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8840A
Digital Multimeter

Instruction Manual

PN 879304
December 1991 Rev. 3, 5/97

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 in-guard program memory, calibration memory, and display tests. Out-guard program memory is tested when self-test is initiated by a remote command. Microcomputer RAM tests are done only at powerup.

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 in-guard program memory, calibration memory, and display tests. 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:

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 5700A or Fluke 5440A
	ALTERNATIVE: (Must be used with Kelvin-Varley Voltage Divider) Voltage Range: 0-1000V dc Voltage Accuracy: 20 ppm + 20 ppm of range	Fluke 343A
	Kelvin-Varley Voltage Divider: Ratio Range: 0-1.0 Absolute Linearity: ±1 ppm of input at dial setting	Fluke 720A
Resistor Calibrator	Resistance Accuracy: 0.005%	Fluke 5700A or Fluke 5450A, ESI DB62
DC Current Source	Accuracy: ±0.025%	Fluke 5700A or Fluke 5100B
Oscilloscope	General purpose, 60 MHz, with 10 MΩ probe	Philips 3055 or 3355
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 Option -09)
AC Calibrator		Fluke 5700A and Fluke 5725A

Minimum Required Accuracy (By Range)			
Frequency Range	**1, 10, 100 mV[1]**	**1, 10, 100V[2]**	**1000V[2]**
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 5700A or Fluke 5100B

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
Optional Test Equipment	9010A, 9005A or Micro-System Troubleshooter; 9000A-8048 Interface Pod;	

1. Ensure the 8840A is on and has warmed up for at least 1 hour.
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.)
5. Set the DC Calibrator to input negative voltages, and repeat steps C through G of Table 6-2.
6. With the unit is the 2V range, check the A/D linearity by setting the DC Calibrator for each step in Table 6-9, while verifying the display reading is within the limit shown. Set the DC Calibrator for zero volts and disconnect if 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:

1. Ensure the 8840A is on and warmed up for at least 1 hour.
2. Select the VAC function and the slow (S) reading rate.
3. Connect the AC Calibrator to provide a voltage input to the HI and LO INPUT terminals.
4. (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.

5. (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.

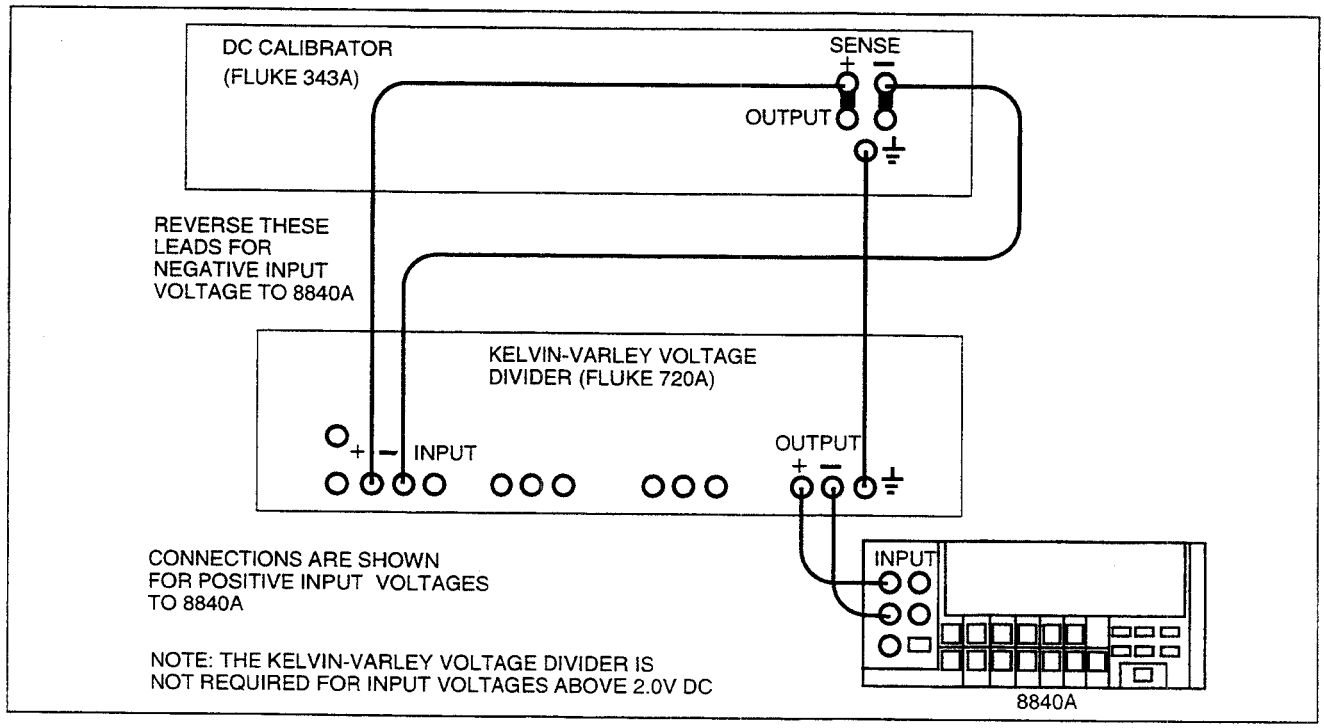


Figure 6-1. Connections for Kelvin-Varley Voltage Divider

Table 6-2. DC Voltage Test

STEP	RANGE	INPUT (V dc)	DISPLAYED READING					
			SLOW		MEDIUM		FAST[2]	
			MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
A[1]	200 mV	0V (short)	-00.003	+00.003	-00.005	+00.005	-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

NOTES:

1. Relative to high-quality short stored using OFFSET feature.
2. When in fast reading rate with internal trigger and transmitting data out of the IEEE-488 interface, the 8840A display must be blanked (command D1) to ensure stated accuracy.

6. Set the AC calibrator to standby and disconnect it from the 8840A.

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 Resistance Calibrator to the 8840A for 4-wire ohms.
3. For each step in Table 6-5, select the indicated range, set the Resistance Calibrator 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.)

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.

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.

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.
4. 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.

Table 6-5. Resistance Test

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

NOTES:
1. Using Offset Control.
2. 4-1/2 Digit Counts.
3. Applies to 4-Wire Ohms Only.
4. When in fast reading rate with internal trigger and transmitting data out of the IEEE-488 interface, the 8840A display must be blanked (command D1) to ensure stated accuracy.

5. 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. Ensure the 8840A is on and warmed up for at least 1 hour.
2. Select the mA AC function.
3. 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.
4. 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.
5. Set the AC Current Source to Standby and disconnect it from the 8840A.

6-9. CALIBRATION

CAUTION

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

NOTE

If U220 is replaced, perform the Erase Calibration Memory procedure (located later in this section) before attempting calibration. Failure to do so may result in an ERROR 29 on the 8840A front panel display.

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

Table 6-6. DC Current Test

STEP	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

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 and delays execution of all remote commands.

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.
3. Enable the calibration mode by pressing the CAL ENABLE switch with a small screw-driver 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.

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

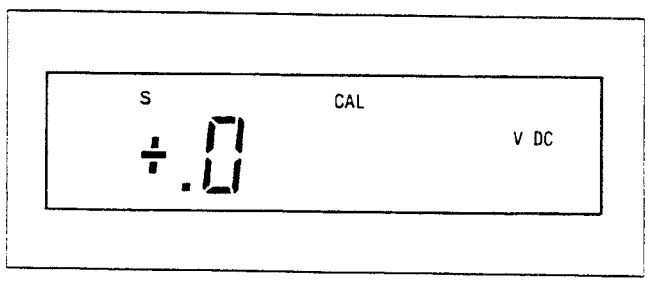


Figure 6-2. First A/D Calibration Prompt

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

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. If the A/D calibration is discontinued prior to completion, the last complete set of A/D calibration constants will be retained unchanged.

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.

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.)

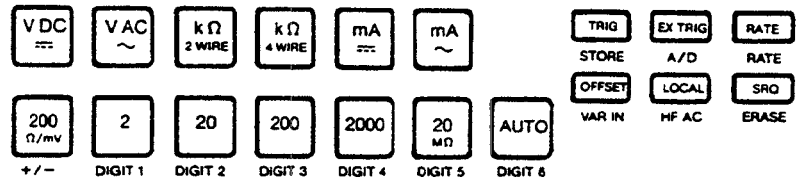
3. After the last input is stored, the 8840A begins taking readings in the 2V range of the VDC function. (The CAL annunciator remains on.) Verify the A/D calibration using the test points in Table 6-9. If you wish to repeat the A/D Calibration procedure, press the A/D button.

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.

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



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

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

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

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 (±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.

Table 6-10. Offset and Gain Calibration

STEP	DISPLAYED PROMPT				
	VDC	VAC[1]	2 WIRE kΩ 4 WIRE kΩ	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	1000.0 mA AC
C	+1.900 V DC	1.000 V AC	1.000 kΩ		
D	+19.00 V DC	10.00 V AC	10.00 kΩ	Steps C-G not applicable for these functions.	
E	+190.0 V DC	100.0 V AC	100.0 kΩ		
F	+1000. V DC	500. V AC	1000. kΩ		
G	Step G not applicable for these functions.		10.00 MΩ		

NOTE:
1. Inputs should be at 1 kHz +/-10%. Performance may be enhanced for specific frequencies (see text).

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.

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.

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.

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)

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.

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.

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.

6-19. 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.

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 "cl" (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:

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]

NOTES:

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 prompt of 200V ac.

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.

3. 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.

Table 6-13. Tolerance Limits

CALIBRATION	TOLERANCE
1. A/D Calibration	±244 counts from prompt
2. Offset and Gain Calibration	
VDC, mA DC	±488 counts from prompt
Ohms	±3002 counts from prompt
VAC, mA AC	±3002 counts from prompt
3. HF AC Calibration	±9999 counts from prompt

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.

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 mΩ "floor" which would otherwise result in 25 digits of error in the 200Ω 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 "100Ω" output from the 5450A, and measure this value as in step 3.
5. Find and record the numerical difference between the values calculated in steps 3 and 4. This value will be used as the variable input for calibrating the 200Ω range in 2-wire ohms.
6. Repeat steps 4 and 5 using the "1 kΩ" 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 variable input for calibrating the 2 kΩ range in 2-wire ohms.
7. Press the UUT's 2 WIRE kΩ button. This selects the Offset and Gain calibration procedure for the 2-wire ohms function and prompts for zero input. Select the "SHORT" from the 5450A, and calibrate all the zeros by pressing STORE.

8. Select the "100Ω" output from the 5450A and calibrate the high point for the 200Ω range, entering the value computed in step 5 as a variable input.
9. Select the "1 kΩ" output from the 5450A and calibrate the high point for the 2 kΩ 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.

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.

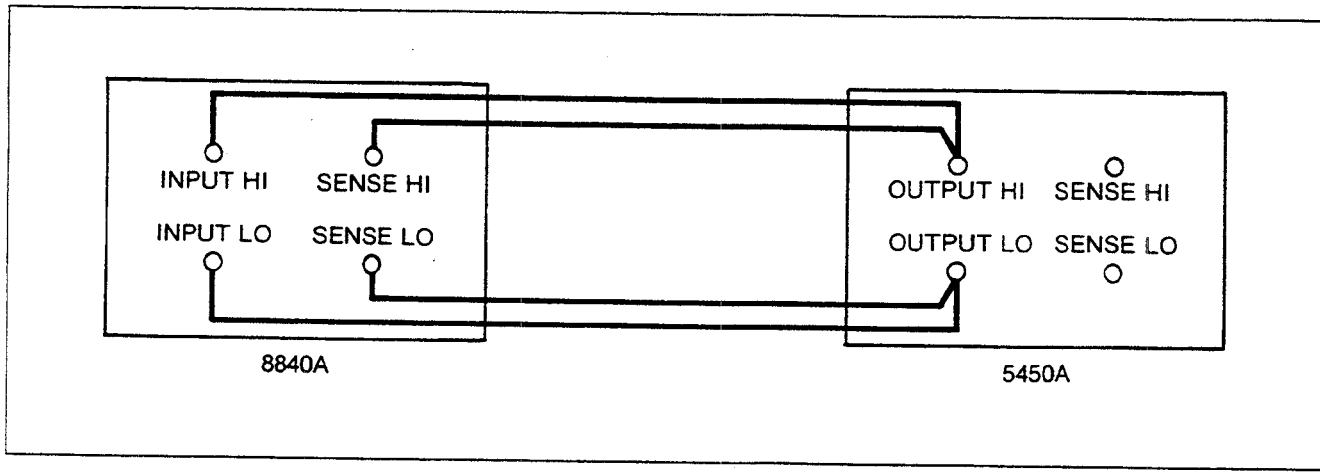


Figure 6-4. Optimizing Use of the 5450A

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 and C3 commands can take up to 22 seconds to execute. You must determine when these commands are complete before sending more commands. See Timing Considerations in text.
A/D	C1	Selects the A/D Calibration procedure.

Table 6-14. Commands Used During Remote Calibration (cont)

FRONT PANEL FEATURE	CORRESPONDING COMMAND	COMMENTS
HF AC	C2	Selects the High-Frequency AC Calibration procedure.
ERASE	C3	After receiving this command the display shows the erase mode prompt ('cl'). (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), or by checking the Cal Step Complete bit in the serial poll register.
--	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).

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 remote 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 SAMPLE COMPLETE signal is inactive. 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. If during this time the controller continues to send the 8840A more commands, the commands may fill up the 8840A's input buffer. 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. An SRQ is generated and the Cal Step Complete bit in the serial poll status response is set when a cal command is complete. This approach depends on capabilities of the controller being used.
3. Executing a delay in controller software after sending each command. (Not recommended.)

Table 6-15. Error Numbers Which Are Displayed When Commands Are Not Valid

COMMAND	NORMAL MODE	SELF TEST	CALIBRATION MODE			
			A/D CAL	OFFSET & GAIN CAL	HF AC CAL	VERIFICATION MODE
Bn		60	52	52	52	52
C0	51	60				54
C1	51	60				
C2	51	60				
C3	51	60				
Dn		60	52	52	52	52
Fn		60				
G0						
G1						
G2	51	60				54
G3		60				
G4						
G5						
G6						
G7						
N						
P0		60	52	52	52	52
P1						
P2	51	60	56			54
P3	51	60				
R0		60	52	52	52	52
R1-6		60	52			
R7		60	52	52	52	52
Sn		60	52	52	52	
Tn		60	52	52	52	52
Wn						
X0						
Yn						
Z0		60	52	52	52	52
*		60	52	52	52	52
?		60				

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). Any command other than C0 after C3 will abort the erasure. 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 1722A 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.

6-27. DISASSEMBLY PROCEDURE

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE THE POWER CORD AND TEST LEADS BEFORE DISASSEMBLING THE INSTRUMENT. OPENING COVERS MAY EXPOSE LIVE PARTS.

CAUTION

To avoid contaminating the printed circuit assemblies (PCAs), handle the PCAs by their edges. Do not handle the areas of the PCAs that are not solder masked unless absolutely necessary. These areas must be cleaned if contaminated.

```
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.

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,"G2"
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