator presses the front panel switches.

The digital circuit controls the 5450A. The microprocessor on the digital circuit decodes operator inputs from the display circuit and translates this information into signals to be sent back to the display circuit and the analog circuit. The digital circuit also contains the IEEE-488 interface circuitry which provides for remote operation of the 5450A.

The analog circuit provides the stimulus to the unit under test (UUT). The circuit contains the relays, relay logic, and resistors to provide the appropriate resistance source to the external terminals.

The power supply circuit of the 5450A provides supply voltages to all other circuits in the 5450A.

3-3. CIRCUIT DESCRIPTION

The four major circuits of the 5450A shown in Figure 3-1 are laid out on five printed circuit assemblies (PCAs): the Digital PCA, the Memory PCA, the Analog PCA, the Display PCA, and the Power Supply PCA. For reference, the location of the five PCAs is shown in Section 5. Detailed schematics are provided in Section 9.

The digital circuit is laid out on the Digital PCA and the Memory PCA. The Digital PCA consists of the microprocessor and IEEE-488 controller circuitry. The Memory PCA contains the ROMs and the EAROM for use by the microprocessor.

The power supply circuit is distributed throughout the instrument. The major components are the Power Supply PCA and power transformer, which are housed together in the transformer compartment towards the rear of the instrument.

The display circuit is contained on the Display PCA, which is located behind the front panel bezel. The Display PCA contains the front panel switches and light emitting diode (LED) displays.

The analog circuit is contained on the Analog PCA, which contains resistors, relays, and relay decoding logic.

3-4. Power Supply Circuit

The 5450A power supply circuit consists of the power supply assembly (which consists of the the transformer and Power Supply PCA) and also consists of circuitry on the Digital PCA (providing regulation for the digital +5V dc voltage supply), the Analog PCA (providing rectification, regulation, and filtering of voltages for the logic and relays), and the Display PCA (providing regulation for the Display PCA supply).

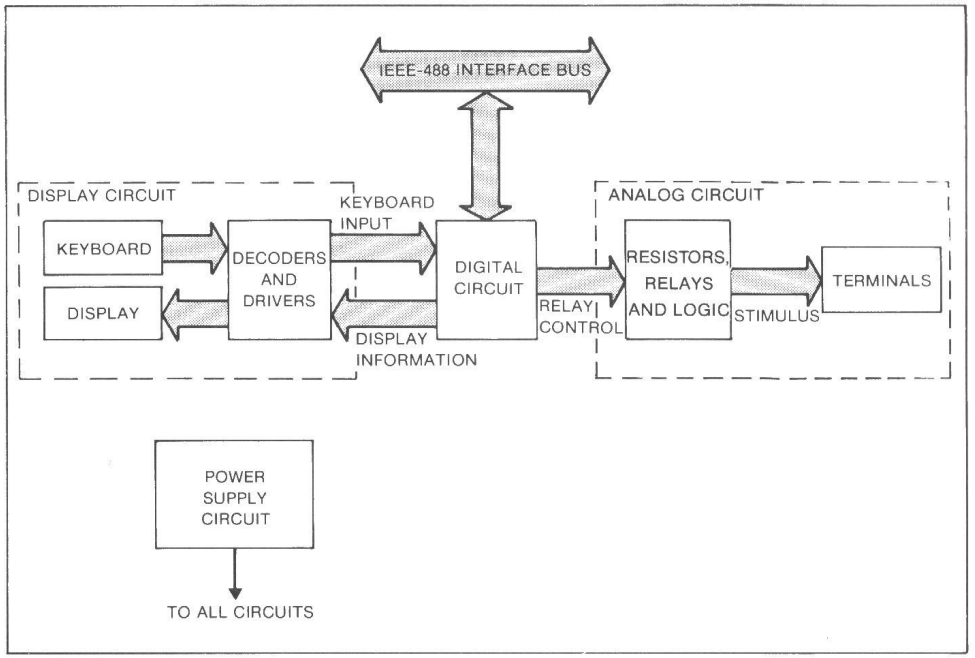


Figure 3-1. Functional Block Diagram

Power transformer T1 provides all voltages to the circuits of the 5450A. The input voltage comes from plug/line filter J10. The voltage is fed through rear panel fuse F201. A spare F201 is contained on the side of the transformer compartment inside the 5450A. The supply is switched via the front panel POWER switch.

3-5. ANALOG SUPPLY CIRCUIT

One secondary winding of power transformer T1 goes to the Analog PCA via J2. This signal is full-wave rectified via CR4 and CR5. Prior to rectification, the low and high leads are fused by 2-amp fast-blow fuses (F1 and F2). A spare fuse is located on the power supply chassis to replace either F1 or F2. The voltage is filtered by C8 and regulated to +5V dc by VR1. The resulting +5V dc voltage is called VCC and is used to supply the digital components on the Analog PCA.

VCC is also indirectly used to energize the relays on the Analog PCA. An unregulated voltage of approximately 8V dc is applied for about 15 ms across the relay coils to energize the relay. The pulse is provided by turning on Q1 and by limiting the amplitude with R2, Q1, CR1, and CR3. To eliminate the heating of the coils (and the subsequent increase of thermal EMFs), the voltage across the relay coils is then reduced to approximately 3.5V dc by sending VCC through CR2 and turning off Q1 to provide a relay holding voltage. The signal to drive the relays is referenced as RELAY PWR. The logic to create the pulse is discussed under the Analog Circuit heading later in this section.

3-6. DIGITAL SUPPLY CIRCUIT

The primary +5V dc signal for the logic components on the Digital PCA and Memory PCA is called VCC. The return for this voltage is called VSS. To indicate when power is applied, CR201 lights up when VCC is present. (CR201 is located near the large filter capacitor on the Digital PCA.)

On the Digital PCA, regulator U202 takes the rectified output from CR1 and CR2 on the Power Supply PCA and, with its associated components, provides the unguarded +5V operating voltage for the logic circuits. R210, in parallel with U202, provides an increased load capability. Test jumper J201 disconnects the supply, R210, and the load, so that the supply can be checked without a load. The variable resistor R204 is used to adjust VCC to the nominal +5V dc. The voltage may be

easily set while monitoring the voltage across TP201 (VCC) and TP202 (VSS).

3-7. DISPLAY SUPPLY CIRCUIT

The Display PCA uses the VUNREG output from the Power Supply PCA. This rectified and filtered signal is regulated on the Display PCA by U14 to create a +5V regulated signal called VLED. This supply is used for all the components on the Display PCA. The signal is returned via VUNREG RETURN.

3-8. Display Circuit

The Display PCA has two primary functions. First, it displays information to the operator. Second, it accepts the operator's instructions via the front panel switches. The display consists of four, two-character, fourteen-segment displays. The switches provide digital inputs to the microprocessor and operate completely in full duplex mode. All information is transferred to the microprocessor, and the resultant front panel indication is sent back to the display.

3-9. DISPLAYS

The alphanumeric display characters (DS1-DS4) are duplexed. Each character has two cathodes and eight anodes. Segments A1-G1 are enabled (lit) when cathode K1 or K3 is low and the appropriate anode(s) are high. Segments A2-G2 are enabled when the appropriate anode(s) are high and K2 or K4 is low. DP2 is lit when the DP anode is high and K2 is low. DP4 is lit when DP anode is high and K4 is low.

The characters are turned on in pairs. The cathode K1 of DS1 is enabled at the same time as cathode K1 of DS3. Next, cathodes K2 of DS1 and K2 of DS3 are enabled. This sequence continues until K4 of DS2 and K4 of DS4 are enabled, after which the cathodes of DS5-DS4 are enabled. The sequence is then repeated. This process is interrupt-driven by the microprocessor, and as such, periodically begins based on time-synchronized interrupts to the microprocessor. Cycles begin about each 20 ms for a 60 Hz line source.

Data lines D0-D7 provide input information to the display. As a sequence begins, data is strobed into decoder U12. The output from pins 5 and 6 of U12 enable latches U11 or U1. The output is gated from U12 to U11 and U1 by U9 when the input to U9 ($\overline{SEG}$) is low. Data indicating the anodes to be lit is latched into U11 and U1 before each is disabled. Once these latches have stored the information to be displayed, U10 is used to decode the data lines into a cathode signal to drive the desired cathodes of DS1-DS4 low. The latch U10 is enabled by the signal $\overline{DIGIT}$ going low. Source drivers U15 and U2 provide the current to the display characters, and U7, U8, and U15 sink the current. The LEDs in the switches are driven similarly, with the unary bit of U12 (U12-4) activating the cathodes, and U11 or U1 driving the anodes.

3-10. SWITCHES

The switches S1-S20 on the display are read once during each refresh cycle of the Display PCA. U10 sequentially enables each column of switches (e.g., S2 and S1 or S6, S5, S4, and S3). As the column is enabled, the $\overline{SW}$ signal is set low to gate the column through three-state driver U13. The column is then read by the microprocessor via D0, D1, D3, D4, and D5 lines.

3-11. Digital Circuit

The digital circuit is contained on the Digital PCA and the Memory PCA. The Memory PCA contains ROMs and EAROM. The Digital PCA is divided into three separate sections: the digital controller, the IEEE-488 interface, and the power supply. The first two sections of the Digital PCA are described below; the third section (the power supply) is discussed under a previous heading. Certain portions of the Digital PCA circuitry are not used in this particular application of the PCA; this circuitry is not discussed.

3-12. CLOCK CIRCUIT

The microprocessor is provided with a 4 MHz square wave by the clock circuit. Crystal Y1 is an 8 MHz oscillator that clocks the standard binary counter, U20. Outputs from the counter, in addition to the 4 MHz output, are 2 MHz, which is not used in this particular application, and 1 MHz, for use in the IEEE-488 circuitry. The parallel inverters at U19-10 and U19-12, with R6, keep the rise and fall time of the clock within specifications. Ringing is kept within acceptable limits by R7.

3-13. MICROPROCESSOR

The microprocessor is a single component with fully decoded and timed output signals to control standard memory or peripheral circuits. Supply voltage for the device is 5V dc. The only clock required is a single-phase, 5V, 4 MHz square wave.

The internal register configuration of the microprocessor contains 208 bits of read/write memory accessible to the program. The registers include two sets of general-purpose accumulator and flag registers that may be used as four 16-bit pairs or as eight 8-bit individuals. Also included is a 16-bit stack pointer that allows implementation of multiple-level interrupts and unlimited subroutine nesting. Tabular data manipulation and relocatable code implementation is accomplished with the two 16-bit registers. The memory refresh and interrupt vector registers are not used in this application. The last register is a 16-bit program counter.

3-14. RESET

The instrument circuitry is automatically reset at power up. When one-shot U36-12 is triggered, it provides U22-13 and 12 with a high and low signal respectively to provide a reset to the controller assembly. Line voltage (FLINE) input from U23-11 triggers U36, releasing the counter U28, which in turn clocks U22 on a count of eight to remove the reset. This places the reset on the circuit for a predetermined time during power up.

When power is removed, U36-12 times out and sets U22 to apply a reset to the circuitry. Resistor R19 and capacitor C29 provide a timeout for resetting the instrument by shorting test points TP9 and TP10 together.

3-15. WAIT

A WAIT signal is input to the microprocessor at U18-24 to indicate that the addressed memory or I/O device needs an extended bus cycle. The signal can be generated by the IEEE-488 circuit or by U9 as a result of an M1 output from the microprocessor. M1 is active when the microprocessor is performing an op code fetch cycle. The M1 memory access is shorter than all other cycles, in order to provide for the refresh cycle (not used). One WAIT state is added to allow for the access time of the ROMs.

3-16. INTERRUPT

Two sources of interrupts are used in the 5450A. These are the IEEE-488 circuit and the phase-locked loop circuit. The interrupt signals are combined in a wired-OR circuit for an input to the microprocessor at U18-16. R26 is a passive pull-up for the line, and in conjunction with C31, filters high frequency chassis noise (10 MHz) to prevent spurious inputs. U17-4 in the OR circuit is active (low) from an interrupt from the IEEE-488. Line-synchronous interrupts (MARK) are generated by U17-6 each time the phase-locked loop output has a positive transition. The MARK is enabled and cleared by signal MARK EN at U35-1 from U8-19.

The microprocessor output is synchronized to the line frequency by the phase locked loop (PLL). The line frequency input (U29-14) is multiplied by 8 by the PLL circuitry U28 and U29. The PLL output (U29-4), which is eight times the input frequency, provides a clock for MARK interrupts (U35-3) and display blanking (U21-1).

3-17. ANALOG PCA DATA TRANSFER

The Digital PCA transfers information to the Analog PCA via the cable connected to J15 on the Digital PCA. Data transferred to the Analog PCA decodes to relay calls and to a signal to toggle the voltage used to energize the relays. Data transferred from the Analog PCA is a digital indication that the CALIBRATION switch is either enabled or disabled. The data lines of J15 (D0-D7) are tri-state and may be used to send or receive data.

To send information to the Analog PCA, the following sequence occurs: U18 conditions address lines A0, A1, A2, A3, A6, and A7 to indicate that data is to be sent to the Analog PCA. At the same time, D0-D7 of U18 are set to indicate the particular relay that is to be called. Once this data is available, U18 pulls $\overline{\text{IOREQ}}$ (U18-20) low. At this time, the address information (A0, A1, A2, A3, A6, A7) is decoded in U25, U16, and U34 to set the $\overline{\text{WRITE0}}$ signal low at U25-14 and J15-3. This signal is sent to the Analog PCA via J15-2 and indicates that the data on J15-9 through J15-16 is valid to be decoded.

Once all the relay data is latched into the Analog PCA, the address lines of U18 are set to make the $\overline{\text{WRITE1}}$ line (J15-6) go low. This enables the relay drivers and pulses relay voltage high (approximately 8V dc). About 15 ms later, the same sequence occurs again. This time, the result of the $\overline{\text{WRITE1}}$ line going low is to toggle the voltage for the relays low (approximately 3.5V dc). The $\overline{\text{STATUS1}}$ signal (J15-1) is used to clear all of the relay latches on the Analog PCA.

To receive information about the status of the CALIBRATION switch from the Analog PCA, the following sequence occurs: U18 conditions data lines A0, A1, A2, A3, A6, and A7 to indicate that data is to be received from the Analog PCA. Once this data is available, U18 pulls $\overline{\text{IOREQ}}$ low. At this time, this address information is decoded in U25, U16, and U34 to set the $\overline{\text{READ0}}$ signal low at U25-13 and J15-2. This signal is sent to the Analog PCA and passes the status of the CALIBRATION switch to D7 (J1-9). U18 then reads the data lines to input this information.

3-18. MEMORY SELECT

The memory for the digital controller consists of four RAMs (random access memory), three ROMs (actually PROMS, programmable read-only memory), one EAROM (electrically alterable read-only memory), and the necessary control circuits. The ROMs and EAROM and decoder circuit are located on the Memory PCA above and towards the front of the Digital PCA.

The A10, A11, A12, A13, and A15 address lines of U18 are decoded by U2 to generate the chip select signal for the RAM ICs (pin 8 on U4, U5, U6, and U7). The lower address lines of U18 (A0-A9) are directly decoded by the RAMs.

The ROMs and EAROM located on the Memory PCA are connected by two cables to the Digital PCA. The first cable connects to U14 on the Digital PCA and carries the data (D0-D7) and lower order addresses (A0-A10). The second cable connects to P16 on the Digital PCA and carries the upper address lines (A11-A15), $\overline{\text{MEMREQ}}$, $\overline{\text{WR}}$, $\overline{\text{RFSH}}$, and $\overline{\text{RESET}}$. The high-order address signals from P16 are decoded by U1 on the Memory PCA to set $\overline{\text{OE}}$ on the appropriate ROM to enable output.

In addition to the two digital signal cables that originate on the Digital PCA, the Memory PCA has another cable that originates on the Analog PCA. This cable normally connects VCC to $\overline{\text{WE}}$ (write enable) on the EAROM. This disables the possibility of writing data to the EAROM. This is particularly important to prevent undesired writes during instrument power-up sequences. When the rear panel CALIBRATION switch is in the ENABLE position, the $\overline{\text{WE}}$ line to the EAROM is connected to $\overline{\text{WR}}$ from the Digital PCA. This allows data to be written into the EAROM.

3-19. DISPLAY BLANK

The phase-locked loop clocks U21-1 to count toward eight. If it reaches that count without being reset by the SW signal from U25-8, U21-6 goes high and blanks the front panel display. This prevents the possibility of the microprocessor stopping for some reason when data is latched into the front panel and destroying the LEDs by allowing too long a duty cycle.

3-20. IEEE-488 INTERFACE

All utilized device interface functions defined by the IEEE-488 interface standard (IEEE Standard 488-1978) are performed within U101. The bidirectional data lines (DI01-DI08) from U108 and U109 are normally three-state drivers; however, when parallel poll is selected (not used in the 5450A), they change to open collector. The control lines in U110 are bidirectional under the control of U101. Control lines NRFD, NDAC, and SRQ have open collector outputs; the remaining control lines are three-state.

The interface is addressed from the digital controller with A7 high and A6 low in conjunction with $\overline{\text{IOREQ}}$ low. A0, A1, and A2 are used to address the internal registers in U101. Switch S103 places the instrument IEEE-488 address on the bus when U102 is enabled from U101. Timing is provided by a 1 MHz clock derived from the 4 MHz clock on the Digital PCA. The 1 MHz clock is synchronized to the microprocessor I/O access cycle by U103, U104, and U105.

3-21. Analog Circuit

The analog circuit is contained on the Analog PCA, which resides on the right when the instrument is viewed from the front. The Analog PCA contains the resistors, the relays to select the resistors, and the logic necessary to decode and energize the relays from signals received from the Digital PCA. The nature of the digital signals originating from the Digital PCA is discussed in the digital circuit description earlier in this section. The Analog PCA also contains regulation and filtering for its 5V dc power supply, logic, and relays. This circuitry is discussed in the power supply circuit description earlier in this section.

The Analog PCA has two sections, the digital section and the analog section. Each is described below.

3-22. DIGITAL SECTION

The digital section of the Analog PCA consists of the logic to decode the logic commands from the Digital PCA and energize the relays.

To deenergize relays, the following sequence occurs: $\overline{\text{STATUS0}}$ (J1-1) becomes low. This signal goes to U1-4 to provide a larger drive capability. The signal originating from U1-6 clears all the latches on the Analog PCA, which deenergizes all of the relays. Simultaneously, the signal resets U2, which is the flip-flop that specifies whether the relays will receive a high or low voltage to the coils. The reset sets low voltage.

Data lines D0-D7 are then set to the desired relay call by the microprocessor. This data is transferred to the output of U4 (U4-11 through U4-18) by $\overline{\text{WRITE0}}$ going low. $\overline{\text{WRITE0}}$, which is low, goes through U1 to cause $\overline{\text{EN}}$ (U4-12) to go low. The output of U4 is decoded two ways. The output of U4-11 through U4-14 is decoded by U5 to chip-enable either U6, U9, U14, or U16 to receive the data. The output of U4-15 through U4-18 consists of the data that will be latched into the enabled IC (U6, U9, U14, or U16). The actual latch occurs when the output of decoder U5 goes low, thus setting $\overline{\text{EN}}$ low for the desired latch. The actions described in this paragraph are repeated until all of the relays to be energized are latched into U6, U9, U14, and U16.

Once the relay data is clocked into the latches, $\overline{\text{WRITE1}}$ goes low momentarily. This not only toggles U2 to condition the relay voltage to be high (RELAY PWR), it transfers the data held in U6, U9, U14, and U16 to U8, U10, U13, and U15. These latches directly drive U7, U11, U12, U17, and U18, which are the relay current sinks. These current sinks also contain transient suppressor diodes. Approximately 15 ms after $\overline{\text{WRITE1}}$ goes low to energize the relays, $\overline{\text{WRITE1}}$ goes low again. This time, the result is to toggle flip-flop U2 to condition the relay power supply to go to the lower-voltage holding state. This supply is discussed in more detail in the description of the power supply, above.

The status of the CALIBRATION switch is read back to the Digital PCA periodically. The setting of the CALIBRATION switch (S1) ties U4-11 either to VCC via a pull-up resistor (R1), or to low. The read occurs when $\overline{\text{READ0}}$ goes low, indicating that U4 is to be a driver to the Digital PCA as opposed to a receiver. $\overline{\text{READ0}}$ also asserts $\overline{\text{EN}}$ on U4. The Digital PCA then reads D7 (U4-9).

3-23. ANALOG SECTION

The analog section of the Analog PCA contains the resistors, relays, and cabling to provide the appropriate

stimulus. There are three special concerns that need to be addressed with the printed circuit board layout, cabling, and relays: thermal EMFs, contact resistance, and leakage.

Thermal EMFs are small voltages (in the microvolt region) that are generated when dissimilar metals are placed together and the temperature is elevated (similar to the effect of a thermocouple). In the lower resistance values, where measurement voltage levels are small, the effect of thermal EMFs on total measurement uncertainty can become significant. EMFs are combated in the 5450A via several techniques. First, when possible, similar metals are used in critical areas. For example, the front panel terminals and lugs are both made of similar, low thermal alloy to minimize thermal EMFs. Secondly, to reduce the temperature gradient in the relays, the energization voltages are reduced once the relay is once actuated.

Contact resistance inside the relays can be significant for 2-wire units under test (UUTs). Generally, the effect of contact resistance is minimal for 4-wire resistance measurements because the input impedance of the measuring device is high on the sense leads, and the source leads typically carry constant current. Since the contact resistance of the 5450A is compensated in the 2-wire configuration (by the 2 WIRE COMP feature), repeatability is the primary concern. To minimize contact resistance and maximize repeatability, in most signal paths, the relays are high-quality, gold-plated, cross-bar type relays with paralleled contacts.

Another consideration of the analog connection circuitry is that of leakage. Leakage is the parasitic resistance between the high and low leads of a connection due to the resistance of dielectric materials such as the printed circuit board itself. The effects of leakage are increased in high-humidity environments. The 5450A specifications allow for this effect. In addition, in the higher resistance ranges, reed-type relays are used to greatly reduce the leakage. The reed-type relays offer higher levels of thermal EMFs and contact resistance than the telephone-type relays used in the lower resistance ranges. However, the effects of thermal EMFs and contact resistances are minimized since typical UUTs measure higher resistances with commensurately higher voltages.

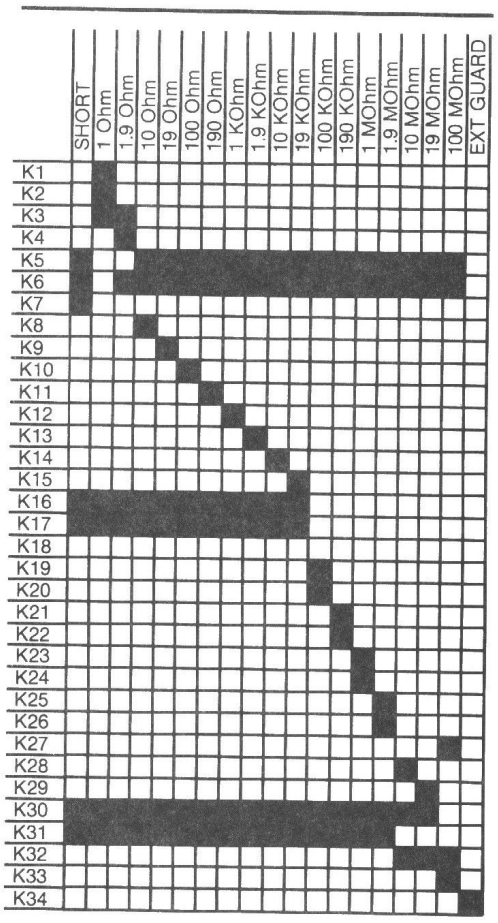
The other leakage reduction techniques used include the use of Teflon standoffs and hand wiring in critical areas. Because of leakage, it is important that the special handling outlined in the service section of this manual be strictly observed.

The resistors used in the 5450A are of the highest quality. In most cases, several resistors (two or four) are matched by TC (temperature coefficient) in equal and opposite amounts to allow a lower temperature coefficient for the value. The primary resistances of the 5450A are achieved by a "chain" of resistors. For example, to achieve 19Ω, a 9Ω resistor (actually four 36Ω resistors in parallel) is connected in series with a 10Ω resistor (actually four 40Ω resistors in parallel). 100Ω is achieved by putting a 81Ω resistor in series with the previous two, and so on. The exceptions to this in the 5450A are the 1Ω and 1.9Ω resistors, which are not chained together or used in conjunction with higher resistances.

Another function of the 5450A Analog PCA is to program the external guard resistor. This low-accuracy 100Ω resistor ties OUTPUT LO terminal to the GUARD terminal during normal operation. In the event that external guard is requested (by the EXT GUARD switch), K34 is energized to disconnect this resistor. The resistors that are called to generate any particular configuration are shown in Table 3-1.

*Trademark of E.E. Dupont DeNemours & Co.

Table 3-1. Relay Truth Table

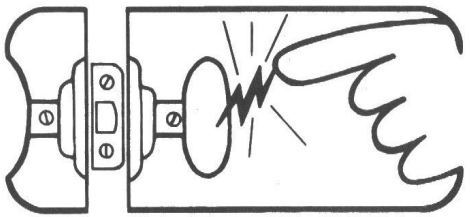


BLACK AREA INDICATES ENERGIZED RELAY

static awareness

A Message From

John Fluke Mfg. Co., Inc.

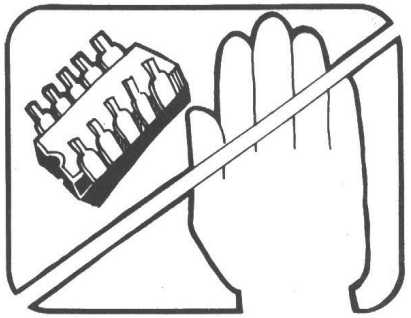


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

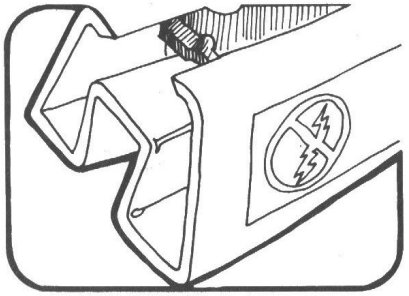
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

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

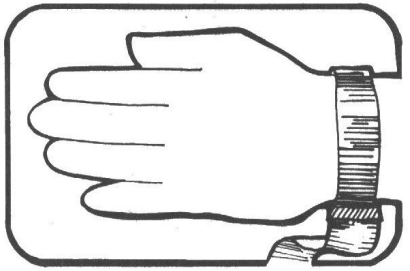
The following practices should be followed to minimize damage to S.S. devices.



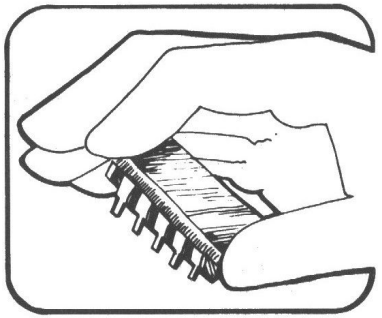
1. MINIMIZE HANDLING



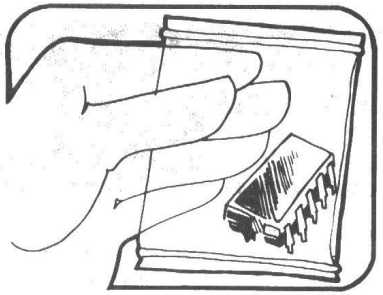
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



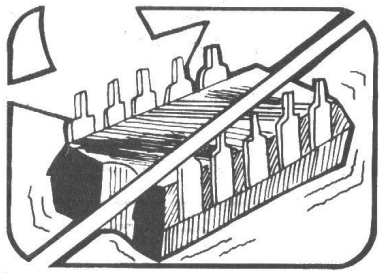
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



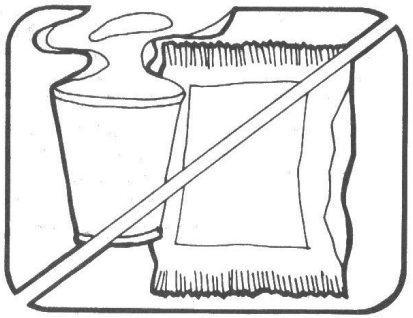
4. HANDLE S.S. DEVICES BY THE BODY



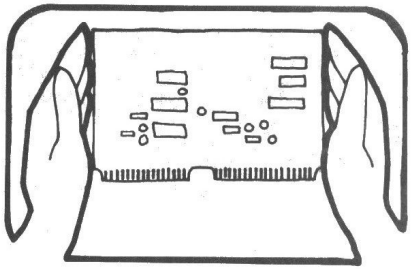
5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT



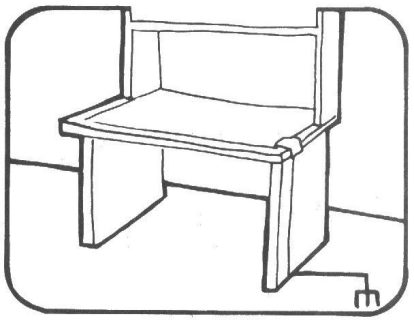
6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



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



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 HELPS TO PROTECT 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.

A complete line of static shielding bags and accessories is available from Fluke Parts Department, Telephone 800-526-4731 or write to:

JOHN FLUKE MFG. CO., INC.
PARTS DEPT. M/S 86
9028 EVERGREEN WAY
EVERETT, WA 98204

* Dow Chemical

J0089D-07U8604/SE EN Litho in U.S.A.
Rev. 1 MAR 86

Section 4
Maintenance

WARNING

THESE SERVICE INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

4-1. INTRODUCTION

This section contains information regarding the maintenance of the 5450A Resistance Calibrator. The section includes routine maintenance, disassembly, performance test/calibration, and troubleshooting.

A 90-day or one-year calibration cycle may be used depending on the specifications necessary for the particular application of the 5450A. The test equipment required for the calibration procedure is given in Table 4-1. Test equipment with equivalent specifications may also be used. To aid in troubleshooting, a DMM (such as a Fluke 77) and a logic probe are also recommended.

Suggested cables to interconnect the test equipment during calibration are listed in Table 4-2. As many of the cables are non-standard, the table includes construction details.

4-2. SERVICE INFORMATION

The 5450A is warranted for a period of one year upon shipment of the instrument to the original purchaser. Conditions of the warranty are given in the front of this manual. Malfunctions that occur within the limits of the warranty will be corrected at no cost to the user. For in-warranty repair, call the the Fluke Technical Service Center designated to service your area. A complete list of Technical Service Centers is given in Section 7.

Instruments returned for repair or calibration should be shipped via United Parcel Service or "Best Way" prepaid. The instrument should be shipped in the original packing carton, or if it is not available, in 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. Dated proof-of-purchase may be required for in-warranty repairs. If requested, an estimate will be provided before work is begun on instruments that are beyond the warranty period.

4-3. GENERAL MAINTENANCE

4-4. Setting Line Voltage

WARNING

TO AVOID SHOCK HAZARD, PERFORM THE VOLTAGE SELECTION PROCEDURE EXACTLY AS PRESENTED. LINE POWER VOLTAGE MAY BE PRESENT IF THE PROCEDURE IS NOT FOLLOWED EXACTLY.

If the line voltage set at the factory is incorrect for your application, it may be reset to 100, 120, 220, or 240V ac. To reset the power supply to a new voltage:

1. Ensure that the instrument is disconnected from all power sources.