

5520A

Multi-Product Calibrator

Service Manual

LIMITED WARRANTY & LIMITATION OF LIABILITY

Each Fluke product is warranted to be free from defects in material and workmanship under normal use and service. The warranty period is one year and begins on the date of shipment. Parts, product repairs and services are warranted for 90 days. This warranty extends only to the original buyer or end-user customer of a Fluke authorized reseller, and does not apply to fuses, disposable batteries or to any product which, in Fluke's opinion, has been misused, altered, neglected or damaged by accident or abnormal conditions of operation or handling. Fluke warrants that software will operate substantially in accordance with its functional specifications for 90 days and that it has been properly recorded on non-defective media. Fluke does not warrant that software will be error free or operate without interruption.

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Fluke's warranty obligation is limited, at Fluke's option, to refund of the purchase price, free of charge repair, or replacement of a defective product which is returned to a Fluke authorized service center within the warranty period.

To obtain warranty service, contact your nearest Fluke authorized service center or send the product, with a description of the difficulty, postage and insurance prepaid (FOB Destination), to the nearest Fluke authorized service center. Fluke assumes no risk for damage in transit. Following warranty repair, the product will be returned to Buyer, transportation prepaid (FOB Destination). If Fluke determines that the failure was caused by misuse, alteration, accident or abnormal condition of operation or handling, Fluke will provide an estimate of repair costs and obtain authorization before commencing the work. Following repair, the product will be returned to the Buyer transportation prepaid and the Buyer will be billed for the repair and return transportation charges (FOB Shipping Point).

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Safety Information

This Calibrator complies with IEC publication 1010-1 (1992-1), Safety Requirements for Electrical Measuring, Control and Laboratory Equipment, and ANSI/ISA-S82.01-1994, and CAN/CSA-C22.2 No. 1010.1-92. This manual contains information, warnings, and cautions that must be followed to ensure safe operation and to maintain the Calibrator in a safe condition. Use of this Calibrator in a manner not specified herein may impair the protection provided by the Calibrator.

This Calibrator is designed for IEC 1010-1 Installation Category II use. It is not designed for connection to circuits rated over 4800 VA.

Warning statements identify conditions or practices that could result in personal injury or loss of life.

Caution statements identify conditions or practices that could result in damage to equipment.

SYMBOLS MARKED ON THE CALIBRATOR



WARNING Risk of electric shock. Refer to the manual (see the Index for references).



GROUND Ground terminal to chassis (earth).



Attention Refer to the manual (see the Index for references). This symbol indicates that information about usage of a feature is contained in the manual.

AC POWER SOURCE

The Calibrator is intended to operate from an ac power source that will not apply more than 264V ac rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is required for safe operation.

USE THE PROPER FUSE

To avoid fire hazard, use only the specified replacement fuse:

- For 100 V or 120 V operation, use a 5A/250V time delay fuse (Fluke PN 109215).
- For 220 V or 240 V operation, use a 2.5A/250V time delay fuse (Fluke PN 851931).

GROUNDING THE CALIBRATOR

The Calibrator uses controlled overvoltage techniques that require the Calibrator to be grounded whenever normal mode or common mode ac voltages or transient voltages may occur. The enclosure must be grounded through the grounding conductor of the power cord, or through the rear panel CHASSIS GROUND binding post.

USE THE PROPER POWER CORD

Use only the power cord and connector appropriate for the voltage and plug configuration in your country.

Use only a power cord that is in good condition.

Refer power cord and connector changes to qualified service personnel.

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

To avoid explosion, do not operate the Calibrator in an atmosphere of explosive gas.

CHECK INSULATION RATINGS

Verify that the voltage applied to the unit under test does not exceed the insulation rating of the UUT and the interconnecting cables.

DO NOT REMOVE COVER DURING OPERATION

To avoid personal injury or death, do not remove the Calibrator cover without first removing the power source connected to the rear panel. Do not operate the Calibrator without the cover properly installed. Normal calibration is accomplished with the cover closed. Access procedures and the warnings for such procedures are contained in the Service Manual. Service procedures are for qualified service personnel only.

DO NOT ATTEMPT TO OPERATE IF PROTECTION MAY BE IMPAIRED

If the Calibrator appears damaged or operates abnormally, protection may be impaired. Do not attempt to operate the Calibrator under these conditions. Refer all questions of proper Calibrator operation to qualified service personnel.

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Chapter 1

Introduction and Specifications

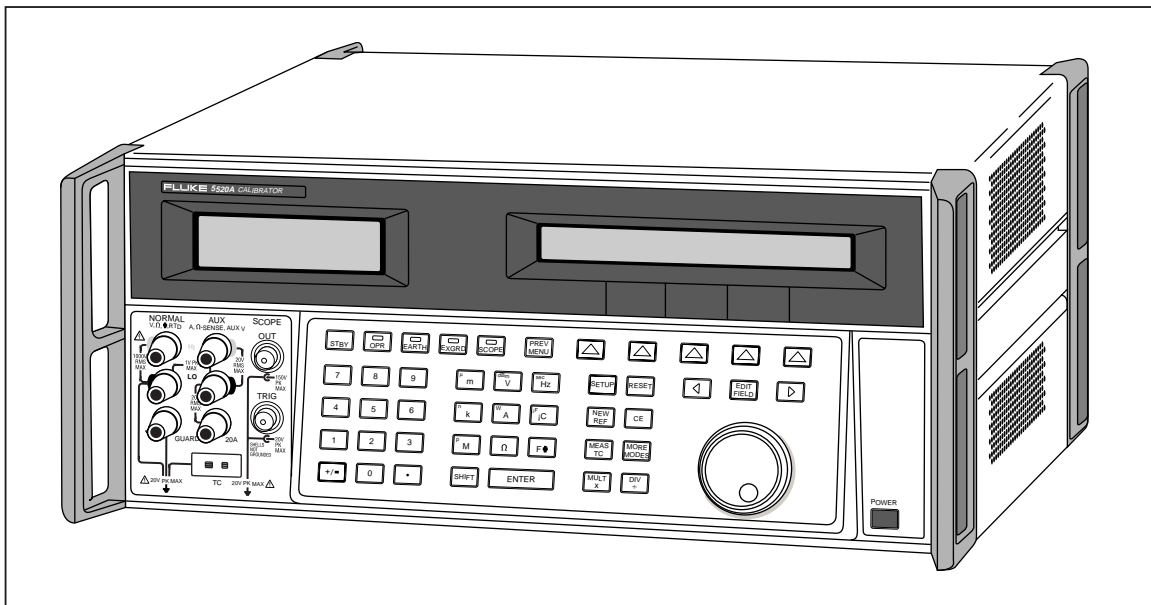
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1-1. Introduction

The Fluke Model 5520A Multi-Product Calibrator (Figure 1-1) is a precise instrument that calibrates a wide variety of electrical measuring instruments. With the 5520A Calibrator, you can calibrate precision multimeters that measure ac or dc voltage, ac or dc current, ac or dc power, resistance, capacitance, and temperature. The 5520A can display pressure measurements when used with a Fluke 700 Series Pressure Module. With the SC600 and SC300 Oscilloscope Calibration options, you can use the 5520A Calibrator to calibrate analog and digital oscilloscopes. Specifications are provided in this chapter (specifications for the oscilloscope calibration options are provided in Chapter 6).

Warning

If the 5520A Calibrator is operated in any way not specified by this manual or other documentation provided by Fluke, the protection provided by the Calibrator may be impaired.



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Figure 1-1. 5520A Multi-Product Calibrator

1-2. **Operation Overview**

The 5520A Calibrator may be operated at the front panel in the local mode, or remotely using RS-232 or IEEE-488 ports. For remote operations, several software options are available to integrate 5520A operation into a wide variety of calibration requirements.

1-3. **Local Operation**

Typical local operations include front panel connections to the Unit Under Test (UUT), and then manual keystroke entries at the front panel to place the calibrator in the desired output mode. The front panel layout facilitates hand movements from left to right, and multiply and divide keys make it easy to step up or down at the press of a single key. You can also review 5520A Calibrator specifications at the push of two keys.

1-4. **Remote Operation (RS-232)**

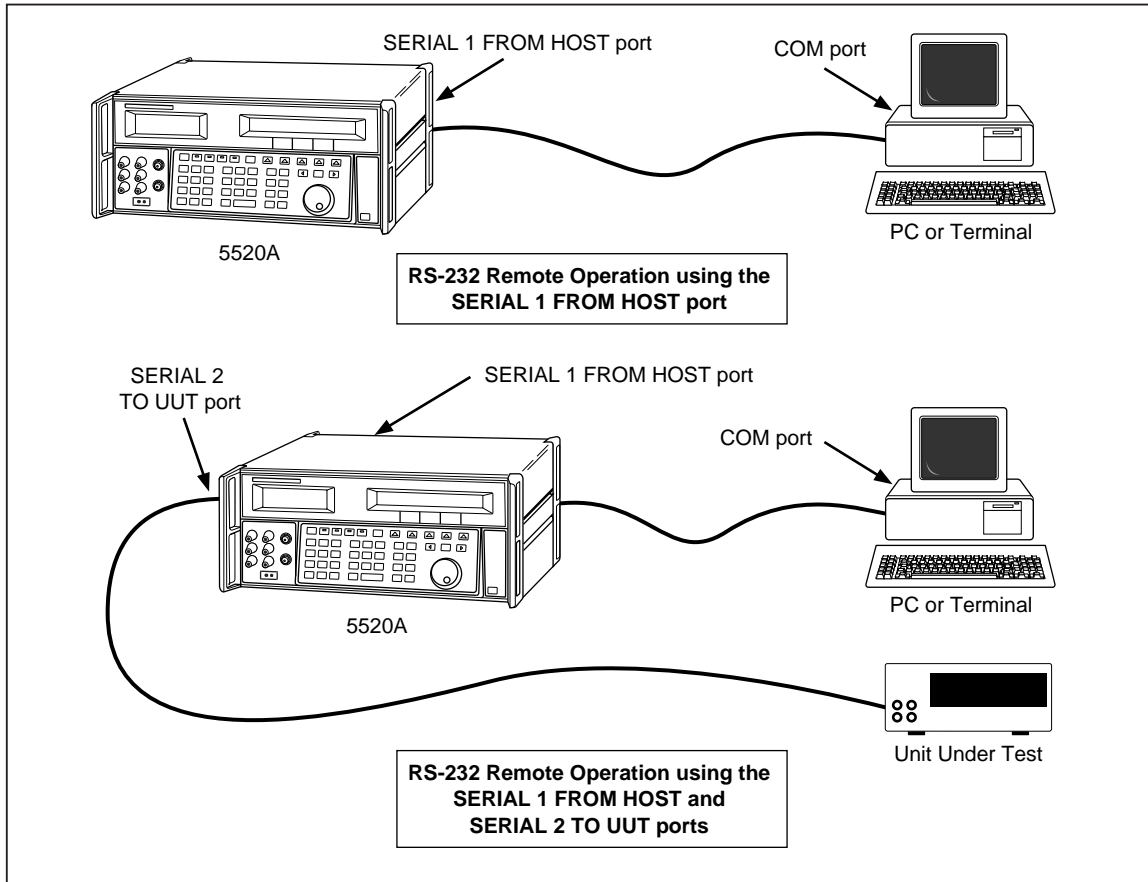
There are two rear-panel serial data RS-232 ports: SERIAL 1 FROM HOST, and SERIAL 2 TO UUT (Figure 1-2). Each port is dedicated to serial data communications for operating and controlling the 5520A during calibration procedures. For complete information on remote operation, see Chapter 5 of the *5520A Operators Manual*.

The SERIAL 1 FROM HOST serial data port connects a host terminal or personal computer to the 5520A. You have several choices for sending commands to the 5520A: you can enter commands from a terminal (or a PC running a terminal program), you can write your own programs using BASIC, or you can run optional Windows-based software such as 5500/CAL or MET/CAL. The 5500/CAL software includes more than 200 example procedures covering a wide range of test tools the 5520A can calibrate.

The SERIAL 2 TO UUT serial data port connects a UUT to a PC or terminal via the 5520A (see Figure 1-3). This “pass-through” configuration eliminates the requirement for two COM ports at the PC or terminal. A set of four commands control the operation of the SERIAL 2 TO UUT serial port. See Chapter 6 of the *5520A Operators Manual* for a discussion of the UUT_* commands. The SERIAL 2 TO UUT port is also used to connect to the Fluke 700 series pressure modules.

1-5. **Remote Operation (IEEE-488)**

The 5520A rear panel IEEE-488 port is a fully programmable parallel interface bus meeting standard IEEE-488.1 and supplemental standard IEEE-488.2. Under the remote control of an instrument controller, the 5520A Calibrator operates exclusively as a “talker/listener.” You can write your own programs using the IEEE-488 command set or run the optional Windows-based MET/CAL software. (See the *5520A Operators Manual* for a discussion of the general commands available for IEEE-488 operation, and Chapter 3 of this manual for remote commands used for 5520A calibration.)



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Figure 1-2. RS-232 Remote Connections

1-6. Service Information

In case of difficulty within the 1-year Warranty period, return the Calibrator to a Fluke Service Center for Warranty repair. For out of Warranty repair, contact a Fluke Service Center for a cost estimate.

This service manual provides instructions for verification of performance, calibration, and maintenance. If you choose to repair a malfunction, information in this manual can help you to determine which module (printed circuit assembly) has a fault.

1-7. How to Contact Fluke

To contact Fluke, call one of the following telephone numbers:

USA and Canada: 1-888-99-FLUKE (1-888-993-5853)

Europe: +31 402-678-200

Japan: +81-3-3434-0181

Singapore: +65-738-5655

Anywhere in the world: +1-425-356-5500

Or, visit Fluke's Web site at www.fluke.com.

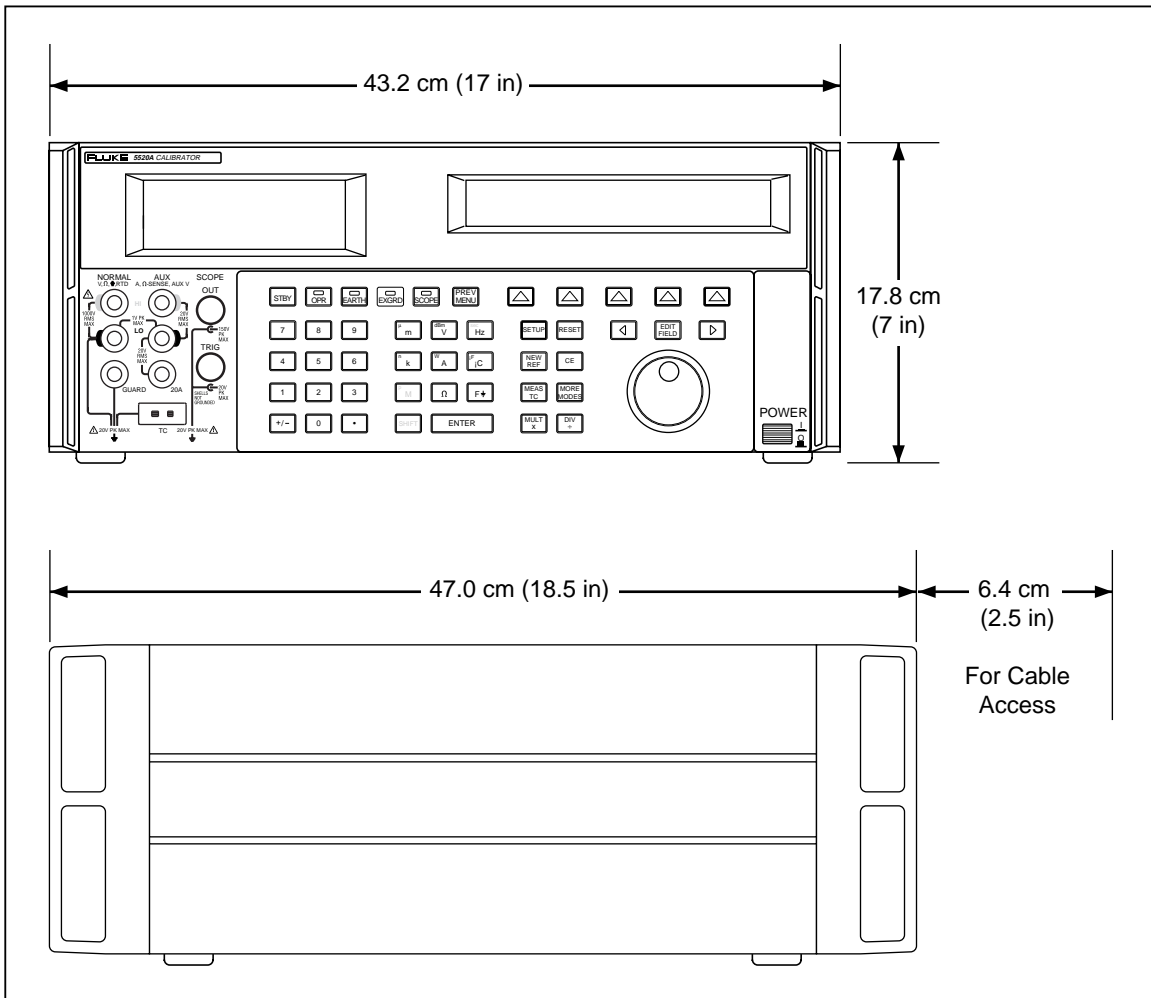
1-8. Specifications

The following tables list the 5520A specifications. All specifications are valid after allowing a warm-up period of 30 minutes, or twice the time the 5520A has been turned off. (For example, if the 5520A has been turned off for 5 minutes, the warm-up period is 10 minutes.)

All specifications apply for the temperature and time period indicated. For temperatures outside of $t_{cal} \pm 5\text{ }^{\circ}\text{C}$ (t_{cal} is the ambient temperature when the 5520A was calibrated), the temperature coefficient as stated in the General Specifications must be applied.

The specifications also assume the Calibrator is zeroed every seven days or whenever the ambient temperature changes more than $5\text{ }^{\circ}\text{C}$. The tightest ohms specifications are maintained with a zero cal every 12 hours within $\pm 1\text{ }^{\circ}\text{C}$ of use.

Also see additional specifications later in this chapter for information on extended specifications for ac voltage and current. The dimensional outline for the 5520A Calibrator is shown in Figure 1-3.



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Figure 1-3. 5520A Calibrator Dimensional Outline

1-9. General Specifications

Warmup Time	Twice the time since last warmed up, to a maximum of 30 minutes.
Settling Time	Less than 5 seconds for all functions and ranges except as noted.
Standard Interfaces	IEEE-488 (GPIB), RS-232
Temperature Performance	<ul style="list-style-type: none"> • Operating: 0 °C to 50 °C • Calibration (tcal): 15 °C to 35 °C • Storage: -20 °C to 70 °C
Temperature Coefficient	Temperature coefficient for temperatures outside tcal \pm 5 °C is 10% of the stated specification per °C for temperatures in the range of 0 °C to 35 °C. Above 35 °C, the temperature coefficient is 20% of the stated specification per °C.
Relative Humidity	<ul style="list-style-type: none"> • Operating: <80% to 30 °C, <70% to 40 °C, <40% to 50 °C • Storage: <95%, noncondensing <p>Note: After long periods of storage at high humidity, a drying out period (with the power on) of at least one-week may be required.</p>
Altitude	<ul style="list-style-type: none"> • Operating: 3,050 m (10,000 ft) maximum • Nonoperating: 12,200 m (40,000 ft) maximum
Safety	Complies with IEC 1010-1 (1992-1); ANSI/ISA-S82.01-1994; CAN/CSA-C22.2 No. 1010.1-92
Analog Low Isolation	20 V
EMC	Complies with EN 61326-1/1997, Class A (EMC); thermocouple simulating and measuring are not specified for operation in electromagnetic fields above 0.4 V/m.
Line Power	<ul style="list-style-type: none"> • Line Voltage (selectable): 100 V, 120 V, 220 V, 240 V • Line Frequency: 47 Hz to 63 Hz • Line Voltage Variation: \pm 10% about line voltage setting <p>Note: For optimal performance at full dual outputs (e.g. 1000 V, 20 A), choose a line voltage setting that is \pm 7.5% from nominal.</p>
Power Consumption	600 VA
Dimensions	<ul style="list-style-type: none"> • Height, 17.8 cm (7 inches), standard rack increment, plus 1.5 cm (0.6 inch) for feet on bottom of unit; • Width, 43.2 cm (17 inches), standard rack width • Depth, 47.3 cm (18.6 inches) overall
Weight (without options)	22 kg (49 lb)

1-10. DC Voltage Specifications

Range	Absolute Uncertainty, tcal ± 5 °C ± (ppm of output + μV)		Stability	Resolution μV	Max Burden [1]
	90 days	1 year	24 hours, ± 1 °C ± (ppm output + μV)		
0 to 329.9999 mV	15 + 1	20 + 1	3 + 1	0.1	50 Ω
0 to 3.299999 V	9 + 2	11 + 2	2 + 1.5	1	10 mA
0 to 32.99999 V	10 + 15	12 + 15	2 + 10	10	10 mA
30 V to 329.9999 V	15 + 150	18 + 150	2.5 + 100	100	5 mA
100 V to 1000.000 V	15 + 1500	18 + 1500	3 + 300	1000	5 mA
Auxiliary Output (dual output mode only) [2]					
0 to 329.999 mV	300 + 350	400 + 350	30 + 100	1	5 mA
0.33V to 3.29999V	300 + 350	400 + 350	30 + 100	10	5 mA
3.3 V to 7 V	300 + 350	400 + 350	30 + 100	100	5 mA
TC Simulate and Measure in Linear 10 μV/°C and 1 mV/°C modes [3]					
0 to 329.999 mV	40 + 3	50 + 3	5 + 2	0.1	10 Ω
<p>[1] Remote sensing is not provided. Output resistance is < 5 mΩ for outputs ≥ 0.33 V. The AUX output has an output resistance of < 1Ω. TC simulation has an output impedance of 10 Ω ± 1 Ω.</p> <p>[2] Two channels of dc voltage output are provided.</p> <p>[3] TC simulating and measuring are not specified for operation in electromagnetic fields above 0.4 V/m.</p>					

Range	Noise	
	Bandwidth 0.1 Hz to 10 Hz p-p ± (ppm output + floor)	Bandwidth 10 Hz to 10 kHz rms
0 to 329.9999 mV	0 + 1 μV	6 μV
0 to 3.299999 V	0 + 10 μV	60 μV
0 to 32.99999 V	0 + 100 μV	600 μV
30 to 329.9999 V	10 + 1 mV	20 mV
100 to 1000.000 V	10 + 5 mV	20 mV
Auxiliary Output (dual output mode only) [1]		
0 to 329.999 mV	0 + 5 μV	20 μV
0.33 V to 3.29.999 V	0 + 20 μV	200 μV
3.3 V to 7 V	0 + 100 μV	1000 μV
<p>[1] Two channels of dc voltage output are provided.</p>		

1-11. DC Current Specifications

Range	Absolute Uncertainty, tcal ± 5 °C ± (ppm of output + μA)		Resolution	Max Compliance Voltage V	Max Inductive Load μH
	90 days	1 year			
0 to 329.999 μA	120 + 0.02	150 + 0.02	1 nA	10	400
0 to 3.29999 mA	80 + 0.05	100 + 0.05	0.01 μA	10	
0 to 32.9999 mA	80 + 0.25	100 + 0.25	0.1 μA	7	
0 to 329.999 mA	80 + 2.5	100 + 2.5	1 μA	7	
0 to 1.09999 A	160 + 40 [1]	200 + 40 [1]	10 μA	6	
1.1 A to 2.99999 A	300 + 40 [1]	380 + 40 [1]	10 μA	6	
0 to 10.9999 A (20 A Range)	380 + 500 [1]	500 + 500 [1]	100 μA	4	
11 A to 20.5 A [2]	800 + 750	1000 + 750	100 μA	4	

[1] Floor specification doubles within 30 seconds of an output current > 10A.

[2] Duty Cycle: Currents < 11 A may be provided continuously. For currents > 11 A, see Figure 1-4. The current may be provided 60-T-I minutes any 60 minute period where T is the temperature in °C (room temperature is about 23 °C) and I is the output current in amperes. For example, 17 A, at 23 °C could be provided for 60-17-23 = 20 minutes each hour.

Range	Noise	
	Bandwidth 0.1 Hz to 10 Hz p-p	Bandwidth 10 Hz to 10 kHz rms
0 to 329.999 μA	2 nA	20 nA
0 to 3.29999 mA	20 nA	200 nA
0 to 32.9999 mA	200 nA	2.0 μA
0 to 329.999 mA	2000 nA	20 μA
0 to 2.99999 A	20 μA	1 mA
0 to 20.5 A	200 μA	10 mA

DC Current Specifications (cont)

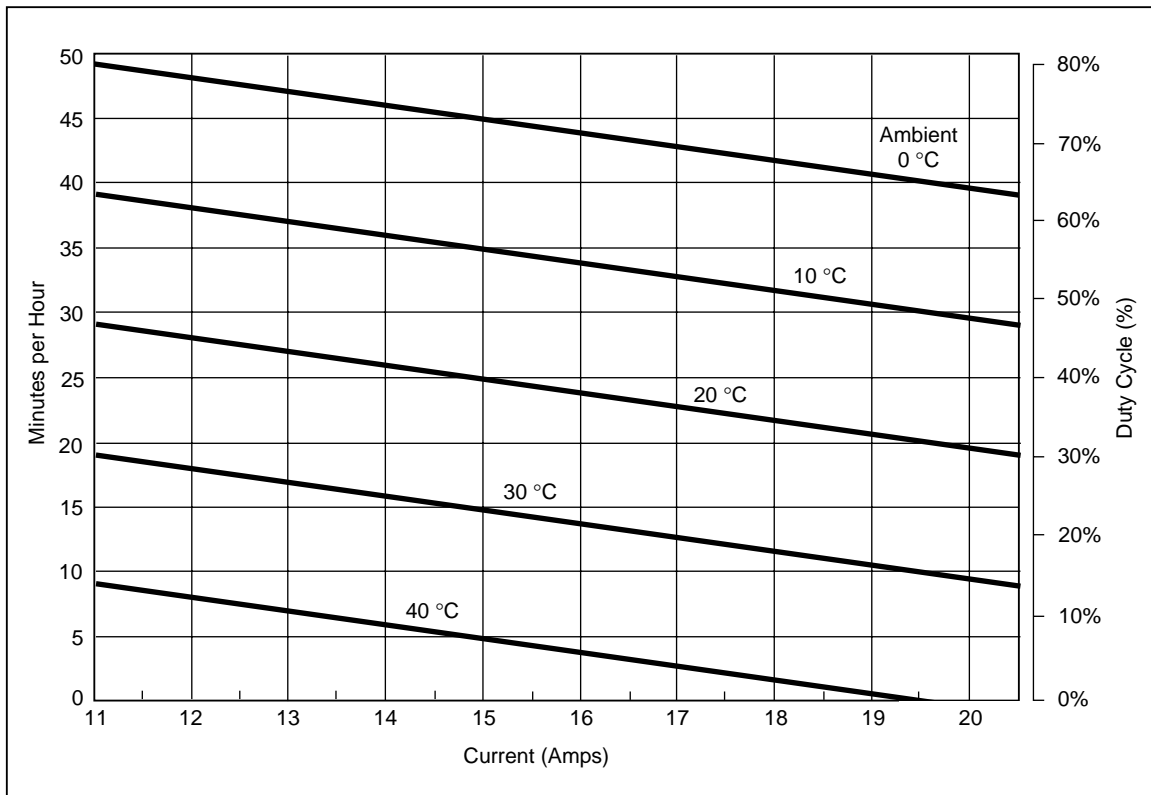


Figure 1-4. Allowable Duration of Current > 11 A

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1-12. Resistance Specifications

Range [1]	Absolute Uncertainty, tcal $\pm 5^\circ\text{C}$ \pm (ppm of output + floor) [2]				Resolution Ω	Allowable Current [3]
	ppm of output		Floor Time & temp since ohms zero cal			
	90 days	1 year	12 hrs $\pm 1^\circ\text{C}$	7 days $\pm 5^\circ\text{C}$		
0 to 10.9999 Ω	35	40	0.001	0.01	0.0001	1 mA to 125 mA
11 Ω to 32.9999 Ω	25	30	0.0015	0.015	0.0001	1 mA to 125 mA
33 Ω to 109.9999 Ω	22	28	0.0014	0.015	0.0001	1 mA to 70 mA
110 Ω to 329.9999 Ω	22	28	0.002	0.02	0.0001	1 mA to 40 mA
330 Ω to 1.099999 k Ω	22	28	0.002	0.02	0.001	1 mA to 18 mA
1.1 k Ω to 3.299999 k Ω	22	28	0.02	0.2	0.001	100 μA to 5 mA
3.3 k Ω to 10.999999 k Ω	22	28	0.02	0.1	0.01	100 μA to 1.8 mA
11 k Ω to 32.999999 k Ω	22	28	0.2	1	0.01	10 μA to 0.5 mA
33 k Ω to 109.999999 k Ω	22	28	0.2	1	0.1	10 μA to 0.18 mA
110 k Ω to 329.999999 k Ω	25	32	2	10	0.1	1 μA to 0.05 mA
330 k Ω to 1.09999999 M Ω	25	32	2	10	1	1 μA to 0.018 mA
1.1 M Ω to 3.29999999 M Ω	40	60	30	150	1	250 nA to 5 μA
3.3 M Ω to 10.99999999 M Ω	110	130	50	250	10	250 nA to 1.8 μA
11 M Ω to 32.99999999 M Ω	200	250	2500	2500	10	25 nA to 500 nA
33 M Ω to 109.99999999 M Ω	400	500	3000	3000	100	25 nA to 180 nA
110 M Ω to 329.99999999 M Ω	2500	3000	100000	100000	1000	2.5 nA to 50 nA
330 M Ω to 1100 M Ω	12000	15000	500000	500000	10000	1 nA to 13 nA

[1] Continuously variable from 0 Ω to 1.1 G Ω .

[2] Applies for 4-WIRE compensation only. For 2-WIRE and 2-WIRE COMP, add 5 μV per Amp of stimulus current to the floor specification. For example, in 2-WIRE mode, at 1 k Ω , the floor specification within 8 hours of an ohms zero cal for a measurement current of 250 μA is $0.002 \Omega + 5 \mu\text{V} / 250 \mu\text{A} = 0.022 \Omega$. Maximum measurement lead resistance for no additional error in 2-WIRE COMP: 5 Ω .

[3] For currents lower than shown, the floor adder increases by $\text{Floor}_{(\text{new})} = \text{Floor}_{(\text{old})} \times I_{\text{min}}/I_{\text{actual}}$. For example, a 50 μA stimulus measuring 100 Ω has a floor uncertainty of $0.0015 \Omega \times 1 \text{ mA}/50 \mu\text{A} = 0.03 \Omega$, assuming an ohms zero calibration within 12 hours.

1-13. AC Voltage (Sinewave) Specifications

Range	Frequency	Absolute Uncertainty, tcal $\pm 5^\circ\text{C}$ \pm (ppm of output + μV)		Resolution	Max Burden	Max Distortion and Noise 10 Hz to 5 MHz Bandwidth \pm (% output + floor)
		90 days	1 year			
1.0 mV to 32.999 mV	10 Hz to 45 Hz	600 + 6	800 + 6	1 μV	50 Ω	0.15 + 90 μV
	45 Hz to 10 kHz	120 + 6	150 + 6			0.035 + 90 μV
	10 kHz to 20 kHz	160 + 6	200 + 6			0.06 + 90 μV
	20 kHz to 50 kHz	800 + 6	1000 + 6			0.15 + 90 μV
	50 kHz to 100 kHz	3000 + 12	3500 + 12			0.25 + 90 μV
	100 kHz to 500 kHz	6000 + 50	8000 + 50			0.3 + 90 μV
33 mV to 329.999 mV	10 Hz to 45 Hz	250 + 8	300 + 8	1 μV	50 Ω	0.15 + 90 μV
	45 Hz to 10 kHz	140 + 8	145 + 8			0.035 + 90 μV
	10 kHz to 20 kHz	150 + 8	160 + 8			0.06 + 90 μV
	20 kHz to 50 kHz	300 + 8	350 + 8			0.15 + 90 μV
	50 kHz to 100 kHz	600 + 32	800 + 32			0.20 + 90 μV
	100 kHz to 500 kHz	1600 + 70	2000 + 70			0.20 + 90 μV
0.33 V to 3.29999 V	10 Hz to 45 Hz	250 + 50	300 + 50	10 μV	10 mA	0.15 + 200 μV
	45 Hz to 10 kHz	140 + 60	150 + 60			0.035 + 200 μV
	10 kHz to 20 kHz	160 + 60	190 + 60			0.06 + 200 μV
	20 kHz to 50 kHz	250 + 50	300 + 50			0.15 + 200 μV
	50 kHz to 100 kHz	550 + 125	700 + 125			0.20 + 200 μV
	100 kHz to 500 kHz	2000 + 600	2400 + 600			0.20 + 200 μV
3.3 V to 32.9999 V	10 Hz to 45 Hz	250 + 650	300 + 650	100 μV	10 mA	0.15 + 2 mV
	45 Hz to 10 kHz	125 + 600	150 + 600			0.035 + 2 mV
	10 kHz to 20 kHz	220 + 600	240 + 600			0.08 + 2 mV
	20 kHz to 50 kHz	300 + 600	350 + 600			0.2 + 2 mV
	50 kHz to 100 kHz	750 + 1600	900 + 1600			0.5 + 2 mV
33 V to 329.999 V	45 Hz to 1 kHz	150 + 2000	190 + 2000	1 mV	5 mA, except 20 mA for 45 Hz to 65 Hz	0.15 + 10 mV
	1 kHz to 10 kHz	160 + 6000	200 + 6000			0.05 + 10 mV
	10 kHz to 20 kHz	220 + 6000	250 + 6000			0.6 + 10 mV
	20 kHz to 50 kHz	240 + 6000	300 + 6000			0.8 + 10 mV
	50 kHz to 100 kHz	1600 + 50000	2000 + 50000			1.0 + 10 mV
330 V to 1020 V	45 Hz to 1 kHz	250 + 10000	300 + 10000	10 mV	2 mA, except 6 mA for 45 Hz to 65 Hz	0.15 + 30 mV
	1 kHz to 5 kHz	200 + 10000	250 + 10000			0.07 + 30 mV
	5 kHz to 10 kHz	250 + 10000	300 + 10000			0.07 + 30 mV

AC Voltage (Sinewave) Specifications (cont)

Auxiliary Output [dual output mode only]						
Range	Frequency	Absolute Uncertainty, tcal ± 5 °C ± (% of output + μV)		Resolution	Max Burden	Max Distortion and Noise 10 Hz to 100 kHz Bandwidth ± (% output + floor)
		90 days	1 year			
10 mV to 329.999 mV	10 Hz to 20 Hz	0.15 + 370	0.2 + 370	1 μV	5 mA	0.2 + 200 μV
	20 Hz to 45 Hz	0.08 + 370	0.1 + 370			0.06 + 200 μV
	45 Hz to 1 kHz	0.08 + 370	0.1 + 370			0.08 + 200 μV
	1 kHz to 5 kHz	0.15 + 450	0.2 + 450			0.3 + 200 μV
	5 kHz to 10 kHz	0.3 + 450	0.4 + 450			0.6 + 200 μV
	10 Hz to 30 kHz	4.0 + 900	5.0 + 900			1 + 200 μV
0.33 V to 3.29999 V	10 Hz to 20 Hz	0.15 + 450	0.2 + 450	10 μV	5 mA	0.2 + 200 μV
	20 Hz to 45 Hz	0.08 + 450	0.1 + 450			0.06 + 200 μV
	45 Hz to 1 kHz	0.07 + 450	0.09 + 450			0.08 + 200 μV
	1 kHz to 5 kHz	0.15 + 1400	0.2 + 1400			0.3 + 200 μV
	5 kHz to 10 kHz	0.3 + 1400	0.4 + 1400			0.6 + 200 μV
	10 kHz to 30 kHz	4.0 + 2800	5.0 + 2800			1 + 200 μV
3.3 V to 5 V	10 Hz to 20 Hz	0.15 + 450	0.2 + 450	100 μV	5 mA	0.2 + 200 μV
	20 Hz to 45 Hz	0.08 + 450	0.1 + 450			0.06 + 200 μV
	45 Hz to 1 kHz	0.07 + 450	0.09 + 450			0.08 + 200 μV
	1 kHz to 5 kHz	0.15 + 1400	0.2 + 1400			0.3 + 200 μV
	5 kHz to 10 kHz	0.3 + 1400	0.4 + 1400			0.6 + 200 μV

Notes:

- Remote sensing is not provided. Output resistance is < 5 mΩ for outputs ≥0.33 V. The AUX output resistance is < 1Ω. The maximum load capacitance is 500 pF, subject to the maximum burden current limits.
- There are two channels of voltage output. The maximum frequency of the dual output is 30 kHz.

1-14. AC Current (Sinewave) Specifications

LCOMP off						
Range	Frequency	Absolute Uncertainty, tcal ± 5 °C ± (% of output + μA)		Compliance adder ± (μA/V)	Max Distortion & Noise 10 Hz to 100 kHz BW ± (% output + floor)	Max Inductive Load μH
		90 days	1 year			
29.00 μA to 329.99 μA	10 Hz to 20 Hz	0.16 + 0.1	0.2 + 0.1	0.05	0.15 + 0.5 μA	200
	20 Hz to 45 Hz	0.12 + 0.1	0.15 + 0.1	0.05	0.1 + 0.5 μA	
	45 Hz to 1 kHz	0.1 + 0.1	0.125 + 0.1	0.05	0.05 + 0.5 μA	
	1 kHz to 5 kHz	0.25 + 0.15	0.3 + 0.15	1.5	0.5 + 0.5 μA	
	5 kHz to 10 kHz	0.6 + 0.2	0.8 + 0.2	1.5	1.0 + 0.5 μA	
	10 kHz to 30 kHz	1.2 + 0.4	1.6 + 0.4	10	1.2 + 0.5 μA	
0.33 mA to 3.2999 mA	10 Hz to 20 Hz	0.16 + 0.15	0.2 + 0.15	0.05	0.15 + 1.5 μA	200
	20 Hz to 45 Hz	0.1 + 0.15	0.125 + 0.15	0.05	0.06 + 1.5 μA	
	45 Hz to 1 kHz	0.08 + 0.15	0.1 + 0.15	0.05	0.02 + 1.5 μA	
	1 kHz to 5 kHz	0.16 + 0.2	0.2 + 0.2	1.5	0.5 + 1.5 μA	
	5 kHz to 10 kHz	0.4 + 0.3	0.5 + 0.3	1.5	1.0 + 1.5 μA	
	10 kHz to 30 kHz	0.8 + 0.6	1.0 + 0.6	10	1.2 + 0.5 μA	
3.3 mA to 32.999 mA	10 Hz to 20 Hz	0.15 + 2	0.18 + 2	0.05	0.15 + 5 μA	50
	20 Hz to 45 Hz	0.075 + 2	0.09 + 2	0.05	0.05 + 5 μA	
	45 Hz to 1 kHz	0.035 + 2	0.04 + 2	0.05	0.07 + 5 μA	
	1 kHz to 5 kHz	0.065 + 2	0.08 + 2	1.5	0.3 + 5 μA	
	5 kHz to 10 kHz	0.16 + 3	0.2 + 3	1.5	0.7 + 5 μA	
	10 kHz to 30 kHz	0.32 + 4	0.4 + 4	10	1.0 + 0.5 μA	
33 mA to 329.99 mA	10 Hz to 20 Hz	0.15 + 20	0.18 + 20	0.05	0.15 + 50 μA	50
	20 Hz to 45 Hz	0.075 + 20	0.09 + 20	0.05	0.05 + 50 μA	
	45 Hz to 1 kHz	0.035 + 20	0.04 + 20	0.05	0.02 + 50 μA	
	1 kHz to 5 kHz	0.08 + 50	0.10 + 50	1.5	0.03 + 50 μA	
	5 kHz to 10 kHz	0.16 + 100	0.2 + 100	1.5	0.1 + 50 μA	
	10 kHz to 30 kHz	0.32 + 200	0.4 + 200	10	0.6 + 50 μA	
0.33 A to 1.09999 A [1]	10 Hz to 45 Hz	0.15 + 100	0.18 + 100		0.2 + 500 μA	2.5
	45 Hz to 1 kHz	0.036 + 100	0.05 + 100		0.07 + 500 μA	
	1 kHz to 5 kHz	0.5 + 1000	0.6 + 1000	[3]	1 + 500 μA	
	5 kHz to 10 kHz	2.0 + 5000	2.5 + 5000	[4]	2 + 500 μA	
1.1 A to 2.99999 A [1]	10 Hz to 45 Hz	0.15 + 100	0.18 + 100		0.2 + 500 μA	2.5
	45 Hz to 1 kHz	0.05 + 100	0.06 + 100		0.07 + 500 μA	
	1 kHz to 5 kHz	0.5 + 1000	0.6 + 1000	[3]	1 + 500 μA	
	5 kHz to 10 kHz	2.0 + 5000	2.5 + 5000	[4]	2 + 500 μA	
3 A to 10.9999 A [1]	45 Hz to 100 Hz	0.05 + 2000	0.06 + 2000		0.2 + 3 mA	1
	100 kHz to 1 kHz	0.08 + 2000	0.10 + 2000		0.1 + 3 mA	
	1 kHz to 5 kHz	2.5 + 2000	3.0 + 2000		0.8 + 3 mA	
11A to 20.5 A [2]	45 Hz to 100 Hz	0.1 + 5000	0.12 + 5000		0.2 + 3 mA	1
	100 Hz to 1 kHz	0.13 + 5000	0.15 + 5000		0.1 + 3 mA	
	1 kHz to 5 kHz	2.5 + 5000	3.0 + 5000		0.8 + 3 mA	

[1] Floor specification doubles within 30 seconds of an output current > 10 A.
 [2] Duty Cycle: Currents < 11 A may be provided continuously. For currents > 11 A, see Figure 1-4. The current may be provided 60-T-I minutes any 60 minute period where T is the temperature in °C (room temperature is about 23°C) and I is the output current in Amps. For example, 17 A, at 23°C could be provided for 60-17-23 = 20 minutes each hour.
 [3] For compliance voltages greater than 1 V, add 1 mA/V to the floor specification from 1 kHz to 5 kHz.
 [4] For compliance voltages greater than 1 V, add 5 mA/V to the floor specification from 5 kHz to 10 kHz.

AC Current (Sinewave) Specifications (cont)

LCOMP on						
Range	Frequency	Absolute Uncertainty, $t_{cal} \pm 5$ $^{\circ}\text{C}$ \pm (% of output + μA)		Max Distortion & Noise, 10 Hz to 100 kHz BW \pm (% output + μA)	Max Inductive Load μH	
		90 days	1 year			
29.00 μA to 329.99 μA	10 Hz to 100 Hz 100 Hz to 1 kHz	0.2 + 0.2 0.5 + 0.5	0.25 + 0.2 0.6 + 0.5	0.1 + 1.0 0.05 + 1.0	400	
0.33 mA to 3.2999 mA	10 Hz to 100 Hz 100 Hz to 1 kHz	0.2 + 0.3 0.5 + 0.8	0.25 + 0.3 0.6 + 0.8	0.15 + 1.5 0.06 + 1.5		
3.3 mA to 32.999 mA	10 Hz to 100 Hz 100 Hz to 1 kHz	0.07 + 4 0.18 + 10	0.08 + 4 0.2 + 10	0.15 + 5 0.05 + 5		
33 mA to 329.99 mA	10 Hz to 100 Hz 100 Hz to 1 kHz	0.07 + 40 0.18 + 100	0.08 + 40 0.2 + 100	0.15 + 50 0.05 + 50		
0.33 A to 2.99999 A [1]	10 Hz to 100 Hz 100 to 440 Hz	0.1 + 200 0.25 + 1000	0.12 + 200 0.3 + 1000	0.2 + 500 0.25 + 500		
3 A to 20.5 A [1] [2]	45 to 100 Hz 100 to 440 Hz	0.1 + 2000 0.8 + 5000	0.12 + 2000 1.0 + 5000	0.1 + 0 0.5 + 0		400 [3]

[1] Floor specification doubles within 30 seconds of an output current > 10 A.
 [2] Duty Cycle: Currents < 11 A may be provided continuously. For currents > 11 A, see Figure 1-4. The current may be provided 60-T-I minutes any 60 minute period where T is the temperature in $^{\circ}\text{C}$ (room temperature is about 23°C) and I is the output current in Amps. For example, 17 A, at 23°C could be provided for $60-17-23 = 20$ minutes each hour.
 [3] Subject to compliance limit.

Range	Resolution μA	Max Compliance Voltage V rms
0.029 mA to 0.32999 mA	0.01	7
0.33 mA to 3.29999 mA	0.01	7
3.3 mA to 32.9999 mA	0.1	5
33 mA to 329.999 mA	1	5
0.33 A to 2.99999 A	10	4
3 A to 20.5 A	100	3

[1] Subject to specification adder for compliance voltages greater than 1 V rms.

1-15. Capacitance Specifications

Range	Absolute Uncertainty, tcal ± 5 °C ± (% of output + floor)		Resolution	Allowed Frequency or Charge-Discharge Rate		
	90 days	1 year		Min and Max to Meet Specification	Typical Max for < 0.5% Error	Typical Max for < 1% Error
0.19 nF to 0.3999 nF	0.38 + 0.01 nF	0.5 + 0.01 nF	0.1 pF	10 Hz to 10 kHz	20 kHz	40 kHz
0.4 nF to 1.0999 nF	0.38 + 0.01 nF	0.5 + 0.01 nF	0.1 pF	10 Hz to 10 kHz	30 kHz	50 kHz
1.1 nF to 3.2999 nF	0.38 + 0.01 nF	0.5 + 0.01 nF	0.1 pF	10 Hz to 3 kHz	30 kHz	50 kHz
3.3 nF to 10.9999 nF	0.19 + 0.01 nF	0.25 + 0.01 nF	0.1 pF	10 Hz to 1 kHz	20 kHz	25 kHz
11 nF to 32.9999 nF	0.19 + 0.1 nF	0.25 + 0.1 nF	0.1 pF	10 Hz to 1 kHz	8 kHz	10 kHz
33 nF to 109.999 nF	0.19 + 0.1 nF	0.25 + 0.1 nF	1 pF	10 Hz to 1 kHz	4 kHz	6 kHz
110 nF to 329.999 nF	0.19 + 0.3 nF	0.25 + 0.3 nF	1 pF	10 Hz to 1 kHz	2.5 kHz	3.5 kHz
0.33 μF to 1.09999 μF	0.19 + 1 nF	0.25 + 1 nF	10 pF	10 Hz to 600 Hz	1.5 kHz	2 kHz
1.1 μF to 3.29999 μF	0.19 + 3 nF	0.25 + 3 nF	10 pF	10 Hz to 300 Hz	800 Hz	1 kHz
3.3 μF to 10.9999 μF	0.19 + 10 nF	0.25 + 10 nF	100 pF	10 Hz to 150 Hz	450 Hz	650 Hz
11 μF to 32.9999 μF	0.30 + 30 nF	0.40 + 30 nF	100 pF	10 Hz to 120 Hz	250 Hz	350 Hz
33 μF to 109.999 μF	0.34 + 100 nF	0.45 + 100 nF	1 nF	10 Hz to 80 Hz	150 Hz	200 Hz
110 μF to 329.999 μF	0.34 + 300 nF	0.45 + 300 nF	1 nF	0 to 50 Hz	80 Hz	120 Hz
0.33 mF to 1.09999 mF	0.34 + 1 μF	0.45 + 1 μF	10 nF	0 to 20 Hz	45 Hz	65 Hz
1.1 mF to 3.2999 mF	0.34 + 3 μF	0.45 + 3 μF	10 nF	0 to 6 Hz	30 Hz	40 Hz
3.3 mF to 10.9999 mF	0.34 + 10 μF	0.45 + 10 μF	100 nF	0 to 2 Hz	15 Hz	20 Hz
11 mF to 32.9999 mF	0.7 + 30 μF	0.75 + 30 μF	100 nF	0 to 0.6 Hz	7.5 Hz	10 Hz
33 mF to 110 mF	1.0 + 100 μF	1.1 + 100 μF	10 μF	0 to 0.2 Hz	3 Hz	5 Hz

Notes:

- The output is continuously variable from 190 pF to 110 mF.
- Specifications apply to both dc charge/discharge capacitance meters and ac RCL meters. The maximum allowable peak voltage is 3 V. The maximum allowable peak current is 150 mA, with an rms limitation of 30 mA below 1.1 μF and 100 mA for 1.1 μF and above.
- The maximum lead resistance for no additional error in 2-wire COMP mode is 10 Ω.

1-16. Temperature Calibration (Thermocouple) Specifications

TC Type [1]	Range °C [2]	Absolute Uncertainty Source/Measure tcal ±5 °C ± °C [3]		TC Type [1]	Range °C [2]	Absolute Uncertainty Source/Measure tcal ±5 °C ± °C [3]	
		90 days	1 year			90 days	1 year
B	600 to 800	0.42	0.44	L	-200 to -100	0.37	0.37
	800 to 1000	0.34	0.34		-100 to 800	0.26	0.26
	1000 to 1550	0.30	0.30		800 to 900	0.17	0.17
	1550 to 1820	0.26	0.33	N	-200 to -100	0.30	0.40
C	0 to 150	0.23	0.30		-100 to -25	0.17	0.22
	150 to 650	0.19	0.26		-25 to 120	0.15	0.19
	650 to 1000	0.23	0.31		120 to 410	0.14	0.18
	1000 to 1800	0.38	0.50	410 to 1300	0.21	0.27	
	1800 to 2316	0.63	0.84	R	0 to 250	0.48	0.57
E	-250 to -100	0.38	0.50		250 to 400	0.28	0.35
	-100 to -25	0.12	0.16		400 to 1000	0.26	0.33
	-25 to 350	0.10	0.14		1000 to 1767	0.30	0.40
	350 to 650	0.12	0.16	S	0 to 250	0.47	0.47
	650 to 1000	0.16	0.21		250 to 1000	0.30	0.36
J	-210 to -100	0.20	0.27		1000 to 1400	0.28	0.37
	-100 to -30	0.12	0.16	1400 to 1767	0.34	0.46	
	-30 to 150	0.10	0.14	T	-250 to -150	0.48	0.63
	150 to 760	0.13	0.17		-150 to 0	0.18	0.24
	760 to 1200	0.18	0.23		0 to 120	0.12	0.16
K	-200 to -100	0.25	0.33		120 to 400	0.10	0.14
	-100 to -25	0.14	0.18	U	-200 to 0	0.56	0.56
	-25 to 120	0.12	0.16		0 to 600	0.27	0.27
	120 to 1000	0.19	0.26				
	1000 to 1372	0.30	0.40				

- [1] Temperature standard ITS-90 or IPTS-68 is selectable.
TC simulating and measuring are not specified for operation in electromagnetic fields above 0.4 V/m.
- [2] Resolution is 0.01 °C
- [3] Does not include thermocouple error

1-17. Temperature Calibration (RTD) Specifications

RTD Type	Range °C [1]	Absolute Uncertainty tcal ±5 °C ± °C [2]		RTD Type	Range °C [1]	Absolute Uncertainty tcal ±5 °C ± °C [2]	
		90 days	1 year			90 days	1 year
Pt 395, 100 Ω	-200 to -80	0.04	0.05	Pt 385, 500 Ω	-200 to -80	0.03	0.04
	-80 to 0	0.05	0.05		-80 to 0	0.04	0.05
	0 to 100	0.07	0.07		0 to 100	0.05	0.05
	100 to 300	0.08	0.09		100 to 260	0.06	0.06
	300 to 400	0.09	0.10		260 to 300	0.07	0.08
	400 to 630	0.10	0.12		300 to 400	0.07	0.08
	630 to 800	0.21	0.23		400 to 600	0.08	0.09
Pt 3926, 100 Ω	-200 to -80	0.04	0.05	Pt 385, 1000 Ω	600 to 630	0.09	0.11
	-80 to 0	0.05	0.05		-200 to -80	0.03	0.03
	0 to 100	0.07	0.07		-80 to 0	0.03	0.03
	100 to 300	0.08	0.09		0 to 100	0.03	0.04
	300 to 400	0.09	0.10		100 to 260	0.04	0.05
400 to 630	0.10	0.12	260 to 300		0.05	0.06	
Pt 3916, 100 Ω	-200 to -190	0.25	0.25		300 to 400	0.05	0.07
	-190 to -80	0.04	0.04	400 to 600	0.06	0.07	
	-80 to 0	0.05	0.05	600 to 630	0.22	0.23	
	0 to 100	0.06	0.06	PtNi 385, 120 Ω (Ni120)	-80 to 0	0.06	0.08
	100 to 260	0.06	0.07		0 to 100	0.07	0.08
	260 to 300	0.07	0.08		100 to 260	0.13	0.14
	300 to 400	0.08	0.09	Cu 427, 10 Ω [3]	-100 to 260	0.3	0.3
	400 to 600	0.08	0.10				
600 to 630	0.21	0.23					
Pt 385, 200 Ω	-200 to -80	0.03	0.04				
	-80 to 0	0.03	0.04				
	0 to 100	0.04	0.04				
	100 to 260	0.04	0.05				
	260 to 300	0.11	0.12				
	300 to 400	0.12	0.13				
	400 to 600	0.12	0.14				
	600 to 630	0.14	0.16				

[1] Resolution is 0.003 °C

[2] Applies for COMP OFF (to the 5520A Calibrator front panel NORMAL terminals) and 2 wire and 4-wire compensation.

[3] Based on MINCO Application Aid No. 18

1-18. DC Power Specification Summary

	Voltage Range	Current Range		
		0.33 mA to 329.99 mA	0.33 A to 2.9999 A	3 A to 20.5 A
		Absolute Uncertainty, tcal ± 5 °C, ± (% of watts output) [1]		
90 days	33 mV to 1020 V	0.021	0.019 [2]	0.06 [2]
1 year	33 mV to 1020 V	0.023	0.022 [2]	0.07 [2]

[1] To determine dc power uncertainty with more precision, see the individual “AC Voltage Specifications,” “AC Current Specifications,” and “Calculating Power Uncertainty.”

[2] Add 0.02% unless a settling time of 30 seconds is allowed for output currents > 10 A or for currents on the highest two current ranges within 30 seconds of an output current > 10 A.

1-19. AC Power (45 Hz to 65 Hz) Specification Summary, PF=1

	Voltage Range	Current Range			
		3.3 mA to 8.999 mA	9 mA to 32.999 mA	33 mA to 89.99 mA	90 mA to 329.99 mA
		Absolute Uncertainty, tcal ± 5 °C, ± (% of watts output) [1]			
90 days	33 to 329.999 mV	0.13	0.09	0.13	0.09
	330 mV to 1020 V	0.11	0.07	0.11	0.07
1 year	33 to 329.999 mV	0.14	0.10	0.14	0.10
	330 mV to 1020 V	0.12	0.08	0.12	0.08

	Voltage Range	Current Range [2]			
		0.33 A to 0.8999 A	0.9 A to 2.1999 A	2.2 A to 4.4999 A	4.5 A to 20.5 A
		Absolute Uncertainty, tcal ± 5 °C, ± (% of watts output) [1]			
90 days	33 to 329.999 mV	0.12	0.10	0.12	0.10
	330 mV to 1020 V	0.10	0.08	0.11	0.09
1 year	33 to 329.999 mV	0.13	0.11	0.13	0.11
	330 mV to 1020 V	0.11	0.09	0.12	0.10

[1] To determine ac power uncertainty with more precision, see the individual “DC Voltage Specifications” and “DC Current Specifications” and “Calculating Power Uncertainty.”

[2] Add 0.02% unless a settling time of 30 seconds is allowed for output currents > 10 A or for currents on the highest two current ranges within 30 seconds of an output current > 10 A.

1-20. Power and Dual Output Limit Specifications

Frequency	Voltages (NORMAL)	Currents	Voltages (AUX)	Power Factor (PF)
dc	0 to ± 1020 V	0 to ± 20.5 A	0 to ± 7 V	—
10 Hz to 45 Hz	33 mV to 32.9999 V	3.3 mA to 2.99999 A	10 mV to 5 V	0 to 1
45 Hz to 65 Hz	33 mV to 1000 V	3.3 mA to 20.5 A	10 mV to 5 V	0 to 1
65 Hz to 500 Hz	330 mV to 1000 V	33 mA to 2.99999 A	100 mV to 5 V	0 to 1
65 Hz to 500 Hz	3.3 V to 1000 V	33 mA to 20.5 A	100 mV to 5 V	0 to 1
500 Hz to 1 kHz	330 mV to 1000 V	33 mA to 20.5 A	100 mV to 5 V	1
1 kHz to 5 kHz	3.3 V to 1000 V [1]	33 mA to 2.99999 A	100 mV to 5 V [1]	1
5 kHz to 10 kHz	3.3 V to 1000 V [2]	33 mA to 329.99 mA	1 V to 5 V [2]	1

[1] In dual voltage output mode, voltage is limited to 3.3 V to 500 V in the NORMAL output.

[2] In dual voltage output mode, voltage is limited to 3.3 V to 250 V in the NORMAL output.

Notes

The range of voltages and currents shown in “DC Voltage Specifications,” “DC Current Specifications,” “AC Voltage (Sinewave) Specifications,” and “AC Current (Sinewave) Specifications” are available in the power and dual output modes (except minimum current for ac power is 0.33 mA). However, only those limits shown in this table are specified. See “Calculating Power Uncertainty” to determine the uncertainty at these points.

The phase adjustment range for dual ac outputs is 0° to $\pm 179.99^\circ$. The phase resolution for dual ac outputs is 0.01° .

1-21. Phase Specifications

1-Year Absolute Uncertainty, tcal ± 5 °C, (Δ Φ °)					
10 Hz to 65 Hz	65 Hz to 500 Hz	500 Hz to 1 kHz	1 kHz to 5 kHz	5 kHz to 10 kHz	10 kHz to 30 kHz
0.10°	0.25°	0.5°	2.5°	5°	10°

Phase (Φ) Watts	Phase (Φ) VARs	PF	Power Uncertainty Adder due to Phase Error					
			10 Hz to 65 Hz	65 Hz to 500 Hz	500 Hz to 1 kHz	1 kHz to 5 kHz	5 kHz to 10 kHz	10 kHz to 30 kHz
0°	90°	1.000	0.00%	0.00%	0.00%	0.10%	0.38%	1.52%
10°	80°	0.985	0.03%	0.08%	0.16%	0.86%	1.92%	4.58%
20°	70°	0.940	0.06%	0.16%	0.32%	1.68%	3.55%	7.84%
30°	60°	0.866	0.10%	0.25%	0.51%	2.61%	5.41%	11.54%
40°	50°	0.766	0.15%	0.37%	0.74%	3.76%	7.69%	16.09%
50°	40°	0.643	0.21%	0.52%	1.04%	5.29%	10.77%	22.21%
60°	30°	0.500	0.30%	0.76%	1.52%	7.65%	15.48%	31.60%
70°	20°	0.342	0.48%	1.20%	2.40%	12.08%	24.33%	49.23%
80°	10°	0.174	0.99%	2.48%	4.95%	24.83%	49.81%	100.00%
90°	0°	0.000	—	—	—	—	—	—

Note

To calculate exact ac watts power adders due to phase uncertainty for values not shown, use the following formula:

$$Adder(\%) = 100 \left(1 - \frac{\cos(\Phi + \Delta\Phi)}{\cos(\Phi)} \right)$$

For example: for a PF of .9205 (Φ = 23) and a phase uncertainty of ΔΦ = 0.15, the ac watts power adder is:

$$Adder(\%) = 100 \left(1 - \frac{\cos(23+0.15)}{\cos(23)} \right) = 0.11\%$$

1-22. Calculating Power Uncertainty

Overall uncertainty for power output in watts (or VARs) is based on the root sum square (rss) of the individual uncertainties in percent for the selected voltage, current, and power factor parameters:

$$\text{Watts uncertainty} \quad U_{\text{power}} = \sqrt{U^2_{\text{voltage}} + U^2_{\text{current}} + U^2_{\text{PFadder}}}$$

$$\text{VARs uncertainty} \quad U_{\text{VARs}} = \sqrt{U^2_{\text{voltage}} + U^2_{\text{current}} + U^2_{\text{VARsadder}}}$$

Because there are an infinite number of combinations, you should calculate the actual ac power uncertainty for your selected parameters. The method of calculation is best shown in the following examples (using 90-day specifications):

Example 1 Output: 100 V, 1 A, 60 Hz, Power Factor = 1.0 ($\Phi=0$), 1 year specifications

Voltage Uncertainty Uncertainty for 100 V at 60 Hz is 150 ppm + 2 mV, totaling:
 $100 \text{ V} \times 190 \times 10^{-6} = 15 \text{ mV}$ added to 2 mV = 17 mV. Expressed in percent:
 $17 \text{ mV}/100 \text{ V} \times 100 = \underline{0.017\%}$ (see “AC Voltage (Sinewave) Specifications”).

Current Uncertainty Uncertainty for 1 A is 0.036% + 100 μA , totaling:
 $1 \text{ A} \times 0.00036 = 360 \mu\text{A}$ added to 100 $\mu\text{A} = 0.46 \text{ mA}$. Expressed in percent:
 $0.46 \text{ mA}/1 \text{ A} \times 100 = \underline{0.046\%}$ (see “AC Current (Sinewaves) Specifications”).

PF Adder Watts Adder for PF = 1 ($\Phi=0$) at 60 Hz is 0% (see “Phase Specifications”).

$$\text{Total Watts Output Uncertainty} = U_{\text{power}} = \sqrt{0.017^2 + 0.046^2 + 0^2} = 0.049\%$$

Example 2 Output: 100 V, 1 A, 400 Hz, Power Factor = 0.5 ($\Phi=60$)

Voltage Uncertainty Uncertainty for 100 V at 400 Hz is, 150 ppm + 2 mV, totaling:
 $100 \text{ V} \times 190 \times 10^{-6} = 15 \text{ mV}$ added to 2 mV = 17 mV. Expressed in percent:
 $17 \text{ mV}/100 \text{ V} \times 100 = \underline{0.017\%}$ (see “AC Voltage (Sinewave) Specifications”).

Current Uncertainty Uncertainty for 1 A is 0.036% + 100 μA , totaling:
 $1 \text{ A} \times 0.00036 = 360 \mu\text{A}$ added to 100 $\mu\text{A} = 0.46 \text{ mA}$. Expressed in percent:
 $0.46 \text{ mA}/1 \text{ A} \times 100 = \underline{0.046\%}$ (see “AC Current (Sinewaves) Specifications”).

PF Adder Watts Adder for PF = 0.5 ($\Phi=60$) at 400 Hz is 0.76% (see “Phase Specifications”).

$$\text{Total Watts Output Uncertainty} = U_{\text{power}} = \sqrt{0.017^2 + 0.046^2 + 0.76^2} = 0.76\%$$

VARs When the Power Factor approaches 0.0, the watts output uncertainty becomes unrealistic because the dominant characteristic is the VARs (volts-amps-reactive) output. In these cases, calculate the Total VARs Output Uncertainty, as shown in example 3:

Example 3 Output: 100 V, 1 A, 60 Hz, Power Factor = 0.174 ($\Phi=80$)

Voltage Uncertainty Uncertainty for 100 V at 400 Hz is, 150 ppm + 2 mV, totaling:
 $100 \text{ V} \times 190 \times 10^{-6} = 15 \text{ mV}$ added to 2 mV = 17 mV. Expressed in percent:
 $17 \text{ mV}/100 \text{ V} \times 100 = \underline{0.017\%}$ (see “AC Voltage (Sinewave) Specifications”).

Current Uncertainty Uncertainty for 1 A is 0.036% + 100 μA , totaling:
 $1 \text{ A} \times 0.00036 = 360 \mu\text{A}$ added to 100 $\mu\text{A} = 0.46 \text{ mA}$. Expressed in percent:
 $0.46 \text{ mA}/1 \text{ A} \times 100 = \underline{0.046\%}$ (see “AC Current (Sinewaves) Specifications”).

VARs Adder VARs Adder for $\Phi = 80$ at 60 Hz is 0.02% (see “Phase Specifications”).

$$\text{Total VARs Output Uncertainty} = U_{\text{VARs}} = \sqrt{0.017^2 + 0.046^2 + 0.03^2} = 0.058\%$$

1-23. Additional Specifications

The following paragraphs provide additional specifications for the 5520A Calibrator ac voltage and ac current functions. These specifications are valid after allowing a warm-up period of 30 minutes, or twice the time the 5520A has been turned off. All extended range specifications are based on performing the internal zero-cal function at weekly intervals, or when the ambient temperature changes by more than 5 °C.

1-24. Frequency Specifications

Frequency Range	Resolution	1-Year Absolute Uncertainty, $t_{cal} \pm 5^{\circ}\text{C}$	Jitter
0.01 Hz to 119.99 Hz	0.01 Hz	2.5 ppm \pm 5 μHz [1]	100 nS
120.0 Hz to 1199.9 Hz	0.1 Hz		
1.200 kHz to 11.999 kHz	1.0 Hz		
12.00 kHz to 119.99 kHz	10 Hz		
120.0 kHz to 1199.9 kHz	100 Hz		
1.200 MHz to 2.000 MHz	1 kHz		
[1] With REF CLK set to ext, the frequency uncertainty of the 5520A is the uncertainty of the external 10 MHz clock \pm 5 μHz . The amplitude of the 10 MHz external reference clock signal should be between 1 V and 5 V p-p.			

1-25. Harmonics (2nd to 50th) Specifications

Fundamental Frequency [1]	Voltages NORMAL Terminals	Currents	Voltages AUX Terminals	Amplitude Uncertainty
10 Hz to 45 Hz	33 mV to 32.9999 V	3.3 mA to 2.99999 A	10 mV to 5 V	Same % of output as the equivalent single output, but twice the floor adder.
45 Hz to 65 Hz	33 mV to 1000 V	3.3 mA to 20.5 A	10 mV to 5 V	
65 Hz to 500 Hz	33 mV to 1000 V	33 mA to 20.5 A	100 mV to 5 V	
500 Hz to 5 kHz	330 mV to 1000 V	33 mA to 20.5 A	100 mV to 5 V	
5 kHz to 10 kHz	3.3 V to 1000 V	33 mA to 329.9999 mA	100 mV to 5 V	
10 kHz to 30 kHz	3.3 V to 1000 V	33 mA to 329.9999 mA	100 mV to 3.29999 V	

[1] The maximum frequency of the harmonic output is 30 kHz (10 kHz for 3 V to 5 V). For example, if the fundamental output is 5 kHz, the maximum selection is the 6th harmonic (30 kHz). All harmonic frequencies (2nd to 50th) are available for fundamental outputs between 10 Hz and 600 Hz (200 Hz for 3 V to 5 V).

Note

Phase uncertainty for harmonic outputs is 1°, or the phase uncertainty shown in “Phase Specifications” for the particular output, whichever is greater. For example, the phase uncertainty of a 400 Hz fundamental output and 10 kHz harmonic output is 10° (from “Phase Specifications”). Another example, the phase uncertainty of a 60 Hz fundamental output and a 400 Hz harmonic output is 1°.

Example of determining Amplitude Uncertainty in a Dual Output Harmonic Mode

What are the amplitude uncertainties for the following dual outputs?

NORMAL (Fundamental) Output: 100V, 100 Hz

From “AC Voltage (Sinewave) Specifications” the single output specification for 100V, 100 Hz, is 0.015% + 2 mV. For the dual output in this example, the specification is 0.015% + 4 mV as the 0.015% is the same and the floor is twice the value (2 x 2 mV).

AUX (50th Harmonic) Output: 100 mV, 5 kHz

From “AC Voltage (Sinewave) Specifications” the auxiliary output specification for 100 mV, 5 kHz, is 0.15% + 450 mV. For the dual output in this example, the specification is 0.15% + 900 mV as the 0.15% is the same and the floor is twice the value (2 x 450 mV).

1-26. AC Voltage (Sinewave) Extended Bandwidth Specifications

Range	Frequency	1-Year Absolute Uncertainty tcal \pm 5 °C	Max Voltage Resolution
Normal Channel (Single Output Mode)			
1.0 mV to 33 mV	0.01 Hz to 9.99 Hz	\pm (5.0 % of output + 0.5% of range)	Two digits, e.g., 25 mV
34 mV to 330 mV			Three digits
0.4 V to 33 V			Two digits
0.3 V to 3.3V	500.1 kHz to 1 MHz	-8 dB at 1 MHz, typical	Two digits
	1.001 MHz to 2 MHz	-26 dB at 2 MHz, typical	
Auxiliary Output (Dual Output Mode)			
10 mV to 330 mV	0.01 Hz to 9.99 Hz	\pm (5.0 % of output + 0.5% of range)	Three digits
0.4 V to 5V			Two digits

1-27. AC Voltage (Non-Sinewave) Specifications

Trianglewave & Truncated Sine Range, p-p [1]	Frequency	1-Year Absolute Uncertainty, $t_{cal} \pm 5^\circ\text{C}$, \pm (% of output + % of range) [2]	Max Voltage Resolution
Normal Channel (Single Output Mode)			
2.9 mV to 93 V	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits on each range
	10 Hz to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 20 kHz	0.5 + 0.25	
	20 kHz to 100 kHz	5.0 + 0.5	
Auxiliary Output (Dual Output Mode)			
93 mV to 14 V	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits on each range
	10 Hz to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz	5.0 + 0.5	
<p>[1] To convert p-p to rms for trianglewave, multiply the p-p value by 0.2886751. To convert p-p to rms for truncated sinewave, multiply the p-p value by 0.2165063.</p> <p>[2] Uncertainty is stated in p-p. Amplitude is verified using an rms-responding DMM.</p>			

Squarewave Range (p-p) [1]	Frequency	1-Year Absolute Uncertainty, $t_{cal} \pm 5^\circ\text{C}$, \pm (% of output + % of range) [2]	Max Voltage Resolution
Normal Channel (Single Output Mode)			
2.9 mV to 66 V	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits on each range
	10 Hz to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 20 kHz	0.5 + 0.25	
	20 kHz to 100 kHz	5.0 + 0.5	
Auxiliary Output (Dual Output Mode)			
66 mV to 14V	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits on each range
	10 Hz to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz [3]	5.0 + 0.5	
<p>[1] To convert p-p to rms for squarewave, multiply the p-p value by 0.5.</p> <p>[2] Uncertainty is stated in p-p. Amplitude is verified using an rms-responding DMM.</p> <p>[3] Limited to 1 kHz for Auxiliary outputs ≥ 6.6 V p-p.</p>			

1-28. AC Voltage, DC Offset Specifications

Range [1] (Normal Channel)	Offset Range [2]	Max Peak Signal	1-Year Absolute Offset Uncertainty, $t_{cal} \pm 5^\circ\text{C}$ [3] \pm (% dc output + floor)
Sinewaves (rms)			
3.3 mV to 32.999 mV	0 to 50 mV	80 mV	0.1 + 33 μV
33 mV to 329.999 mV	0 to 500 mV	800 mV	0.1 + 330 μV
0.33 mV to 3.29999 V	0 to 5 V	8 V	0.1 + 3300 μV
3.3 V to 32.9999 V	0 to 50 V	55 V	0.1 + 33 mV
Trianglewaves and Truncated Sinewaves (p-p)			
9.3 mV to 92.999 mV	0 to 50 mV	80 mV	0.1 + 93 μV
93 mV to 929.999 mV	0 to 500 mV	800 mV	0.1 + 930 μV
0.93 mV to 9.29999 V	0 to 5 V	8 V	0.1 + 9300 μV
9.3 mV to 92.9999 V	0 to 50 V	55 V	0.1 + 93 mV
Squarewaves (p-p)			
6.6 mV to 65.999 mV	0 to 50 mV	80 mV	0.1 + 66 μV
66 mV to 659.999 mV	0 to 500 mV	800 mV	0.1 + 660 μV
0.66 mV to 6.59999 V	0 to 5 V	8 V	0.1 + 6600 μV
6.6 mV to 65.9999 V	0 to 50 V	55 V	0.1 + 66 mV
<p>[1] Offsets are not allowed on ranges above the highest range shown above.</p> <p>[2] The maximum offset value is determined by the difference between the peak value of the selected voltage output and the allowable maximum peak signal. For example, a 10 V p-p square wave output has a peak value of 5 V, allowing a maximum offset up to ± 50 V to not exceed the 55 V maximum peak signal. The maximum offset values shown above are for the minimum outputs in each range.</p> <p>[3] For frequencies 0.01 Hz to 10 Hz, and 500 kHz to 2 MHz, the offset uncertainty is 5% of output, $\pm 1\%$ of the offset range.</p>			

1-29. AC Voltage, Squarewave Characteristics

Risetime @ 1 kHz Typical	Settling Time @ 1 kHz Typical	Overshoot @ 1 kHz Typical	Duty Cycle Range	Duty Cycle Uncertainty
< 1 μ s	< 10 μ s to 1% of final value	< 2%	1% to 99%, < 3.3 V p-p, 0.01 Hz to 100 kHz	\pm (0.02% of period + 100 ns), 50% duty cycle \pm (0.05% of period + 100 ns), other duty cycles from 10% to 90%

1-30. AC Voltage, Trianglewave Characteristics (typical)

Linearity to 1 kHz	Aberrations
0.3% of p-p value, from 10% to 90% point	< 1% of p-p value, with amplitude >50% of range

1-31. AC Current (Sinewave) Extended Bandwidth Specifications

Range	Frequency	1-Year Absolute Uncertainty tcal \pm 5 $^{\circ}$ C \pm (% of output + % of range) [2]	Max Current Resolution
All current ranges, < 330 mA	0.01 Hz to 10 Hz	5.0 + 0.5	2 digits

1-32. AC Current (Non-Sinewave) Specifications

Triangewave & Truncated Sinewave Range p-p	Frequency	1-Year Absolute Uncertainty tcal ± 5 °C ± (% of output + % of range)	Max Current Resolution
0.047 mA to 0.92999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz	10 + 2	
0.93 mA to 9.29999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz	10 + 2	
9.3 mA to 92.9999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz	10 + 2	
93 mA to 929.999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.5	
	1 kHz to 10 kHz	10 + 2	
0.93 A to 8.49999 A	10 Hz to 45 Hz	0.5 + 1.0	Six digits
	45 Hz to 1kHz	0.5 + 0.5	
	1 kHz to 10 kHz	10 + 2	
8.5 A to 57 A [2]	45 Hz to 500 Hz	0.5 + 0.5	Six digits
	500 Hz to 1 kHz	1.0 + 1.0	
[1] Frequency limited to 1 kHz with LCOMP on.			
[2] Frequency limited to 440 Hz with LCOMP on			

AC Current (Non-Sinewave) Specifications (cont)

Squarewave Range p-p	Frequency	1-Year Absolute Uncertainty, $t_{cal} \pm 5^\circ\text{C}$, \pm (% of output + % of range)	Max Current Resolution
0.047 mA to 0.65999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz	10 + 2	
0.66 mA to 6.59999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz	10 + 2	
6.6 mA to 65.9999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 kHz to 10 kHz	10 + 2	
66 mA to 659.999 mA [1]	0.01 Hz to 10 Hz	5.0 + 0.5	Two digits
	10 Hz to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.5	
	1 kHz to 10 kHz	10 + 2	
0.66 A to 5.99999 A [2]	10 Hz to 45 Hz	0.5 + 1.0	Six digits
	45 Hz to 1 kHz	0.5 + 0.5	
	1 kHz to 10 kHz	10 + 2	
6 A to 41 A [2]	45 Hz to 500 Hz	0.5 + 0.5	Six digits
	500 Hz to 1 kHz	1.0 + 1.0	
[1] Frequency limited to 1 kHz with LCOMP on.			
[2] Frequency limited to 440 Hz with LCOMP on.			

1-33. AC Current, Squarewave Characteristics (typical)

Range	LCOMP	Risetime	Settling Time	Overshoot
I < 6A @ 400 Hz	off	25 μ s	40 μ s to 1% of final value	< 10% for < 1 V Compliance
3A & 20A Ranges	on	100 μ s	200 μ s to 1% of final value	< 10% for < 1 V Compliance

1-34. AC Current, Trianglewave Characteristics (typical)

Linearity to 400 Hz	Aberrations
0.3% of p-p value, from 10% to 90% point	< 1% of p-p value, with amplitude > 50% of range

Chapter 2

Theory of Operation

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2-1. Introduction

This chapter provides a block diagram discussion of the calibrator's analog and digital sections. Figure 2-1 shows the arrangement of assemblies inside the 5520A. The Oscilloscope Calibration Option is described in the Options chapter.

The 5520A produces calibration outputs of the following functions and ranges:

- DC voltage from 0 V to ± 1000 V.
- AC voltage from 1 mV to 1000 V, with output from 10 Hz to 500 kHz.
- AC current from 0.01 μ A to 20.5 A, with output from 10 Hz to 30 kHz.
- DC current from 0 to ± 20.5 A.
- Resistance values from a short circuit to 1.1 G Ω .
- Capacitance values from 190 pF to 110 mF.
- Simulated output for Resistance Temperature Detectors (RTDs).
- Simulated output for thermocouples.

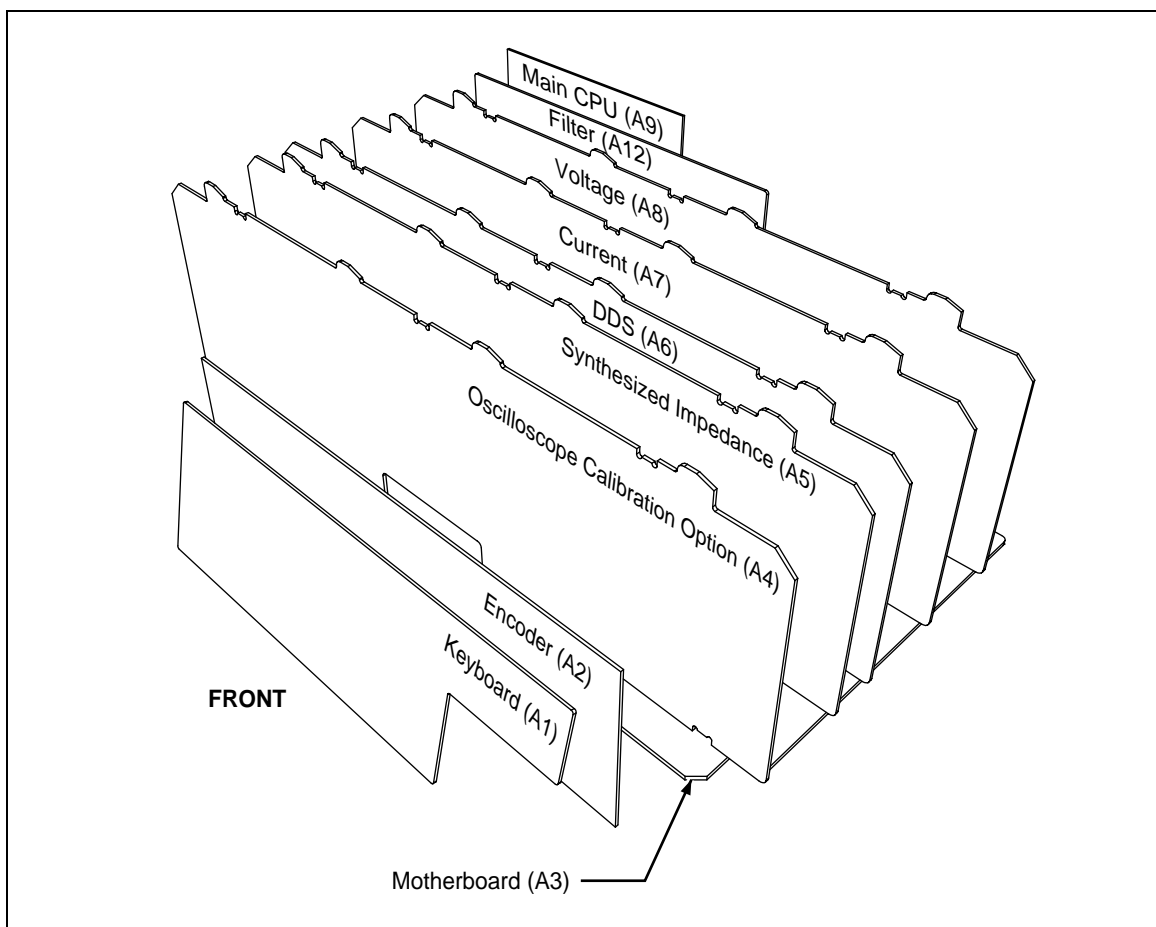


Figure 2-1. 5520A Internal Layout

2-2. Encoder Assembly (A2)

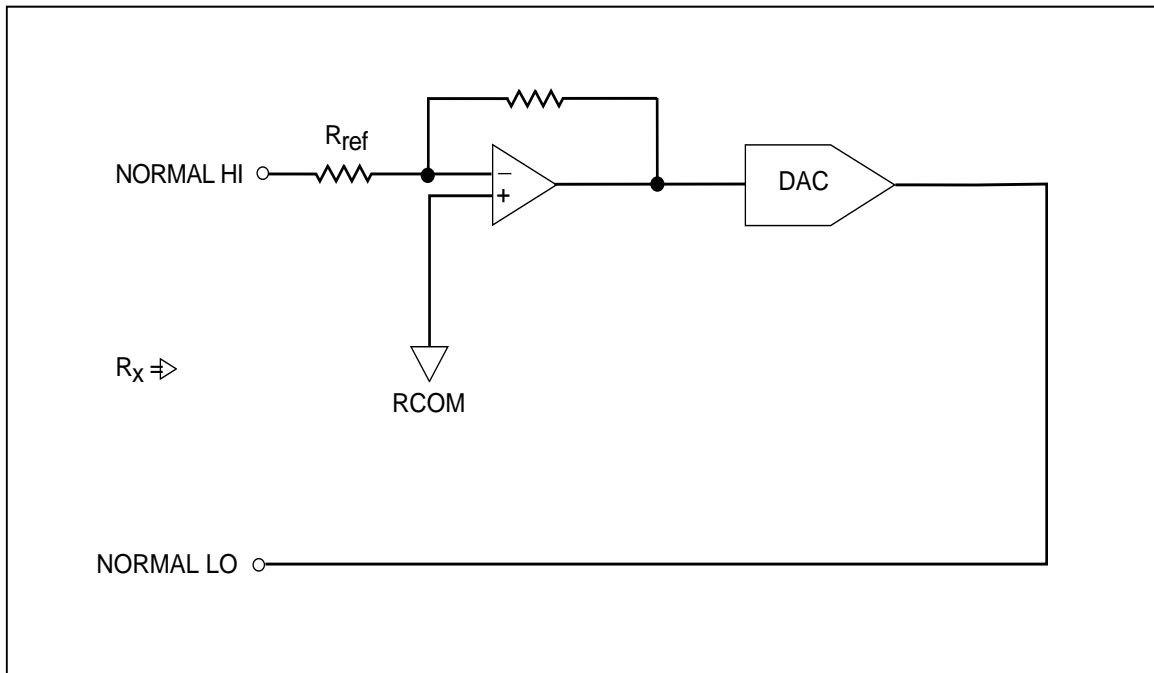
The Encoder assembly (A2) has its own microprocessor and is in communication with the Main CPU (A9) on the Rear Panel through a serial link. Memory for the Encoder assembly is contained in EPROM. The Encoder assembly handles the interface to the Keyboard assembly (A1).

2-3. Synthesized Impedance Assembly (A5)

The Synthesized Impedance assembly (A5) generates variable resistance and capacitance outputs. It uses discrete resistors and capacitors as references, with an amplifier in series. Figure 2-2 is a block diagram of the synthesized resistance function. Figure 2-3 is a block diagram of the synthesized capacitance function.

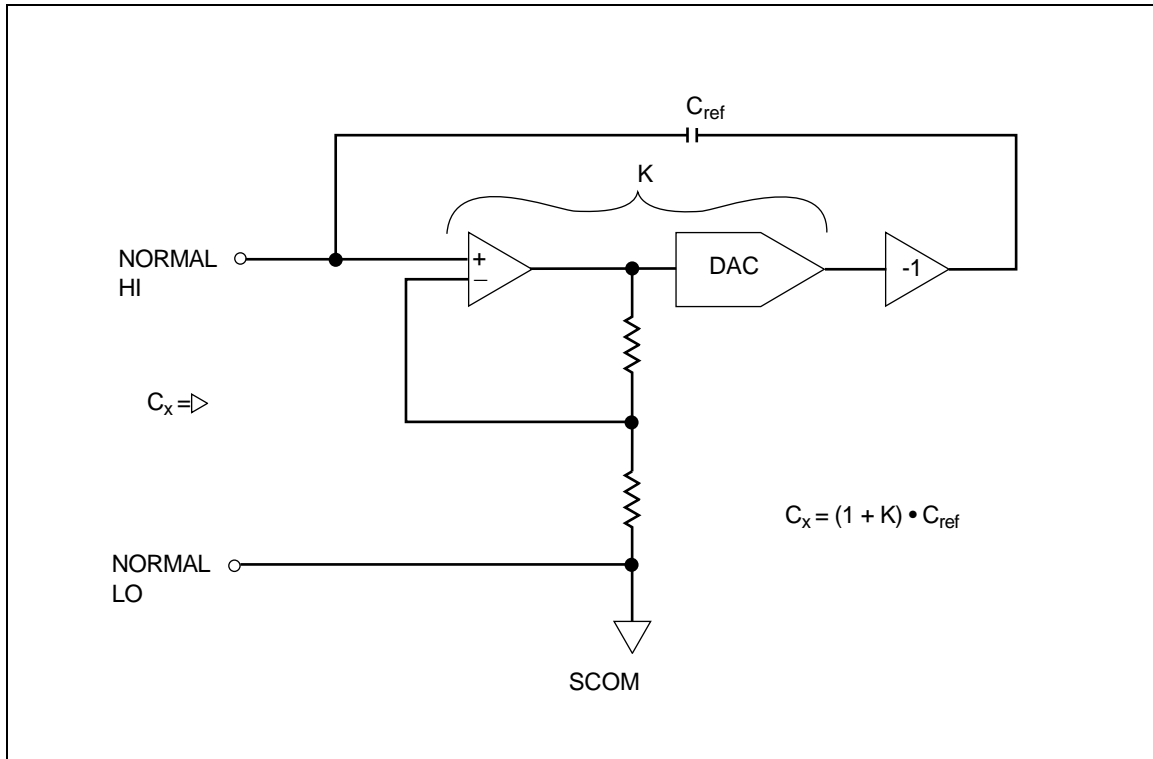
For resistance synthesis, there is a two-wire compensation circuit, an input amplifier, two DACs (coarse and fine) with offset adjust, and an output LO buffer.

For capacitance synthesis, there is a two-wire compensation circuit, selectable references, an input amplifier, two DACs (coarse and fine), and an output LO buffer.



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Figure 2-2. Synthesized Resistance Function



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Figure 2-3. Synthesized Capacitance Function

2-4. DDS Assembly (A6)

The DDS (Direct Digital Synthesis) assembly (A6) contains the following blocks:

- References for all voltage and current functions.
- Gain determining elements for voltage functions and thermocouple measuring and sourcing.
- ± 7 V references.
- Thermocouple sourcing and measuring amplifier.
- An A/D (Analog-to-Digital) measurement system for monitoring all functions.
- Self calibration circuitry.
- Zero calibration circuitry.
- Precision voltage channel DAC (VDAC).
- Precision current channel DAC (IDAC).
- Dual-channel DDS (Direct Digital Synthesizer).

These functional blocks, when used with the Voltage (A8) and/or Current (A7) assemblies, provide single or dual channel ac and dc volts, amps, and watts, offsettable and nonsinusoidal waveforms, duty cycle, thermocouple measuring and sourcing, internal calibration and diagnostics, and digital control over all the analog assemblies.

DACS are used to control the level of dc signals and to control the amplitude of ac signals.

The dual-channel DDS (Direct Digital Synthesizer) generates finely stepped digital waveforms that take the form of sine, triangular, and other waveforms.

2-5. Current Assembly (A7)

The Current assembly outputs six current ranges (330 μ A, 3.3 mA, 33 mA, 330 mA, 3 A, and 20 A) and three voltage ranges (330 mV, 3.3 V, and 5V) to the AUX outputs. The 20 A outputs are sourced through the 20 A AUX binding posts.

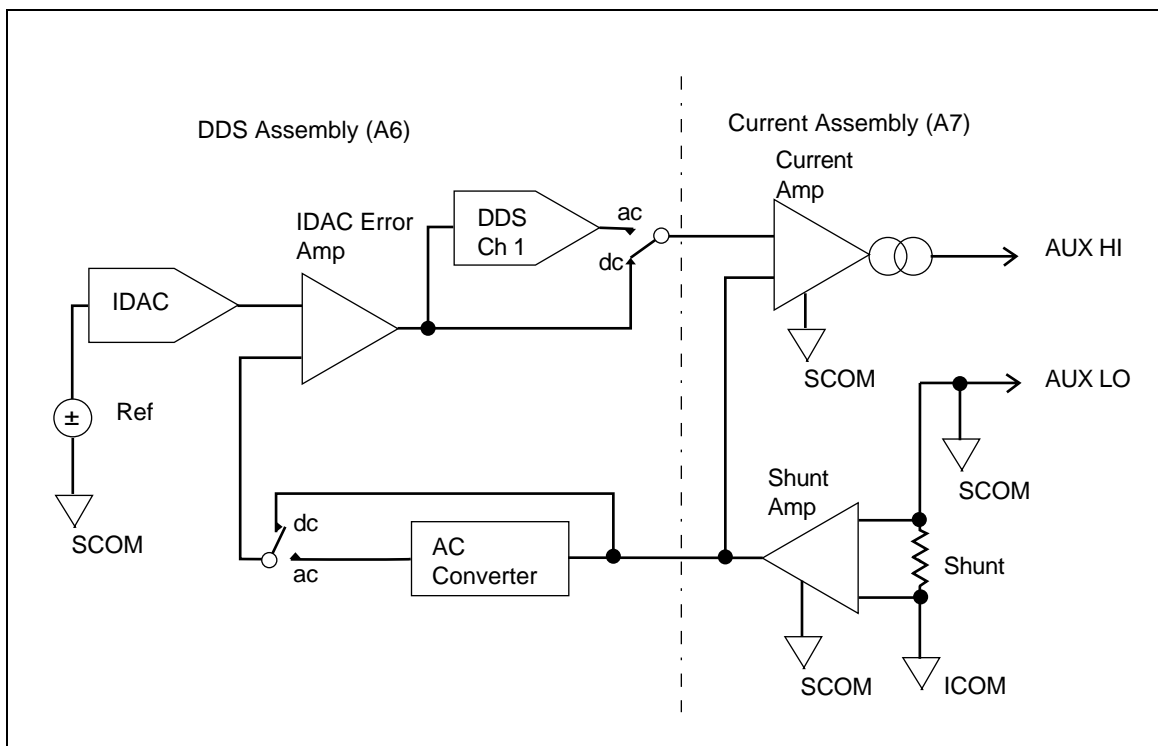
The Current assembly works together with the DDS (A6) assembly. The Filter (A12) assembly provides the high current power supplies.

The Current assembly (A7) contains the following blocks:

- A floating supply.
- Several stages of transconductance amplifier.
- Current-sensing shunts and shunt amplifier. (These are the accuracy-setting elements.)
- AUX voltage function.

Operating power for the Current assembly is filtered by the Filter assembly (A12). Its common is separated from SCOM by a shunt resistor.

Figure 2-4 is a block diagram of the current function. Note that the DDS assembly works together with the Current assembly to generate current outputs.



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Figure 2-4. Current Function (AUX Out Ranges)

2-6. Voltage Assembly (A8)

The Voltage assembly (A8) generates dc and ac voltage outputs in the range 3.3 V and above. It also provides all the inguard supplies referenced to SCOM as described under the heading “Power Supplies.”

Figure 2-5 is a block diagram of the voltage function and shows the signal paths for dc and ac voltage outputs. The DAC shown in the figure is VDAC, which resides on the DDS assembly. Note that the voltage amplifier for outputs ≥ 3.3 V resides on the Voltage assembly, but the amplifier for voltage outputs < 3.3 V is on the DDS assembly.

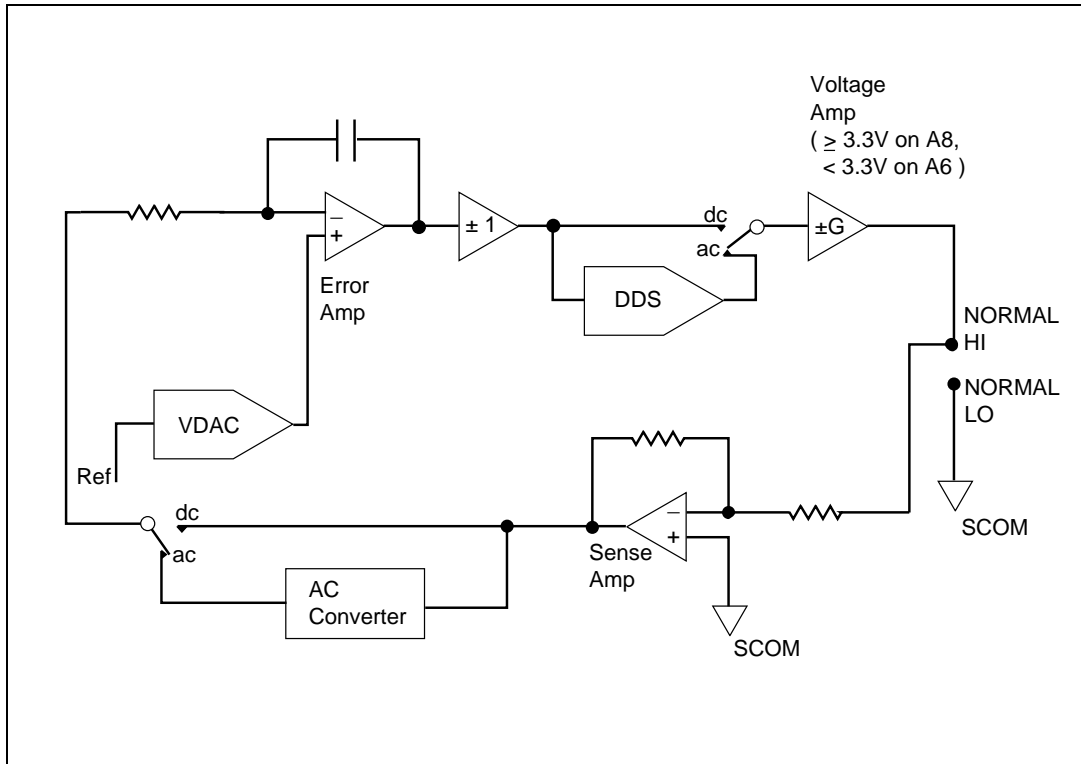


Figure 2-5. Voltage Function

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2-7. Main CPU Assembly (A9)

The Main CPU (A9) attached to the rear panel assembly communicates with the following assemblies:

- Inguard CPU on the DDS assembly (A6)
- Display assembly CPU
- Serial and IEEE interfaces
- External amplifier (5725A)

The main CPU memory is Flash ROM. There is a real-time clock with a battery backup.

Each analog assembly has the same bus structure:

- One or more Chip Select lines
- Common data bus that connects to the motherboard, latched in by latches
- A Fault line that sets all modules to a safe state in case of malfunction

Signals to the front panel jacks are routed by output relays on the motherboard.

2-8. Power Supplies

AC line voltage is applied through a line filter to a power module in the rear panel that provides switching for four line voltages. The outputs of the power module are wired directly to the primaries of the mains transformer. The safety ground wire is attached from the power module to the rear panel.

Major internal grounds are SCOM, which is tied to OUTPUT LO and the guard shell, ICOM, which is the internal ground for the current function, and GCOM, which is the outguard common and is tied to earth ground.

2-9. Outguard Supplies

The motherboard generates the outguard power supplies: +12VG, -12VG, and +5VG. All the transformer connections for the outguard supplies come through one bundle of wires connected to the motherboard with P1. A row of test points is provided in front of the fan for the raw and regulated supplies. The outguard supplies are used only by the CPU assembly (A9) and Encoder (A2) assemblies.

2-10. Inguard Supplies

The inguard supplies are located on the Voltage assembly (A8). The mains transformer connections (inguard SCOM referenced) are connected to the Motherboard (A3). Current protection devices for each of the supplies are located on the Motherboard. It is unlikely these devices will blow unless there is another fault since the regulators will limit current below the device ratings.

Filter capacitors for the high-current supply for the Current assembly (A7) are located on the Filter assembly (A12).

The inguard SCOM referenced supplies are +15 V, -15 V, +5 V, -5 V, and +5RLH. The +5 V and +5RLH supplies share the same raw supply. The +5RLH supply is used exclusively as a relay driver and is nominally about 6.3 V. Test points for these supplies are located in a row across the top of the Voltage assembly. The 65 V supplies are rectified and filtered on the Motherboard but regulated on the Voltage assembly (A8).

Chapter 3

Calibration and Verification

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3-1. Introduction

You should recalibrate at the end of either a 90-day or 1-year calibration interval. If you recalibrate every 90 days, use the 90-day specifications, which provide higher performance. Use the Verification procedure or any part thereof any time you need to verify that the Calibrator is meeting its specifications.

Fluke recommends that you return the 5520A to Fluke for calibration and verification. The Fluke Service Center uses a software-controlled verification process and provides a detailed test report including traceability to national standards. If you plan to calibrate or verify the 5520A at your site, use this chapter as a guide. The procedures in this chapter are manual versions of the software-controlled process used at the Fluke Service Center.

3-2. Equipment Required for Calibration and Verification

The equipment listed in Table 3-1 is required to calibrate and verify performance of the 5520A. If a specified instrument is not available, you can substitute an instrument that has the same, or better performance.

Table 3-1. Consolidated List of Required Equipment for Calibration and Verification

Quan.	Manufacturer	Model	Equipment	Purpose
1	Fluke	5500A/LEADS	Test lead set	All functions
1	Hewlett Packard	3458A with -002 Option	DMM	DC voltage, dc current, resistance, capacitance, thermocouple measurement and sourcing
1	Fluke	752A	Reference Divider 100:1, 10:1	DC voltage
1	Keithley	155	Null Detector	DC voltage (calibrate Fluke 752A for dc voltage)
1	Fluke	742A-1k	Resistance Standard, 1 k Ω	DC current
1	Fluke	742A-100	Resistance Standard, 100 Ω	DC current
1	Fluke	742A-10	Resistance Standard, 10 Ω	DC current
1	Fluke	742A-1	Resistance Standard, 1 Ω	DC current
1	Guildline	9230	0.1 Ω shunt	DC current, verification procedure only
1	Guildline	9230	0.01 Ω shunt	DC current
1	Fluke	742A-1M	Resistance Standard, 1 M Ω	Resistance
1	Fluke	742A-10 M	Resistance Standard, 10 M Ω	Resistance
1	Guildline	9334/100 M	Resistance Standard, 100 M Ω	Resistance
1	Guildline	9334/1G	Resistance Standard, 1G Ω	Resistance
1	Fluke	PN 900394	Type N to dual banana adapter	AC voltage
1	Fluke	5790A	AC Measurement Standard	AC voltage, ac current

Table 3-1. Consolidated List of Required Equipment for Calibration and Verification (cont)

Quan.	Manufacturer	Model	Equipment	Purpose
1	Fluke	A40	10 mA, 20 mA, 200 mA, 2 A current shunts	AC current
1	Fluke	A40A	20 A current shunt	AC current
1	Fluke	792A-7004	A40 Current Shunt Adapter	AC current
1	various	metal film resistors	1 k Ω , 200 Ω	AC current
1	Fluke	PM 9540/BAN	Cable Set	Capacitance
1	Fluke	PM 6304C	LCR Meter	Capacitance
1	Fluke	5700A	Calibrator	Precision current source for ac/dc current transfers, and to use in conjunction with an HP3458A DMM for thermocouple measurement function
1	ASTM	56 C	Mercury thermometer	Thermocouple measurement
1	various	various	Dewar flask and cap, mineral oil lag bath	Thermocouple measurement
1	North Atlantic Or Clarke-Hess	2000 6000	Precision Phase Meter [1]	Phase
1	Fluke	PN 690567	Fluke resistor network used as a shunt, 0.01 Ω , 0.09 Ω , 0.9 Ω values needed	Phase
1	Fluke	6680B	Frequency Counter	Frequency
[1] If desired, the test uncertainty ratio (TUR) may be improved by characterizing the phase meter with a primary phase standard like the Clarke-Hess 5500 prior to usage.				

3-3. Calibration

The standard 5520A has no internal hardware adjustments. Oscilloscope Options have hardware adjustments; see Chapter 6. The Control Display prompts you through the entire calibration procedure. Calibration occurs in the following major steps:

1. The 5520A sources specific output values and you measure the outputs using traceable measuring instruments of higher accuracy. The 5520A automatically programs the outputs and prompts you to make external connections to appropriate measurement instruments.
2. At each measure and enter step, you can press the **OPTIONS**, and **BACK UP STEP** softkeys to redo a step, or **SKIP STEP** to skip over a step.
3. You enter the measured results either manually through the front panel keyboard or remotely with an external terminal or computer.

Note

Intermixed with the "output and measure" procedures are internal 5520A calibration procedures that require no action by the operator.

4. The 5520A computes a software correction factor and stores it in volatile memory.
5. When the calibration process is complete, you are prompted to either store all the correction factors in nonvolatile memory or discard them and start over.

For routine calibration, all steps except frequency and phase are necessary. All the routine calibration steps are available from the front panel interface as well as the remote interface (IEEE-488 or serial). Frequency and phase calibration are recommended after instrument repair, and are available only by way of the remote interface (IEEE-488 or serial). Remote commands for calibration are described later in this chapter.

3-4. Starting Calibration

From the front panel, you start calibration by pressing the **SETUP** key, followed by the **CAL** softkey twice, then **5520A CAL**. The **CALIBRATION SWITCH** on the 5520A rear panel can be in either position when you begin calibration. It must be set for **ENABLE** to store the correction factors into nonvolatile memory.

After you press the **5520A CAL** softkey, the procedure works as follows:

1. The 5520A automatically programs the outputs and prompts you to make external connections to appropriate measurement instruments.
2. The 5520A then goes into Operate mode, or asks you to place it into Operate mode.
3. You are then prompted to enter into the 5520A the value read on the measurement instrument.

Note

*At each measure and enter step, you can redo a step by pressing the **OPTIONS**, and **BACK UP STEP** softkey, or skip over a step by pressing the **SKIP STEP** softkey.*

3-5. DC Volts Calibration (NORMAL Output)

The equipment listed in Table 3-2 is required for calibration of the dc volts function. (The equipment is also listed in the consolidated table, Table 3-1.)

Table 3-2. Test Equipment Required for Calibrating DC Volts

Quan.	Manufacturer	Model	Equipment
1	Fluke	5500A/LEADS	Test lead set
1	Hewlett Packard	3458A with -002 Option	DMM
1	Fluke	752A	Reference Divider
1	Keithley	155	Null Detector

Proceed as follows to calibrate the dc voltage function:

1. On the HP 3458A, perform the ACAL (autocal) ALL and MATH NULL functions as described in the HP 3458A user documentation.
2. Verify that the UUT (Unit Under Test) is in Standby.
3. Start 5520A calibration as described under the previous heading.
4. Perform an internal DC Zeros Calibration as prompted.
5. Connect the test equipment as shown in Figure 3-1.
6. Measure and enter the values into the UUT for steps 1 through 6 in Table 3-3 as prompted. You will need to disconnect and reconnect the DMM as prompted during these steps.
7. Verify that the UUT is in Standby.
8. Connect the DMM and Reference Divider to the UUT as shown in Figure 3-2.
9. For voltages 30 Vdc and above, see the next section.

Table 3-3. Calibration Steps for DC Volts

Step	5520A Output (NORMAL)
1	1.000000 V
2	3.000000 V
3	-1.000000 V
4	-3.000000 V
5	0.0000 mV
6	300.0000 mV
7	30.00000 V
8	300.0000 V
9	1000.000 V

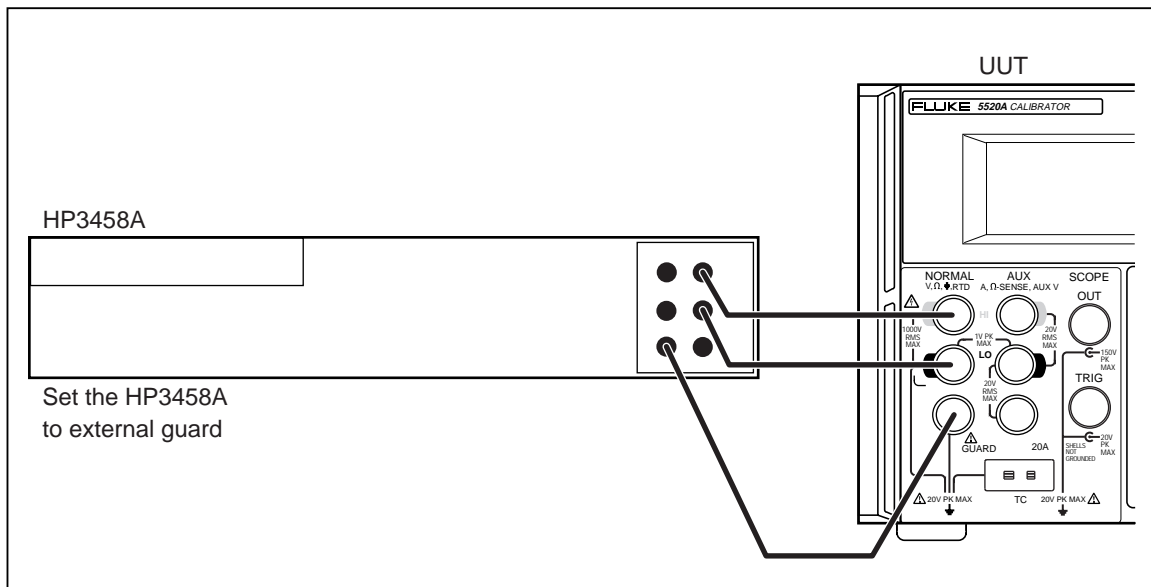


Figure 3-1. Connections for Calibrating DC Volts up to 30 V

3-6. DC Volts Calibration (30 Vdc and Above)

Use the following procedure to calibrate the dc voltage function (30 Vdc and above).

1. Prior to using the 752A, perform the self-calibration on the 752A using the null detector and a 20 V source. See the documentation from the 752A for more details.
2. Connect the 5520A (unit under test), 752A, and HP3458A as in Figure 3-2. Make sure that the ground to guard strap on the 752A is not connected.
3. The HP3458A should be used on the 10 Vdc range for all measurements. The 752A mode switch should be set to 10:1 for the 30 V measurement, and to 100:1 for all voltages above 30 V.
4. Measure and enter the values into the UUT for steps 7 through 9 in Table 3-3 (30 V and above) as prompted.
5. Verify that the UUT is in Standby and disconnect the test equipment.

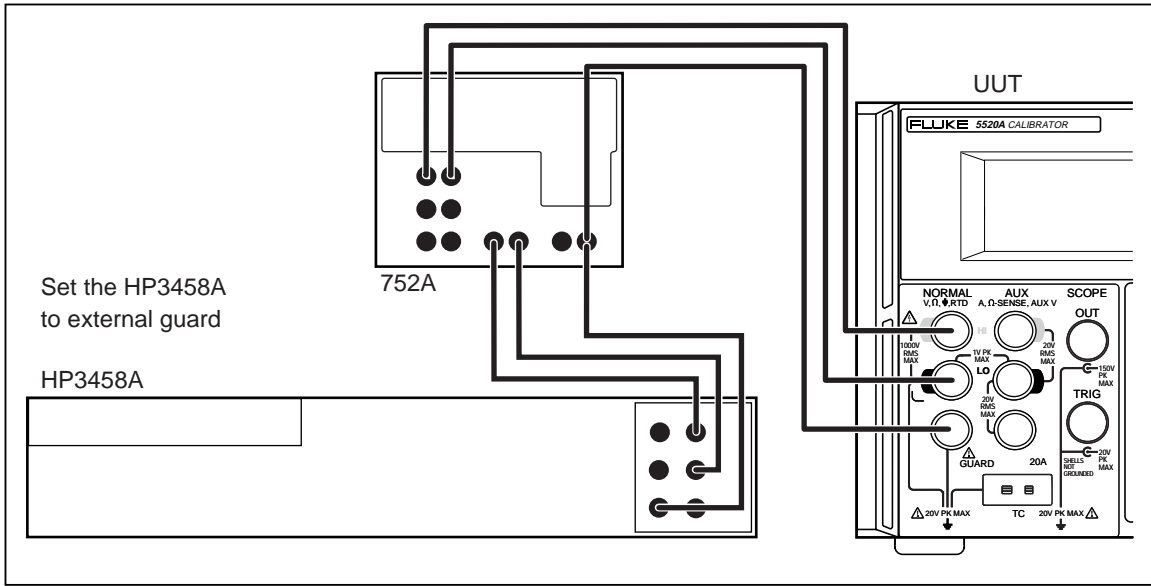


Figure 3-2. Connections for Calibrating DC Volts 30 V and Above

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3-7. AC Volts Calibration (NORMAL Output)

The equipment listed in Table 3-4 is required for calibration of the ac volts function. (The equipment is also listed in the consolidated table, Table 3-1.)

Table 3-4. Test Equipment Required for Calibrating AC Volts

Quan.	Manufacturer	Model	Equipment
1	Fluke	5500A/LEADS	Test lead set
1	Fluke	PN 900394	Type N to dual banana adapter
1	Fluke	5790A	AC Measurement Standard

Proceed as follows to calibrate the ac voltage function:

1. Measure the 5520A output using Input 1 of a Fluke 5790A AC Measurement Standard. Use a Type N to dual banana adapter as Figure 3-3 shows.
2. Enter the measured values into the 5520A for each step in Table 3-5 as prompted.

Table 3-5. Calibration Steps for AC Volts

Step	5520A Output (NORMAL)	
	Amplitude	Frequency
1	3.29990 V	100.00 Hz
2	0.33000 V	100.00 Hz
3	3.00000 V	500.0 kHz
4	3.0 V	9.99 Hz
5	30.000 mV	100.00 Hz
6	300.000 mV	100.00 Hz
7	300.000 mV	500.0 kHz
8	30.0000 V	100.00 Hz
9	300.000 V	70.00 kHz
10	1000.00 V	100.00 Hz
11	1000.00 V	7.000 kHz

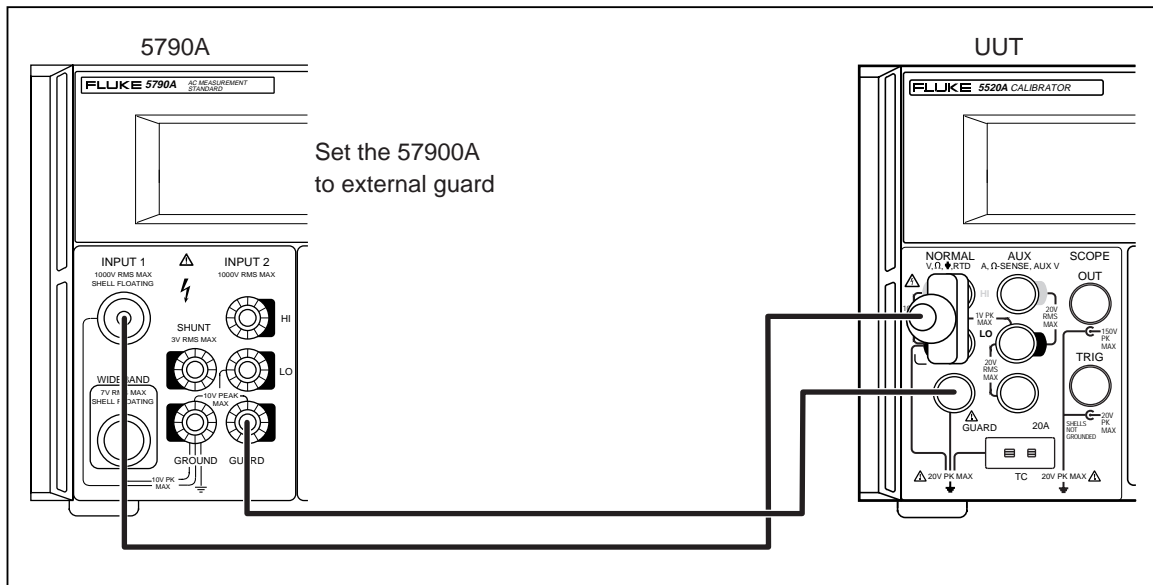


Figure 3-3. Connections for Calibrating AC Volts

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3-8. Thermocouple Function Calibration

The equipment listed in Table 3-6 is required for calibration of the thermocouple measure and source functions. (The equipment is also listed in the consolidated table, Table 3-1.)

Table 3-6. Test Equipment Required for Calibrating the Thermocouple Function

Quan.	Manufacturer	Model	Equipment
1	Fluke	5520A/LEADS	Test lead set (includes Type-J thermocouple, wire, and mini plug)
4 feet	various	various	24-gauge solid copper telephone wire
1	ASTM	56C	Mercury thermometer
1	various	various	Dewar flask and cap, mineral oil lag bath
1	Hewlett Packard	3458A with -002 option	DMM

Proceed as follows to calibrate the thermocouple function:

1. Verify that the UUT is in standby.
2. With nothing connected to the UUT terminals, press the GO ON softkey as prompted to start TC calibration. Wait for the internal calibration steps to complete.
3. Connect the HP3458A DMM to the TC terminals using solid copper telephone wire and a copper (uncompensated) TC miniplug as shown in Figure 3-4. Attach the wires directly to the DMM binding posts. Set the DMM to read dc millivolts.
4. Enter the measured value into the UUT for step 1 in Table 3-7 as prompted.
5. Disconnect the test equipment.
6. Connect a Type-J thermocouple to the TC terminals on the UUT, and immerse the thermocouple and a precision mercury thermometer in a mineral oil lag bath that is within ± 2 °C of ambient temperature. The test setup is shown in Figure 3-5.
7. Wait at least 3 minutes for the temperature readings to stabilize, then read the temperature on the mercury thermometer and enter it into the UUT.

Table 3-7. Calibration Steps for Thermocouple Measurement

Step	5520A Output (AUX HI, LO)
1	300 mV dc (NORMAL)
2	Enter temperature read from mercury thermometer as prompted

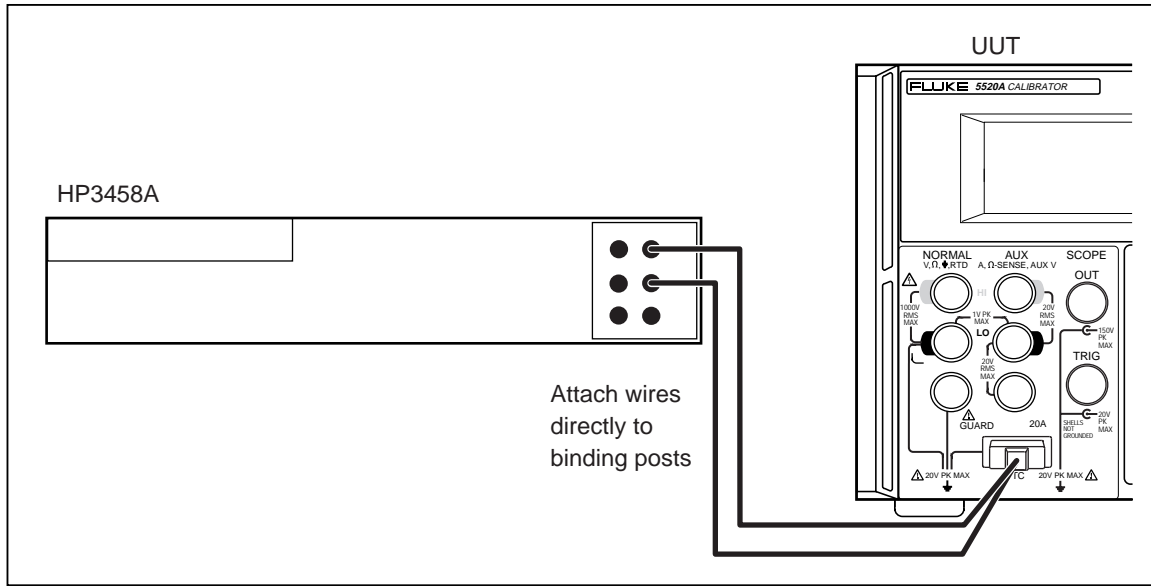


Figure 3-4. Connections for Calibrating Thermocouple Sourcing

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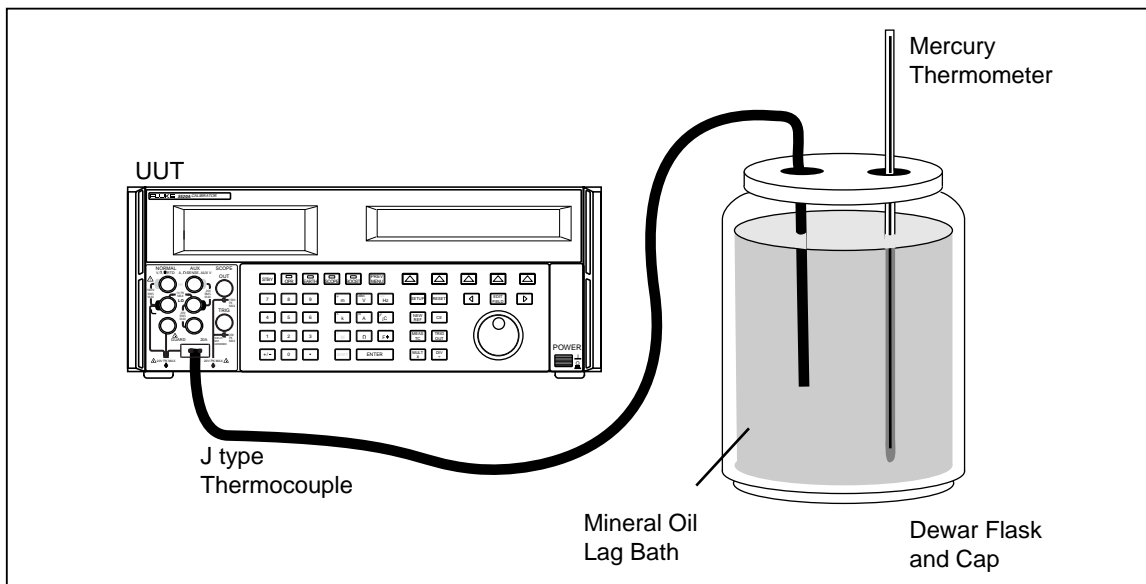


Figure 3-5. Connections for Calibrating Thermocouple Measuring

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3-9. DC Current Calibration

The equipment listed in Table 3-8 is required for calibration of the dc current function. (The equipment is also listed in the consolidated table, Table 3-1.)

You must use the calibrated dc current function of the 5520A later to prepare for ac calibration. Because of this, you must save the dc current constants after dc current calibration and exit calibration, then resume calibration. The following procedure for dc current calibration explains how to save, exit, and resume calibration.

Table 3-8. Test Equipment Required for Calibrating DC Current

Quan.	Manufacturer	Model	Equipment
1	Fluke	5500A/LEADS	Test lead set
1	Hewlett Packard	3458A with -002 option	DMM
1	Fluke	742A-1k	Resistance Standard, 1 k Ω
1	Fluke	742A-100	Resistance Standard, 100 Ω
1	Fluke	742A-10	Resistance Standard, 10 Ω
1	Fluke	742A-1	Resistance Standard, 1 Ω
1	Guildline	9230	0.01 Ω shunt

Proceed as follows to calibrate the dc current function:

1. Perform the ACAL ALL and MATH NULL operations on the HP 3458A before you begin.
2. Verify that the UUT is in standby.
3. Set the DMM to measure dc voltage.
4. Connect the DMM and 742A-1k Resistance Standard to the UUT as shown in Figure 3-6.
5. On the first dc current calibration point in Table 3-9, wait for the output to settle, record the DMM voltage reading, and compute the UUT current output using the certified resistance value of the 742A.
6. Enter the computed value into the UUT.
7. Proceed to the next calibration point, verify that the UUT is in standby, and disconnect the 742A.
8. Repeat steps 3 through 6 above using the resistance standard or current shunt specified for each calibration point in Table 3-9.
9. Exit calibration and save the calibration constants modified so far by using the front panel menus or the CAL_STORE remote command.

Table 3-9. Calibration Steps for DC Current

Step	5520A Output (AUX HI, LO)	Shunt to Use
1	300.000 μ A	Fluke 742A-1k 1 k Ω Resistance Standard
2	3.00000 mA	Fluke 742A-100 100 Ω Resistance Standard
3	30.000 mA	Fluke 742A-10 10 Ω Resistance Standard
4	300.000 mA	Fluke 742A-1 1 Ω Resistance Standard
5	2.00000 A	Guildline 9230 0.01 Ω shunt
	20A, LO	
6	10.0000 A	Guildline 9230 0.01 Ω shunt

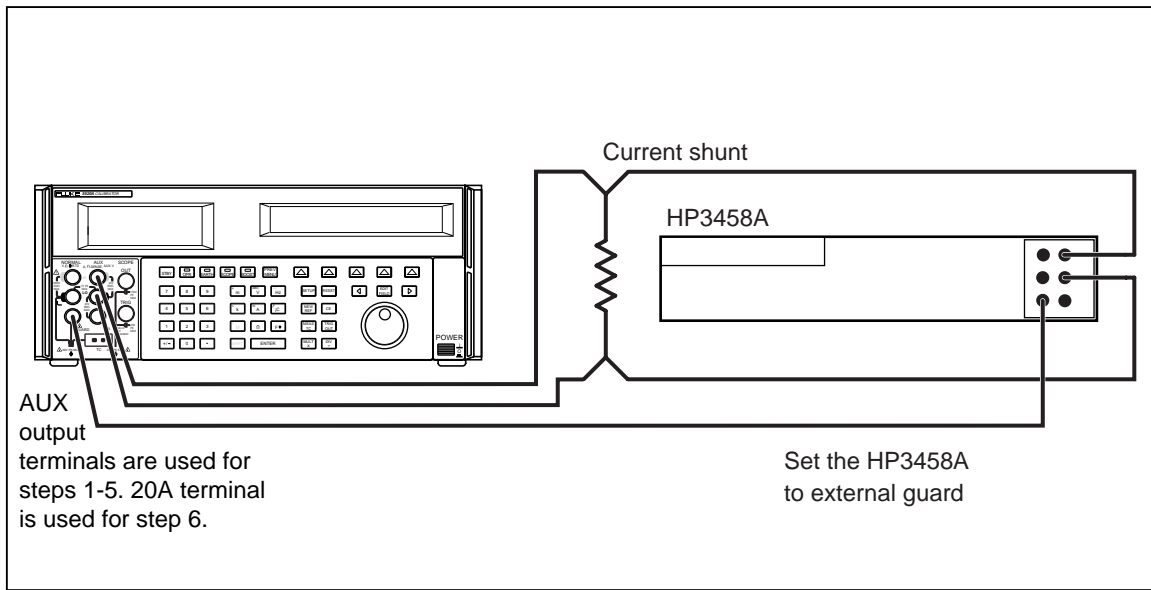


Figure 3-6. Connections for Calibrating DC Current

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3-10. AC Current Calibration

Note

DC Current must be calibrated before proceeding with ac current calibration.

The ac current calibration uses a number of current shunts that require dc characterization before they can be used. DC characterization can be performed with the 5520A, as long as you perform the entire 5520A dc current calibration first. During dc characterization, data is obtained for each of the ac current levels required by the ac current calibration procedure. For example, if a shunt is used for .33 mA ac and 3.3 mA ac calibrations, data must be obtained at .33 mA dc and 3.3 mA dc.

Follow these steps to characterize the shunt:

1. Connect the test equipment as shown in Figure 3-7.

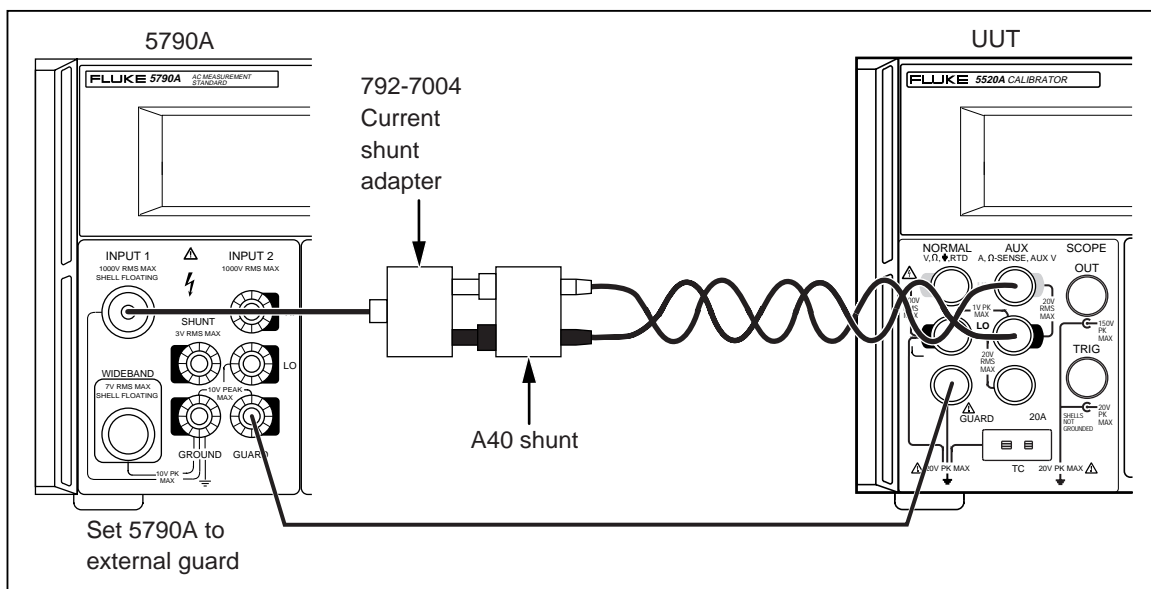


Figure 3-7. Connections for Calibrating AC Current with a Fluke A40 Shunt

2. For each amplitude listed in Table 3-11, apply the equivalent +(positive) and - (negative) dc current from the 5520A.
3. Compute the actual dc characterization value using this formula:

$$\frac{((+ \text{ value}) - (- \text{ value}))}{2}$$

The time between the dc characterization of a current shunt and its use in the calibration process should be kept to an absolute minimum. To reduce this time, each shunt is characterized as it is needed. As the ac current calibration procedure is performed, it must be temporarily aborted each time a new shunt value is required. After the required shunt is characterized, the calibration procedure is resumed at the previous point using the newly characterized shunt.

The following example explains this procedure:

1. Perform the dc current calibration procedure.
2. Using Table 3-11, select the first required current shunt (A40-10 mA)

3. Perform a dc characterization of the shunt at the amplitude specified in the table (as demonstrated above).
4. Restart the ac current calibration procedure and using the blue softkeys, perform the SKIP STEP command to reach the step(s) requiring the newly characterized shunt.
5. Place the 5520A in OPERATE and measure the ac voltage across the shunt.
6. Using the data derived during the dc characterization and the ac correction factors supplied for the shunt by the manufacturer, calculate the ac current and enter this value into the calibrator.
7. Continue this process until Table 3-11 is complete.

Following are some important remote commands used in this procedure:

- CAL_START MAIN, AI Start the ac current calibration procedure.
- CAL_SKIP Skip to the appropriate calibration step.
- CAL_ABORT Used to exit calibration between steps.
- CAL_NEXT Perform the next calibration step.
- CAL_STORE Store the new calibration constants

Because of the complexity of this procedure, it is highly recommended that the process be automated. See Figure 3-9 for a MET/CAL code fragment that demonstrates an automated approach.

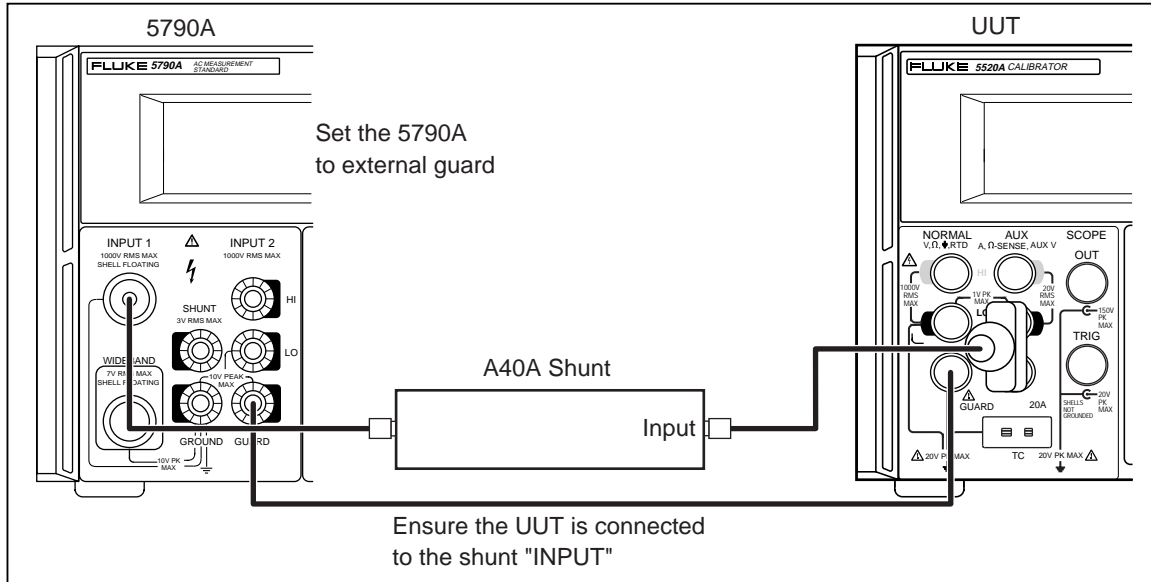
The equipment listed in Table 3-10 is required for calibration of the ac current function. (The equipment is also listed in the consolidated table, Table 3-1.) Refer to Figure 3-8 for the proper connections.

Table 3-10. Test Equipment Required for Calibrating AC Current

Quan.	Manufacturer	Model	Equipment
1	Fluke	5500A/LEADS	Test lead set
1	Fluke	PN 900394	Type N to dual banana adapter
1	Fluke	5790A	AC Measurement Standard
1	Fluke	A40-10 mA	Current Shunt, 10 mA
1	Fluke	A40-200 mA	Current Shunt, 200 mA
1	Fluke	A40-2A	Current Shunt, 2 A
1	Fluke	A40A-20A	Current Shunt, 20 A
1	Fluke	792A-7004	A40 Current Shunt Adapter

Table 3-11. Calibration Steps for AC Current

Step	5520A Output (AUX HI, LO)		
	Amplitude	Frequency	Shunt to Use
1	3.29990 mA	100.00 Hz	Fluke A40 10 mA
2	0.33000 mA	100.00 Hz	Fluke A40 10 mA
3	3.00000 mA	10.00 kHz	Fluke A40 10 mA
4	3.00000 mA	30.000 kHz	Fluke A40 10 mA
5	0.30000 mA	100.00 Hz	Fluke A40 10 mA
6	0.30000 mA	10.00 kHz	Fluke A40 10 mA
7	0.30000 mA	30.00 kHz	Fluke A40 10 mA
8	30.0000 mA	100.00 Hz	Fluke A40 200 mA
9	30.0000 mA	10.00 kHz	Fluke A40 200 mA
10	30.0000 mA	30.00 kHz	Fluke A40 200 mA
11	300.000 mA	100.00 Hz	Fluke A40 2 A
12	300.000 mA	10.00 kHz	Fluke A40 2 A
13	300.000 mA	30.00 kHz	Fluke A40 2 A
14	2.00000 A	100.00 Hz	Fluke A40 2 A
15	2.00000 A	1000.0 Hz	Fluke A40 2 A
16	2.00000 A	5000.0 Hz	Fluke A40 2 A
17	2.00000 A	60.00 Hz	Fluke A40 2 A
18	2.00000 A	100.00 Hz	Fluke A40 2 A
19	2.00000 A	440.00 Hz	Fluke A40 2 A
	AUX 20A, LO		
20	10.0000 A	100.00 Hz	Fluke A40A 20 A
21	10.0000 A	500.00 Hz	Fluke A40A 20 A
22	10.0000 A	1000.00 Hz	Fluke A40A 20 A
23	10.0000 A	60.00 Hz	Fluke A40A 20 A
24	10.0000 A	100.00 Hz	Fluke A40A 20 A
25	10.0000 A	440.00 Hz	Fluke A40A 20 A



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Figure 3-8. Connections for Calibrating AC Current with a Fluke A40A Shunt

```

Fluke Corporation - Worldwide Support Center MET/CAL Procedure
=====
INSTRUMENT:          Sub Fluke 5520A ACI ADJ
DATE:                22-Sep-98
AUTHOR:              Gary Bennett, Metrology Specialist
REVISION:            0.6
ADJUSTMENT THRESHOLD: 70%
NUMBER OF TESTS:     1
NUMBER OF LINES:     487
CONFIGURATION:       Fluke 5790A
=====
STEP   FSC   RANGE NOMINAL      TOLERANCE   MOD1      MOD2  3  4 CON
# 10 Sep 98 changed Cal_Info? commands to Out? and checked for 10A -
# needs cal_next to get past display; check for 0 out when ACI is done.
#
1.001 ASK-   R   Q N                U         C         F         W

1.002 HEAD          AC CURRENT ADJUSTMENT
# Set M[10] to 3mA initially
1.003 MATH          M[10] = 0.003
# Reset UUT - get it out of calibration mode.
1.004 IEEEE        *CLS;*RST; *OPC?[I]
1.005 IEEEE        ERR?[I$][GTL]
1.006 MATH          MEM1 = FLD(MEM2,1,"")
1.007 JMPT
1.008 IEEEE        CAL_SW?[I][GTL]
1.009 MEME
1.010 JMPZ          1.012
1.011 JMP           1.015
1.012 HEAD          WARNING! CALIBRATION SWITCH IS NOT ENABLED.
1.013 DISP          The UUT CALIBRATION switch is in NORMAL.
1.013 DISP
1.013 DISP          The switch MUST be in ENABLE to store the
1.013 DISP          new calibration constants.
1.013 DISP
1.013 DISP          Select ENABLE, then press "Advance" to
1.013 DISP          continue with the calibration process.
1.014 JMP           1.008

# Reset 5790A standard.
1.015 ACMS          *
1.016 5790          *                               S
1.017 HEAD          DCI References
1.018 PIC           552A410m
1.019 IEEEE        OUT 3.2999mA, 0HZ; OPER; *OPC?[I][GTL]
1.020 IEEEE        [D30000][GTL]

1.021 ACMS          G
1.022 5790          A                               SH   N  2W

```

Figure 3-9. Sample MET/CAL Program

```

1.023 MATH          M[17] = MEM
# Apply nominal -DC Current to A40
1.024 IEEEE        OUT -3.2999mA, 0HZ; OPER; *OPC?[I][GTL]
1.025 IEEEE        [D5000][GTL]
1.026 ACMS                G
1.027 5790          A          SH      N  2W
1.028 MATH          M[17] = (ABS(MEM) + M[17]) / 2

1.029 IEEEE        OUT .33mA, 0HZ; OPER; *OPC?[I][GTL]
1.030 IEEEE        [D15000][GTL]
1.031 ACMS                G
1.032 5790          A          SH      N  2W
1.033 MATH          M[18] = MEM
# Apply nominal -DC Current to A40
1.034 IEEEE        OUT -.33mA, 0HZ; OPER; *OPC?[I][GTL]
1.035 IEEEE        [D5000][GTL]
1.036 ACMS                G
1.037 5790          A          SH      N  2W
1.038 MATH          M[18] = (ABS(MEM) + M[18]) / 2

1.039 IEEEE        OUT 3mA, 0HZ; OPER; *OPC?[I][GTL]
1.040 IEEEE        [D15000][GTL]
1.041 ACMS                G
1.042 5790          A          SH      N  2W
1.043 MATH          M[19] = MEM
# Apply nominal -DC Current to A40
1.044 IEEEE        OUT -3mA, 0HZ; OPER; *OPC?[I][GTL]
1.045 IEEEE        [D5000][GTL]
1.046 ACMS                G
1.047 5790          A          SH      N  2W
1.048 MATH          M[19] = (ABS(MEM) + M[19]) / 2
1.049 IEEEE        CAL_START MAIN,AI; *OPC?[I][GTL]
1.050 IEEEE        CAL_NEXT; *OPC?[I][GTL]
1.051 HEAD          Calibrating 3.2999mA @ 100Hz
# cal_next is required for initial start.
# after sending AIG330U if you send cal_next 5520A tries to
# start the cal at that time.

# 3.2999mA @ 100Hz
1.052 IEEEE        *CLS;OPER; *OPC?[I][GTL]
1.053 IEEEE        [D5000][GTL]
1.054 ACMS                G
1.055 5790          A          SH      N  2W

# Calculate difference between the average value of both polarities of DC
# Current and the applied AC Current.
1.056 MATH          M[21] = 0.0032999 - (.0032999 * (1 - (MEM / M[17])))
# Determine measurement frequency to retrieve correct AC-DC difference value.
1.057 IEEEE        OUT?[I$][GTL]
1.058 MATH          M[2] = FLD(MEM2,5,"")

```

Figure 3-9. Sample MET/CAL Program (cont)

```
# Retrieve AC-DC difference from data file named "A40-10mA"
1.059 DOS          get_acdc A40-10mA
1.060 JMPT         1.064
1.061 OPBR        An error occurred during get_acdc
1.061 OPBR        Press YES to try again or NO to terminate.
1.062 JMPT         1.059
1.063 JMP          1.231

# Correct the calculated value of AC Current by adding the AC-DC difference
# of the A40-series shunt used at the frequency under test
1.064 MATH         MEM = (M[21] * MEM) + M[21]
# Store corrected value into the UUT
1.065 IEEE        CAL_NEXT [MEM]; *OPC?[I][GTL]
1.066 IEEE        ERR?[I$][GTL]
1.067 MATH         MEM1 = FLD(MEM2,1,"")
1.068 JMPT         1.231
# 'Ask' UUT for next value to calibrate
1.069 IEEE        CAL_REF?[I][GTL]
```

Figure 3-9. Sample MET/CAL Program (cont)

3-11. DC Volts Calibration (AUX Output)

To calibrate the auxiliary dc voltage function, use the same technique as previously described for the normal dc voltage output, except use the AUX HI and LO terminals on the UUT. Table 3-12 lists the calibration steps for AUX dc volts.

Table 3-12. Calibration Steps for AUX DC Volts

Step	5520A Output (AUX)
1	300.000 mV
2	3.00000 V
3	7.00000 V

3-12. AC Volts Calibration (AUX Output)

To calibrate the auxiliary ac voltage function, use the same technique as previously described for the normal ac voltage output, except use the AUX HI and LO terminals on the UUT. Table 3-13 lists the calibration steps for AUX dc volts.

Table 3-13. Calibration Steps for AUX Ouput AC Volts

Step	5520A Output (AUX)	
	Amplitude	Frequency
1	300.000 mV	100 Hz
2	300.000 mV	5 kHz
3	3.00000 V	100 Hz
4	3.00000 V	5 kHz
5	5.0000 V	100 Hz
6	5.0000 V	5 kHz
7	3.0 V	9.99 Hz

3-13. Resistance Calibration

The equipment listed in Table 3-14 is required for calibration of the resistance function. (The equipment is also listed in the consolidated table, Table 3-1.)

Table 3-14. Test Equipment Required for Calibrating Resistance

Quan.	Manufacturer	Model	Equipment
1	Fluke	5500A/LEADS	Test lead set
1	Hewlett Packard	3458A with -002 option	DMM
1	Fluke	742A-1M	Resistance Standard, 1 M Ω
1	Fluke	742A-10M	Resistance Standard, 10 M Ω
1	Guildline	9334/100M	Resistance Standard, 100 M Ω
1	Guildline	9334/1G	Resistance Standard, 1G Ω

Proceed as follows to calibrate the resistance function:

1. On the HP 3458A, perform the ACAL (autocal) ALL and MATH NULL functions as described in the HP 3458A user documentation.
2. Verify that the UUT (Unit Under Test) is in Standby.
3. Follow the prompt on the Control Display to connect the DMM to the UUT for 4-wire ohms measurement as shown in Figure 3-10.
4. Press the GO ON softkey and wait for the internal calibration steps to complete.
5. Measure and enter the values into the UUT for calibration steps 1 through 8 in Table 3-15 as prompted.
6. Disconnect the DMM from the UUT, and connect it to the Fluke 742A-1M Resistance Standard as shown in Figure 3-11. Scale the 1 M Ω DMM range to the Resistance Standard as described in the HP3458A user documentation.
7. Connect the UUT to the DMM in a 2-wire ohms configuration as shown in Figure 3-12.
8. Measure and enter the values into the UUT for calibration steps 9 through 11 in Table 3-15 as prompted.
9. Disconnect the DMM from the UUT, and connect it to the Fluke 742A-10M Resistance Standard. Scale the 10 M Ω DMM range to the Resistance Standard as described in the HP3458A user documentation.
10. Connect the UUT to the DMM in a 2-wire ohms configuration as shown in Figure 3-12.
11. Measure and enter the values into the UUT for calibration steps 12 and 13 in Table 3-15 as prompted.
12. Disconnect the DMM from the UUT, and connect it to the Guildline 9334/100M Resistance Standard as shown in Figure 3-13. Scale the 100 M Ω DMM range to the Resistance Standard as described in the HP3458A user documentation.
13. Connect the UUT to the DMM in a 2-wire ohms configuration as shown in Figure 3-12.

14. Measure and enter the values into the UUT for calibration steps 14 and 15 in Table 3-15 as prompted.
15. Disconnect the DMM from the UUT, and connect it to the Guildline 9334H/1G Resistance Standard. Scale the 1 G Ω DMM range to the Resistance Standard as described in the HP3458A user documentation.
16. Connect the UUT to the DMM in a 2-wire ohms configuration as shown in Figure 3-12.
17. Measure and enter the value into the UUT for calibration step 16 in Table 3-15 as prompted.
18. Verify that the UUT is in Standby and disconnect the test equipment.

Table 3-15. Calibration Steps for Resistance

Step	5520A Output (4-Wire Ohms, NORMAL and AUX)
1	1.0000 Ω
2	11.0000 Ω
3	110.0000 Ω
4	0.350000 k Ω
5	1.100000 k Ω
6	3.50000 k Ω
7	11.00000 k Ω
8	35.0000 k Ω
	2-Wire Ohms, NORMAL
9	110.0000 k Ω
10	0.350000 M Ω
11	1.100000 M Ω
12	3.50000 M Ω
13	11.00000 M Ω
14	35.0000 M Ω
15	110.000 M Ω
16	400.00 M Ω

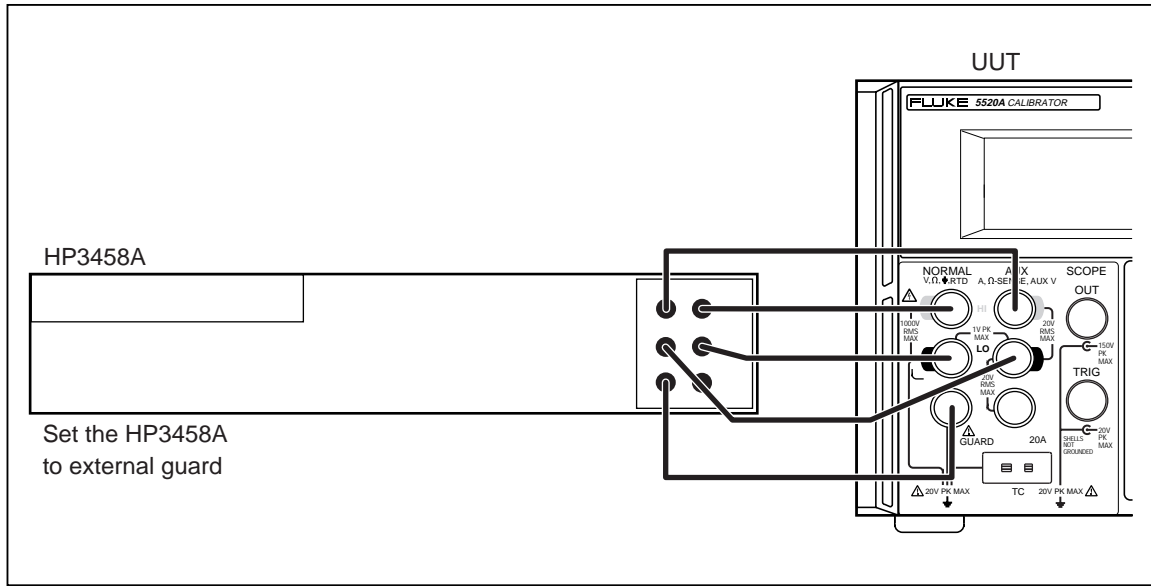


Figure 3-10. Four-Wire Resistance Connection

yg111f.eps

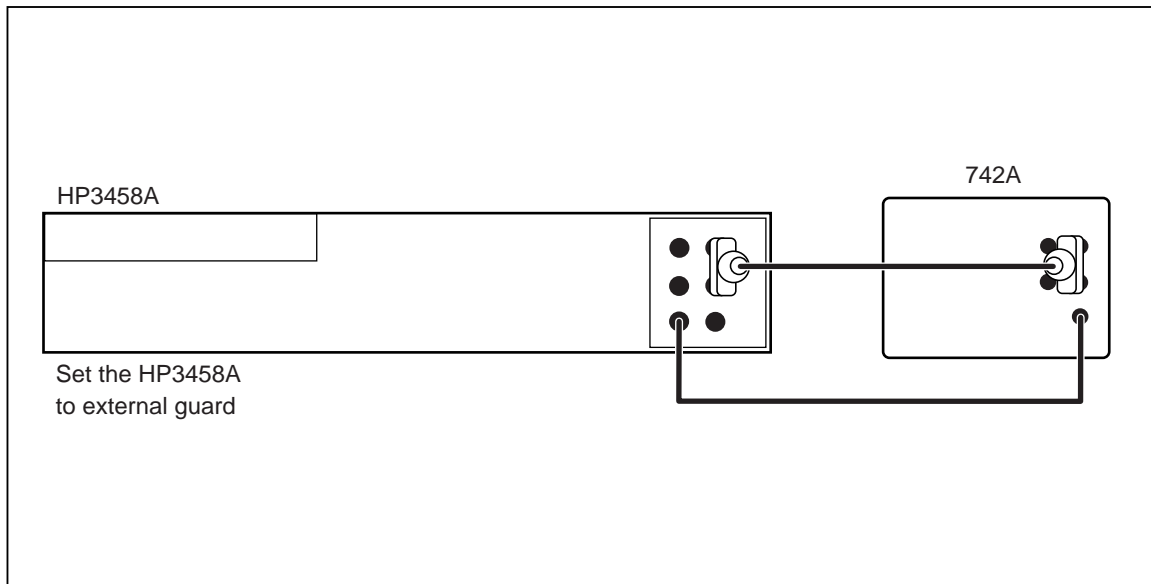


Figure 3-11. Scaling the DMM to a Fluke 742A

yg112f.eps

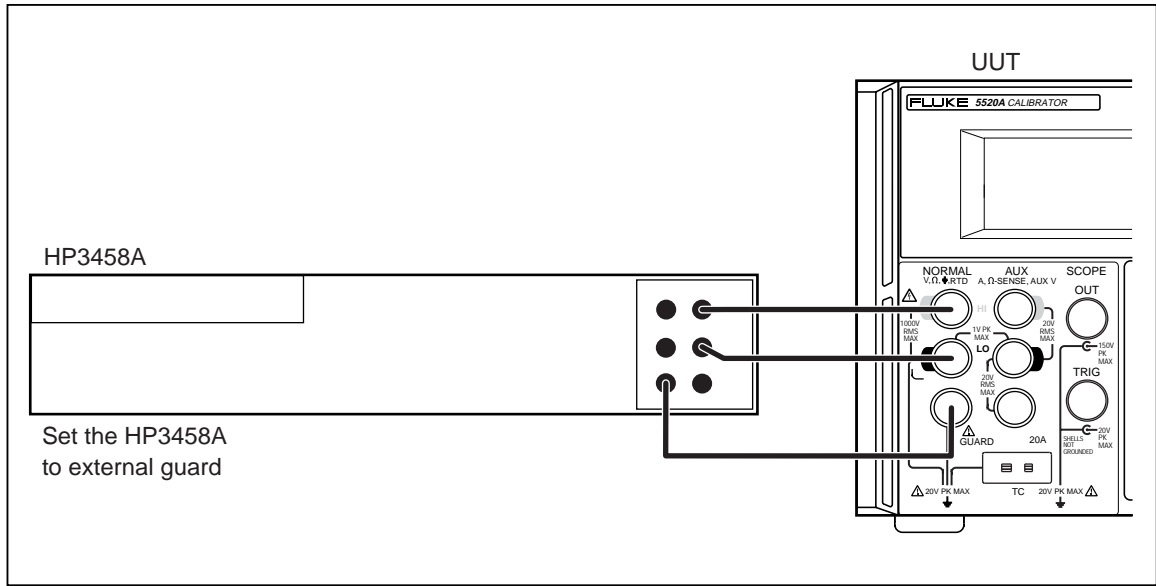


Figure 3-12. Two-Wire Resistance Connection

yg113f.eps

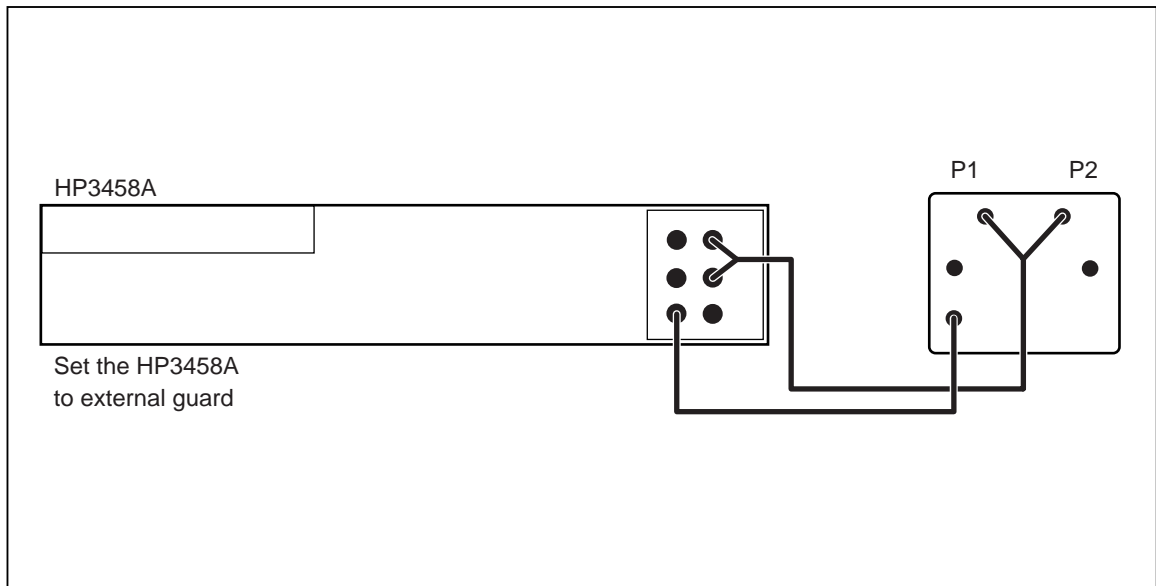


Figure 3-13. Scaling the DMM to a Guildline 9334

yg114f.eps

3-14. Capacitance Calibration

The equipment listed in Table 3-16 is required for calibration of the resistance function. (The equipment is also listed in the consolidated table, Table 3-1.)

Table 3-16. Test Equipment Required for Calibrating Capacitance

Quan.	Manufacturer	Model	Equipment
1	Fluke	PM 9540/BAN	Cable Set
1	Fluke	PM 6304C	LCR Meter

Proceed as follows to calibrate the capacitance function:

1. Connect the UUT to the LCR meter using the Fluke PM 9540/BAN cables as shown in Figure 3-14. These special cables eliminate the need for a four-wire connection.

Note

Make sure there are no other connections to the 5520A, especially the SCOPE BNC. Connecting any additional grounds to the 5520A can cause erroneous capacitance outputs.

2. Select the frequency on the LCR meter per table 3-17.
3. Measure and enter the values into the UUT for the calibration steps in Table 3-17 as prompted. The right column in the table shows the best stimulus frequency for each calibration point.
4. Verify that the UUT is in Standby and disconnect the LCR meter.

Table 3-17. Calibration Steps for Capacitance

Step	5520A Output (NORMAL)	
	5520A Calibration Output	Best Stimulus Frequency
1	200 pF	1 kHz
2	0.5000 nF	1 kHz
3	1.1000 nF	1 kHz
4	3.5000 nF	1 kHz
5	11.0000 nF	1 kHz
6	35.000 nF	1 kHz
7	110.000 nF	1 kHz
8	0.35000 μ F	100 Hz
9	1.10000 μ F	100 Hz
10	3.3000 μ F	100 Hz
11	11.0000 μ F	100 Hz
12	33.000 μ F	100 Hz

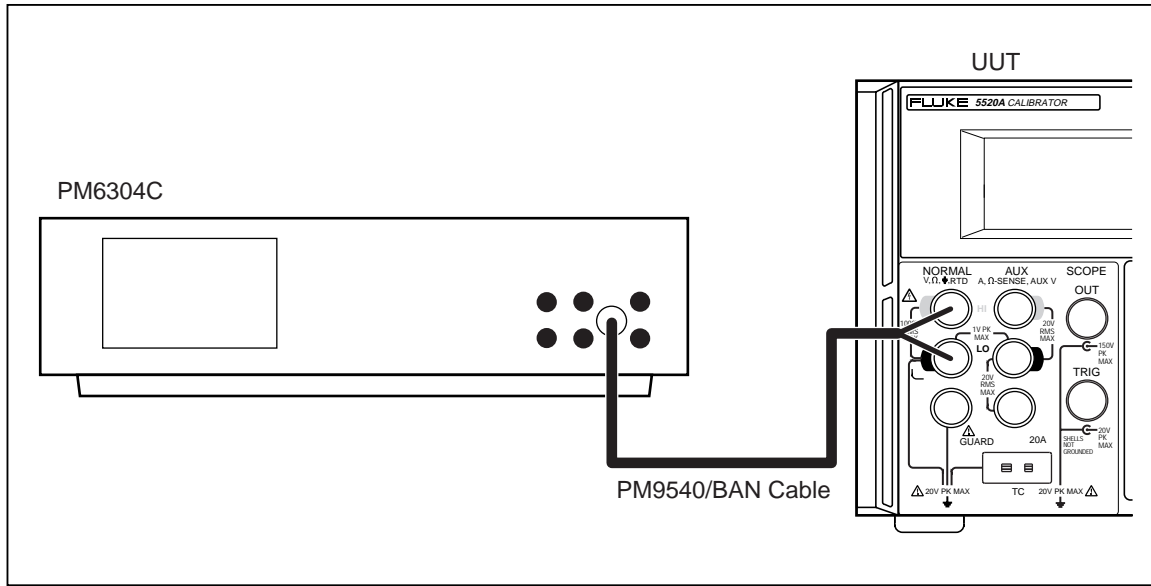


Figure 3-14. Connections for Calibrating Capacitance

yg115f.eps

3-15. Frequency Calibration

Note

The remaining steps in the calibration procedure are not necessary unless the 5520A has been repaired. They are called “Factory Cal,” and are accessible only via the remote interface.

Frequency calibration is only accessible by remote command. See “Remote Commands for 5520A Calibration,” later in this chapter. In remote, you can jump to Frequency calibration by sending the command:

```
CAL_START FACTORY
```

In Frequency calibration, the 5520A outputs 3 V rms at 500 kHz. Measure the frequency with a Fluke PM 6680 Frequency Counter. Enter the frequency reading into the 5520A when prompted.

3-16. NORMAL Volts and AUX Volts Phase

NORMAL volts and AUX volts phase calibration is only accessible by remote command. See “Remote Commands for 5520A Calibration,” later in this chapter. In remote, you can jump to NORMAL volts and AUX volts phase calibration by sending the command:

```
CAL_START FACTORY, PHASE
```

Measure with a precision phase meter, and an appropriate value low inductance shunt. The absolute value and stability of the shunts are not important. Enter the measured values when prompted. The 5520A is automatically set to LOs open.

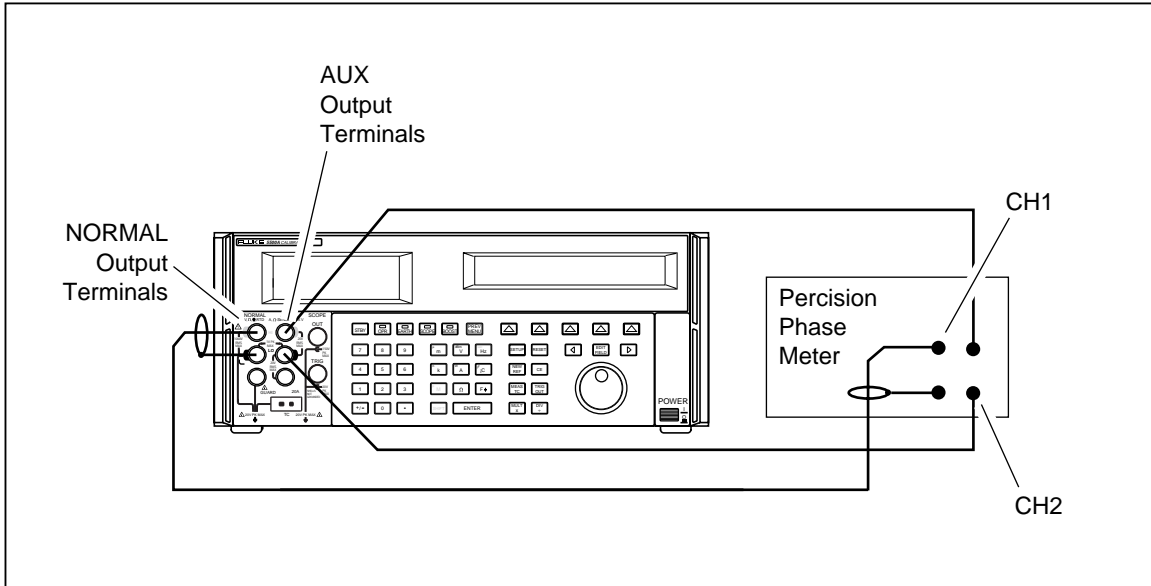


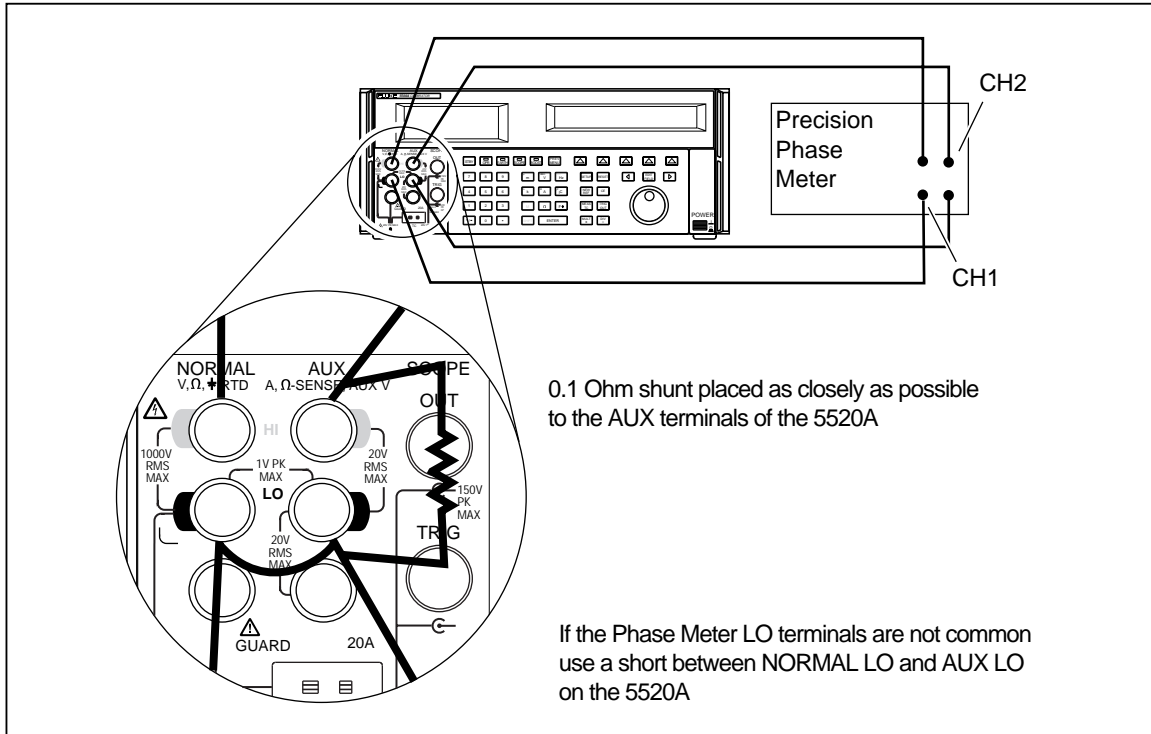
Figure 3-15. Normal Volts and AUX Volts Phase Calibration

yg014f.eps

3-17. Volts and AUX Current Phase

The 5520A is automatically set to LOs open. You need to externally connect the NORMAL LO and AUX LO. To measure the phase, connect a 0.1 Ω , 1.0 W low-inductive shunt directly across the AUX terminals and sense the voltage there with a phase meter of suitable accuracy. In remote, you can jump to NORMAL volts and AUX current phase calibration by sending the command:

```
CAL_START FACTORY , IPHASE
```



yg015f.eps

Figure 3-16. Volts and Current Phase Calibration

3-18. Calibration Remote Commands

Calibration of the 5520A using remote commands is simple. To access the standard calibration steps, simply send the command:

CAL_START MAIN

To access the factory calibration steps, send the command:

CAL_START FACTORY

To jump to specific calibration steps, these two commands can be modified by specifying an entry point. The allowable entry points are as shown in Table 3-18.

Table 3-18. Jumping to a Specific Calibration Step in Remote

Entry points for CAL_START MAIN	Modifier
AC Volts	AV
Thermocouple Measuring	TEMPX
DC Current	ICAL
AC Current	AI
AUX DC Volts	V2
AUX AC Volts	AVS
Resistance	R
Capacitance	C
Entry points for CAL_START FACTORY	Modifier
NORMAL Volts and AUX Volts Phase	PHASE
Volts and Current Phase	IPHASE

For example, to jump directly to ac volts calibration, send the command:

```
CAL_START MAIN,AV
```

To go directly to Resistance calibration, send the command:

```
CAL_START MAIN,R
```

To go directly to Phase calibration, send the command:

```
CAL_START FACTORY,PHASE
```

These calibration commands can be used with either the IEEE-488 or serial interface. To use the serial interface, and without having to write a calibration program, do the following:

1. Connect the appropriate COM port from a PC to the 5520A Serial 1 connector, using a Fluke PM8914 cable.
2. Call up the Terminal program from within Microsoft Windows. Set the communications parameters to match that of the 5520A.
3. Press . At the prompt, type the desired calibration command, e.g.,
CAL_START FACTORY.

The following is an alphabetical list of the IEEE-488/RS-232 remote calibration commands for the 5520A Calibrator (for remote commands pertaining to normal operation of the 5520A, please see the *5520A Operators Manual*). For sorting purposes, this list ignores the * character that precedes the common commands. The remote commands duplicate activities that can be initiated from the front panel in local operation.

IEEE-488 (GPIB) and RS-232 Applicability Each command title listed in this section shares the same remote interface applicability, IEEE-488 (general purpose interface bus, or GPIB) and RS-232 remote operations, and command group: Sequential, Overlapped, and Coupled.

IEEE-488 RS-232 Sequential Overlapped Coupled

Sequential Commands Commands executed immediately as they are encountered in the data stream are called sequential commands. Anything not overlapped or coupled is sequential.

Overlapped Commands Commands that require additional time to execute are called overlapped commands because they can overlap the next command before completing execution.

Coupled Commands Some commands are coupled commands because they “couple” in a compound command sequence. Care must be taken to be sure the action of one command does not disable the action of a second command and thereby cause a fault.

CAL_ABORT

Description: Instruct 5520A to abort calibration procedure after present step

Example: CAL_ABORT

CAL_BACKUP

Description: Skip to next entry point in calibration procedure.

CAL_DATE?

Description: Return a calibration date associated with stored calibration constants.

The date is returned with the same format as the CLOCK command.

Parameter: Which date: MAIN, ZERO, OHMSZERO, SCOPE

Response: The date

CAL_DAYS?

Description: Return the number of days and hours since the last calibration constants were stored.

Parameter: Which date: MAIN, ZERO, OHMSZERO, SCOPE

Response: 1. (Integer) Days
2. (Integer) Hours

CAL_FACT

Description: Set the procedure "fault action" flag. Procedures refer to both calibration and diagnostic procedures. This command is more useful for diagnostics than calibration.

Parameter: (Character) CONT to continue on faults or ABORT to abort on faults

Example: CAL_FACT ABORT (this is the default)

CAL_FACT?

Description: Get the procedure "fault action" flag

Response: (Character) CONT or ABORT

Example: ABORT

CAL_FAULT?

Description: Get information about calibration error (if one occurred)

Response: 1. error number (use EXPLAIN? command to interpret)
2. Name of step where error occurred

CAL_INFO?

Description: Return message or instructions associated with running step

Response: (String) the message string

CAL_NEXT

Description: Continue a calibration procedure if it is waiting for a CAL_NEXT command.

Parameter: (Optional) reference value (used if it's waiting for a reference) If the reference value has no unit, the unit is assumed to be that returned by the CAL_REF? command

Example: CAL_NEXT
 CAL_NEXT 2.999987

CAL_REF?

Description: Return nominal value expected for reference entry

- Response:
1. The nominal value
 2. The accepted or implied unit
 3. Example: 3.000000e+00,V

CAL_SKIP

Description: Skip to next entry point in calibration procedure.

CAL_SECT

Description: Skip to next section of calibration procedure.

CAL_START

Description: Start a calibration procedure

- Parameter:
1. Procedure name:
 - MAIN is the procedure for the 5520A minus any scope cal option
 - ZERO is the internal procedure to correct zero offsets
 - OHMSZERO is the internal procedure to touch up resistance offsets
 - FACTORY is the procedure run in the factory
 - SCOPE is the procedure for the 5520A-SC300 scope cal option
 - SC600 is the procedure for the 5520A-SC600 scope cal option
 - DIAG is the diagnostic pseudo-cal procedure
 - NOT aborts a procedure after the step underway
 2. (Optional) name of the step at which to start.

If this parameter is not provided, it starts at the beginning.

Example: CAL_START MAIN
CAL_START MAIN,DVG3_3

CAL_STATE?

Description: Return state of calibration
Response: RUN - Running a calibration step
REF - Waiting for a CAL_NEXT with reference (measurement) value
INS - Instruction available, waiting for a CAL_NEXT
NOT - Not in a calibration procedure (or at end of one)

CAL_STEP?

Description: Return name of step currently running
Response: (Char) the step name
Example: IDAC_RATIO (running IDAC ratio calibration)
NOT (not running a calibration procedure now)

CAL_STORE

Description: Store new calibration constants (CAL switch must be ENABLEd)

CAL_STORE?

Description: Return whether a cal store is needed
Response: 1 is yes, 0 if no

CAL_SW?

Description: Return the setting of the calibration enable switch
Response: (Integer) 1 for enable, 0 for normal
Example: 1

EOFSTR

Description: Sets the End-Of-File character string used for calibration reports.
The maximum length is two characters. The EOF setting is saved in nonvolatile memory.
Parameter: The EOF string (two characters maximum)

EOFSTR?

Description: Returns the End-Of-File character string used for calibration reports

Parameter: None
Response: (String) The End-Of-File character string

PR_RPT

Description: Prints a self-calibration report out the selected serial port
Parameter: 1. Type of report to print: STORED, ACTIVE, or CONSTS
2. Format of report: PRINT (designed to be read)
SPREAD (designed to be loaded into a spreadsheet)
3. Calibration interval to be used for instrument specifications in the report: I90D (90 day specifications) or I1Y (1 year specifications)
4. Serial port out which to print report: HOST or UUT
Example: PR_RPT STORED,PRINT,I90D,HOST

RPT?

Description: Returns a self-calibration report.
Parameter: 1. Type of report to return: STORED, ACTIVE, or CONSTS
2. Format of report: PRINT (designed to be read)
SPREAD (designed to be loaded into a spreadsheet)
3. Calibration interval to be used for instrument specifications in the report:
I90D (90 day specifications) or I1Y (1 year specifications)
Example: RPT? STORED,PRINT,I90D

RPT_PLEN

Description: Sets the page length used for calibration reports. This setting is stored in nonvolatile memory.
Parameter: Page length

RPT_PLEN?

Description: Returns the page length used for calibration reports.
Parameter: None
Response: (Integer) Page length

RPT_STR

Description: Sets the user report string used for calibration reports. The string is stored in nonvolatile memory. The CALIBRATION switch must be set to ENABLE.
Parameter: String of up to 40 characters

RPT_STR?

Description: Returns the user report string used for calibration reports.

Parameter: None

Response: (String) Up to 40 characters

STOP_PR

Description: Terminates printing a calibration report if one was being printed.

Parameter: None

UNCERT?

Description: Returns specified uncertainties for the present output. If there is no specification for an output, the uncertainty returned is zero.

Parameter: 1. (Optional) The preferred unit in which to express the primary output uncertainty (default is PCT).
2. (Optional) The preferred unit in which to express the secondary output uncertainty (default is same as primary unit).

Response: 1. (Float) 90 day specified uncertainty of primary output.
2. (Float) 1 year specified uncertainty of primary output.
3. (Character) unit of primary output uncertainty.
4. (Float) 90 day specified uncertainty of secondary output.
5. (Float) 1 year specified uncertainty of secondary output.
6. (Character) unit of secondary output uncertainty.

Example: With a power output of 1V, 1A, 1kHz:
UNCERT?
Returns 2.00E-02,2.10E-02,PCT,4.60E-02,6.00E-02,PCT

3-19. Generating a Calibration Report

Three different calibration reports are available from the 5520A, each one either formatted for printing, or in comma-separated variable format for importation into a spreadsheet. Using the REPORT SETUP softkey under UTILITY FUNCTS / CAL, you select lines per page, calibration interval, type of report, format, and which serial port to use. The specification shown in these reports depends on the interval selected in the REPORT SETUP menu.

The three types of report are as follows:

- “**stored**,” lists output shifts as a result of the most recent stored calibration constants.
- “**active**,” lists output shifts as a result of a calibration just performed but whose calibration constants are not yet stored.
- “**consts**,” which is a listing of the active set of raw calibration constant values.

3-20. Performance Verification Tests

The following tests are used to verify the performance of the 5520A Calibrator. If an out-of-tolerance condition is found, the instrument can be re-calibrated using the front panel or the remote interface as described previously in this chapter.

Use the same test equipment and connection methods as used in the preceding calibration procedures.

Zero the 5520A Calibrator before testing by completing “Zeroing the Calibrator” as described next.

3-21. Zeroing the Calibrator

Zeroing recalibrates internal circuitry, most notably dc offsets in all ranges of operation. To meet the specifications in Chapter 1, zeroing is required every 7 days, or when the 5520A Calibrator ambient temperature changes by more than 5°C. There are two zeroing functions: total instrument zero (ZERO) and ohms-only zero (OHMS ZERO). Before performing the verification tests, perform the total instrument zero.

Complete the following procedure to zero the calibrator. (Note: The 5520A Calibrator rear panel CALIBRATION switch does not have to be enabled for this procedure.)

1. Turn on the Calibrator and allow a warmup period of at least 30 minutes.
2. Press the **RESET** key.
3. Install a low-ohm copper short circuit across the 20 A and AUX LO terminals.
4. Press the **SETUP** key, opening the setup menu.
5. Press the CAL softkey, opening the calibration information menu.
6. Press the CAL softkey.
7. Press the ZERO softkey to totally zero the 5520A Calibrator. After the zeroing routine is complete (20 minutes), press the **RESET** key to reset the calibrator.

3-22. Verifying DC Volts (NORMAL Output)

Verify that the 5520A performance is within the limits in Table 3-19, using the same equipment and techniques specified previously for calibration.

Table 3-19. Verification Tests for DC Voltage (NORMAL Output)

Range	Output	Lower Limit	Upper Limit
329.9999 mV	0.0000 mV	-0.0010 mV	0.0010 mV
329.9999 mV	329.0000 mV	328.9941 mV	329.0059 mV
329.9999 mV	-329.0000 mV	-329.0059 mV	-328.9941 mV
3.299999 V	0.000000 V	-0.000002 V	0.000002 V
3.299999 V	1.000000 V	0.999989 V	1.000011 V
3.299999 V	-1.000000 V	-1.000011 V	-0.999989 V
3.299999 V	3.290000 V	3.289968 V	3.290032 V
3.299999 V	-3.290000 V	-3.290032 V	-3.289968 V
32.99999 V	0.00000 V	-0.00002 V	0.00002 V
32.99999 V	10.00000 V	9.99989 V	10.00012 V
32.99999 V	-10.00000 V	-10.00012 V	-9.99989 V
32.99999 V	32.90000 V	32.89966 V	32.90034 V
32.99999 V	-32.90000 V	-32.90034V	-32.89966 V
329.9999 V	50.0000 V	49.9991 V	50.0009 V
329.9999 V	329.0000 V	328.9949 V	329.0051 V
329.9999 V	-50.0000 V	-50.0009 V	-49.9991 V
329.9999 V	-329.0000 V	-329.0051 V	-328.9949 V
1000.000 V	334.000 V	333.993 V	334.007 V
1000.000 V	900.000 V	899.985 V	900.015 V
1000.000 V	1020.000 V	1019.983 V	1020.017 V
1000.000 V	-334.000 V	-334.007 V	-333.993 V
1000.000 V	-900.000 V	-900.015 V	-899.985 V
1000.000 V	-1020.000 V	-1020.017 V	-1019.983 V

3-23. Verifying DC Volts (AUX Output)

Verify that the 5520A performance is within the limits in Table 3-20, using the same equipment and techniques specified previously for calibration.

Table 3-20. Verification Tests for DC Voltage (AUX Output)

Range	Output	Lower Limit	Upper Limit
329.999 mV	0.000 mV	-0.350 mV	0.350 mV
329.999 mV	329.000 mV	328.551 mV	329.449 mV
329.999 mV	-329.000 mV	-329.449 mV	-328.551 mV
3.29999 V	0.33000 V	0.32955 V	0.33045 V
3.29999 V	3.29000 V	3.28866 V	3.29134 V
3.29999 V	-3.29000 V	-3.29134 V	-3.28866 V
7.0000 V	7.0000 V	6.9976 V	7.0025 V
7.0000 V	-7.0000 V	-7.0025 V	-6.9976 V

3-24. Verifying DC Current

Verify that the 5520A performance is within the limits in Table 3-22, using the same equipment and techniques specified previously for calibration. Use the shunt values listed in Table 3-21.

Table 3-21. Shunt Values for DC Current Calibration and Verification

Range of Verification Points	Shunt
± (0 to 329.000 μ A)	Fluke 742A-1k 1k Ω Resistance Standard
± (1.9 mA to 3.29000 mA)	Fluke 742A-100 100 Ω Resistance Standard
± (19.0000 mA to 32.9000 mA)	Fluke 742A-10 10 Ω Resistance Standard
± (190.000 mA to 329.000 mA)	Fluke 742A-1 1 Ω Resistance Standard
± (1.09000 A)	Guildline 9230 0.1 Ω Shunt
± (2.00000 A to 20.0000 A)	Guildline 9230 0.01 Ω Shunt

Table 3-22. Verification Tests for DC Current (AUX Output)

Range	Output	Lower Limit	Upper Limit
329.999 μ A	0.000 μ A	-0.020 μ A	0.020 μ A
329.999 μ A	190.000 μ A	189.957 μ A	190.043 μ A
329.999 μ A	-190.000 μ A	-190.043 μ A	-189.957 μ A
329.999 μ A	329.000 μ A	328.941 μ A	329.059 μ A
329.999 μ A	-329.000 μ A	-329.059 μ A	-328.941 μ A
3.29999 mA	0.00000 mA	-0.00005 mA	0.00005 mA
3.29999 mA	1.90000 mA	1.89980 mA	1.90020 mA
3.29999 mA	-1.90000 mA	-1.90020 mA	-1.89980 mA
3.29999 mA	3.29000 mA	3.28969 mA	3.29031 mA
3.29999 mA	-3.29000 mA	-3.29031 mA	-3.28969 mA
32.9999 mA	0.0000 mA	-0.00025 mA	0.00025 mA
32.9999 mA	19.0000 mA	18.9982 mA	19.0018 mA
32.9999 mA	-19.0000 mA	-19.0018 mA	-18.9982 mA
32.9999 mA	32.9000 mA	32.8971 mA	32.9029 mA
32.9999 mA	-32.9000 mA	-32.9029 mA	-32.8971 mA
329.999 mA	0.000 mA	-0.0025 mA	0.0025 mA
329.999 mA	190.000 mA	189.982 mA	190.018 mA
329.999 mA	-190.000 mA	-190.018 mA	-189.982 mA
329.999 mA	329.000 mA	328.971 mA	329.029 mA
329.999 mA	-329.000 mA	-329.029 mA	-328.971 mA
2.99999 A	0.00000 A	-0.00004 A	0.00004 A
2.99999 A	1.09000 A	1.08979 A	1.09021 A
2.99999 A	-1.09000 A	-1.09021 A	-1.08979 A
2.99999 A	2.99000 A	2.98906 A	2.99094 A
2.99999 A	-2.99000 A	-2.99094 A	-2.98906 A
20.5000 A	0.0000 A	-0.0005 A	0.0005 A
20.5000 A	10.9000 A	10.8954 A	10.9046 A
20.5000 A	-10.9000 A	-10.9046 A	-10.8954 A
20.5000 A	20.0000 A	19.9833 A	20.0168 A
20.5000 A	-20.0000 A	-20.0168 A	-19.9833 A

3-25. Verifying Resistance

Verify that the 5520A performance is within the limits in Table 3-23, using the same equipment and techniques specified previously for calibration. Use four-wire measurements up to and including 119 k Ω , then two-wire for the higher value resistances.

Table 3-23. Verification Tests for Resistance

Range	Output	Lower Limit	Upper Limit
10.9999 Ω	0.0000 Ω	-0.0010 Ω	0.0010 Ω
10.9999 Ω	2.0000 Ω	1.9989 Ω	2.0011 Ω
10.9999 Ω	10.9000 Ω	10.8986 Ω	10.9014 Ω
32.9999 Ω	11.9000 Ω	11.8982 Ω	11.9018 Ω
32.9999 Ω	19.0000 Ω	18.9980 Ω	19.0020 Ω
32.9999 Ω	30.0000 Ω	29.9978 Ω	30.0023 Ω
109.9999 Ω	33.0000 Ω	32.9979 Ω	33.0021 Ω
109.9999 Ω	109.0000 Ω	108.9962 Ω	109.0038 Ω
329.9999 Ω	119.0000 Ω	118.9954 Ω	119.0046 Ω
329.9999 Ω	190.0000 Ω	189.9938 Ω	190.0062 Ω
329.9999 Ω	300.0000 Ω	299.9914 Ω	300.0086 Ω
1.099999 k Ω	0.330000 k Ω	0.329991 k Ω	0.330009 k Ω
1.099999 k Ω	1.090000 k Ω	1.089974 k Ω	1.090026 k Ω
3.299999 k Ω	1.190000 k Ω	1.189954 k Ω	1.190046 k Ω
3.299999 k Ω	1.900000 k Ω	1.899938 k Ω	1.900062 k Ω
3.299999 k Ω	3.000000 k Ω	2.999914 k Ω	3.000086 k Ω
10.999999 k Ω	3.300000 k Ω	3.29991 k Ω	3.30009 k Ω
10.999999 k Ω	10.900000 k Ω	10.89974 k Ω	10.90026 k Ω
32.999999 k Ω	11.900000 k Ω	11.89954 k Ω	11.90046 k Ω
32.999999 k Ω	19.000000 k Ω	18.99938 k Ω	19.00062 k Ω
32.999999 k Ω	30.000000 k Ω	29.99914 k Ω	30.00086 k Ω
109.9999 k Ω	33.0000 k Ω	32.9991 k Ω	33.0009 k Ω
109.9999 k Ω	109.0000 k Ω	108.9974 k Ω	109.0026 k Ω
329.9999 k Ω	119.0000 k Ω	118.9950 k Ω	119.0050 k Ω
329.9999 k Ω	190.0000 k Ω	189.9933 k Ω	190.0068 k Ω
329.9999 k Ω	300.0000 k Ω	299.9905 k Ω	300.0095 k Ω
1.099999 M Ω	0.330000 M Ω	0.329990 M Ω	0.330010 M Ω
1.099999 M Ω	1.090000 M Ω	1.089971 M Ω	1.090029 M Ω

Table 3-23. Verification Tests for Resistance (cont)

Range	Output	Lower Limit	Upper Limit
3.299999 MΩ	1.190000 MΩ	1.189922 MΩ	1.190078 MΩ
3.299999 MΩ	1.900000 MΩ	1.899894 MΩ	1.900106 MΩ
3.299999 MΩ	3.000000 MΩ	2.999850 MΩ	3.000150 MΩ
10.99999 MΩ	3.30000 MΩ	3.29959 MΩ	3.30041 MΩ
10.99999 MΩ	10.90000 MΩ	10.89875 MΩ	10.90125 MΩ
32.99999 MΩ	11.90000 MΩ	11.89512 MΩ	11.90488 MΩ
32.99999 MΩ	19.00000 MΩ	18.99370 MΩ	19.00630 MΩ
32.99999 MΩ	30.00000 MΩ	29.99150 MΩ	30.00850 MΩ
109.9999 MΩ	33.0000 MΩ	32.9838 MΩ	33.0162 MΩ
109.9999 MΩ	109.0000 MΩ	108.9534 MΩ	109.0466 MΩ
329.9999 MΩ	119.0000 MΩ	118.6025 MΩ	119.3975 MΩ
329.9999 MΩ	290.0000 MΩ	289.1750 MΩ	290.8250 MΩ
1100.000 MΩ	400.000 MΩ	394.700 MΩ	405.300 MΩ
1100.000 MΩ	640.000 MΩ	631.820 MΩ	648.180 MΩ
1100.000 MΩ	1090.000 MΩ	1076.420 MΩ	1103.580 MΩ

3-26. Verifying AC Voltage (NORMAL Output)

Verify that the 5520A performance is within the limits in Table 3-24, using the same equipment and techniques specified previously for calibration.

Table 3-24. Verification Tests for AC Voltage (NORMAL Output)

Range	Output	Frequency	Lower Limit	Upper Limit
32.999 mV	3.000 mV	45 Hz	2.994 mV	3.006 mV
32.999 mV	3.000 mV	10 kHz	2.994 mV	3.006 mV
32.999 mV	30.000 mV	9.5 Hz	28.335 mV	31.665 mV
32.999 mV	30.000 mV	10 Hz	29.976 mV	30.024 mV
32.999 mV	30.000 mV	45 Hz	29.990 mV	30.010 mV
32.999 mV	30.000 mV	1 kHz	29.990 mV	30.010 mV
32.999 mV	30.000 mV	10 kHz	29.990 mV	30.010 mV
32.999 mV	30.000 mV	20 kHz	29.989 mV	30.011 mV
32.999 mV	30.000 mV	50 kHz	29.970 mV	30.030 mV
32.999 mV	30.000 mV	100 kHz	29.898 mV	30.102 mV
32.999 mV	30.000 mV	450 kHz	29.770 mV	30.230 mV
329.999 mV	33.000 mV	45 Hz	32.987 mV	33.013 mV
329.999 mV	33.000 mV	10 kHz	32.987 mV	33.013 mV
329.999 mV	300.000 mV	9.5 Hz	283.350 mV	316.650 mV
329.999 mV	300.000 mV	10 Hz	299.917 mV	300.083 mV
329.999 mV	300.000 mV	45 Hz	299.950 mV	300.050 mV
329.999 mV	300.000 mV	1 kHz	299.950 mV	300.050 mV
329.999 mV	300.000 mV	10 kHz	299.950 mV	300.050 mV
329.999 mV	300.000 mV	20 kHz	299.947 mV	300.053 mV
329.999 mV	300.000 mV	50 kHz	299.902 mV	300.098 mV
329.999 mV	300.000 mV	100 kHz	299.788 mV	300.212 mV
329.999 mV	300.000 mV	500 kHz	299.450 mV	300.550 mV
3.29999 V	0.33000 V	45 Hz	0.32989 V	0.33011 V
3.29999 V	0.33000 V	10 kHz	0.32989 V	0.33011 V
3.29999 V	3.00000 V	9.5 Hz	2.83350 V	3.16650 V
3.29999 V	3.00000 V	10 Hz	2.99920 V	3.00080 V
3.29999 V	3.00000 V	45 Hz	2.99952 V	3.00048 V
3.29999 V	3.00000 V	1 kHz	2.99952 V	3.00048 V
3.29999 V	3.00000 V	10 kHz	2.99952 V	3.00048 V
3.29999 V	3.00000 V	20 kHz	2.99946 V	3.00054 V

Table 3-24. Verification Tests for AC Voltage (NORMAL Output) (cont)

Range	Output	Frequency	Lower Limit	Upper Limit
3.29999 V	3.00000 V	50 kHz	2.99920 V	3.00080 V
3.29999 V	3.00000 V	100 kHz	2.99823 V	3.00178 V
3.29999 V	3.00000 V	450 kHz	2.99340 V	3.00660 V
3.29999 V	3.29000 V	2 MHz	0.07500 V (Note)	
32.9999 V	3.3000 V	45 Hz	3.2990 V	3.3010 V
32.9999 V	3.3000 V	10 kHz	3.2990 V	3.3010 V
32.9999 V	30.0000 V	9.5 Hz	28.3350 V	31.6650 V
32.9999 V	30.0000 V	10 Hz	29.9919 V	30.0082 V
32.9999 V	30.0000 V	45 Hz	29.9957 V	30.0044 V
32.9999 V	30.0000 V	1 kHz	29.9957 V	30.0044 V
32.9999 V	30.0000 V	10 kHz	29.9957 V	30.0044 V
32.9999 V	30.0000 V	20 kHz	29.9928 V	30.0072 V
32.9999 V	30.0000 V	50 kHz	29.9904 V	30.0096 V
32.9999 V	30.0000 V	90 kHz	29.9759 V	30.0241 V
329.999 V	33.000 V	45 Hz	32.993 V	33.007 V
329.999 V	33.000 V	10 kHz	32.989 V	33.011 V
329.999 V	300.000 V	45 Hz	299.953 V	300.047 V
329.999 V	300.000 V	1 kHz	299.953 V	300.047 V
329.999 V	300.000 V	10 kHz	299.946 V	300.054 V
329.999 V	300.000 V	18 kHz	299.928 V	300.072 V
329.999 V	300.000 V	50 kHz	299.922 V	300.078 V
329.999 V	200.000 V	100 kHz	199.630 V	200.370 V
1020.00 V	330.00 V	45 Hz	329.91 V	330.09 V
1020.00 V	330.00 V	10 kHz	329.91 V	330.09 V
1020.00 V	1000.00 V	45 Hz	999.74 V	1000.26 V
1020.00 V	1000.00 V	1 kHz	999.79 V	1000.21 V
1020.00 V	1000.00 V	5 kHz	999.79 V	1000.21 V
1020.00 V	1000.00 V	8 kHz	999.74 V	1000.26 V
1020.00 V	1020.00 V	1 kHz	1019.79 V	1020.21 V
1020.00 V	1020.00 V	8 kHz	1019.74 V	1020.27 V
Note: Typical specification is -24 dB at 2 MHz				

3-27. Verifying AC Voltage (AUX Output)

Verify that the 5520A performance is within the limits in Table 3-25, using the same equipment and techniques specified previously for calibration.

Table 3-25. Verification Tests for AC Voltage (AUX Output)

Range	Output, AUX (Note)	Frequency	Lower Limit	Upper Limit
329.999 mV	10.000 mV	45 Hz	9.622 mV	10.378 mV
329.999 mV	10.000 mV	1 kHz	9.622 mV	10.378 mV
329.999 mV	10.000 mV	5 kHz	9.535 mV	10.465 mV
329.999 mV	10.000 mV	10 kHz	9.520 mV	10.480 mV
329.999 mV	10.000 mV	30 kHz	8.700 mV	11.300 mV
329.999 mV	300.000 mV	9.5 Hz	283.350 mV	316.650 mV
329.999 mV	300.000 mV	10 Hz	299.180 mV	300.820 mV
329.999 mV	300.000 mV	45 Hz	299.390 mV	300.610 mV
329.999 mV	300.000 mV	1 kHz	299.390 mV	300.610 mV
329.999 mV	300.000 mV	5 kHz	299.100 mV	300.900 mV
329.999 mV	300.000 mV	10 kHz	298.650 mV	301.350 mV
329.999 mV	300.000 mV	30 kHz	287.100 mV	312.900 mV
3.29999 V	3.00000 V	9.5 Hz	2.825 V	3.175 V
3.29999 V	3.00000 V	10 Hz	2.99505 V	3.00495 V
3.29999 V	3.00000 V	45 Hz	2.99745 V	3.00255 V
3.29999 V	3.00000 V	1 kHz	2.99745 V	3.00255 V
3.29999 V	3.00000 V	5 kHz	2.99410 V	3.00590 V
3.29999 V	3.00000 V	10 kHz	2.98960 V	3.01040 V
3.29999 V	3.00000 V	30 kHz	2.87720 V	3.12280 V
5.00000 V	5.00000 V	9.5 Hz	4.72500 V	5.27500 V
5.00000 V	5.00000 V	10 Hz	4.99205 V	5.00795 V
5.00000 V	5.00000 V	45 Hz	4.99605 V	5.00395 V
5.00000 V	5.00000 V	1 kHz	4.99605 V	5.00395 V
5.00000 V	5.00000 V	5 kHz	4.99110 V	5.00890 V
5.00000 V	5.00000 V	10 kHz	4.98360 V	5.01640 V
Note: set the NORMAL output to 300 mV.				

3-28. Verifying AC Current

Verify that the 5520A performance is within the limits in Table 3-27. Use the previously verified UUT dc current function as the dc current source for making ac/dc current transfers with the 5790A. Use the shunt values listed in Table 3-26. See Figure 3-17 for proper equipment connections. For ranges 19 mA to 2 A, refer to Figure 3-7 and above 2 A, refer to Figure 3-8 for proper setup connections.

Table 3-26. Shunt Values for AC Current Verification

Range of Verification Points (rms values)	Shunt
0 to 329.000 μ A	1 k Ω metal film resistor in a shielded box
1.9 mA to 3.29990 mA	200 Ω metal film resistor in a shielded box
19 mA to 3.3 mA	Fluke A40 20 mA Shunt
30.0000 mA to 190 mA	Fluke A40 200 mA Shunt
300.000 mA to 2 A	Fluke A40 2A Shunt
2.99000 A to 20.0000 A	Fluke A40A 20A Shunt

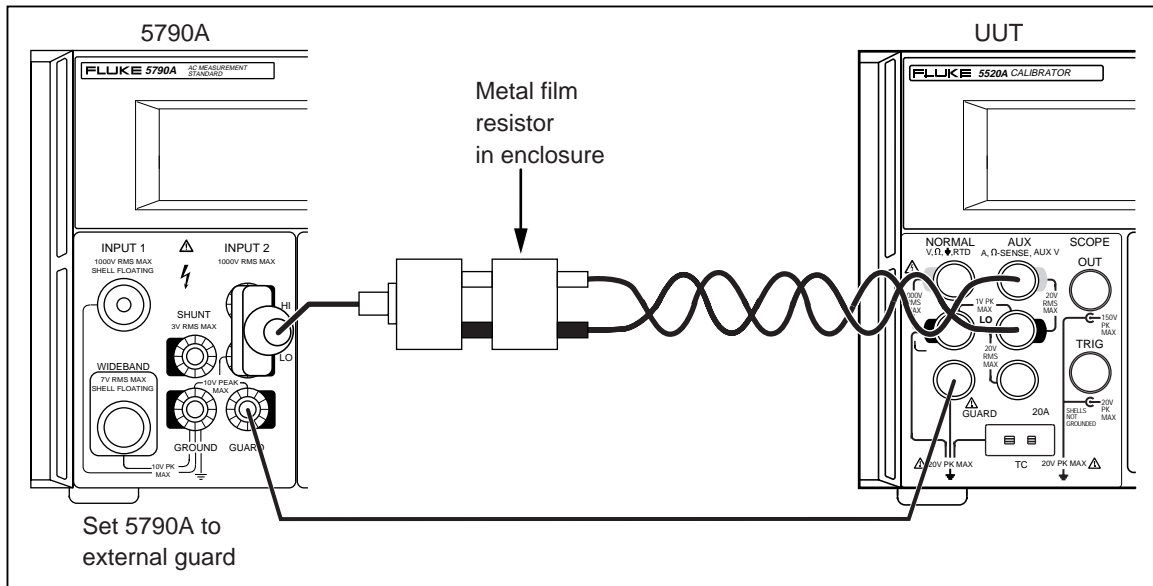


Figure 3-17. Connections for Verifying AC Current with a Metal Film Resistor (3.2999 mA and Below)

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Table 3-27. Verification Tests for AC Current

Range	Output	Frequency	Lower Limit	Upper Limit
329.99 μ A	33.00 μ A	1 kHz	32.87 μ A	33.13 μ A
329.99 μ A	33.00 μ A	10 kHz	32.60 μ A	33.40 μ A
329.99 μ A	33.00 μ A	30 kHz	32.20 μ A	33.80 μ A
329.99 μ A	190.00 μ A	45 Hz	189.71 μ A	190.29 μ A
329.99 μ A	190.00 μ A	1 kHz	189.71 μ A	190.29 μ A
329.99 μ A	190.00 μ A	10 kHz	188.66 μ A	191.34 μ A
329.99 μ A	190.00 μ A	30 kHz	187.32 μ A	192.68 μ A
329.99 μ A	329.00 μ A	10 Hz	328.37 μ A	329.63 μ A
329.99 μ A	329.00 μ A	45 Hz	328.57 μ A	329.43 μ A
329.99 μ A	329.00 μ A	1 kHz	328.57 μ A	329.43 μ A
329.99 μ A	329.00 μ A	5 kHz	328.03 μ A	329.97 μ A
329.99 μ A	329.00 μ A	10 kHz	326.83 μ A	331.17 μ A
329.99 μ A	329.00 μ A	30 kHz	324.65 μ A	333.35 μ A
3.2999 mA	0.3300 mA	1 kHz	0.3296 mA	0.3304 mA
3.2999 mA	0.3300 mA	5 kHz	0.3293 mA	0.3307 mA
3.2999 mA	0.3300 mA	30 kHz	0.3268 mA	0.3332 mA
3.2999 mA	1.9000 mA	1 kHz	1.8983 mA	1.9017 mA
3.2999 mA	1.9000 mA	10 kHz	1.8921 mA	1.9079 mA
3.2999 mA	1.9000 mA	30 kHz	1.8842 mA	1.9158 mA
3.2999 mA	3.2900 mA	10 Hz	3.2846 mA	3.2954 mA
3.2999 mA	3.2900 mA	45 Hz	3.2872 mA	3.2928 mA
3.2999 mA	3.2900 mA	1 kHz	3.2872 mA	3.2928 mA
3.2999 mA	3.2900 mA	5 kHz	3.2845 mA	3.2955 mA
3.2999 mA	3.2900 mA	10 kHz	3.2765 mA	3.3035 mA
3.2999 mA	3.2900 mA	30 kHz	3.2631 mA	3.3169 mA
32.999 mA	3.3000 mA	1 kHz	3.297 mA	3.303 mA
32.999 mA	3.3000 mA	5 kHz	3.296 mA	3.304 mA
32.999 mA	3.3000 mA	30 kHz	3.285 mA	3.315 mA
32.999 mA	19.0000 mA	1 kHz	18.991 mA	19.009 mA
32.999 mA	19.0000 mA	10 kHz	18.967 mA	19.033 mA
32.999 mA	19.0000 mA	30 kHz	18.935 mA	19.065 mA
32.999 mA	32.9000 mA	10 Hz	32.849 mA	32.951 mA

Table 3-27. Verification Tests for AC Current (cont)

Range	Output	Frequency	Lower Limit	Upper Limit
32.999 mA	32.9000 mA	1 kHz	32.886 mA	32.914 mA
32.999 mA	32.9000 mA	5 kHz	32.877 mA	32.923 mA
32.999 mA	32.9000 mA	10 kHz	32.844 mA	32.956 mA
32.999 mA	32.9000 mA	30 kHz	32.791 mA	33.009 mA
329.99 mA	33.0000 mA	1 kHz	32.97 mA	33.03 mA
329.99 mA	33.0000 mA	5 kHz	32.92 mA	33.08 mA
329.99 mA	33.0000 mA	30 kHz	32.69 mA	33.31 mA
329.99 mA	190.0000 mA	1 kHz	189.91 mA	190.09 mA
329.99 mA	190.0000 mA	10 kHz	189.60 mA	190.40 mA
329.99 mA	190.0000 mA	30 kHz	189.19 mA	190.81 mA
329.99 mA	329.0000 mA	10 Hz	328.49 mA	329.51 mA
329.99 mA	329.0000 mA	45 Hz	328.86 mA	329.14 mA
329.99 mA	329.0000 mA	1 kHz	328.86 mA	329.14 mA
329.99 mA	329.0000 mA	5 kHz	328.69 mA	329.31 mA
329.99 mA	329.0000 mA	10 kHz	328.37 mA	329.63 mA
329.99 mA	329.0000 mA	30 kHz	327.75 mA	330.25 mA
2.99999 A	0.33000 A	1 kHz	0.32978 A	0.33022 A
2.99999 A	0.33000 A	5 kHz	0.32735 A	0.33265 A
2.99999 A	0.33000 A	10 kHz	0.31840 A	0.34160 A
2.99999 A	1.09000 A	10 Hz	1.08827 A	1.09174 A
2.99999 A	1.09000 A	45 Hz	1.08951 A	1.09049 A
2.99999 A	1.09000 A	1 kHz	1.08951 A	1.09049 A
2.99999 A	1.09000 A	5 kHz	1.08355 A	1.09645 A
2.99999 A	1.09000 A	10 kHz	1.06320 A	1.11680 A
2.99999 A	2.99000 A	10 Hz	2.98542 A	2.99459 A
2.99999 A	2.99000 A	45 Hz	2.98840 A	2.99160 A
2.99999 A	2.99000 A	1 kHz	2.98840 A	2.99160 A
2.99999 A	2.99000 A	5 kHz	2.97405 A	3.00595 A
2.99999 A	2.99000 A	10 kHz	2.92520 A	3.05480 A
20.5000 A	3.3000 A	500 Hz	3.2954 A	3.3046 A
20.5000 A	3.3000 A	1 kHz	3.2954 A	3.3046 A
20.5000 A	3.3000 A	5 kHz	3.2155 A	3.3845 A

Table 3-27. Verification Tests for AC Current (cont)

Range	Output	Frequency	Lower Limit	Upper Limit
20.5000 A	10.9000 A	45 Hz	10.8926 A	10.9075 A
20.5000 A	10.9000 A	65 Hz	10.8926 A	10.9075 A
20.5000 A	10.9000 A	500 Hz	10.8893 A	10.9107 A
20.5000 A	10.9000 A	1 kHz	10.8893 A	10.9107 A
20.5000 A	10.9000 A	5 kHz	10.6255 A	11.1745 A
20.5000 A	20.0000 A	45 Hz	19.9750 A	20.0250 A
20.5000 A	20.0000 A	65 Hz	19.9750 A	20.0250 A
20.5000 A	20.0000 A	500 Hz	19.9690 A	20.0310 A
20.5000 A	20.0000 A	1 kHz	19.9690 A	20.0310 A
20.5000 A	20.0000 A	5 kHz	19.4950 A	20.5050 A

3-29. Verifying Capacitance

Verify that the 5520A performance is within the limits in Table 3-28. Use the PM 6304C RCL Meter directly for capacitance values up to and including 109.000 μF . Above 109.000 μF , you must use a timed charge up routine with a constant current source in order to achieve the required test uncertainty ratio.

To verify capacitance greater than 109.000 μF , see the section titled “200 μF to 110 mF Capacitance Verification” found later in this chapter.

Table 3-28. Verification Tests for Capacitance

Range	Output	Test Frequency or Current	Lower Limit	Upper Limit
0.3999 nF	0.1900 nF	5 kHz	0.1793 nF	0.2007 nF
0.3999 nF	0.3500 nF	1 kHz	0.3387 nF	0.3613 nF
1.0999 nF	0.4800 nF	1 kHz	0.4682 nF	0.4918 nF
1.0999 nF	0.6000 nF	1 kHz	0.5877 nF	0.6123 nF
1.0999 nF	1.0000 nF	1 kHz	0.9862 nF	1.0138 nF
3.2999 nF	2.0000 nF	1 kHz	1.9824 nF	2.0176 nF
10.9999 nF	7.0000 nF	1 kHz	6.9767 nF	7.0233 nF
10.9999 nF	10.9000 nF	1 kHz	10.8693 nF	10.9307 nF
32.9999 nF	20.0000 nF	1 kHz	19.8620 nF	20.1380 nF
109.999 nF	70.000 nF	1 kHz	69.767 nF	70.233 nF
109.999 nF	109.000 nF	1 kHz	108.693 nF	109.307 nF
329.999 nF	200.000 nF	1 kHz	199.320 nF	200.680 nF
329.999 nF	300.000 nF	1 kHz	299.130 nF	300.870 nF

Table 3-28. Verification Tests for Capacitance (cont)

Range	Output	Test Frequency or Current	Lower Limit	Upper Limit
1.09999 μF	0.70000 μF	100 Hz	0.69767 μF	0.70233 μF
1.09999 μF	1.09000 μF	100 Hz	1.08693 μF	1.09307 μF
3.29999 μF	2.00000 μF	100 Hz	1.99320 μF	2.00680 μF
3.29999 μF	3.00000 μF	100 Hz	2.99130 μF	3.00870 μF
10.9999 μF	7.0000 μF	100 Hz	6.9767 μF	7.0233 μF
10.9999 μF	10.9000 μF	100 Hz	10.8693 μF	10.9307 μF
32.9999 μF	20.0000 μF	100 Hz	19.9100 μF	20.0900 μF
32.9999 μF	30.0000 μF	100 Hz	29.8800 μF	30.1200 μF
109.999 μF	70.000 μF	50 Hz	69.662 μF	70.338 μF
109.999 μF	109.000 μF	50 Hz	108.529 μF	109.471 μF
329.999 μF	200.000 μF	54 μA dc	199.020 μF	200.980 μF
329.999 μF	300.000 μF	80 μA dc	298.680 μF	301.320 μF
1.09999 mF	0.33000 mF	90 μA dc	0.32788 mF	0.33212 mF
1.09999 mF	0.70000 mF	180 μA dc	0.69662 mF	0.70338 mF
1.09999 mF	1.09000 mF	270 μA dc	1.08529 mF	1.09471 mF
3.2999 mF	1.1000 mF	270 μA dc	1.0933 mF	1.1067 mF
3.2999 mF	2.0000 mF	540 μA dc	1.9902 mF	2.0098 mF
3.2999 mF	3.0000 mF	800 μA dc	2.9868 mF	3.0132 mF
10.9999 mF	3.3000 mF	900 μA dc	3.2788 mF	3.3212 mF
10.9999 mF	10.9000 mF	2.7 mA dc	10.8529 mF	10.9471 mF
32.9999 mF	20.0000 mF	5.4 mA dc	19.8300 mF	20.1700 mF
32.9999 mF	30.0000 mF	8.0 mA dc	29.7600 mF	30.2400 mF
110.000 mF	33.000 mF	9.0 mA dc	32.570 mF	33.430 mF
110.000 mF	110.000 mF	27.0 mA dc	108.800 mF	111.200 mF

3-30. 200 μF to 110 mF Capacitance Verification

The 5520A calibrator can source capacitance values much larger than what most RCL meters can measure. The method described below uses a dc current from a precision current source and a high speed sampling digital multimeter to verify the 5520A capacitance outputs from 200 μF to 110 mF.

3-31. Capacitance Measurement

By definition, capacitance is the product of an applied current and the ratio of the charging time to the charging voltage:

$$C = I * \frac{\Delta t}{\Delta v}$$

A technique for measuring capacitance is to apply a known current across the capacitor and measure the voltage change over a known time interval.

Table 3-29. Test Equipment Required for High-value Capacitance Measurement

Quan.	Manufacturer	Model	Equipment
1	Fluke	5500A/LEADS	Test lead set
1	Hewlett Packard	3458A	DMM
1	Fluke	5700A	Calibrator
Computer control of the instruments is highly recommended to eliminate manual timing uncertainties.			

Note

For this technique, the amplitude of the current is chosen to limit compliance voltage across the capacitor under test to < 3 V over a charging interval of 10 seconds. Refer to Table 3-28 for the dc current required for each capacitance value to be verified.

For proper timing, implementing this routine under computer control is highly recommended. See Figure 3-19. for an example Visual Basic program. If you wish to perform this verification under manual control, the HP 3458A DMM can be programmed from its front panel to give the necessary timing and reading storage. Please refer to the HP 3458A operator’s documentation for more information.

Proceed as follows to measure high-end capacitance:

1. Connect the Fluke 5700A, 5520A, HP 3458A DMM and computer as shown in Figure 3-18 below. See Table 3-29 for the equipment required.
2. Lock the HP 3458A in the 10 V dc range.
3. Program the meter to take 100 samples at 1 ms-aperture width and a 100 ms sweep for a total of 10 seconds on a trigger command.
4. Enter the desired capacitance on the 5520A and place the 5520A into Operate mode.
5. Enter the predetermined DCI level on the 5700A.
6. Set the 5700A to Operate.
7. As soon as the calibrator's remote status indicates a settled condition, your computer program should trigger the HP 3458A reading sequence. Voltage sensing is performed at the 5520A output.
8. At the completion of the measurement, set the 5700A to Standby and then retrieve the data from the HP 3458A.

Note

If operating under manual control, and you do not activate the 5700A Standby key in a timely manner, either the 5520A or 5700A will automatically trip into Standby because of an overload condition. This is acceptable and should not affect the readings over the 10 second measurement period.

9. The capacitance is computed as the product of the dc current and the ratio of the time interval (10 seconds) divided by $(V_{final} - V_{initial})$.

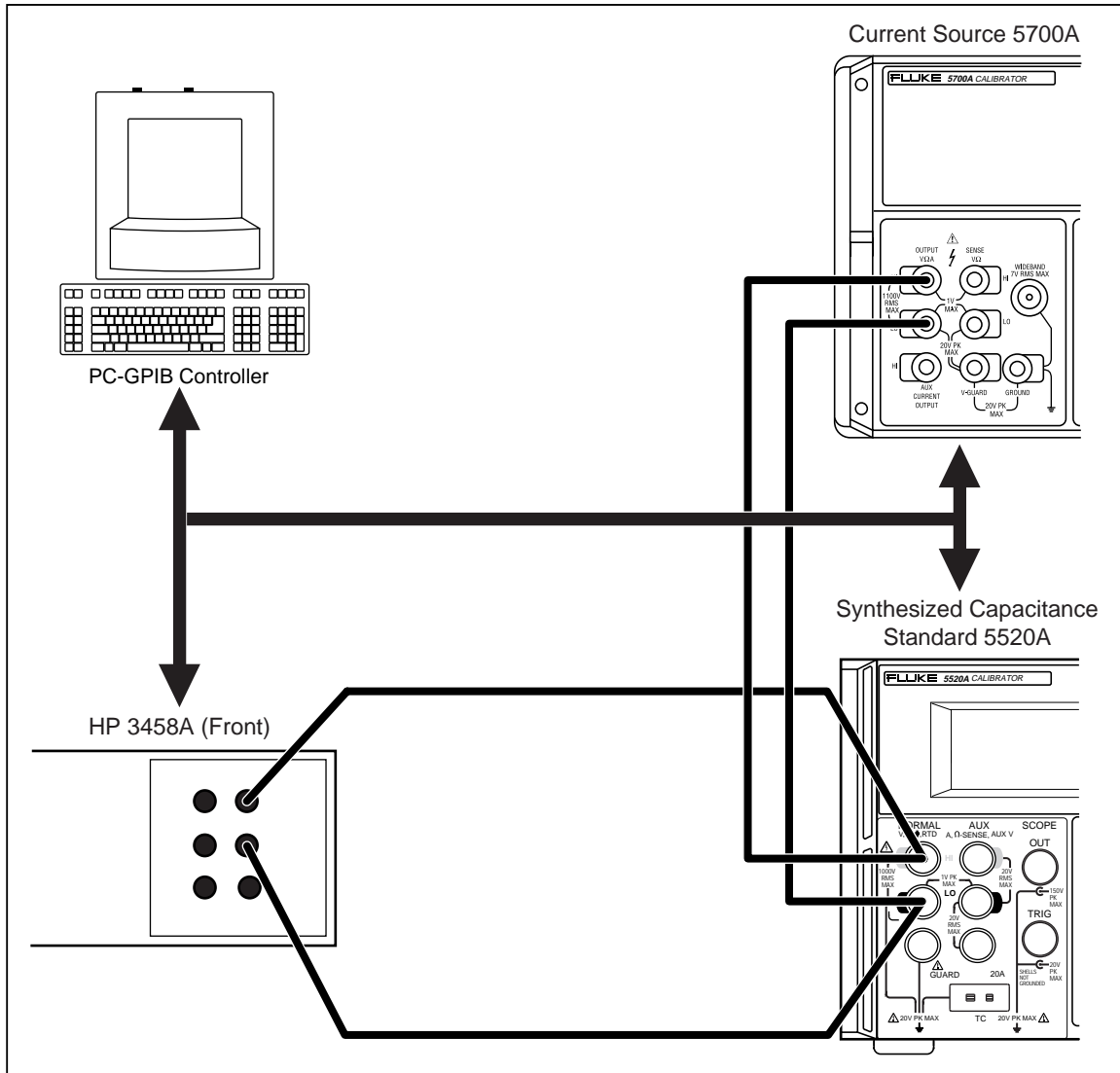


Figure 3-18. High Value Capacitance Measurement Set-up

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```

'Initial 3458 Set-up:

errmsg = gpibPut(a_3458, "TARM HOLD; DCV 10; APER 1.0e-3; MEM FIFO; SWEEP 0.1, 100; END
ALWAYS")
-----
'5700 setup

  If (range(stp) > .002) Then    ' 1mF range with LCR Meter, 3mF range with I charge
    ' 3458 has already been set-up for measurement; now
    ' set up system 5700 for DCI output, set to OPERate
    errmsg = gpibPut(a_5700, "CUR_POST AUX; OUT " + Str$(dci(stp)) + " A, 0 Hz")
    srcSettled
    errmsg = gpibPut(a_5700, "OPER")
    srcSettled
    Call trig_3458(stp)
    errmsg = gpibPut(a_5700, "STBY")
  End If
-----

Sub trig_3458 (stp As Integer)

  Dim x As Integer, errmsg As String, response As String, no_samples As Integer, deltav
  As Single
  result = 0

  ' all of the voltage data is stuck into this array for optional regression analysis
  Dim CapChan As Integer
  CapChan = FreeFile
  Open "C:\DATA\HICAP." & Format$(Str$(stp), "#") For Output As CapChan

  ' this triggers the readings and stores them internally in the 3458
  errmsg = gpibPut(a_3458, "TARM SGL")

  ' retrieve the number of samples stored - loop until meter is finished taking samples
  errmsg = gpibPut(a_3458, "MCOUNT?")
  Do
    response = Space$(80)
    errmsg = gpibGet(a_3458, response)
  Loop Until (Len(response) <> 0)
  no_samples = Val(response)

  ' now retrieve the data and put into array
  Print #CapChan, Val(response)
  For x = 1 To no_samples
    Do
      response = Space$(80)
      errmsg = gpibGet(a_3458, response)
    
```

Figure 3-19. Example Visual Basic Program

```
Loop Until (Len(response) <> 0)
    capdata(x) = Val(response)
    Print #CapChan, Val(response)
Next x
Close #CapChan

' throw out first and last reading, compute delta v
deltav = capdata(no_samples - 1) - capdata(2)

' dci() is the current; multiply by the charge time and divide product by change in
voltage
' charge time is (10 seconds - 2*100mS samples - 100mS for 0th sample)
result = (dci(stp) * 9.7) / deltav

End Sub
```

Figure 3-19. Example Visual Basic Program (cont)

3-32. Measurement Uncertainty

An example of how to compute measurement uncertainty for a 3 mF verification is shown below.

Error Analysis Example: 3 mF tested at 800 μ A

- 5700A DCI, 2.0 mA range: 50 ppm + 10 nA; at 800 μ A: 62.5 ppm.
- HP 3458A DCV, 10 V range: 4.1 ppm of reading + 0.05 ppm of range.
- HP 3458A time base uncertainty: 100 ppm.
- UUT (Fluke 5520A) 3.0 mF: 0.44%

While the HP 3458A dc volts accuracy is not specified for sample rates other than NPLC of 100, Fluke testing indicates the DMM is within 25 ppm for the fast sample rate. Adding the error terms yields (62.5 ppm + 25 ppm + 100 ppm) = 187.5 ppm, or 0.0187%, for a test uncertainty ratio (TUR) > 20:1. The DMM has a number of other error sources: linearity, uncertainty on the 10 V range at 2% of full scale, uncertainty in fast sample mode and internal trigger timing uncertainty are all of concern. Furthermore, the current source accuracy is not independent of the continuously changing compliance voltage. Fluke tests were performed to quantify each of these error sources, and none were found to contribute more than 0.02%. This is not significant relative to the 5520A capacitance verification. See Table 3-28 in this chapter for capacitance verification tests.

3-33. Verifying Thermocouple Simulation (Sourcing)

Verify that the 5520A performance is within the limits in Table 3-30. Use the HP3458A DMM as the measurement device. Use copper connectors and copper wires.

Table 3-30. Verification Tests for Thermocouple Simulation

TC Type	Output, °C	Lower Limit, mV	Upper Limit, mV
10 μ V/°C	0.00 °C (0.0000 mV)	-0.0030	0.0030
	100.00 °C (1.0000 mV)	0.99696	1.00304
	-100.00 °C (-1.0000 mV)	-1.00304	-.99696
	1000.00 °C (10.0000 mV)	9.99660	10.00340
	-1000.00 °C (-10.0000 mV)	-10.0034	-9.9966
	10000.00 °C (100.0000 mV)	99.9930	100.0070
	-10000.00 °C (-100.0000 mV)	-100.0070	-99.9930

3-34. Verifying Thermocouple Measurement

Verify that the 5520A performance is within the limits in Table 3-31. Use a Fluke 5500A Calibrator or similar instrument as the millivolt source, connected in parallel with an HP3458A DMM. At each verification point, use the 5500A error mode controls to adjust the calibrator output for a nominal reading on the DMM. Use copper connectors and copper wires.

Table 3-31. Verification Tests for Thermocouple Measurement

TC Type	Input, mV	Lower Limit, °C	Upper Limit, °C
10 μ V/°C	0.00 °C (0.0000 mV)	-0.30	0.30
	10000.00 °C (100.0000 mV)	9999.30	10000.70
	-10000.00 °C (-100.0000 mV)	-10000.70	-9999.30
	30000.00 °C (300.0000 mV)	29998.50	30001.50
	-30000.00 °C (-300.0000 mV)	-30001.50	-29998.50

3-35. Verifying Phase Accuracy, Volts and AUX Volts

Verify that the 5520A performance is within the limits in Table 3-32, using a precision phase meter.

Table 3-32. Verification Tests for Phase Accuracy, V and V

Range, Normal Output, V	Output, Normal V	Freq- uency	Range, AUX Output	Output, AUX	Phase °	Lower Limit °	Upper Limit °
3.29999	3.00000	65 Hz	3.29999 V	3.00000 V	0	-0.10	0.10
		400 Hz				-0.25	0.25
		1 kHz				-0.50	0.50
		5 kHz				-2.50	2.50
		10 kHz				-5.00	5.00
		30 kHz				-10.00	10.00
		65 Hz			60	59.90	60.10
		400 Hz				59.75	60.25
		1 kHz				59.50	60.50
		5 kHz				57.50	62.50
		10 kHz				55.00	65.00
		30 kHz				50.00	70.00
		65 Hz			90	89.90	90.10
		400 Hz				89.75	90.25
		1 kHz				89.50	90.50
		5 kHz				87.50	92.50
		10 kHz				85.00	95.00
		30 kHz				80.00	100.00
32.9999	30.0000	65 Hz				89.90	90.10
329.999	50.000	65 Hz				89.90	90.10

3-36. Verifying Phase Accuracy, Volts and Current

Verify that the 5520A performance is within the limits in Table 3-33, using a precision phase meter with a shunt, as specified previously for calibration.

Table 3-33. Verification Tests for Phase Accuracy, V and I

Range, Normal Output	Output, Normal	Freq- uency	Range, AUX Output	Output, AUX	Phase °	Lower Limit °	Upper Limit °
329.999 mV	30.000 mV	65 Hz	329.99 mA	300.00 mA	0	-0.10	0.10
329.999 mV	30.000 mV	1 kHz	329.99 mA	300.00 mA	0	-0.50	0.50
329.999 mV	30.000 mV	30 kHz	329.99 mA	300.00 mA	0	-10.00	10.00
329.999 mV	200.000 mV	65 Hz	2.99999 A	2.00000 A	0	-0.10	0.10
329.999 mV	50.000 mV	65 Hz	20.5000 A	5.0000 A	0	-0.10	0.10
329.999 mV	50.000 mV	400 Hz	20.5000 A	5.0000 A	0	-0.25	0.25
329.999 mV	30.000 mV	65 Hz	329.99 mA	300.00 mA	60	59.90	60.10
329.999 mV	200.000 mV	65 Hz	2.99999 A	2.00000 A	60	59.90	60.10
329.999 mV	200.000 mV	65 Hz	20.5000 A	20.0000 A	60	59.90	60.10
329.999 mV	200.000 mV	400 Hz	20.5000 A	20.0000 A	60	59.75	60.25
32.9999 V	3.3000 V	65 Hz	329.99 mA	300.00 mA	0	-0.10	0.10
32.9999 V	3.3000 V	65 Hz	2.99999 A	2.00000 A	0	-0.10	0.10
32.9999 V	3.3000 V	65 Hz	20.5000 A	5.0000 A	0	-0.10	0.10
32.9999 V	3.3000 V	400 Hz	20.5000 A	5.0000 A	0	-0.25	0.25
32.9999 V	3.3000 V	65 Hz	329.99 mA	300.00 mA	90	89.90	90.10
32.9999 V	3.3000 V	65 Hz	2.99999 A	2.00000 A	90	89.90	90.10
32.9999 V	3.3000 V	65 Hz	20.5000 A	20.0000 A	90	89.90	90.10
32.9999 V	3.3000 V	400 Hz	20.5000 A	20.0000 A	90	89.75	90.25
329.999 V	33.000 V	65 Hz	329.99 mA	300.00 mA	0	-0.10	0.10
329.999 V	33.000 V	65 Hz	2.99999 A	2.00000 A	0	-0.10	0.100
329.999 V	33.000 V	65 Hz	20.5000 A	5.0000 A	0	-0.10	0.10
329.999 V	33.000 V	400 Hz	20.5000 A	5.0000 A	0	-0.25	0.25
329.999 V	33.000 V	65 Hz	329.99 mA	300.00 mA	90	89.90	90.10
329.999 V	33.000 V	65 Hz	2.99999 A	2.00000 A	90	89.90	90.10
329.999 V	33.000 V	65 Hz	20.5000 A	20.0000 A	90	89.90	90.10
329.999 V	33.000 V	400 Hz	20.5000 A	20.0000 A	90	89.75	90.25

3-37. Verifying Frequency Accuracy

Verify that the 5520A performance is within the limits in Table 3-34, using a Fluke PM 6680B Frequency Counter.

Table 3-34. Verification Tests for Frequency

Range, Normal Output, V	Output, Normal, V	Frequency	Lower Limit*	Upper Limit*
3.29999	3.00000	119.00 Hz	118.99970 Hz	119.00030 Hz
		120.0 Hz	119.99970 Hz	120.00031 Hz
		1000.0 Hz	999.9975 Hz	1000.0025 Hz
		100.00 kHz	99,999.75 Hz	100,000.25 Hz

* Frequency accuracy is specified for 1 year

Chapter 4

Maintenance

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4-1. Introduction

Because this is a high performance instrument, it is not recommended that the user service the boards to the component level. In many different ways it is easy to introduce a subtle long-term stability problem by handling the boards. Access procedures are provided for those who want to replace a faulty module.

4-2. Access Procedures

Use the following procedures to remove the following assemblies:

- Analog modules.
- Main CPU (A9).
- Rear Panel Module (transformer and ac line input components).
- Filter PCA (A12).
- Encoder (A2) and display assemblies.
- Keyboard PCA, and thermocouple I/O pca.

4-3. Removing Analog Modules

Proceed as follows to remove the Voltage (A8), Current (A7), DDS (A6), or Synthesized Impedance (A5) modules:

1. Remove the eight Phillips screws from the top cover.
2. Remove the top cover.
3. Remove the eight Phillips screws from the guard box cover. The locations of the analog modules are printed on the guard box cover.
4. Lift off the guard box cover using the finger pull on the rear edge of the cover.
5. On the desired analog module, release the board edge locking ears.
6. Lift the board out of its socket in the Motherboard. Lay the board shield side down.
7. To remove the shield, remove Phillips screw at the center of the shield, then pull the sides of the shield away from the board.
8. To reinstall the shield, first align one set of tabs then press the other side into place.

4-4. Removing the Main CPU (A9)

You can remove the Main CPU (A9) without removing the rear panel or Filter PCA (A12). Proceed as follows to remove the Main CPU PCA:

1. Remove the 3/16" jack screws from the SERIAL 1, SERIAL 2, and BOOST AMPLIFIER connectors.
2. Remove the 1/4" jack screws from the IEEE-488 connector.
3. Remove the three Phillips screws from the right side of the rear panel.
4. Remove the ribbon cable from the Main CPU PCA (A9). There is not much room, but the cable is reachable.
5. Lift out the Main CPU PCA.

4-5. Removing Rear Panel Assemblies

Proceed as follows to remove the transformer and the ac line input filter. Figure 4-1 shows an exploded view of the rear panel assemblies.

1. Remove the two rear handles by removing the six Allen screws from the handles.
2. Remove the eight Phillips screws from the bottom cover.
3. Remove the bottom cover.
4. Remove the three Phillips screws that are accessible through holes in the bottom flange.
5. Remove the power switch pushrod.
6. Remove the rear panel. There are three large cables, plus one for fan power. This assumes that you have already removed the Main CPU (A9). If the Main CPU is still installed, there will be one more cable.

4-6. Removing the Filter PCA (A12)

Proceed as follows to remove the Filter PCA (A12):

1. Remove the top cover and guard box cover as described under “Removing Analog Modules.”
2. Remove all the analog modules.
3. Remove the five Phillips screws from the front side of the rear guard box wall.
4. Lift out the Filter PCA.

4-7. Removing the Encoder (A2) and Display PCAs

Proceed as follows to remove the Encoder PCA (A2) and display pca's. Figure 4-2 shows an exploded view of the front panel assemblies.

1. Remove top and bottom covers.
2. With the bottom side up, unplug all the cables going to the front panel. One of these cables is fastened by a cable tie that must be cut, then replaced with a new one when reassembling.
3. Remove the two front handles by removing the six Allen screws from the handles.
4. Remove the front panel. The Encoder PCA (A2) and display pca's are now accessible.

4-8. Removing the Keyboard and Accessing the Output Block

To remove the keyboard and access the output block, proceed as follows:

1. Do all four steps of the previous procedure.
2. Unlatch the plastic catches that fasten the front panel together.
3. Remove the four Phillips screws that are around the output block.
4. Remove the output cables.
5. Separate the two main parts of the front panel.

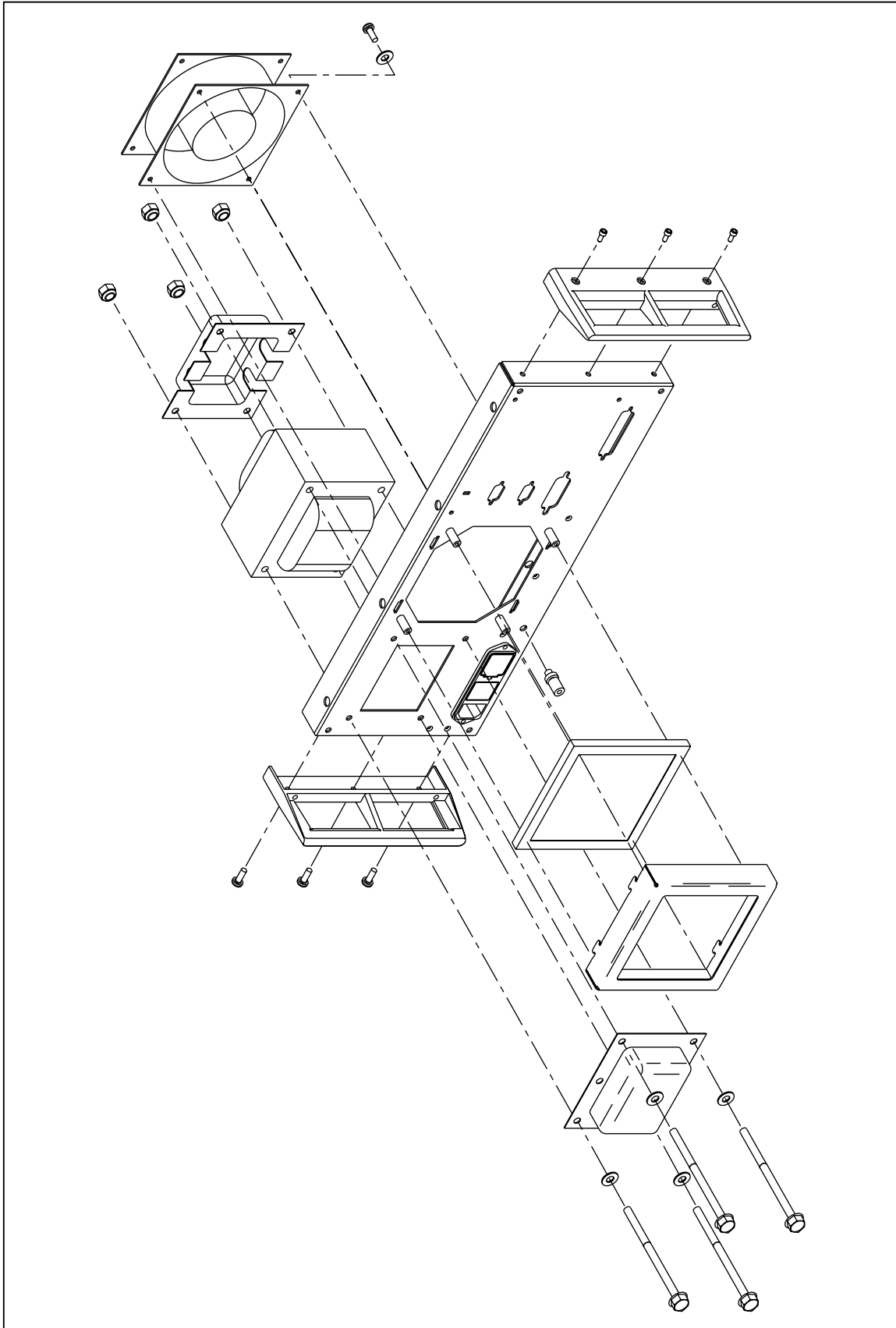


Figure 4-1. Exploded View of Rear Panel Assemblies

om016f.eps

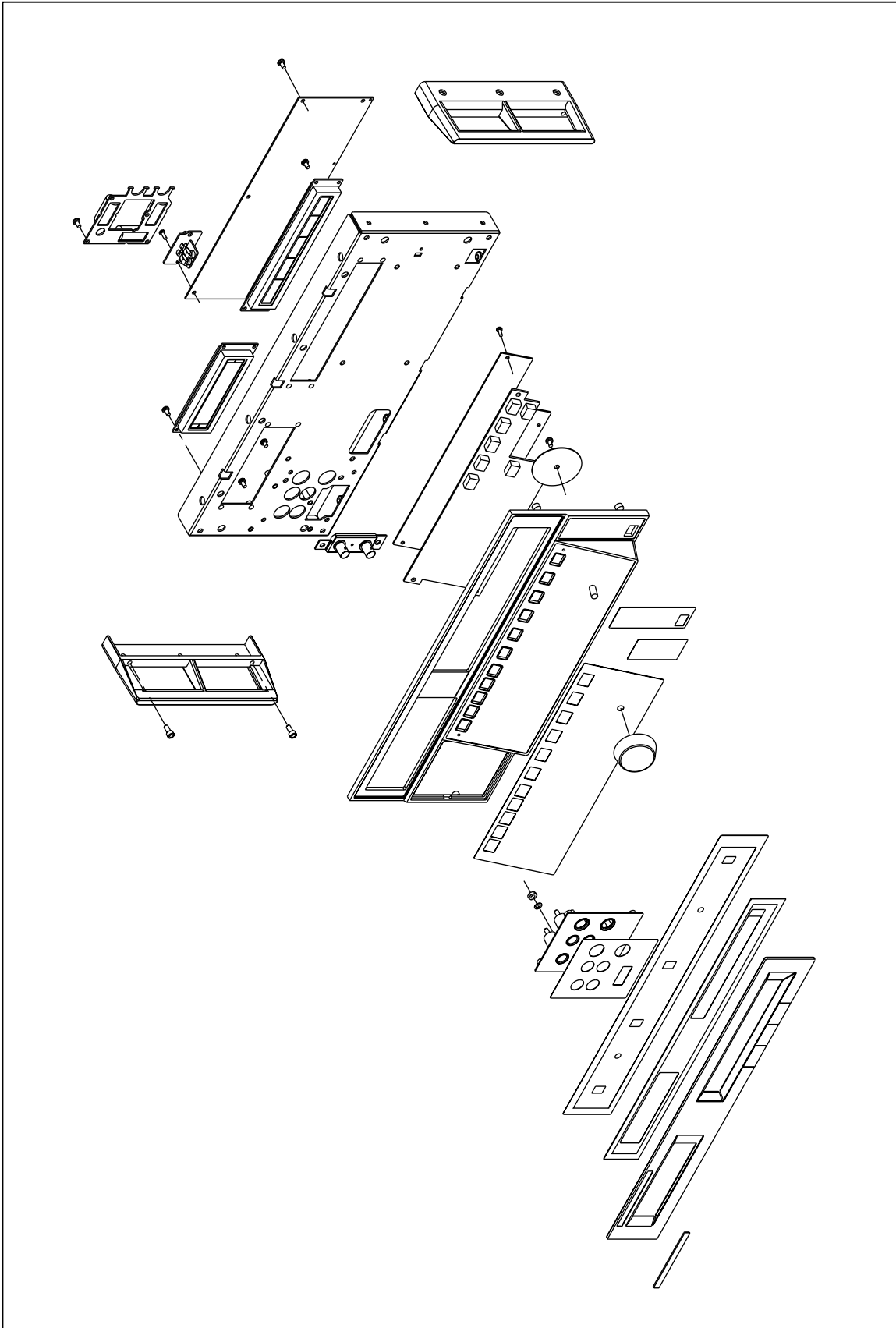


Figure 4-2. Exploded View of Front Panel Assemblies

om017f.eps

4-9. Diagnostic Testing

5520A internal software provides extensive self-testing capabilities. In case of a malfunction, this is an excellent place to begin testing to isolate a faulty module.

Note

Self-tests should only be run after the 5520A has completed its warm-up.

Access the diagnostics menu as follows:

Press **SETUP** followed by UTILITY FUNCTNS, and SELF TEST. The menu presents the following choices:

- DIAG -- Runs internal diagnostics.
- FRONT PANEL -- Allows you to test the front panel knob, keys, bell, and displays.
- SERIAL IF TEST -- Does a loopback test between the two serial ports. For this test, you attach a straight-through serial cable between the two serial ports. At least pins 2, 3, and 5 need to be connected.
- DIGITAL TEST -- Checks the RAM and bus on the Main CPU (A9).

4-10. Running Diagnostics

Press **SETUP** followed by UTILITY FUNCTNS, SELF TEST, and DIAG. The menu presents the following choices: OPTIONS and GO ON. Press GO ON to start diagnostics. The 5520A prompts you to remove all cables from the front panel outputs. Install a low-ohm copper short circuit across the 20 A and Aux Lo terminals.

After you press the GO NO softkey, an automatic sequence of tests begins. Diagnostics runs a set of steps similar to zero calibration and reports similar errors.

4-11. Testing the Front Panel

Press **SETUP** followed by UTILITY FUNCTNS, SELF TEST, and FRONT PANEL. The menu presents the following choices: KNOB TEST, KEY TEST BELL TEST, and DISPLAY. These tests are described next:

- KNOB TEST -- Tests the knob encoder by showing a cursor that moves when you turn the knob.
- KEY TEST -- Lets you check the proper functioning of each key. When you press a key, the name of the key shows on the display. Press PREV MENU to exit this test.
- BELL TEST -- Lets you ring the bell (beeper) for various timed periods.
- DISPLAY -- Checks all the segments of the two displays.

4-12. Complete List of Error Messages

The following is a list of the 5520A Calibrator error messages. The error message format is shown in Table 4-1.

Table 4-1. Error Message Format

Error Number	(Message Class : Description)	Text characters
0 to 65535	QYE Query Error, caused by a full input buffer, unterminated action or interrupted action	F Error is displayed on the front panel as it occurs
	DDE Device-Specific Error, caused by the 5520A due to some condition, for example, overrange	R Error is queued to the remote interface as it occurs
	EXE Execution Error, caused by an element outside of, or inconsistent with, the 5520A capabilities	S Error causes instrument to go to Standby
	CME Command Error, caused by incorrect command syntax, unrecognized header, or parameter of the wrong type	D Error causes instrument returns to the power up state
		(none) Error is returned to the initiator only (i.e., local initiator or remote initiator)

0	(QYE:)	No Error
1	(DDE:FR)	Error queue overflow
100	(DDE:FR D)	Inguard not responding (send)
101	(DDE:FR D)	Inguard not responding (recv)
102	(DDE:FR D)	Lost sync with inguard
103	(DDE:FR)	Invalid guard xing command
104	(DDE:FR D)	Hardware relay trip occurred
105	(DDE:FR D)	Inguard got impatient
106	(DDE:FR D)	A/D fell asleep
107	(DDE:FR D)	Inguard watchdog timeout
108	(DDE:FR)	Inguard is obsolete
109	(DDE:FR D)	Inguard parity error
110	(DDE:FR D)	Inguard overrun error
111	(DDE:FR D)	Inguard framing error
112	(DDE:FR D)	Inguard fault error
113	(DDE:FR D)	Inguard fault input error
114	(DDE:FR D)	Inguard fault detect error
115	(DDE:FR D)	Inguard read/write error
300	(DDE:)	Invalid procedure number
301	(DDE:)	No such step in procedure
302	(DDE:)	Can't change that while busy
303	(DDE:)	Can't begin/resume cal there

304	(DDE:)	Wrong unit for reference
305	(DDE:)	Entered value out of bounds
306	(DDE:)	Not waiting for a reference
307	(DDE:)	Continue command ignored
308	(DDE:FR)	Cal constant outside limits
309	(DDE:FR)	Cal try to null failed
310	(DDE:FR D)	Sequence failed during cal
311	(DDE:FR D)	A/D measurement failed
312	(DDE:FR)	Invalid cal step parameter
313	(DDE:)	Cal switch must be ENABLED
314	(DDE:FR)	Divide by zero encountered
315	(DDE:FR)	Must be in OPER at this step
316	(DDE:FR)	Open thermocouple for RJ cal
317	(DDE:FR)	Bad reference Z or entry
318	(DDE:FR)	Cal takes DAC over top limit
319	(DDE: R)	Zero cal needed every 7 days
320	(DDE: R)	Ohms zero needed every 12 hours
398	(QYE:F)	Unusual cal fault %d
399	QYE:F)	Fault during %s
400	(DDE:FR D)	Encoder not responding VERS
401	(DDE:FR D)	Encoder not responding COMM
402	(DDE:FR D)	Encoder not responding STAT
403	(DDE:FR)	Encoder self-test failed
405	(DDE:FR)	Message over display R side
406	(DDE:FR)	Unmappable character #%d
407	(DDE:FR)	Encoder did not reset
408	(DDE:FR)	Encoder got invalid command
409	(DDE:FR D)	Encoder unexpectedly reset
500	(DDE:)	Internal state error
501	(DDE:)	Invalid keyword or choice
502	(DDE:)	Harmonic must be 1 - 50
503	(DDE:)	Frequency must be >= 0
504	(DDE:)	AC magnitude must be > 0
505	(DDE:)	Impedance must be >= 0
506	(DDE:)	Function not available
507	(DDE:)	Value not available
508	(DDE:)	Cannot enter watts by itself
509	(DDE:)	Output exceeds user limits
510	(DDE:)	Duty cycle must be 1.0-99.0
511	(DDE:)	Power factor must be 0.0-1.0
512	(DDE:)	Can't select that field now
513	(DDE:)	Edit digit out of range
514	(DDE:)	Can't switch edit field now
515	(DDE:)	Not editing output now
516	(DDE:)	dBm only for single sine ACV
517	(DDE:)	Freq too high for non-sine
518	(DDE:)	Value outside locked range
519	(DDE:)	Must specify an output unit
520	(DDE:)	Can't do two freqs at once
521	(DDE:)	Can't source 3 values at once
522	(DDE:)	Temp must be degrees C or F
523	(DDE:)	Can't do that now

526	(DDE:)	Limit too small or large
527	(DDE:)	No changes except RESET now
528	(DDE:)	Offset out of range
529	(DDE:)	Cannot edit to or from 0 Hz
530	(DDE:)	Bad state image - not loaded
531	(DDE:)	TC offset limited to +/-500 C
532	(DDE:)	Can't go to STBY in Meas TC
533	(DDE:)	Can't set an offset now
534	(DDE:)	Can't lock this range
535	(DDE:)	Can't set phase or PF now
536	(DDE:)	Can't set wave now
537	(DDE:)	Can't set harmonic now
538	(DDE:)	Can't change duty cycle now
539	(DDE:)	Can't change compensation now
540	(DDE:FR)	Current OUTPUT moved to 5725A
541	(DDE:)	TC ref must be valid TC temp
542	(DDE:)	Can't turn EARTH on now
543	(DDE: D)	STA couldn't update OTD
544	(DDE:)	Can't enter W with non-sine
545	(DDE:)	Can't edit now
546	(DDE:)	Can't set trigger to that now
547	(DDE:)	Can't set output imp. now
548	(DDE:FR)	Compensation is now OFF
549	(DDE:)	Period must be >= 0
550	(DDE:)	A report is already printing
551	(DDE:)	ScopeCal option not installed
552	(DDE:)	Not a ScopeCal function
553	(DDE:)	Can't set marker shape now
554	(DDE:)	Can't set video parameter now
555	(DDE:)	Marker location out of range
556	(DDE:)	Pulse width must be 1 - 255
557	(DDE:)	Can't set range directly now
558	(DDE:)	Not a range for this function
559	(DDE:)	Can't set TD pulse now
560	(DDE:)	ZERO_MEAS only for C or PRES meas
561	(DDE:FR)	That requires a -SC option
562	(DDE:FR)	That requires a -SC600 option
563	(DDE:)	Time limit must be 1s-60s
564	(DDE:)	Can't set ref. phase now
565	(DDE:)	ZERO_MEAS reading not valid
566	(DDE:)	Can't set dampen now
567	(DDE:)	Can't turn EXGRD on now
600	(DDE:FR D)	Outguard watchdog timeout
601	(DDE:FR)	Power-up RAM test failed
602	(DDE:FR)	Power-up GPIB test failed
700	(DDE: R)	Saving to NV memory failed
701	(DDE: R)	NV memory invalid
702	(DDE: R)	NV invalid so default loaded
703	(DDE: R)	NV obsolete so default loaded
800	(DDE:FR)	Serial parity error %s
801	(DDE:FR)	Serial framing error %s
802	(DDE:FR)	Serial overrun error %s

803	(DDE:FR)	Serial characters dropped %s
900	(DDE:FR)	Report timeout - aborted
1000	(DDE:FR)	Sequence failed during diag
1200	(DDE:FR)	Sequence name too long
1201	(DDE:FR)	Sequence RAM table full
1202	(DDE:FR)	Sequence name table full
1300	(CME: R)	Bad syntax
1301	(CME: R)	Unknown command
1302	(CME: R)	Bad parameter count
1303	(CME: R)	Bad keyword
1304	(CME: R)	Bad parameter type
1305	(CME: R)	Bad parameter unit
1306	(EXE: R)	Bad parameter value
1307	(QYE: R)	488.2 I/O deadlock
1308	(QYE: R)	488.2 interrupted query
1309	(QYE: R)	488.2 unterminated command
1310	(QYE: R)	488.2 query after indefinite response
1311	(DDE: R)	Invalid from GPIB interface
1312	(DDE: R)	Invalid from serial interface
1313	(DDE: R)	Service only
1314	(EXE: R)	Parameter too long
1315	(CME: R)	Invalid device trigger
1316	(EXE: R)	Device trigger recursion
1317	(CME: R)	Serial buffer full
1318	(EXE: R)	Bad number
1319	(EXE: R)	Service command failed
1320	(CME: R)	Bad binary number
1321	(CME: R)	Bad binary block
1322	(CME: R)	Bad character
1323	(CME: R)	Bad decimal number
1324	(CME: R)	Exponent magnitude too large
1325	(CME: R)	Bad hexadecimal block
1326	(CME: R)	Bad hexadecimal number
1328	(CME: R)	Bad octal number
1329	(CME: R)	Too many characters
1330	(CME: R)	Bad string
1331	(DDE: R)	OPER not allowed while error pending
1332	(CME:FR)	Can't change UUT settings now
1500	(DDE:FRS)	Compliance voltage exceeded
1501	(DDE:FRS)	Shunt amp over or underload
1502	(DDE:FRS)	Current Amp Thermal Limit Exceeded
1503	(DDE:FRS)	Output current lim exceeded
1504	(DDE:FRS)	Input V or A limit exceeded
1505	(DDE:FRS)	VDAC counts out of range
1506	(DDE:FRS)	IDAC counts out of range
1507	(DDE:FRS)	AC scale dac counts out of range
1508	(DDE:FRS)	DC scale dac counts out of range
1509	(DDE:FRS)	Frequency dac counts out of range
1510	(DDE:FRS)	IDAC counts (DC OFFSET) out of range
1511	(DDE:FRS)	ZDAC counts out of range
1512	(DDE:FRS)	Can't read External Clock register
1513	(DDE:FRS)	External Clock too Fast

1514	(DDE:FRS)	External Clock too Slow
1515	(DDE:FR D)	Can't load waveform for scope mode
1600	(DDE:FR D)	OPM transition error
1601	(DDE:FR D)	TC measurement fault
1602	(DDE:FR D)	Z measurement fault
65535	(DDE:FR)	Unknown error %d

Chapter 5
List of Replaceable Parts

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5-1. Introduction

This chapter contains an illustrated list of replaceable parts for Fluke model 5520A Multi-Product Calibrator. Parts are listed by assembly; alphabetized by reference designator. Each assembly is accompanied by an illustration showing the location of each part and its reference designator. Refer to Tables 5-1 through 5-3.

The parts lists give the following information:

- Reference designator (for example, “R52”)
- An indication if the part is subject to damage by static discharge (* near the part description)
- Description
- Fluke stock number
- Total quantity
- Any special notes (i.e., factory-selected part)

Caution

A * symbol indicates a device that may be damaged by static discharge.

5-2. How to Obtain Parts

Electronic components may be ordered directly from the Fluke Corporation and its authorized representatives by using the part number under the heading Fluke Stock No. Parts price information is available from the Fluke Corporation or its representatives.

To contact Fluke, call one of the following telephone numbers:

USA and Canada: 1-888-99-FLUKE (1-888-993-5853)

Europe: +31 402-678-200

Japan: +81-3-3434-0181

Singapore: +65-738-5655

Anywhere in the world: +1-425-356-5500

Or, visit the Fluke web site at **www.fluke.com**. A list of service centers is available on the Fluke web site.

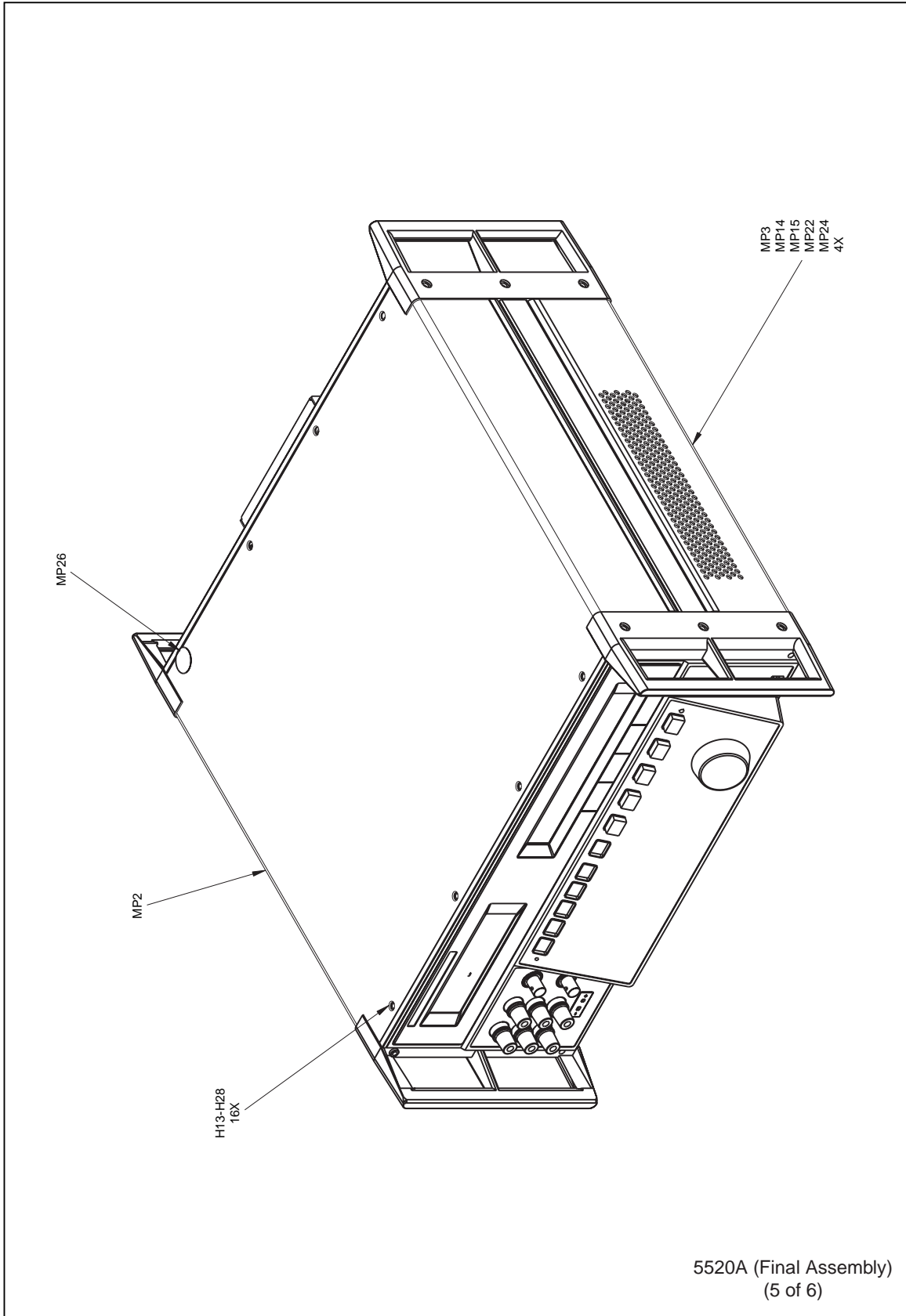
In the event that the part ordered has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

To ensure prompt delivery of the correct part, include the following information when you place an order:

- Instrument model and serial number
- Part number and revision level of the pca (printed circuit assembly) containing the part.
- Reference designator
- Fluke stock number
- Description (as given under the Description heading)
- Quantity

Table 5-1. Chassis Assembly

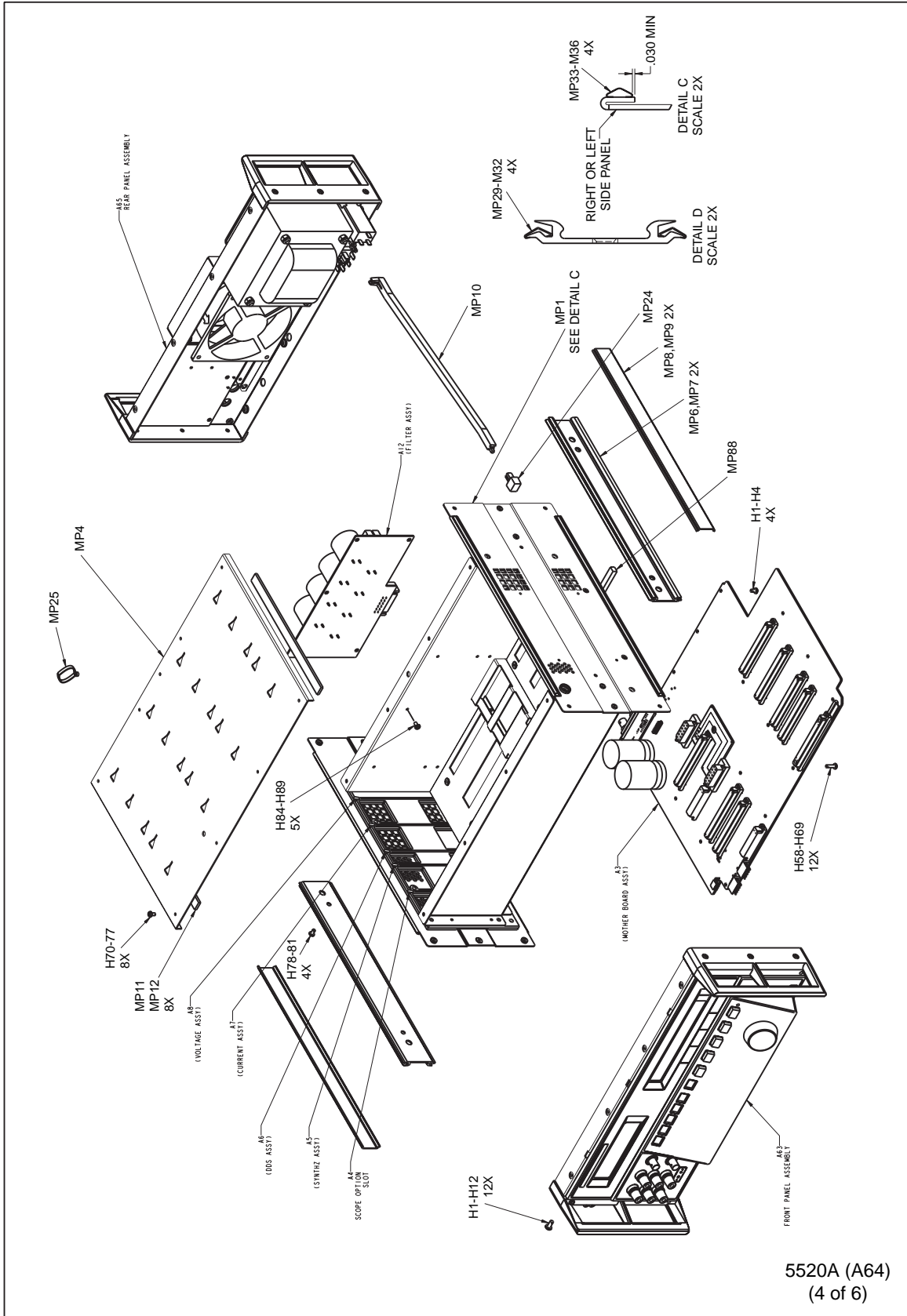
Reference Designator	Description	Fluke Stock No.	Total Quantity
A1	*PCB, KEYBOARD	760868	1
A2	*PCA, ENCODER	627232	1
A3	*PCA, SUB-ASSY, MOTHERBOARD	626694	1
A5	*PCA, SYNTHESIZED IMPEDANCE	626892	1
A6	*PCA, DDS	626900	1
A7	*PCA, CURRENT	626918	1
A8	*PCA, SUB-ASSY, VOLTAGE	626710	1
A9	*PCA, MAIN CPU	626934	1
A12	*PCA, SUB-ASSY, FILTER	626736	1
BT1	BATTERY,LITHIUM,3.0V,0.560AH	821439	1
H1-12	SCREW,CAP,SCKT,SS,8-32,.375	295105	12
H13-20	SCREW,FHU,P,LOCK,MAG SS,6-32,.	320093	8
H21-28,H78-81	SCREW,FHU,P,LOCK,MAG SS,6-32,.	320093	12
H58-69	SCREW,PH,P,LOCK,SS,6-32,.500	320051	12
H82-89	SCREW,PH,P,LOCK,STL,6-32,.250	152140	8
H90,H93	CONN ACC,COAX,BNC,NUT	622719	2
H91,H94	CONN ACC,COAX,BNC,LOCKWASHER	622743	2
MP1	ASSEMBLY, CHASSIS, RIVETED	617255	1
MP2	COVER, INSTRUMENT TOP	647146	1
MP3	COVER, INSTRUMENT BOTTOM	627213	1
MP4	COVER, ANALOG, TOP	937086	1
MP6,MP7	EXTRUSION, SIDE	937271	2
MP8,MP9	INSERT, PLASTIC SIDE	937276	2
MP10	PUSH ROD	945241	1
MP11,MP12	TAPE,FOAM,VINYL,.500,.125	330449	1
MP14,MP15,MP22,MP24	BOTTOM FOOT, MOLDED, GRAY #7	868786	4
MP25	AIDE,PCB PULL	541730	1
MP26,MP19	LABEL,CALIB, CERTIFICATION SEA	802306	2
MP29-32	GRND STRIP,CU FINGERS,.32,12.5	601770	4
MP33,MP34	GRND STRIP,CU FINGERS,ADHES,.3	601762	2
MP35,MP36	GRND STRIP,CU FINGERS,ADHES,.3	601762	2
MP88	TAPE,FOAM,POLYUR,W/LINER,.3125	603134	1
* Indicates a device that may be damaged by static discharge.			



5520A (Final Assembly)
(5 of 6)

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Figure 5-1. Chassis Assembly



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Figure 5-1. Chassis Assembly (cont)

Table 5-2. Front Panel Assembly

Reference Designator	Description	Fluke Stock No.	Total Quantity
H1-14,H28	SCREW,PH,P,LOCK,STL,6-32,.250	152140	15
H15-18	SCREW,CAP,SKT,SS,8-32,.375	295105	4
H19-27,H36, H37	SCREW,WH,P,THD FORM,STL,5-20,.	494641	11
H29,H60,H61	BINDING POST-RED	886382	3
H38-041,H50-55	WASHER, LOW THERMAL #8	859939	10
H42-45,H63-68	NUT, LOW THERMAL, 8-32	850334	10
H46-49	SCREW,PH,P,LOCK,STL,6-32,.625	152181	4
H58,H62	BINDING POST-BLACK	886379	2
H59	BINDING POST-BLUE	886366	1
H71-76	SCREW,PH,P,LOCK,SS,6-32,.500	320051	6
J1,J2	CONN,COAX,BNC(F),CABLE	412858	2
MP1	FRONT PANEL, MODIFIED	937284	1
MP2	PANEL, FRONT	626108	1
MP3,MP4	HANDLE,INSTRUMENT, GRAY #7	886333	2
MP6	OUTPUT BLOCK	625704	1
MP8	DECAL, OUTPUT BLOCK	625731	1
MP9	LENS, BEZEL	945246	1
MP11	ADHESIVE, BEZEL	945258	1
MP12	NAMEPLATE	626983	1
MP13	LCD MODULE,16X2 CHAR,TRANSMISS	929179	1
MP14	LCD MODULE,40X2 CHAR,TRANSMISS	929182	1
MP18	DECAL, POWER ON/OFF	886312	1
MP20	DECAL, KEYPAD	886304	1
MP21	ENCODER WHEEL	764548	1
MP22	KNOB, ENCODER, GREY	868794	1
MP24	POWER BUTTON, ON/OFF	775338	1
MP31	CLAMP,TOROID	627080	1
MP32,MP33	GASKET, FRONT PANEL	627072	2
MP34	GASKET, CONDUCTIVE	627064	1
MP35	CLAMP,CABLE,.50 ID,ADHESIVE MO	688629	1
MP36	GROMMET,SLOT,RUBBER,.406,.062	501593	1
MP38,MP39	MOUNT,SHOCK,FOAM,ADHES,.312,.6	107687	2
MP40,MP41	CLIP,FLAT CABLE FERRITE CORE	643822	2

Table 5-2. Front Panel Assembly (cont)

Reference Designator	Description	Fluke Stock No.	Total Quantity
MP42,MP43	CORE,FERRITE,FLAT CABLE,2.0W,2	643814	2
MP47	CABLE ACCESS,TIE,11.00L,.19W,3	501734	1
MP48	SHIELD, DISPLAY	661717	1
MP55	GROMMET,EXTRUDED,POLYETHYLENE,	854351	1
MP67	TAPE,FOAM,VINYL,.500,.062	282152	1
MP66	BEZEL, FRONT PANEL	945238	1
S7	KEYPAD, ELASTOMERIC	626967	1
W99	CABLE, OUTPUT TO MOTHER BOARD	625936	1

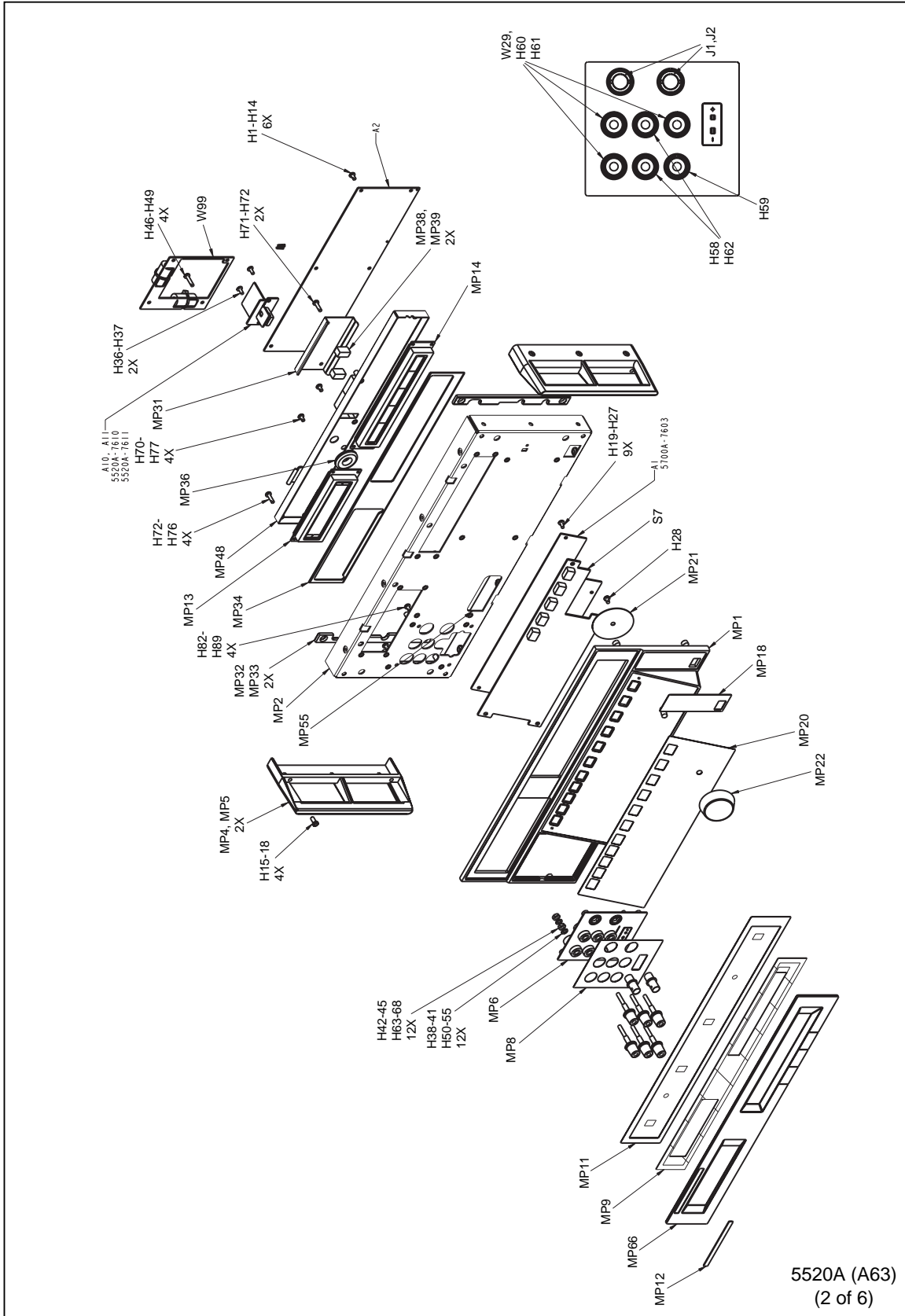


Figure 5-2. Front Panel Assembly

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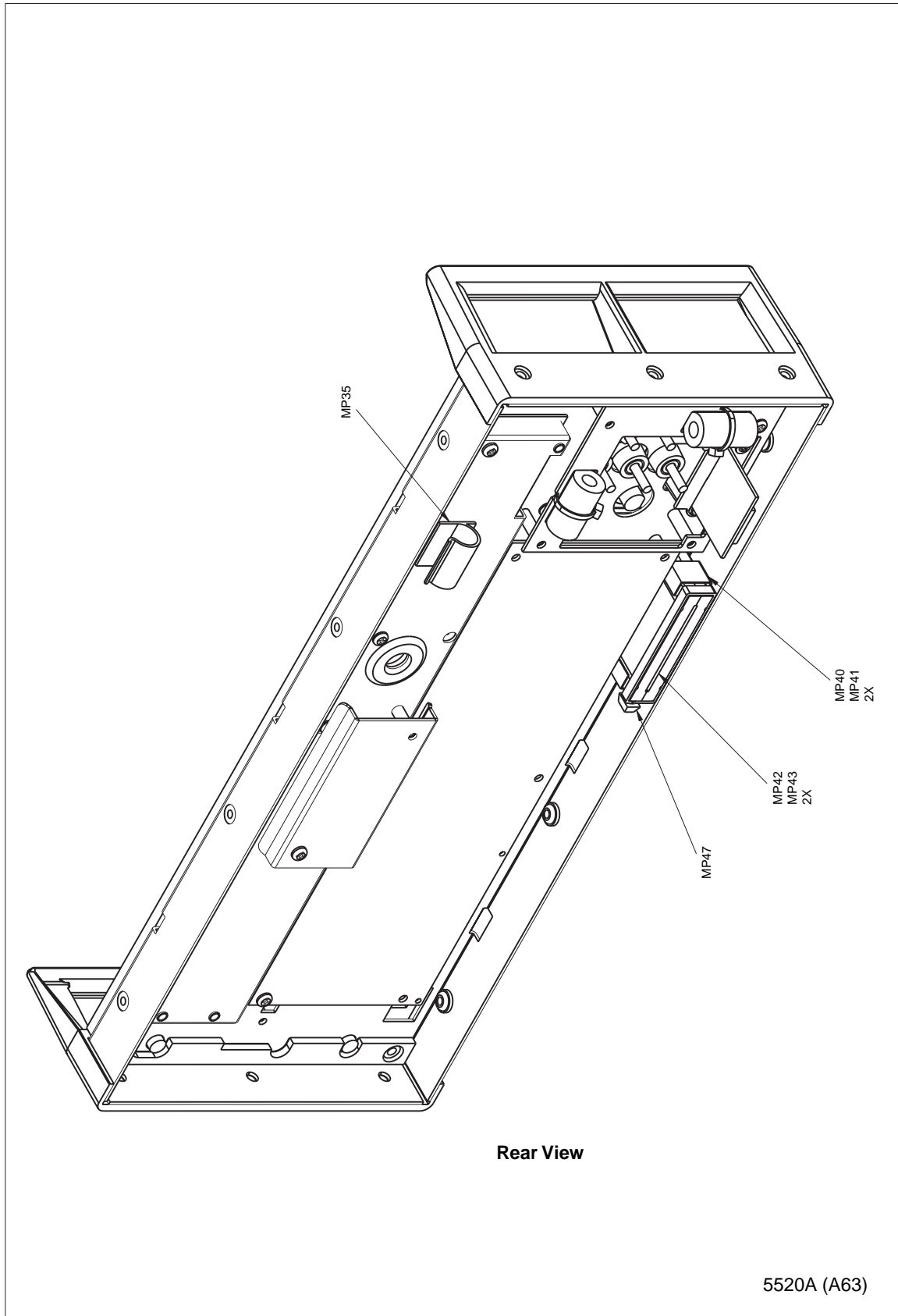


Figure 5-2. Rear View Front Panel Assembly (cont)

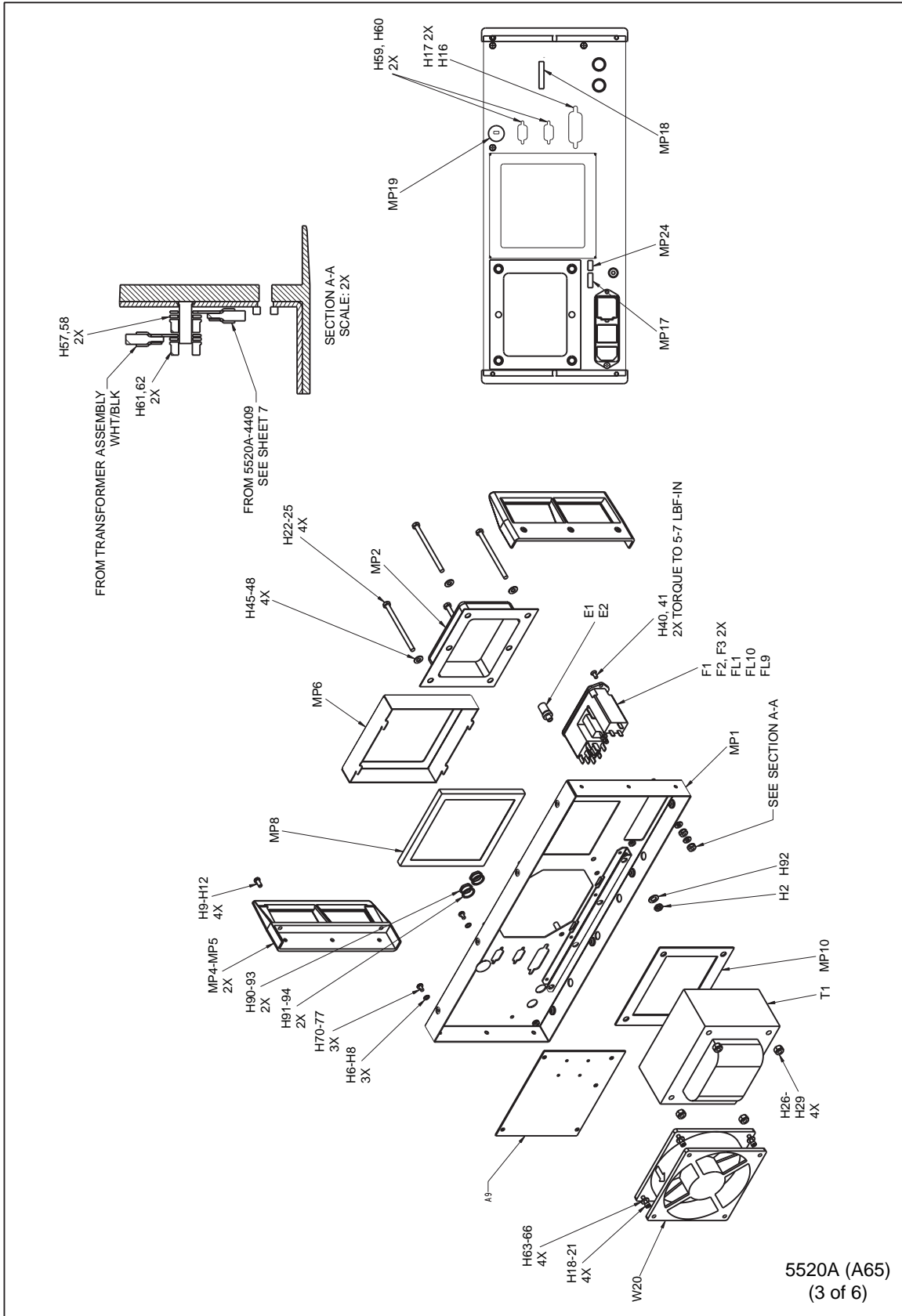
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Table 5-3. Rear Panel Assembly

Reference Designator	Description	Fluke Stock No.	Total Quantity
E1	BINDING HEAD, PLATED	102889	1
E2	BINDING POST, STUD, PLATED	102707	1
F1	FUSE, .25X1.25,5A,250V,SLOW	109215	1
F2,F3	FUSE, .25X1.25,2.5A,250V,SLOW	851931	2
FL1	FILTER,LINE,250VAC,4A,W/ENTRY	944269	1
FL10	FILTER,LINE,PART,FUSE DRWR W/S	944277	1
FL9	FILTER,LINE,PART,VOLTAGE SELEC	944272	1
H2	NUT,HEX,BR,1/4-28	110619	1
H3-5	SCREW,PH,P,LOCK,STL,6-32,.250	152140	3
H6-8	WASHER,FLAT,STL,.160,.281,.010	111005	3
H9-12	SCREW,CAP,SCKT,SS,8-32,.375	295105	4
H16,H17	CONN ACC,MICRO-RIBBON,SCREW LO	854737	2
H18-21	SCREW,CAP,SCKT,STL,LOCK,6-32,.	944772	4
H22-25	SCREW, MODIFIED	660933	4
H26-29	NUT,HEX,ELASTIC STOP,STL,10-32	944350	4
H40,H41	SCREW,FHU,P,SS,6-32,.312	867234	2
H45-48	WASHER,FLAT,STL,.203,.434,.031	110262	4
H49,H50	WASHER,FLAT,STL,.191,.289,.010	111047	2
H52,H56	NUT, LOW THERMAL, 8-32	850334	2
H53,H55	WASHER, LOW THERMAL #8	859939	2
H57,H58	WASHER,FLAT,SS,.174,.375,.030	176743	2
H59,H60	CONN ACC,D-SUB,JACKSCREW KIT,.	944715	2
H61,H62	NUT,EXT LOCK,STL,8-32	195263	2
H63-66	WASHER,FLAT,STL,.170,.375,.031	110288	4
H92	WASHER,LOCK,INTRNL,STL,.267ID	110817	1
MP1	PANEL, REAR	626975	1
MP2	TRANSFORMER COVER, PAINTED	647138	1
MP4,MP5	HANDLE,INSTRUMENT, GRAY #7	886333	2
MP6	HOUSING, AIR FILTER	937107	1
MP8	AIR FILTER	945287	1
MP10	SHIM,TRANSFORMER	625985	1
MP17	DECAL, CSA	864470	1

Table 5-3. Rear Panel Assembly (cont)

Reference Designator	Description	Fluke Stock No.	Total Quantity
MP18	LABEL,VINYL,1.500,.312	844712	1
MP20,MP21	CABLE ACCESS,TIE,4.00L,.10W,.7	172080	2
MP22	LABEL,MYLAR,GROUND SYMBOL	911388	1
MP24	LABEL, CE MARK, BLACK	600707	1
MP67	WIRE, 6" GROUND	626116	1
T1	TRANSFORMER, POWER, MAIN	625720	1
W20	FAN ASSEMBLY	843029	1



5520A (A65)
(3 of 6)

Figure 5-3. Rear Panel Assembly

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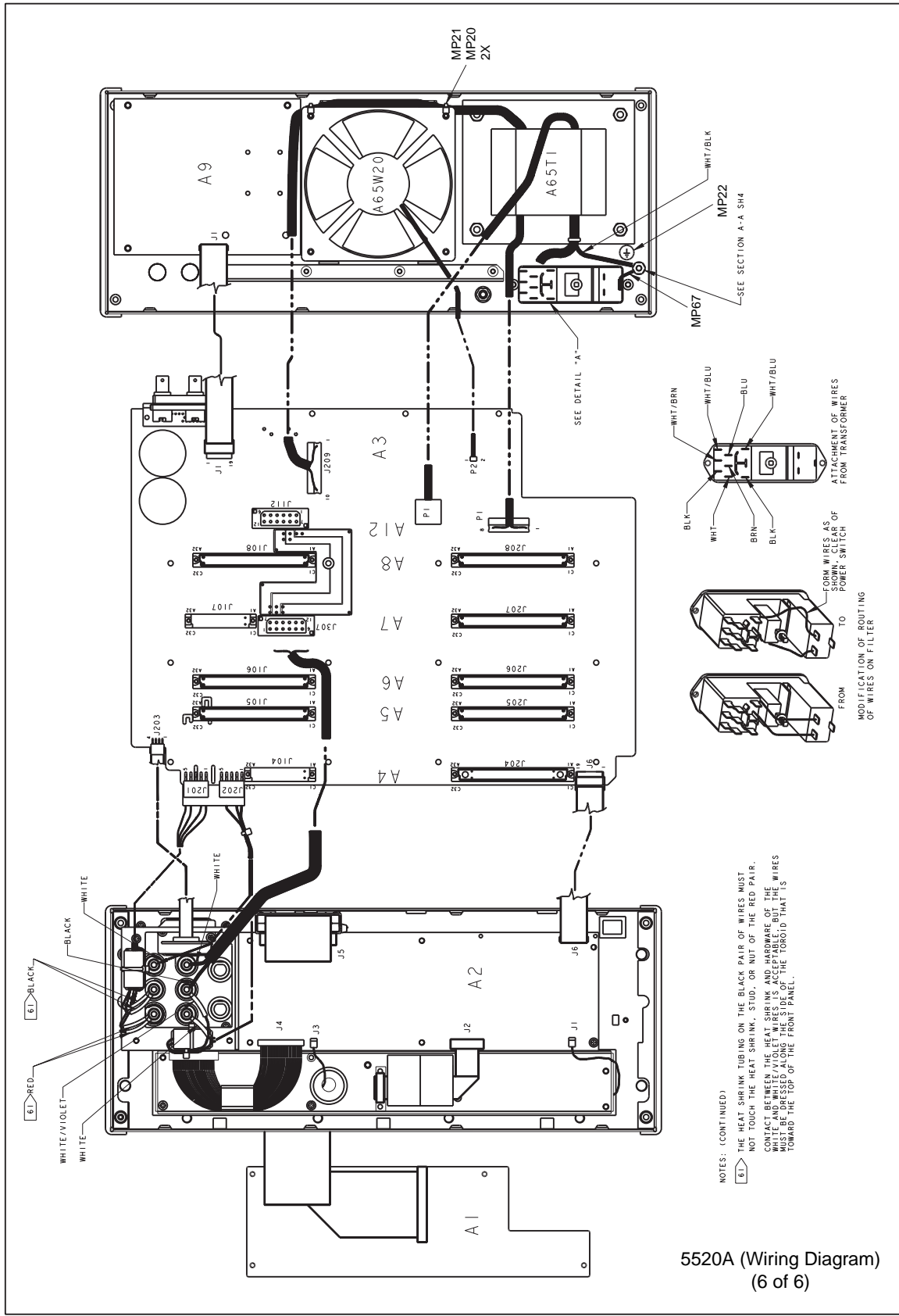


Figure 5-4. Wiring Diagram

Chapter 6

Oscilloscope Calibration Options

- Option 5500A-SC600: see page 6-3.
- Option 5500A-SC300: see page 6-63.

Chapter 6

SC600 Option

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6-1. Introduction

This chapter contains the following information and service procedures for the SC600 Oscilloscope Calibration Option functions.

- Specifications
- Theory of Operation
- Calibration Procedures
- Verification Procedures
- Hardware Adjustments made after Repair

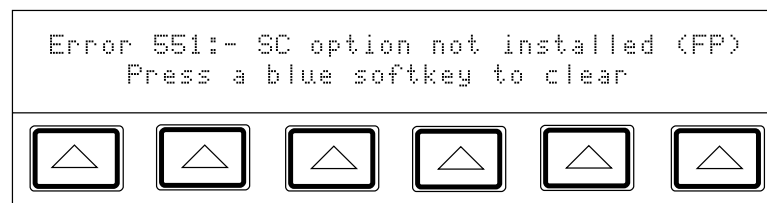
The calibration and verification procedures provide traceable results for all of the SC600 functions as long as they are performed using the recommended equipment. All of the required equipment along with the minimum specifications, are provided in Table 6-15 under “Equipment Requirements for Calibration and Verification.”

The calibration and verification procedures in this chapter are not the ones Fluke uses at the factory. These procedures have been developed to provide you with the ability to calibrate and verify the SC600 at your own site if necessary. You should review all of the procedures in advance to make sure you have the resources to complete them. It is strongly recommended that, if possible, you return your unit to Fluke for calibration and verification.

Hardware adjustments that are made after repair, at the factory or designated Fluke service centers, are provided in detail.

6-2. Maintenance

There are no maintenance techniques or diagnostic remote commands for the SC600 that are available to users. If your SC600 is not installed or not receiving power, the following error message appears on the display when you press **SCOPE** to access the oscilloscope calibration menus.



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If this message is displayed, and you have the SC600 installed in your Calibrator Mainframe, you must return the Calibrator Mainframe to Fluke for repair. If you wish to purchase the SC600, contact your Fluke sales representative.

6-3. SC600 Specifications

These specifications apply only to the SC600 Option. General specifications that apply to the Calibrator Mainframe (hereafter termed the Calibrator) can be found in Chapter 1. The specifications are valid under the following conditions:

- The Calibrator is operated under the conditions specified in Chapter 1.
- The Calibrator has completed a warm-up period of at least twice the length of time the calibrator was powered off, up to a maximum of 30 minutes.
- The SC600 Option has been active longer than 5 minutes.

6-4. Volt Specifications

Table 6-1. Volt Specifications

	Volt Function			
	dc Signal		Square Wave Signal [1]	
	50 Ω Load	1 M Ω Load	50 Ω Load	1 M Ω Load
Amplitude Characteristics				
Range	0 V to ± 6.6 V	0 V to ± 130 V	± 1 mV to ± 6.6 V p-p	± 1 mV to ± 130 V p-p
Resolution	Range 1 mV to 24.999 mV 25 mV to 109.99 mV 110 mV to 2.1999 V 2.2 V to 10.999 V 11 V to 130 V		Resolution 1 μ V 10 μ V 100 μ V 1 mV 10 mV	
Adjustment Range	Continuously adjustable			
1-Year Absolute Uncertainty, tcal ± 5 $^{\circ}$ C	$\pm (0.25\%$ of output + 40 μ V)	$\pm (0.05\%$ of output + 40 μ V)	$\pm (0.25\%$ of output + 40 μ V)	$\pm (0.1\%$ of output + 40 μ V) [2]
Sequence	1-2-5 (e.g., 10 mV, 20 mV, 50 mV)			
Square Wave Frequency Characteristics				
Range	10 Hz to 10 kHz			
1-Year Absolute Uncertainty, tcal ± 5 $^{\circ}$ C	$\pm (2.5$ ppm of setting)			
Typical Aberration within 4 μ s from 50% of leading/trailing edge	< (0.5% of output + 100 μ V)			
[1] Selectable positive or negative, zero referenced square wave.				
[2] For square wave frequencies above 1 kHz, $\pm (0.25\%$ of output + 40 μ V).				

6-5. Edge Specifications

Table 6-2. Edge Specifications

Edge Characteristics into 50 Ω Load		1-Year Absolute Uncertainty, tcal ± 5 °C
Rise Time	≤ 300 ps	(+0 ps / -100 ps)
Amplitude Range (p-p)	5.0 mV to 2.5 V	± (2% of output + 200 μV)
Resolution	4 digits	
Adjustment Range	± 10% around each sequence value (indicated below)	
Sequence Values	5 mV, 10 mV, 25 mV, 50 mV, 60 mV, 80 mV, 100 mV, 200 mV, 250 mV, 300 mV, 500 mV, 600 mV, 1 V, 2.5 V	
Frequency Range [1]	1 kHz to 10 MHz	± (2.5 ppm of setting)
Typical Jitter, edge to trigger	< 5 ps (p-p)	
Leading Edge Aberrations [2]	within 2 ns from 50% of rising edge	< (3% of output + 2 mV)
	2 to 5 ns	< (2% of output + 2 mV)
	5 to 15 ns	< (1% of output + 2 mV)
	after 15 ns	< (0.5% of output + 2 mV)
Typical Duty Cycle	45% to 55%	
Tunnel Diode Pulse Drive	Square wave at 100 Hz to 100 kHz, with variable amplitude of 60 V to 100 V p-p.	
[1] Above 2 MHz rise time specification < 350 ps.		
[2] All edge aberration measurements made with Tektronix 11801 mainframe with SD26 input module.		

6-6. Leveled Sine Wave Specifications

Table 6-3. Leveled Sine Wave Specifications

Leveled Sine Wave Characteristics into 50Ω	Frequency Range			
	50 kHz (reference)	50 kHz to 100 MHz	100 MHz to 300 MHz	300 MHz to 600 MHz
Amplitude Characteristics (for measuring oscilloscope bandwidth)				
Range (p-p)	5 mV to 5.5 V			
Resolution	< 100 mV: 3 digits ≥ 100 mV: 4 digits			
Adjustment Range	continuously adjustable			
1-Year Absolute Uncertainty, tcal ± 5 °C	± (2% of output + 300 μV)	± (3.5% of output + 300 μV)	± (4% of output + 300 μV)	± (6% of output + 300 μV)
Flatness (relative to 50 kHz)	not applicable	± (1.5% of output + 100 μV)	± (2% of output + 100 μV)	± (4% of output + 100 μV)
Short-Term Amplitude Stability	≤ 1% [1]			
Frequency Characteristics				
Resolution	10 kHz			
1-Year Absolute Uncertainty, tcal ± 5 °C	± 2.5 ppm			
Distortion Characteristics				
2nd Harmonic	≤ -33 dBc			
3rd and Higher Harmonics	≤ -38 dBc			
[1] Within one hour after reference amplitude setting, provided temperature varies no more than ± 5°C.				

6-7. Time Marker Specifications

Table 6-4. Time Marker Specifications

Time Marker into 50 Ω	5 s to 50 ms	20 ms to 100 ns	50 ns to 20 ns	10 ns	5 ns to 2 ns
1-Year Absolute Uncertainty at Cardinal Points, tcal ± 5 °C	± (25 ppm + 15 mHz)	± 2.5 ppm	± 2.5 ppm	± 2.5 ppm	± 2.5 ppm
Wave Shape	spike or square	spike, square, or 20%-pulse	spike or square	square or sine	sine
Typical Output Level	> 1 V p-p [1]	> 1 V p-p [1]	> 1 V p-p [1]	>1 V p-p [1]	> 1 V p-p
Typical Jitter (rms)	< 10 ppm	< 1 ppm	< 1 ppm	< 1 ppm	< 1 ppm
Sequence	5-2-1 from 5 s to 2 ns (e.g., 500 ms, 200 ms, 100 ms)				
Adjustment Range [2]	At least ± 10% around each sequence value indicated above.				
Frequency Resolution	4 digits				
[1] Typical rise time of square wave and 20%-pulse (20% duty cycle pulse) is < 1.5 ns.					
[2] Time marker uncertainty is ± 50 ppm away from the cardinal points.					

6-8. Wave Generator Specifications

Table 6-5. Wave Generator Specifications

Wave Generator Characteristics	Square Wave, Sine Wave, and Triangle Wave into 50 Ω or 1 MΩ
Amplitude	
Range	into 1 MΩ: 1.8 mV to 55 V p-p into 50 Ω: 1.8 mV to 2.5 V p-p
1-Year Absolute Uncertainty, tcal ± 5 °C, 10 Hz to 10 kHz	± (3% of p-p output + 100 μV)
Sequence	1-2-5 (e.g., 10 mV, 20 mV, 50 mV)
Typical DC Offset Range	0 to ± (≥40% of p-p amplitude) [1]
Frequency	
Range	10 Hz to 100 kHz
Resolution	4 or 5 digits depending upon frequency
1-Year Absolute Uncertainty, tcal ± 5 °C	± (25 ppm + 15 mHz)
[1] The DC offset plus the wave signal must not exceed 30 V rms.	

6-9. Pulse Generator Specifications

Table 6-6. Pulse Generator Specifications

Pulse Generator Characteristics	Positive pulse into 50Ω
Typical rise/fall times	< 1.5 ns
Available Amplitudes	2.5 V, 1 V, 250 mV, 100 mV, 25 mV, 10 mV
Pulse Width	
Range	4 ns to 500 ns [1]
Uncertainty [2]	5% ±2 ns
Pulse Period	
Range	20 ms to 200 ns (50 Hz to 5 MHz)
Resolution	4 or 5 digits depending upon frequency and width
1-Year Absolute Uncertainty at Cardinal Points, tcal ± 5 °C	± 2.5 ppm
[1] Pulse width not to exceed 40% of period. [2] Pulse width uncertainties for periods below 2 μs are not specified.	

6-10. Trigger Signal Specifications (Pulse Function)

Table 6-7. Trigger Signal Specifications (Pulse Function)

Time Marker Period	Division Ratio [1]	Amplitude into 50Ω (p-p)	Typical Rise Time
20 ms to 150 ns	off/1/10/100	≥ 1 V	≤ 2 ns

6-11. Trigger Signal Specifications (Time Marker Function)

Table 6-8. Trigger Signal Specifications (Time Marker Function)

Pulse Period	Division Ratio [1]	Amplitude into 50 Ω (p-p)	Typical Rise Time
5 s to 750 ns	off/1	≥ 1 V	≤ 2 ns
34.9 ms to 7.5 ns	off/10	≥ 1 V	≤ 2 ns
34.9 ms to 2 ns	off/100	≥ 1 V	≤ 2 ns

6-12. Trigger Signal Specifications (Edge Function)

Table 6-9. Trigger Signal Specifications (Edge Function)

Edge Signal Frequency	Division Ratio	Typical Amplitude into 50Ω (p-p)	Typical Rise Time	Typical Lead Time
1 kHz to 10 MHz	off/1	≥ 1 V	≤ 2 ns	40 ns

6-13. Trigger Signal Specifications (Square Wave Voltage Function)

Table 6-10. Trigger Signal Specifications (Square Wave Voltage Function)

Edge Signal Frequency	Division Ratio	Typical Amplitude into 50Ω (p-p)	Typical Rise Time	Typical Lead Time
10 Hz to 10 kHz	off/1	≥ 1 V	≤ 2 ns	1 μs

6-14. Trigger Signal Specifications

Table 6-11. TV Trigger Signal Specifications

Trigger Signal Type	Parameters
Field Formats	Selectable NTSC, SECAM, PAL, PAL-M
Polarity	Selectable inverted or uninverted video
Amplitude into 50 Ω (p-p)	Adjustable 0 to 1.5 V p-p into 50 ohm load, (±7% accuracy)
Line Marker	Selectable Line Video Marker

6-15. Oscilloscope Input Resistance Measurement Specifications

Table 6-12. Oscilloscope Input Resistance Measurement Specifications

Scope input selected	50Ω	1 MΩ
Measurement Range	40Ω to 60Ω	500 kΩ to 1.5 MΩ
Uncertainty	0.1 %	0.1 %

6-16. Oscilloscope Input Capacitance Measurement Specifications

Table 6-13. Oscilloscope Input Capacitance Measurement Specifications

Scope input selected	1 MΩ
Measurement Range	5 pF to 50 pF
Uncertainty	± (5% of input + 0.5 pF) [1]

[1] Measurement made within 30 minutes of capacitance zero reference. SC600 option must be selected for at least five minutes prior to any capacitance measurement, including the zero process.

6-17. Overload Measurement Specifications

Table 6-14. Overload Measurement Specifications

Source Voltage	Typical 'On' current indication	Typical 'Off' current indication	Maximum Time Limit DC or AC (1 kHz)
5 V to 9 V	100 mA to 180 mA	10 mA	setable 1 s to 60 s

6-18. Theory of Operation

The following discussion provides a brief overview of the following SC600 operating modes: voltage, edge, leveled sine wave, time marker, wave generator, video, pulse generator, input impedance, and overload. This discussion will allow you to identify which of the main plug-in boards of the Calibrator Mainframe are defective. Figure 6-1 shows a block diagram of the SC600 Option, also referred to as the A50 board. Functions that are not depicted in the figure are generated from the DDS Assembly (A6 board). For a diagram of all Calibrator Mainframe board assemblies, refer to Figure 2-1.

6-19. Voltage Mode

All signals for the voltage function are generated from the A51 Voltage/Video board, a daughter card to the A50 board. A dc reference voltage is supplied to the A51 board from the A6 DDS board; all dc and ac oscilloscope output voltages are derived from this signal and generated on the A51 board. The output of the A51 board is passed to the A50 Signal board (also attached to the A50 board) and attenuator module and is then cabled to the output connectors on the front panel. The reference dc signal is used to generate both + and - dc and ac signals that are amplified or attenuated to provide the complete range of output signals.

6-20. Edge Mode

The edge clock originates on the DDS A6 board and is passed to the A50 board. The signal is then shaped and split to generate the fast edge and external trigger signals. The edge signal is passed from the A50 board first to the attenuator assembly (where range attenuation occurs) and then to the SCOPE connector BNC on the front panel. If turned on, the trigger is connected to the Trig Out BNC on the front panel.

6-21. Leveled Sine Wave Mode

All of the leveled sine wave signals (from 50 kHz to 600 MHz) are produced on the A50 board. The leveled sine wave signal is passed from the A50 board to the on-board attenuator assembly. The attenuator assembly provides range attenuation and also contains a power detector which maintains amplitude flatness across the frequency range. The signal is then passed to the SCOPE connector BNC on the front panel.

6-22. Time Marker Mode

There are 3 primary “ranges” of time marker operation: 5 s to 20 ms, 10 ms to 2 μ s, and 1 μ s to 2 ns.

The 5 s to 20 ms markers are generated on the A6 DDS board and are passed to the A50 board. The signal path is also split to drive the external trigger circuitry on the A50 board. If turned on, the trigger is connected to the Trig Out BNC on the front panel. The marker signal passing through the A50 board is connected to the attenuator assembly. The signal is then passed to the SCOPE connector BNC on the front panel.

The 10 ms to 2 μ s markers are derived from a square wave signal that is generated on the A6 board and passed to the A50 board for wave shaping and external trigger generation. If the trigger is turned on, the signal is connected to the Trig Out BNC on the front panel. The marker signal is passed from the A50 board to the attenuator assembly and then to the SCOPE connector BNC on the front panel.

The 1 μ s to 2 ns markers are generated from the leveled sine wave generator on the A50 board. This signal is also split to drive the external trigger circuits. If the trigger is turned on, the signal is then connected to the Trig Out BNC on the front panel. The other path routes the signal to the marker circuits on the A50 board, where the signal is shaped into the other marker waveforms. The marker signals are passed from the A50 board to the attenuator assembly and on to the SCOPE connector BNC on the front panel.

6-23. Wave Generator Mode

All signals for the wavegen function are generated from the A6 board and are passed to the A50 board. They are then sent to the attenuator assembly, where range attenuation occurs. Wavegen signals are then sent to the SCOPE connector BNC on the front panel. Video and pulse generator mode signals are derived entirely from dedicated circuitry on the A50 SC600 option board. If there are faults associated only with these functions, the A50 board most likely needs replacement.

6-24. Input Impedance Mode (Resistance)

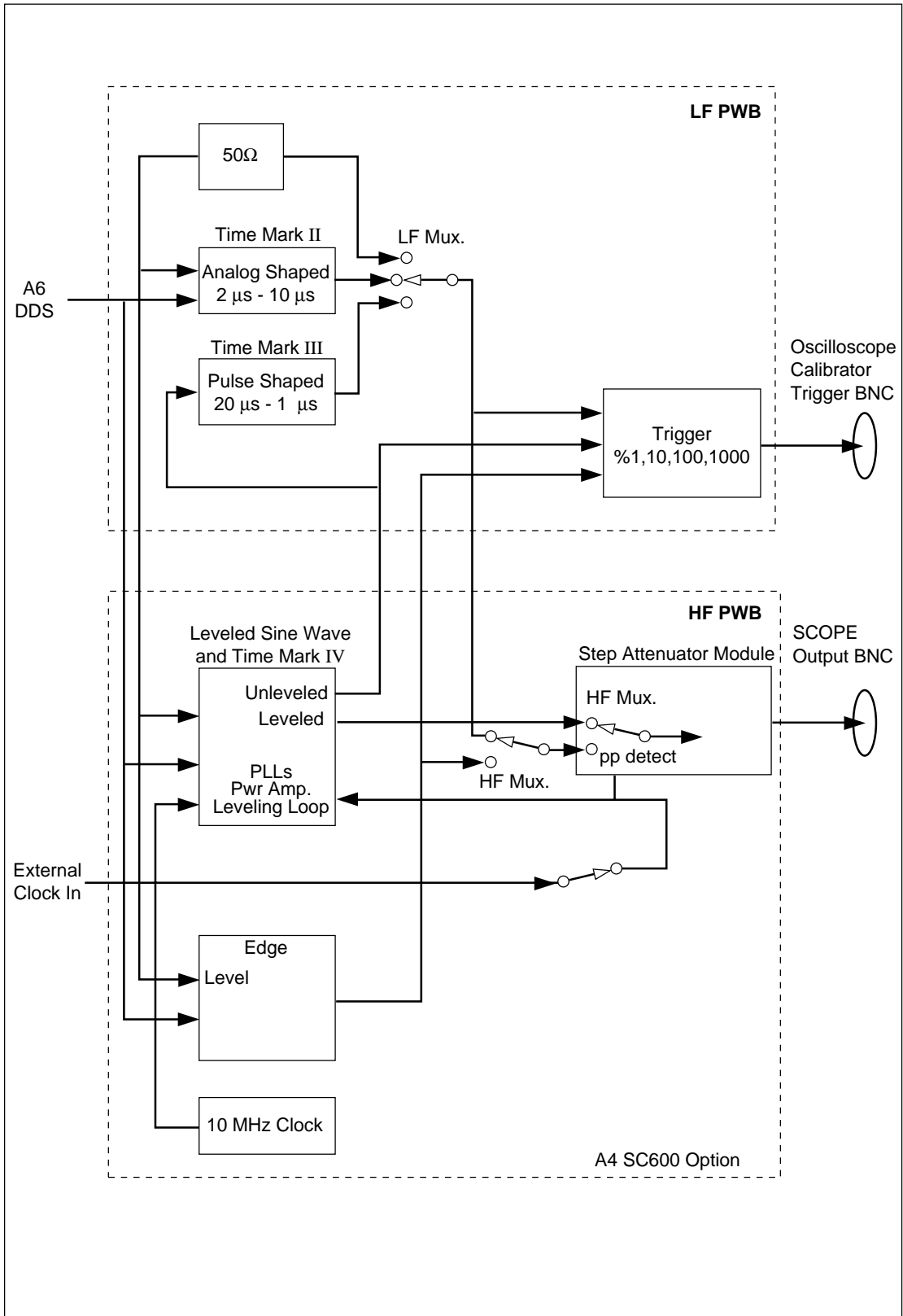
The reference resistors for this mode are on the A50 board, while the DCV reference signal and measuring signals are on the A6 DDS board.

6-25. Input Impedance Mode (Capacitance)

Capacitance measurement circuits are contained on the A50 SC600 Scope Option board, utilizing signals from the leveled sine wave source. If there are faults associated only with capacitance measurement, the A50 board most likely needs replacement.

6-26. Overload Mode

The source voltage for the overload mode is generated on the A51 Voltage/Video board of the A50 SC600 Option board. The voltage is applied to the external 50 Ω load, and the circuit current is monitored by the A6 DDS board.



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Figure 6-1. SC600 Block Diagram

6-27. Equipment Required for Calibration and Verification

Table 6-15 lists the equipment, recommended models, and minimum specifications required for each calibration and verification procedure.

Table 6-15. SC600 Calibration and Verification Equipment

Wave Generator and Edge Amplitude Calibration, AC Voltage and TD Pulser Verification			
Instrument	Model	Minimum Use Specifications	
Digital Multimeter	HP 3458A	Voltage	1.8 mV to ± 130 V p-p Uncertainty: 0.06%
		Edge	4.5 mV to 2.75 V p-p Uncertainty: 0.06%
Adapter	Pomona #1269	BNC(f) to Double Banana Plug	
Termination		Feedthrough $50 \Omega \pm 1\%$ (used with Edge Amplitude Calibration and AC Voltage Verification)	
BNC Cable	(supplied with SC600)		
Edge Rise Time and Aberrations Verification			
High-Frequency Digital Storage Oscilloscope	Tektronix 11801 with Tektronix SD-22/26 sampling head, or Tektronix TDS 820 with 8 GHz bandwidth	Frequency	12.5 GHz
		Resolution	4.5 mV to 2.75 V
Attenuator	Weinschel 9-10 (SMA) or Weinschel 18W-10 or equivalent	10 dB, 3.5 mm (m/f)	
Adapter		BNC(f) to 3.5 mm(m)	
BNC Cable	(supplied with SC600)		
Leveled Sine Wave Amplitude Calibration and Verification			
AC Measurement Standard	Fluke 5790A	Range	5 mV p-p to 5.5 V p-p
		Frequency	50 kHz
Adapter	Pomona #1269	BNC(f) to Double Banana Plug	
Termination		Feedthrough $50 \Omega \pm 1\%$.	
BNC Cable	(supplied with SC600)		
DC and AC Voltage Calibration and Verification, DC Voltage Verification			
Digital Multimeter	HP 3458A		
Adapter	Pomona #1269	BNC(f) to Double Banana Plug	
Termination		Feedthrough $50 \Omega \pm 1\%$.	
BNC Cable	(supplied with SC600)		

Table 6-15. SC600 Calibration and Verification Equipment (cont.)

Pulse Width Calibration and Verification			
High-Frequency Digital Storage Oscilloscope	Tektronix 11801 with Tektronix SD-22/26 sampling head		
Attenuator			3 dB, 3.5 mm (m/f)
Adapter (2)			BNC(f) to 3.5 mm(m)
BNC Cable	(supplied with SC600)		
Leveled Sine Wave Frequency Verification			
Frequency Counter	PM 6680 with option (PM 9621, PM 9624, or PM 9625) and (PM 9690 or PM 9691)		50 kHz to 600 MHz, < 0.15 ppm uncertainty
Adapter	Pomona #3288		BNC(f) to Type N(m)
BNC Cable	(supplied with SC600)		
Leveled Sine Wave Flatness (Low Frequency) Calibration and Verification			
AC Measurement	Fluke 5790A	Range	5 mV p-p to 5.5 V p-p
Standard	with -03 option	Frequency	50 kHz to 10 MHz
Adapter	Pomona #3288	BNC(f) to Type N(m)	
BNC Cable	(supplied with SC600)		
Leveled Sine Wave Harmonics Verification			
Spectrum Analyzer	HP 8590A		
Adapter	Pomona #3288		BNC(f) to Type N(m)
BNC Cable	(supplied with SC600)		
Pulse Period, Edge Frequency, AC Voltage Frequency Verification			
Frequency Counter	PM 6680 with option (PM 9690 or PM 9691)		20 ms to 150 ns, 10 Hz to 10 MHz: < 0.15 ppm uncertainty
BNC Cable	(supplied with SC600)		
Edge Duty Cycle			
Frequency Counter	PM 6680		
BNC Cable	(supplied with SC600)		
Overload Functional Verification			
Termination			Feedthrough 50 Ω \pm 1%.
BNC Cable	(supplied with SC600)		
MeasZ Resistance, Capacitance Verification			
Resistors			1 M Ω and 50 Ω nominal values
Capacitors			50 pF nominal value at the end of BNC(f) connector
Adapters			to connect resistors and capacitors to BNC(f) connector
BNC Cable	(supplied with SC600)		

Table 6-15. SC600 Calibration and Verification Equipment (cont.)

Leveled Sine Wave Flatness (High Frequency) Calibration and Verification			
Instrument	Model	Minimum Use Specifications	
Power Meter	Hewlett-Packard 437B	Range	-42 to +5.6 dBm
		Frequency	10 - 600 MHz
Power Sensor	Hewlett-Packard 8482A	Range	-20 to +19 dBm
		Frequency	10 - 600 MHz
Power Sensor	Hewlett-Packard 8481D	Range	-42 to -20 dBm
		Frequency	10 - 600 MHz
30 dB Reference Attenuator	Hewlett-Packard 11708A (supplied with HP 8481D)	Range	30 dB
		Frequency	50 MHz
Adapter	Hewlett-Packard PN 1250-1474	BNC(f) to Type N(f)	
BNC Cable	(supplied with SC600)		
Leveled Sine Wave Frequency, Time Marker Verification			
Frequency Counter	PM 6680 with option (PM 9621, PM 9624, or PM 9625) and (PM 9690 or PM 9691)	2 ns to 5 s, 50 kHz to 600 MHz: < 0.15 ppm uncertainty	
Adapter	Pomona #3288	BNC(f) to Type N(m)	
BNC Cable	(supplied with SC600)		
Wave Generator Verification			
AC Measurement Standard	Fluke 5790A	Range	1.8 mV p-p to 55 V p-p
		Frequency	10 Hz to 100 kHz
Adapter	Pomona #1269	BNC(f) to Double Banana	
Termination		Feedthrough 50 Ω ± 1%.	
BNC Cable	(supplied with SC600)		

6-28. SC600 Calibration Setup

The procedures in this manual have been developed to provide users the ability to calibrate the SC600 at their own site if they are required to do so. It is strongly recommended that, if possible, you return your unit to Fluke for calibration and verification. The Calibrator Mainframe must be fully calibrated prior to performing any of the SC600 calibration procedures.

The hardware adjustments are intended to be one-time adjustments performed in the factory, however, adjustment may be required after repair. Hardware adjustments must be performed prior to calibration. Calibration must be performed after any hardware adjustments. See “Hardware Adjustments” in this chapter.

The AC Voltage function is dependent on the DC Voltage function. Calibration of the AC Voltage function is required after the DC Voltage is calibrated.

The Calibrator Mainframe must complete a warm-up period and the SC600 must be enabled for at least 5 minutes prior to calibration to allow internal components to

thermally stabilize. The Calibrator Mainframe warm-up period is at least twice the length of time the calibrator was powered off, up to a maximum of 30 minutes. The SC600 is enabled by pressing the front panel **SCOPE** key. The green indicator on the **SCOPE** key will be illuminated when the SC600 is enabled.

Much of the SC600 can be calibrated interactively from the front panel. Enable the SC600 and wait at least 5 minutes. Enter Scope Cal mode by pressing the front panel **SETUP** key, **CAL** blue softkey, second **CAL** blue softkey, and **SCOPE CAL** blue softkey. Entering Scope Cal mode prior to having the SC600 enabled for at least 5 minutes will cause a warning message to be displayed.

All equipment specified for SC600 calibration must be calibrated, certified traceable if traceability is to be maintained, and operating within their normal specified operating environment. It is also important to ensure that the equipment has had sufficient time to warm up prior to its use. Refer to each equipment's operating manual for details.

Before you begin calibration, you may wish to review all of the procedures in advance to ensure you have the resources to complete them.

The Calibrator Mainframe first prompts the user to calibrate the DC Voltage function. If another function is to be calibrated, alternately press the **OPTIONS** and **NEXT SECTION** blue softkeys until the desired function is reached.

6-29. Calibration and Verification of Square Wave Voltage Functions

The Voltage, Edge, and Wave Generator functions have square wave voltages that need to be calibrated or verified. The HP3458A digital multimeter can be programmed from either the front panel or over the remote interface to make these measurements.

6-30. Overview of HP3458A Operation

The Hewlett-Packard 3458A digital multimeter is setup as a digitizer to measure the peak-to-peak value of the signal. It is set to DCV, using various analog-to-digital integration times and triggering commands to measure the topline and baseline of the square wave signal.

6-31. Setup for SC600 Voltage Square Wave Measurements

By controlling the HP 3458A's integration and sample time, it can be used to make accurate, repeatable measurements of both the topline and baseline of the Voltage Square Wave up to 10 kHz. To make these measurements, the HP 3458A's External Trigger function is used in conjunction with the SC600's External Trigger output. In general, the HP 3458A is setup to make an analog-to-digital conversion after receiving the falling edge of an external trigger. The conversion does not take place until a time determined by the 3458A "DELAY" command. The actual integration time is set according to the frequency that the DMM is measuring. Table 6-16 below summarizes the DMM settings required to make topline and baseline measurements. Figure 6-2 illustrates the proper connections for this setup.

Table 6-16. Voltage HP3458A Settings

Voltage Input Frequency	HP 3458A Settings		
	NPLC	DELAY (topline)	DELAY (baseline)
100 Hz	.1	.007 s	.012 s
1 kHz	.01	.0007 s	.0012 s
5 kHz	.002	.00014	.00024
10 kHz	.001	.00007	.00012

For all measurements, the HP 3458A is in DCV, manual ranging, with external trigger enabled. A convenient method to make these measurements from the HP 3458A's front panel is to program these settings into several of the user defined keys on its front panel. For example, to make topline measurements at 1 kHz, you would set the DMM to "NPLC .01; DELAY .0007; TRIG EXT". To find the average of multiple readings, you can program one of the keys to "MATH OFF; MATH STAT" and then use the "RMATH MEAN" function to recall the average or mean value.

Note

For this application, if making measurements of a signal > 1 kHz, the HP 3458A has been known to have .05% to .1% peaking in the 100 mV range. For these signals, lock the HP 3458A to the 1 V range.

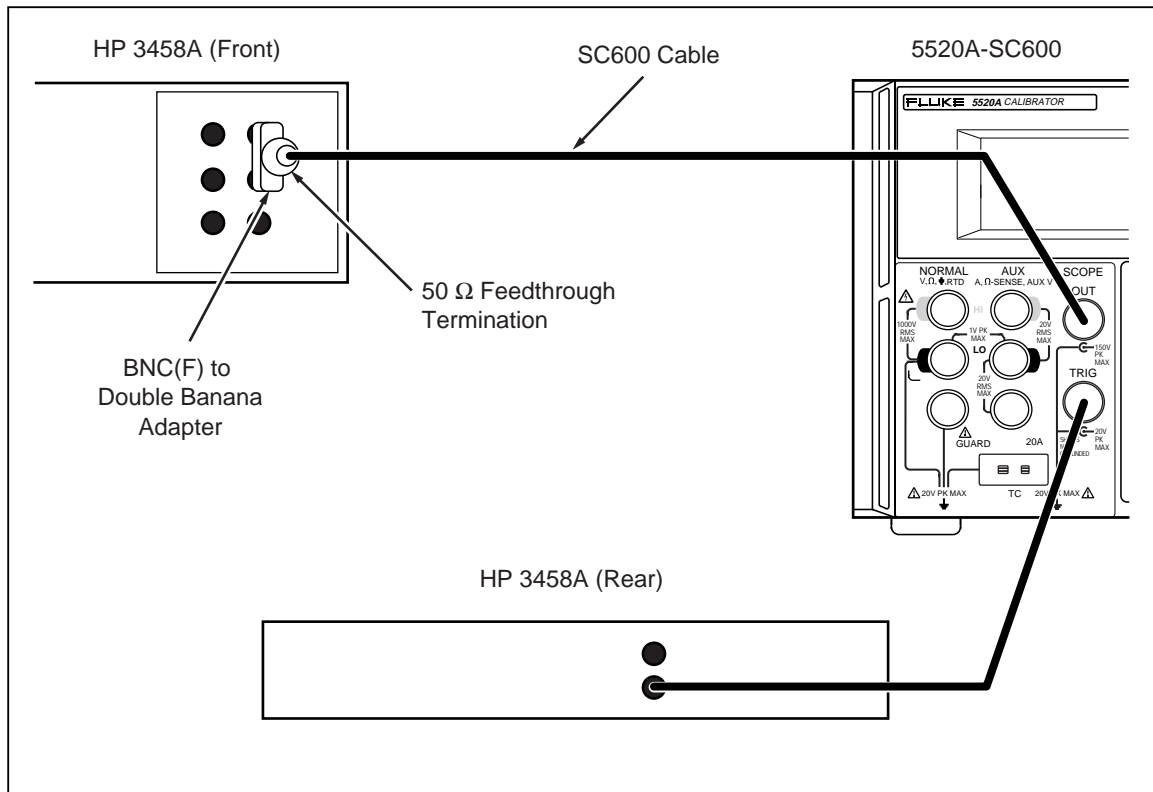


Figure 6-2. Equipment Setup for SC600 Voltage Square Wave Measurements

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6-32. Setup for SC600 Edge and Wave Gen Square Wave Measurements

The setup to measure the topline and baseline of Edge and Wave Generator signals differs slightly from the Voltage Square Wave method described above. The HP 3458A is triggered by a change in input level instead of an external trigger. The trigger level is set to 1% of the DCV range, with ac coupling of the trigger signal. The delay after the trigger event is also changed for the Edge and Wave Generator functions. See Table 6-17 and Figure 6-3.

Table 6-17. Edge and Wave Generator HP3458A Settings

Input Frequency	HP 3458A Settings		
	NPLC	DELAY (topline)	DELAY (baseline)
1 kHz	.01	.0002 s	.0007 s
10 kHz	.001	.00002 s	.00007 s

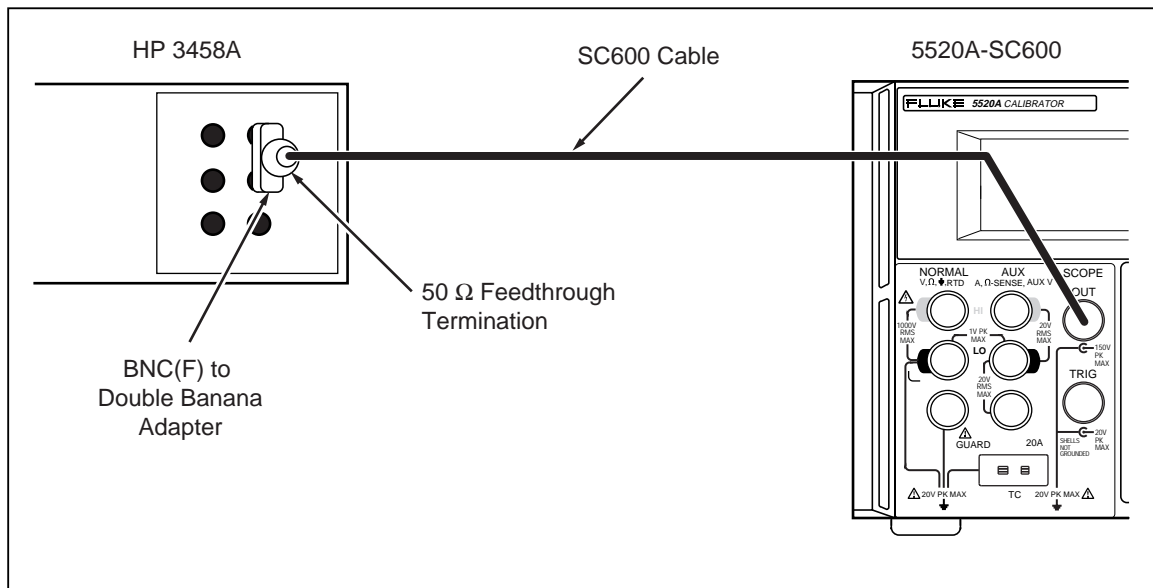


Figure 6-3. Equipment Setup for SC600 Edge and Wave Gen Square Wave Measurements

For all measurements, the HP 3458A is in DCV, manual ranging, with level triggering enabled. A convenient method to make these measurements from the HP 3458A's front panel is to program these settings into several of the user defined keys on its front panel. For example, to make topline measurements at 1 kHz, you would set the DMM to "NPLC .01; LEVEL 1; DELAY .0002; TRIG LEVEL". To find the average of multiple readings, you can program one of the keys to "MATH OFF; MATH STAT" and then use the "RMATH MEAN" function to recall the average or mean value. Refer to Figure 6-3 for the proper connections.

6-33. DC Voltage Calibration

This procedure uses the following equipment:

- Hewlett-Packard 3458A Digital Multimeter
- BNC(f) to Double Banana adapter
- BNC cable supplied with the SC600

Note

Calibrating dc voltage requires ac voltage calibration.

Refer to Figure 6-3 for the proper setup connections.

Set the Calibrator Mainframe in Scope Cal mode, DC Voltage section. Then follow these steps to calibrate DC Voltage.

1. Connect the Calibrator Mainframe's SCOPE connector to the HP 3458A input, using the BNC cable and the BNC(f) to Double Banana adapter.
2. Set the HP 3458A to DCV, Auto Range, NPLC = 10, FIXEDZ = on.
3. Press the **GO ON** blue softkey.
4. Ensure the HP 3458A reading is 0.0 V DC \pm 10 μ V. If not, adjust R121 on A41 (see "Hardware Adjustments" in this chapter.)
5. Press the **GO ON** blue softkey.
6. Calibration voltages 33 V and greater will automatically put the Calibrator Mainframe output in standby. When this occurs, press **OPR** on the Calibrator Mainframe to activate the output. Allow the HP 3458A DC voltage reading to stabilize. Enter the reading via the Calibrator Mainframe front panel keypad, then press **ENTER**.

Note

The Calibrator Mainframe will warn when the entered value is out of bounds. If this warning occurs recheck the setup and carefully re-enter the reading insuring proper multiplier (i.e., m, μ , n, p). If the warning still occurs, repair may be necessary.

7. Repeat steps 6 until the Calibrator Mainframe display indicates that the next steps calibrate ac voltage. Press the **OPTIONS**, then **STORE CONSTS** blue softkeys to store the new calibration constants.

AC voltage must now be calibrated: continue with the next section.

6-34. AC Voltage Calibration

This procedure uses the same equipment and setup as DC Voltage calibration. Refer to Figure 6-3. DC voltages are measured and entered in the Calibrator Mainframe to calibrate the AC Voltage function.

Set up the Calibrator Mainframe to Cal ACV. Press **OPTIONS** and **NEXT SECTION** blue softkeys until the display reads "The next steps calibrate -SC600 ACV". Then follow these steps to calibrate ac voltage.

1. Press the **GO ON** blue softkey.
2. Allow the HP 3458A DC voltage reading to stabilize. Enter the reading via the Calibrator Mainframe front panel keypad, then press **ENTER**.

Note

The Calibrator Mainframe will warn when the entered value is out of bounds. If this warning occurs recheck the setup and carefully re-enter the reading insuring proper multiplier (i.e., m, u, n, p). If the warning still occurs, repair may be necessary.

3. Repeat step 2 until the Calibrator Mainframe display indicates that the next steps calibrate WAVEGEN. Press the **OPTIONS**, then **STORE CONSTS** blue softkeys to store the new calibration constants.

6-35. Wave Generator Calibration

This procedure uses the following equipment:

- Hewlett-Packard 3458A Digital Multimeter
- BNC(f) to Double Banana adapter
- BNC cable supplied with the SC600

Within the calibration menu, press the **OPTIONS** and **NEXT SECTION** blue softkeys until the display reads “WAVEGEN Cal:”. Then follow these steps to calibrate the Wave Generator:

1. Connect the Calibrator Mainframe’s SCOPE connector to the HP 3458A input, using the BNC cable and the BNC(f) to Double Banana adapter.
2. Set the HP 3458A to DCV, NPLC = .01, LEVEL 1, TRIG LEVEL, and the DELAY to .0002 for measuring the upper part of the wave form (i.e. topline), and the DELAY to .0007 for measuring the lower part of the wave form (i.e. baseline). Manually range lock the HP 3458A to the range that gives the most resolution for the topline measurements. Use this same range for the corresponding baseline measurements at each step.
3. For each calibration step, take samples for at least two seconds, using the HP 3458A MATH functions to retrieve the average or mean value. See “Setup for SC600 Edge and Wave Generator Measurements” for more details.

6-36. Edge Amplitude Calibration

This procedure uses the following equipment:

- Hewlett-Packard 3458A Digital Multimeter
- BNC(f) to Double Banana adapter
- BNC cable supplied with the SC600
- 50 Ω feedthrough termination

Refer to Figure 6-3 for the proper setup connections. Press the **OPTIONS** and **NEXT SECTION** blue softkeys until the display reads “Set up to measure fast edge amplitude”. Then follow these steps to calibrate edge amplitude:.

1. Connect the Calibrator Mainframe’s SCOPE connector to the HP 3458A input, using the BNC cable and the BNC(f) to Double Banana.
2. Set the HP 3458A to DCV, NPLC = .01, LEVEL 1, TRIG LEVEL, and the DELAY to .0002 for measuring the upper part of the wave form (i.e. topline), and the DELAY to .0007 for measuring the lower part of the wave form (i.e. baseline). Manually lock the HP 3458A to the range that gives the most resolution for the baseline measurements. Use this same range for the corresponding baseline measurements at

each step. Note that in the EDGE function, the topline is very near 0V, and the baseline is a negative voltage.

3. For each calibration step, take samples for at least two seconds, using the HP 3458A MATH functions to enter the average or mean value. See “Setup for SC600 Edge and Wave Generator Measurements” for more details.

The “true amplitude” of the wave form is the difference between the topline and baseline measurements, correcting for the load resistance error. To make this correction, multiply the readings by $(0.5 * (50 + R_{load})/R_{load})$, where R_{load} = actual feedthrough termination resistance.

6-37. **Leveled Sine Wave Amplitude Calibration**

This procedure uses the following equipment:

- 5790A AC Measurement Standard
- BNC(f) to Double Banana Plug Adapter
- 50 Ω feedthrough termination
- BNC cable supplied with the SC600

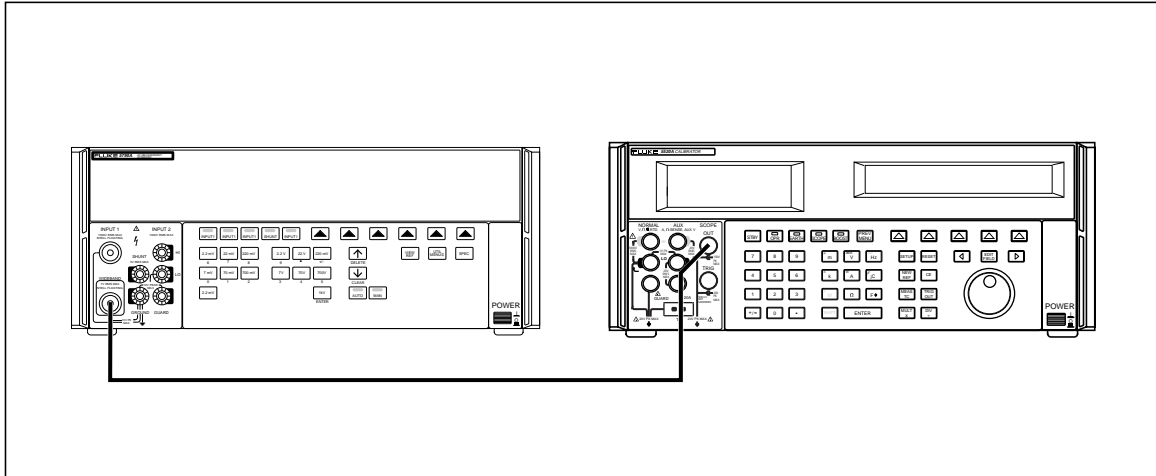
Press the **OPTIONS** and **NEXT SECTION** blue softkeys until the display reads “Set up to measure leveled sine amplitude”. Then follow these steps to calibrate Leveled Sine Wave amplitude.

1. Connect the BNC cable to the Calibrator Mainframe’s SCOPE connector. Connect the other end of the BNC cable to the 50 Ω feedthrough termination then to the 5790A INPUT 2 using the BNC(f) to Double Banana adapter.
2. Set the 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.
3. Press the **GO ON** blue softkey.
4. Press **OPR** to activate operating mode on the Calibrator Mainframe.
5. Allow the 5790A rms reading to stabilize. Multiply the 5790A reading by $(0.5 * (50 + R_{load}) / R_{load})$, where R_{load} = the actual feedthrough termination resistance, to correct for the resistance error. Enter the corrected rms reading via the Calibrator Mainframe front panel keypad, then press **ENTER**.

Note

The Calibrator Mainframe will warn when the entered value is out of bounds. If this warning occurs recheck the setup and calculation and carefully re-enter the corrected rms reading insuring proper multiplier (i.e., m, u, n, p). If the warning still occurs, repair may be necessary.

6. Repeat step 5 until the Calibrator Mainframe display indicates that the next steps calibrate Leveled Sine flatness. Press the **OPTIONS**, then **STORE CONSTS** blue softkeys to store the new calibration constants.



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Figure 6-4. Connecting the Calibrator Mainframe to the 5790A AC Measurement Standard

6-38. *Leveled Sine Wave Flatness Calibration*

Leveled Sine Wave flatness calibration is divided into two frequency bands: 50 kHz to 10 MHz (low frequency) and > 10 MHz to 600 MHz (high frequency). The equipment setups are different for each band. Flatness calibration of the low frequency band is made relative to 50 kHz. Flatness calibration of the high frequency band is made relative to 10 MHz.

Leveled Sine Wave flatness is calibrated at multiple amplitudes. Both low and high frequency bands are calibrated at each amplitude. Calibration begins with the low frequency band, then the high frequency band for the first amplitude, followed by the low frequency band, then the high frequency band for the second amplitude, and so on, until the flatness calibration is complete.

Press the **OPTIONS** and **NEXT SECTION** blue softkeys until the display reads “Set up to measure leveled sine flatness”.

6-39. *Low Frequency Calibration*

Connect the Calibrator Mainframe SCOPE connector to the 5790A WIDEBAND input as described under “Equipment Setup for Low Frequency Flatness”.

Follow these steps to calibrate low frequency Leveled Sine Wave flatness for the amplitude being calibrated.

1. Press the **GO ON** blue softkey.
2. Establish the 50 kHz reference:
 - Allow the 5790A rms reading to stabilize.
 - Press the 5790A **Set Ref** blue softkey. (Clear any previous reference by pressing the 5790A **Clear Ref** blue softkey prior to setting the new reference if required.)
3. Press the **GO ON** blue softkey.
4. Adjust the amplitude using the Calibrator Mainframe front panel knob until the 5790A reference deviation matches the 50 kHz reference within 1000 ppm.
5. Repeat steps 1 to 4 until the Calibrator Mainframe display indicates that the reference frequency is now 10 MHz. Continue with the high frequency calibration.

6-40. High Frequency Calibration

Connect the Calibrator Mainframe SCOPE connector to the power meter and power sensor as described under “Equipment Setup for High Frequency Flatness”.

Follow these steps to calibrate high frequency Leveled Sine Wave flatness for the amplitude being calibrated.

1. Press the **GO ON** blue softkey.
2. Establish the 10 MHz reference:
 - Press the power meter **SHIFT key**, then **FREQ** key and use the arrow keys to enter the power sensor’s 10 MHz Cal Factor. Ensure that the factor is correct, then press the power meter **ENTER** key.
 - Allow the power meter reading to stabilize.
 - Press the Power meter **REL** key.
3. Press the **GO ON** blue softkey.
4. Press the power meter **SHIFT key**, then **FREQ** key and use the arrow keys to enter the power sensor’s Cal Factor for the frequency displayed on the Calibrator Mainframe. Ensure that the factor is correct, then press the power meter **ENTER** key.
5. Adjust the amplitude using the Calibrator Mainframe front panel knob until the power sensor reading matches the 10 MHz reference within 0.1%.
6. Repeat steps 1 to 5 until the Calibrator Mainframe display indicates that either the reference frequency is now 50 kHz or that the next steps calibrate pulse width. Repeat the low frequency calibration procedure for the next amplitude unless the Calibrator Mainframe display indicates that the next steps calibrate pulse width. Press the **OPTIONS**, then **STORE CONSTS** blue softkeys to store the new calibration constants.

6-41. Pulse Width Calibration

This procedure uses the following equipment:

- High Frequency Digital Storage Oscilloscope: Tektronix 11801 with Tektronix SD-22/26 sampling head
- 3 dB attenuator, 3.5 mm (m/f)
- BNC(f) to 3.5 mm(m) adapter (2)
- BNC cable supplied with the SC600
- second BNC cable

Press the **OPTIONS** and **NEXT SECTION** blue softkeys until the display reads “Set up to measure Pulse Width”. Then follow these steps to calibrate pulse width:

1. Connect the BNC cable supplied with the SC600 to the Calibrator Mainframe’s SCOPE connector. Connect the other end of the BNC cable to one BNC(f) to 3.5 mm(m) adapter then to the DSO’s sampling head through the 3 dB attenuator.
2. Using the second BNC(f) to 3.5 mm(m) adapter and BNC cable, connect the Calibrator Mainframe’s TRIG OUT connector to the 11801’s Trigger Input.

3. Set the DSO to these parameters:
 - Main Time Base position (initial): 40 ns
 - Vertical scale: 200 mV/div, +900 mV offset
 - Trigger: source = ext; level = 0.5 V; ext atten = x10; slope = +; mode = auto
 - Measurement Function: positive width
4. Press the **GO ON** blue softkey.
5. Adjust the DSO horizontal scale and main time base position until the pulse signal spans between half and the full display. If no pulse is output, increase the pulse width using the Calibrator Mainframe front panel knob until a pulse is output.
6. If prompted to adjust the pulse width by the Calibrator Mainframe display, adjust the pulse width to as close to 4 ns as possible using the Calibrator Mainframe front panel knob, then press the **GO ON** blue softkey.
7. Allow the DSO width reading to stabilize. Enter the reading via the Calibrator Mainframe front panel keypad, then press **ENTER**.

Note

The Calibrator Mainframe issues a warning when the entered value is out of bounds. If this warning occurs, recheck the setup and carefully re-enter the reading with the proper multiplier (i.e., m, u, n, p). If the warning still occurs, enter a value between the displayed pulse width and the previously entered value. Keep attempting this, moving closer and closer to the displayed pulse width, until the value is accepted. Complete the pulse width calibration procedure. The pulse width calibration procedure must now be repeated until all entered values are accepted the first time without warning.

8. Repeat steps 5 to 7 until the Calibrator Mainframe display prompts to connect a resistor. Press the **OPTIONS**, then **STORE CONSTS** blue softkeys to store the new calibration constants.

6-42. MeasZ Calibration

The MeasZ function is calibrated using resistors and a capacitor of known values. The actual resistance and capacitance values are entered while they are being measure by the Calibrator Mainframe.

The resistors and capacitor must make a solid connection to a BNC(f) to enable a connection to the end of the BNC cable supplied with the SC600. The resistance and capacitance values must be known at this BNC(f) connector. Fluke uses an HP 3458A DMM to make a 4-wire ohms measurement at the BNC(f) connector to determine the actual resistance values and an HP 4192A Impedance Analyzer at 10 MHz to determine the actual capacitance value.

This procedure uses the following equipment:

- Resistors of known values: 1M Ω and 50 Ω nominal
- adapters to connect resistors to BNC(f) connector
- adapters and capacitor to achieve 50 pF nominal value at the end of BNC(f) connector
- BNC cable supplied with the SC600

Refer to Figure 6-5 for setup connections.

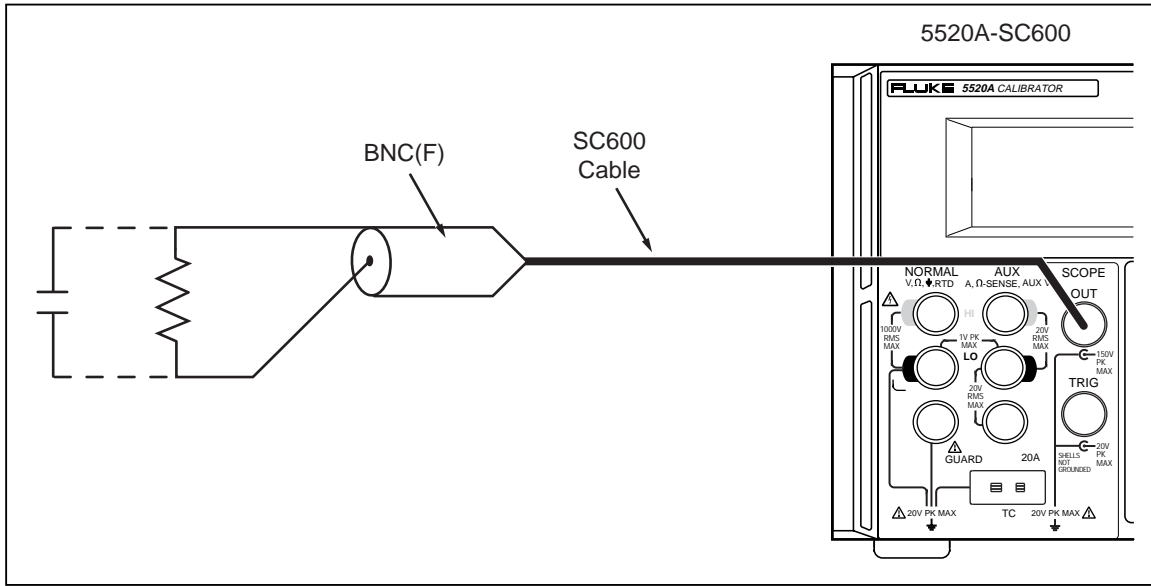


Figure 6-5. MeasZ Function Calibration Setup

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Set the Calibrator Mainframe in Scope Cal mode at the prompt to connect a 50 Ω resistor. Then follow these steps to calibrate MeasZ.

1. Connect the BNC cable to the SCOPE connector. Connect the other end of the BNC cable to the BNC(f) connector attached to the 50 Ω resistance.
2. Press the **GO ON** blue softkey.
3. Enter the actual 50 Ω resistance.

Note

The Calibrator Mainframe will warn when the entered value is out of bounds. If this warning occurs recheck the setup and carefully re-enter the actual resistance insuring proper multiplier (i.e., m, u, n, p). If the warning still occurs, repair may be necessary.

4. When prompted by the Calibrator Mainframe, disconnect the 50 Ω resistance and connect the 1MΩ resistance to the end of the BNC cable.
5. Press the **GO ON** blue softkey.
6. Enter the actual 1MΩ resistance.
7. When prompted for the first reference capacitor by the Calibrator Mainframe, disconnect the 1MΩ resistance and leave nothing attached to the end of the BNC cable.
8. Press the **GO ON** blue softkey.
9. Enter 0.
10. When prompted for the second reference capacitor by the Calibrator Mainframe, connect the 50 pF capacitance to the end of the BNC cable.
11. Press the **GO ON** blue softkey.
12. Enter the actual 50 pF capacitance.

13. The Calibrator Mainframe will prompt that the calibration is complete. Press the **OPTIONS**, then **STORE CONSTS** blue softkeys to store the new calibration constants.

6-43. Verification

All of the Oscilloscope Calibration functions should be verified at least once per year, or each time the SC600 is calibrated. The verification procedures in this section provide traceable results; however the factory uses different procedures and instruments of higher precision than those described here. The procedures in this manual have been developed to provide users the ability to verify the SC600 at their own site if they are required to do so. Fluke strongly recommends that, if possible, you return your unit to Fluke for calibration and verification.

All equipment specified for SC600 verification must be calibrated, certified traceable if traceability is to be maintained, and operating within their normal specified operating environment. It is also important to ensure that the equipment has had sufficient time to warm up prior to its use. Refer to each equipment's operating manual for details.

Before you begin verification, you may wish to review all of the procedures in advance to ensure you have the resources to complete them.

All of the SC600 functions are listed in Table 6-18, with the verification technique indicated.

Table 6-18. Verification Methods for SC600 Functions

Function	Verification Method
DC Voltage	Procedure provided in this manual.
AC Voltage amplitude	Procedure provided in this manual.
AC Voltage frequency	Procedure provided in this manual.
Edge amplitude	Procedure provided in this manual.
Edge frequency, duty cycle, rise time	Procedure provided in this manual.
Tunnel Diode Pulser amplitude	Procedure provided in this manual. See "Voltage and Edge Calibration and Verification" for details.
Leveled sine wave amplitude, frequency, harmonics, and flatness	Procedures provided in this manual.
Time marker period	Procedure provided in this manual.
Wave generator amplitude	Procedure provided in this manual.
Pulse width, period	Procedure provided in this manual.
MeasZ resistance, capacitance	Procedure provided in this manual.
Overload functionality	Procedure provided in this manual.

6-44. DC Voltage Verification

This procedure uses the following equipment:

- Hewlett-Packard 3458A Digital Multimeter
- BNC(f) to Double Banana adapter
- 50 Ω feedthrough termination
- BNC cable supplied with the SC600

For DC voltage verification, refer to Figure 6-3 for the proper setup connections.

Set the Calibrator Mainframe to SCOPE mode, with the Volt menu on the display. Then follow these steps to verify the wave generator function.

6-45. Verification at 1 M Ω

For the 1 M Ω verification, connect the Calibrator Mainframe's SCOPE connector to the HP 3458A input, using the cable and the BNC(f) to Double Banana adapter.

Make sure the Calibrator Mainframe impedance is set to 1 M Ω (The blue softkey under **Output** @ toggles the impedance between 50 Ω and 1 M Ω).

1. Set the HP 3458A to DCV, Auto Range, NPLC = 10, FIXEDZ = on.
2. Program the Calibrator Mainframe to output the voltage listed in Table 6-19. Press **OPR** on the Calibrator Mainframe to activate the output.
3. Allow the HP 3458A reading to stabilize, then record the HP 3458A reading for each voltage in Table 6-19.
4. Compare result to the tolerance column.

6-46. Verification at 50 Ω

For the 50 Ω verification, connect the SCOPE connector to the HP 3458A input, using the cable and the 50 Ω termination connected to the BNC to Banana Plug adapter.

Make sure the Calibrator Mainframe impedance is set to 50 Ω (The blue softkey under **Output** @ toggles the impedance between 50 Ω and 1 M Ω).

1. Set the HP 3458A to DCV, Auto Range, NPLC = 10, FIXEDZ = on.
2. Program the Calibrator Mainframe to output the voltage listed in Table 6-20. Press **OPR** on the Calibrator Mainframe to activate the output.
3. Allow the HP 3458A reading to stabilize, then record the HP 3458A reading for each voltage in Table 6-20.

Multiply the readings by $(0.5 * (50 + R_{load}) / R_{load})$, where R_{load} = the actual feedthrough termination resistance, to correct for the resistance error. Compare result to the tolerance column.

Table 6-19. DC Voltage Verification at 1 M Ω

Calibrator Mainframe output	HP 3458A Reading (V DC)	Tolerance (V DC)
0 mV		0.00004 V
1.25 mV		4.063E-05 V
-1.25 mV		4.063E-05 V
2.49 mV		4.125E-05 V
-2.49 mV		4.125E-05 V
2.5 mV		4.125E-05 V
-2.5 mV		4.125E-05 V
6.25 mV		4.313E-05 V
-6.25 mV		4.313E-05 V
9.90 mV		4.495E-05 V
-9.90 mV		4.495E-05 V
10.0 mV		0.000045 V
-10.0 mV		0.000045 V
17.5 mV		4.875E-05 V
-17.5 mV		4.875E-05 V
24.9 mV		5.245E-05 V
-24.9 mV		5.245E-05 V
25.0 mV		0.0000525 V
-25.0 mV		0.0000525 V
67.5 mV		7.375E-05 V
-67.5 mV		7.375E-05 V
109.9 mV		9.495E-05 V
-109.9 mV		9.495E-05 V
110 mV		0.000095 V
-110 mV		0.000095 V
305 mV		0.0001925 V
-305 mV		0.0001925 V
499 mV		0.0002895 V
-499 mV		0.0002895 V
0.50 V		0.00029 V
-0.50 V		0.00029 V
1.35 V		0.000715 V
-1.35 V		0.000715 V
2.19 V		0.001135 V
-2.19 V		0.001135 V
2.20 V		0.00114 V
-2.20 V		0.00114 V
6.60 V		0.00334 V
-6.60 V		0.00334 V
10.99 V		0.005535 V
-10.99 V		0.005535 V
11.0 V		0.00554 V
-11.0 V		0.00554 V
70.5 V		0.03529 V
-70.5 V		0.03529 V
130.0 V		0.06504 V
-130.0 V		0.06504 V

Table 6-20. DC Voltage Verification at 50 Ω

Calibrator Mainframe output	HP 3458A Rdg (V DC)	Reading x correction	Tolerance (V DC)
0 mV			0.00004 V
2.49 mV			4.623E-05 V
-2.49 mV			4.623E-05 V
9.90 mV			6.475E-05 V
-9.90 mV			6.475E-05 V
24.9 mV			0.0001023 V
-24.9 mV			0.0001023 V
109.9 mV			0.0003148 V
-109.9 mV			0.0003148 V
499 mV			0.0012875 V
-499 mV			0.0012875 V
2.19 V			0.005515 V
-2.19 V			0.005515 V
6.599 V			0.0165375 V
-6.599 V			0.0165375 V

6-47. AC Voltage Amplitude Verification

This procedure uses the following equipment:

- Hewlett-Packard 3458A Digital Multimeter
- BNC(f) to Double Banana adapter
- 50 Ω feedthrough termination
- BNC cable supplied with the SC600
- BNC cable to connect the Calibrator Mainframe TRIG OUT to the HP 3458A Ext Trig

For ac voltage amplitude verification, refer to Figure 6-2 for the proper setup connections.

Set the Calibrator Mainframe to SCOPE mode, with the Volt menu on the display. Then follow these steps to verify the AC Voltage function.

6-48. Verification at 1 M Ω

For the 1 M Ω verification, connect the Calibrator Mainframe's SCOPE connector to the HP 3458A input, using the cable supplied with the Calibrator Mainframe and the BNC(f) to Double Banana adapter. Connect the Calibrator Mainframe TRIG OUT connector to the HP 3458A Ext Trig connector located on the rear of that instrument.

Make sure the Calibrator Mainframe impedance is set to 1 M Ω . (The blue softkey under Output @ toggles the impedance between 50 Ω and 1 M Ω .)

1. When making measurements at 1 kHz, set the HP 3458A to DCV, NPLC = .01, TRIG EXT, and the DELAY to .0007 for measuring the topline of the wave form, and the DELAY to .0012 for measuring the baseline of the wave form. Manually lock the HP 3458A to the range that gives the most resolution for the topline measurements. Use this same range for the corresponding baseline measurements at each step.
2. Enable the Calibrator Mainframe external trigger by toggling the blue softkey under TRIG to /1.
3. Measure the topline first, as indicated in Table 6-21. For each measurement, take samples for at least two seconds, using the HP 3458A MATH functions to determine the average or mean value. See “Setup for SC600 Voltage Square Wave Measurements” for more details.
4. Measure the baseline of each output after the corresponding topline measurement, as indicated in Table 6-21. The peak-to-peak value is the difference between the topline and baseline measurements. Compare the result to the tolerance column.
5. When making measurements at the other frequencies, set up the HP 3458A (NPLC and topline and baseline DELAY) per Table 6-16. (See “Setup for SC600 Voltage Square Wave Measurements.”)

Table 6-21. AC Voltage Verification at 1 MΩ

Calibrator Mainframe Output (1 kHz, or as noted)	HP 3458A Range	Topline Reading	Baseline Reading	Peak-to-Peak	Tolerance (±V)
1 mV	100 mV dc				0.000041
-1 mV	100 mV dc				0.000041
10 mV	100 mV dc				0.00005
-10 mV	100 mV dc				0.00005
25 mV	100 mV dc				0.000065
-25 mV	100 mV dc				0.000065
110 mV	100 mV dc				0.00015
-110 mV	100 mV dc				0.00015
500 mV	1 V dc				0.00054
-500 mV	1 V dc				0.00054
2.2 V	10 V dc				0.00224
-2.2 V	10 V dc				0.00224
11 V	10 V dc				0.01104
-11 V	10 V dc				0.01104
130 V	1000 V dc				0.13004
-130 V	1000 V dc				0.13004
200 mV, 100 Hz	1 V dc				0.00024
200 mV, 1 kHz	1 V dc				0.00024
200 mV, 5 kHz	1 V dc				0.00054
200 mV, 10 kHz	1 V dc				0.00054
2.2 V, 100 Hz	10 V dc				0.00224
2.2 V, 5 kHz	10 V dc				0.00554
2.2 V, 10 kHz	10 V dc				0.00554

6-49. *Verification at 50 Ω*

For the 50 Ω verification, connect the Calibrator Mainframe’s SCOPE connector to the HP 3458A input, using the cable supplied with the Calibrator Mainframe, the external 50 Ω termination, and the BNC(f) to Double Banana adapter. (The 50 Ω termination is closest to the HP 3458A input.) Connect the Calibrator Mainframe TRIG OUT connector to the HP 3458A Ext Trig connector located on the rear of that instrument. Make sure the Calibrator Mainframe impedance is set to 50 Ω. (The blue softkey under Output @ toggles the impedance between 50 Ω and 1 MΩ). Proceed with the following steps:

1. Set the HP 3458A to DCV, NPLC = .01, TRIG EXT, and the DELAY to .0007 for measuring the topline of the wave form, and the DELAY to .0012 for measuring the baseline of the wave form. Manually lock the HP 3458A to the range that gives the most resolution for the topline measurements. Use this same range for the corresponding baseline measurements at each step. See Table 6-22.
2. Enable the Calibrator Mainframe external trigger by toggling the blue softkey under TRIG to /1.
3. Measure the topline first, as indicated in Table 6-22. For each measurement, take samples for at least two seconds, using the HP 3458A MATH functions to determine the average or mean value. See “Setup for SC600 Voltage Square Wave Measurements” for more details.
4. Measure the baseline of each output after the corresponding topline measurement, as indicated in Table 6-22. The peak-to-peak value is the difference between the topline and baseline measurements. Compare the result to the tolerance column.

Table 6-22. AC Voltage Verification at 50 Ω

Calibrator Mainframe Output (1 kHz)	HP 3458A Range	Topline Reading	Baseline Reading	Peak-to-Peak	Peak-to-Peak x Correction	Tolerance (±V)
1 mV	100 mV dc					0.000043
-1 mV	100 mV dc					0.000043
10 mV	100 mV dc					0.000065
-10 mV	100 mV dc					0.000065
25 mV	100 mV dc					0.000103
-25 mV	100 mV dc					0.000103
110 mV	100 mV dc					0.000315
-110 mV	100 mV dc					0.000315
500 mV	1 V dc					0.00129
-500 mV	1 V dc					0.00129
2.2 V	10 V dc					0.00554
-2.2 V	10 V dc					0.00554
6.6 V	10 V dc					0.01654
-6.6 V	10 V dc					0.01654

6-50. AC Voltage Frequency Verification

This procedure uses the following equipment:

- PM 6680 Frequency Counter with an ovenized timebase (Option PM 9690 or PM 9691)
- BNC cable supplied with the SC600

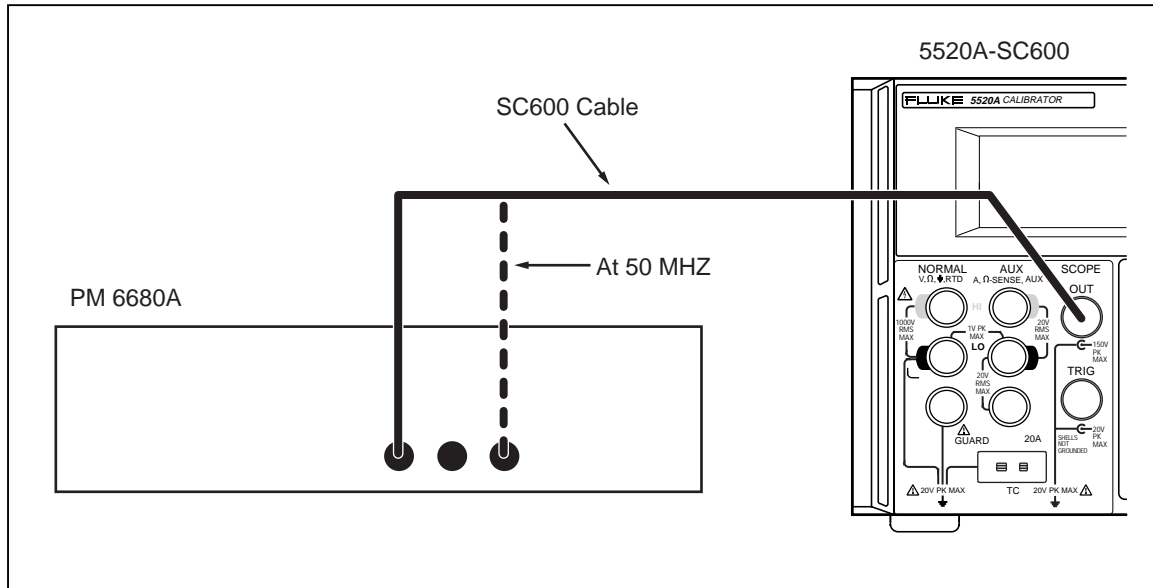


Figure 6-6. AC Voltage Frequency Verification Setup

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Set the Calibrator Mainframe to SCOPE mode, with the Volt menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Then follow these steps to verify ac voltage frequency.

1. Set the PM 6680's FUNCTION to measure frequency on channel A with auto trigger, measurement time set to 1 second or longer, $1M\Omega$ impedance, and filter off.
2. Using the BNC cable, connect the SCOPE connector on the Calibrator Mainframe to PM 6680 channel A.
3. Program the Calibrator Mainframe to output 2.1 V at each frequency listed in Table 6-23.
4. Allow the PM 6680 reading to stabilize, then record the PM 6680 reading for each frequency listed in Table 6-23. Compare to the tolerance column of Table 6-23.

Table 6-23. AC Voltage Frequency Verification

Calibrator Mainframe Frequency (output @ 2.1 V p-p)	PM 6680 Reading (Frequency)	Tolerance
10 Hz		0.000025 Hz
100 Hz		0.00025 Hz
1 kHz		0.0025 Hz
10 kHz		0.025 Hz

6-51. Edge Amplitude Verification

For the Edge Amplitude verification, connect the Calibrator Mainframe’s SCOPE connector to the HP 3458A input, using the cable supplied with the Calibrator Mainframe, the external 50 Ω termination, and the BNC(f) to Double Banana adapter. (The 50 Ω termination is closest to the HP 3458A input.)

1. For measurements of a 1 kHz signal, set the HP 3458A to DCV, NPLC = .01, LEVEL 1, TRIG LEVEL, and the DELAY to .0002 for measuring the upper part of the wave form (i.e. topline), and the DELAY to .0007 for measuring the lower part of the wave form (i.e. baseline). For measurements of a 10 kHz signal, set the HP 3458A to DCV, NPLC = .001, LEVEL 1, TRIG LEVEL, and the DELAY to .00002 for measuring the topline, and the DELAY to .00007 for measuring the baseline.
2. Manually lock the HP 3458A to the range that gives the most resolution for the baseline measurements. Use this same range for the corresponding baseline measurements at each step. Note that in the EDGE function, the topline is very near 0 V, and the baseline is a negative voltage. See Table 6-24.
3. For each calibration step, take samples for at least two seconds, using the HP 3458A MATH functions to enter the average or mean value. See “Setup for SC600 Edge and Wave Generator Measurements” for more details.
4. The peak-to-peak value of the wave form is the difference between the topline and baseline measurements, correcting for the load resistance error. To make this correction, multiply the readings by $(0.5 * (50 + R_{load})/R_{load})$, where R_{load} = actual feedthrough termination resistance. Record each reading as indicated in Table 6-24.

Table 6-24. Edge Amplification Verification

Calibrator Mainframe Edge Output	HP 3458A Range	Topline Reading	Baseline Reading	Peak-to-Peak	Peak-to-Peak x Correction	Tolerance (±V)
100 mV, 1 kHz	100 mV dc					0.0022
1.00V, 1 kHz	1 V dc					0.0202
5 mV, 10 kHz	100 mV dc					0.0003
10 mV, 10 kHz	100 mV dc					0.0004
25 mV, 10 kHz	100 mV dc					0.0007
50 mV, 10 kHz	100 mV dc					0.0012
100 mV, 10 kHz	1 V dc					0.0022
500 mV, 10 kHz	1 V dc					0.0102
1.00 V, 10 kHz	1 V dc					0.0202
2.5 V, 10 kHz	10 V dc					0.0502

6-52. Edge Frequency Verification

This procedure uses the following equipment:

- PM 6680 Frequency Counter with an ovenized timebase (Option PM 9690 or PM 9691)
- BNC cable supplied with the SC600

Refer to Figure 6-6 for proper setup connections. Set the Calibrator Mainframe to SCOPE mode, with the Edge menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Then follow these steps to verify Edge frequency.

1. Set the PM 6680's FUNCTION to measure frequency on channel A with auto trigger, measurement time set to 1 second or longer, 50 Ω impedance, and filter off.
2. Using the BNC cable, connect the SCOPE connector on the Calibrator Mainframe to PM 6680 channel A.
3. Program the Calibrator Mainframe to output 2.5 V at each frequency listed in Table 6-25.
4. Allow the PM 6680 reading to stabilize, then record the PM 6680 reading for each frequency listed in Table 6-25. Compare to the tolerance column of Table 6-25.

Table 6-25. Edge Frequency Verification

Calibrator Mainframe Frequency (output @ 2.5 V p-p)	PM 6680 Reading (Frequency)	Tolerance
1 kHz		0.0025 Hz
10 kHz		0.025 Hz
100 kHz		0.25 Hz
1 MHz		2.5 Hz
10 MHz		25 Hz

6-53. Edge Duty Cycle Verification

This procedure uses the following equipment:

- PM 6680 Frequency Counter
- BNC cable supplied with the SC600

Refer to Figure 6-6 for proper setup connections. Set the Calibrator Mainframe to SCOPE mode, with the Edge menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Then follow these steps to verify Edge duty cycle.

1. Set the PM 6680's FUNCTION to measure duty cycle on channel A with auto trigger, measurement time set to 1 second or longer, 50 Ω impedance, and filter off.
2. Using the BNC cable, connect the SCOPE connector on the Calibrator Mainframe to PM 6680 channel A.
3. Program the Calibrator Mainframe to output 2.5 V at 1 MHz.
4. Allow the PM 6680 reading to stabilize. Compare the duty cycle reading to 50% \pm 5%.

6-54. Edge Rise Time Verification

This procedure tests the edge function's rise time. Aberrations are also checked with the Tektronix 11801 oscilloscope and SD-22/26 sampling head.

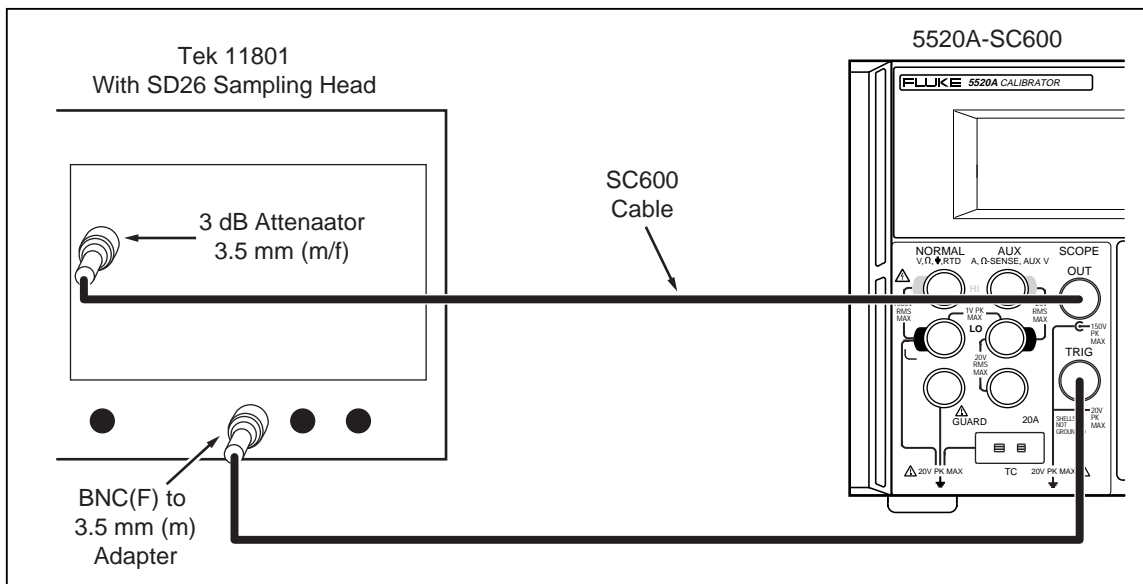
The following equipment is used to verify the edge rise time.

- High Frequency Digital Storage Oscilloscope: Tektronix 11801 with Tektronix SD-22/26 sampling head

- 3 dB attenuator, 3.5 mm (m/f)
- BNC(f) to 3.5 mm(m) adapter (2)
- BNC cable supplied with the SC600
- second BNC cable

Connect the BNC cable supplied with the SC600 to the Calibrator Mainframe's SCOPE connector. Connect the other end of the BNC cable to one BNC(f) to 3.5 mm(m) adapter then to the DSO's sampling head through the 3 dB attenuator.

Using the second BNC(f) to 3.5 mm(m) adapter and BNC cable, connect the Calibrator Mainframe's TRIG OUT connector to the 11801's Trigger Input. Refer to Figure 6-7.



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Figure 6-7. Edge Rise Time Verification Setup

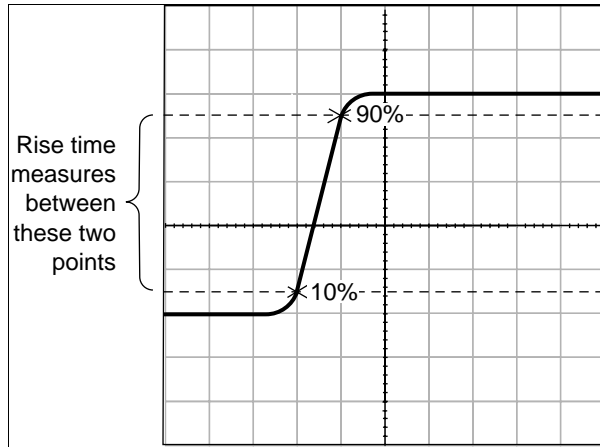
The Calibrator Mainframe should be in SCOPE mode, with the Edge menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Press the softkey under TRIG to select the TRIG/1 External Trigger output. Program the Calibrator Mainframe to output 250 mV @ 1 kHz. Set the DSO to these parameters:

Digital Storage Oscilloscope Setup

Main Time Base position (initial)	40 ns
Horizontal scale	500 ps/div
Measurement Function	Rise Time

1. Program the Calibrator Mainframe to output the voltage and frequency listed in Table 6-26. Press **OPR** on the Calibrator Mainframe to activate the output.
2. Change the vertical scale of the DSO to the value listed in the table. Adjust the main time base position and vertical offset until the edge signal is centered on the display. Record the rise time measurement in column A of Table 6-26.
3. Correct the rise time measurement by accounting for the SD-22/26 sampling head's rise time. The SD-22/26 rise time is specified as < 28 ps. Column B = $\sqrt{(\text{Column A})^2 - (\text{SD-22/26 rise time})^2}$.

4. The edge rise time measured should be less than the time indicated in Table 6-26.



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Figure 6-8. Edge Rise Time

Table 6-26. Edge Rise Time Verification

Calibrator Mainframe Output		DSO Vertical Axis (mV/div)	A 11801 Reading	B Corrected Reading	Tolerance
Voltage	Frequency				
250 mV	1 kHz	20.0			< 300 ps
250 mV	1 MHz	20.0			< 300 ps
250 mV	10 MHz	20.0			< 350 ps
500 mV	1 kHz	50.0			< 300 ps
500 mV	1 MHz	50.0			< 300 ps
500 mV	10 MHz	50.0			< 350 ps
1 V	1 kHz	100.0			< 300 ps
1 V	1 MHz	100.0			< 300 ps
1 V	10 MHz	100.0			< 350 ps
2.5 V	1 kHz	200.0			< 300 ps
2.5 V	1 MHz	200.0			< 300 ps
2.5 V	10 MHz	200.0			< 350 ps

6-55. Edge Abberation Verification

The following equipment is needed for this procedure:

- Tektronix 11801 oscilloscope with SD22/26 sampling head
- Output cable provided with the SC600

Before you begin this procedure, verify that the SC600 is in the edge mode (the Edge menu is displayed), and program it to output 1 V p-p @ 1 MHz. Press **OPR** to activate the output.

Connect the Calibrator Mainframe to the oscilloscope referring to Figure 6-7. Set the oscilloscope vertical to 10 mV/div and horizontal to 1 ns/div. Set the oscilloscope to look at the 90% point of the edge signal; use this point as the reference level. Set the oscilloscope to look at the first 10 ns of the edge signal with the rising edge at the left edge of the oscilloscope display.

With these settings, each vertical line on the oscilloscope represents a 1% aberration. Determine that the SC600 falls within the typical specifications shown in Table 6-27.

Table 6-27. Edge Aberrations

Time from 50% of Rising Edge	Typical Edge Aberrations
0 - 2 ns	< 32 mV (3.2%)
2 - 5 ns	< 22 mV (2.2%)
5 - 15 ns	< 12 mV (1.2%)
> 15 ns	< 7 mV (0.7%)

6-56. Tunnel Diode Pulser Drive Amplitude Verification

This procedure uses the following equipment:

- Hewlett-Packard 3458A Digital Multimeter
- BNC(f) to Double Banana adapter
- BNC cable supplied with the SC600

Set the Calibrator Mainframe in Scope Cal mode, Edge. Proceed with the following steps:

1. Connect the Calibrator Mainframe’s SCOPE connector to the HP 3458A input, using the BNC cable and the BNC(f) to Double Banana adapter. Refer to Figure 6-2 for the proper setup connections.
2. Activate the TD Pulser output by pushing the **TDPULSE** blue softkey. The output should now be at 80 V peak-to-peak, 100 kHz, STANDBY.
3. Set the HP 3458A to DCV, NPLC = .001, LEVEL 1, TRIG LEVEL, and the DELAY to .00012 for measuring the topline and DELAY to .00007 for measuring the baseline. Manually range lock the HP 3458A to the 100 V dc range.
4. Change the Calibrator Mainframe output frequency to 10 kHz. Push the operate key, and use the HP 3458A to measure the topline and baseline.
5. The peak-to-peak value is the difference between the topline and baseline. Record these values in Table 6-28, and compare against the listed tolerance.

Table 6-28. Tunnel Diode Pulser Amplitude Verification

Calibrator Mainframe Edge Output	HP 3458A Range	Topline Reading	Baseline Reading	Peak-to-Peak	Tolerance (±V)
80 V, 10 kHz	100 V dc				1.6

6-57. Leveled Sine Wave Amplitude Verification

This procedure uses the following equipment:

- 5790A AC Measurement Standard
- BNC(f) to Double Banana Plug adapter
- 50Ω feedthrough termination
- BNC cable supplied with the SC600

Refer to Figure 6-17 for the proper setup connections.

Set the Calibrator Mainframe to SCOPE mode, with the Levsine menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Then follow these steps to verify the leveled sine wave amplitude.

1. Connect the BNC cable to the Calibrator Mainframe's SCOPE connector. Connect the other end of the BNC cable to the 50Ω feedthrough termination then to the 5790A INPUT 2 using the BNC(f) to Double Banana adapter.
2. Set the 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.
3. Program the Calibrator Mainframe to output the voltage listed in Table 6-29.
4. Allow the 5790A reading to stabilize, then record the 5790A's rms reading for each voltage listed in Table 6-29.
5. Multiply the rms reading by the conversion factor of 2.8284 to convert it to the peak-to-peak value.
6. Multiply the peak-to-peak value by $(0.5 * (50 + R_{load}) / R_{load})$, where R_{load} = the actual feedthrough termination resistance, to correct for the resistance error. Compare result to the tolerance column.

Table 6-29. Leveled Sine Wave Amplitude Verification

Calibrator Mainframe output (@ 50 kHz)	5790A Reading (V rms)	5790A Reading x 2.8284 (V p-p)	V p-p value x correction	Tolerance (V p-p)
5.0 mV				400 μV
7.5 mV				450 μV
9.9 mV				498 μV
10.0 mV				500 μV
25.0 mV				800 μV
39.0 mV				1.08 mV
40.0 mV				1.10 mV
70.0 mV				1.70 mV
99.0 mV				2.28 mV
100.0 mV				2.30 mV
250.0 mV				5.30 mV
399.0 mV				8.28 mV
0.4 V				8.3 mV
0.8 V				16.3 mV
1.2 V				24.3 mV
1.3 V				26.3 V
3.4 V				68.3 mV
5.5 V				110.3 mV

6-58. Leveled Sine Wave Frequency Verification

This procedure uses the following equipment:

- PM 6680 Frequency Counter with a prescaler for the Channel C input (Option PM 9621, PM 9624, or PM 9625) and ovenized timebase (Option PM 9690 or PM 9691)
- BNC(f) to Type N(m) adapter
- BNC cable supplied with the SC600

Refer to Figure 6-6 for the proper setup connections. Set the Calibrator Mainframe to SCOPE mode, with the Levsine menu on the display. Then follow these steps to verify the leveled sine wave amplitude.

1. Set the PM 6680's FUNCTION to measure frequency with auto trigger, measurement time set to 1 second or longer, and 50 Ω impedance.
2. Using the BNC cable, connect the SCOPE connector on the Calibrator Mainframe to the PM 6680 at the channel indicated in Table 6-30. You will need the BNC-N adapter for the connection to Channel C.
3. Set the filter on the PM 6680 as indicated in the table.
4. Program the Calibrator Mainframe to output as listed in Table 6-30. Press **OPR** on the Calibrator Mainframe to activate the output.
5. Allow the PM 6680 reading to stabilize, then record the PM 6680 reading for each frequency listed in Table 6-30.

Table 6-30. Leveled Sine Wave Frequency Verification

Calibrator Mainframe Frequency (output @ 5.5 V p-p)	PM 6680 Settings		PM 6680 Reading (Frequency)	Tolerance
	Channel	Filter		
50 kHz	A	On		0.125 Hz
500 kHz	A	Off		1.25 Hz
5 MHz	A	Off		12.5 Hz
50 MHz	A	Off		125 Hz
500 MHz	C	Off		1250 Hz

6-59. Leveled Sine Wave Harmonics Verification

This procedure uses the following equipment:

- Hewlett-Packard 8590A Spectrum Analyzer
- BNC(f) to Type N(m) adapter
- BNC cable supplied with the SC600

Refer to Figure 6-9 for proper setup connections.

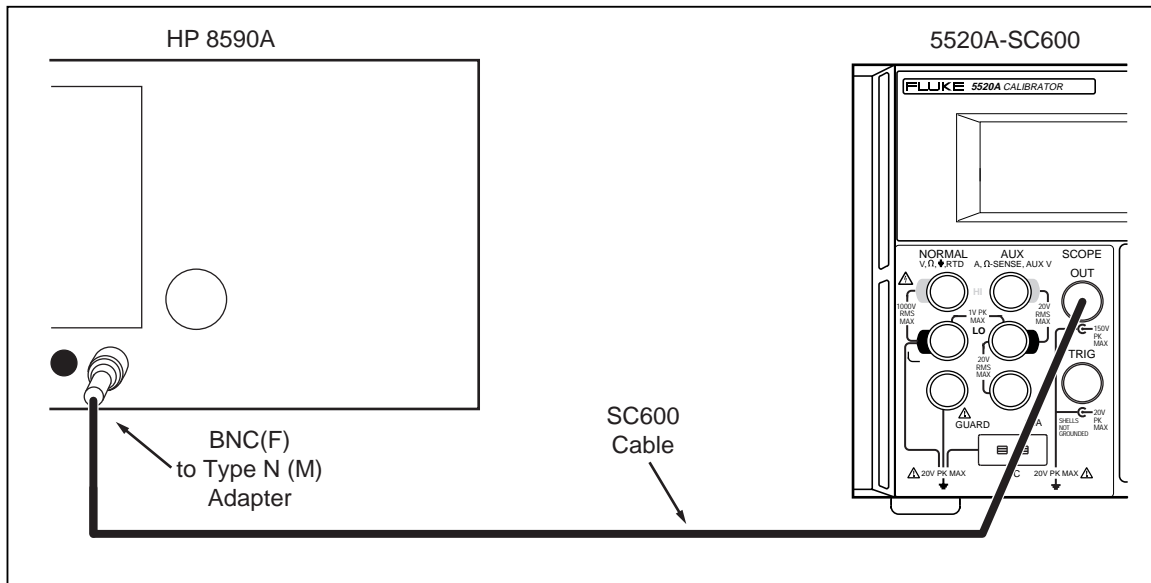


Figure 6-9. Leveled Sine Wave Harmonics Verification Setup

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Set the Calibrator Mainframe to SCOPE mode, with the Levsine menu on the display. Then follow these steps to verify the leveled sine wave harmonics.

1. Using the BNC cable and BNC(f) to Type N(m) adapter, connect the SCOPE connector on the Calibrator Mainframe to the HP 8590A.
2. Program the Calibrator Mainframe to 5.5 V p-p at each frequency listed in Table 6-31. Press **OPR** on the Calibrator Mainframe to activate the output.
3. Set HP 8590A start frequency to the Calibrator Mainframe output frequency. Set HP 8590A stop frequency to 10 times the Calibrator Mainframe output frequency. Set the HP 8590A reference level at +19 dBm.
4. Record the harmonic level reading for each frequency and harmonic listed in Table 6-31. For harmonics 3, 4, and 5, record the highest harmonic level of the three measured. Harmonics should be below the levels listed in the tolerance column of Table 6-31.

Table 6-31. Leveled Sine Wave Harmonics Verification

Calibrator Mainframe Output Frequency (@ 5.5 V p-p)	Harmonic	HP 8590A Reading (dB)	Tolerance
50 kHz	2		-33 dB
50 kHz	3, 4, 5		-46 dB
100 kHz	2		-33 dB
100 kHz	3, 4, 5		-38 dB
200 kHz	2		-33 dB
200 kHz	3, 4, 5		-38 dB
400 kHz	2		-33 dB
400 kHz	3, 4, 5		-38 dB
800 kHz	2		-33 dB
800 kHz	3, 4, 5		-38 dB
1 MHz	2		-33 dB
1 MHz	3, 4, 5		-38 dB
2 MHz	2		-33 dB
2 MHz	3, 4, 5		-38 dB
4 MHz	2		-33 dB
4 MHz	3, 4, 5		-38 dB
8 MHz	2		-33 dB
8 MHz	3, 4, 5		-38 dB
10 MHz	2		-33 dB
10 MHz	3, 4, 5		-38 dB
20 MHz	2		-33 dB
20 MHz	3, 4, 5		-38 dB
40 MHz	2		-33 dB
40 MHz	3, 4, 5		-38 dB
80 MHz	2		-33 dB
80 MHz	3, 4, 5		-38 dB
100 MHz	2		-33 dB
100 MHz	3, 4, 5		-38 dB
200 MHz	2		-33 dB
200 MHz	3, 4, 5		-38 dB
400 MHz	2		-33 dB
400 MHz	3, 4, 5		-38 dB
600 MHz	2		-33 dB
600 MHz	3, 4, 5		-38 dB

6-60. Leveled Sine Wave Flatness Verification

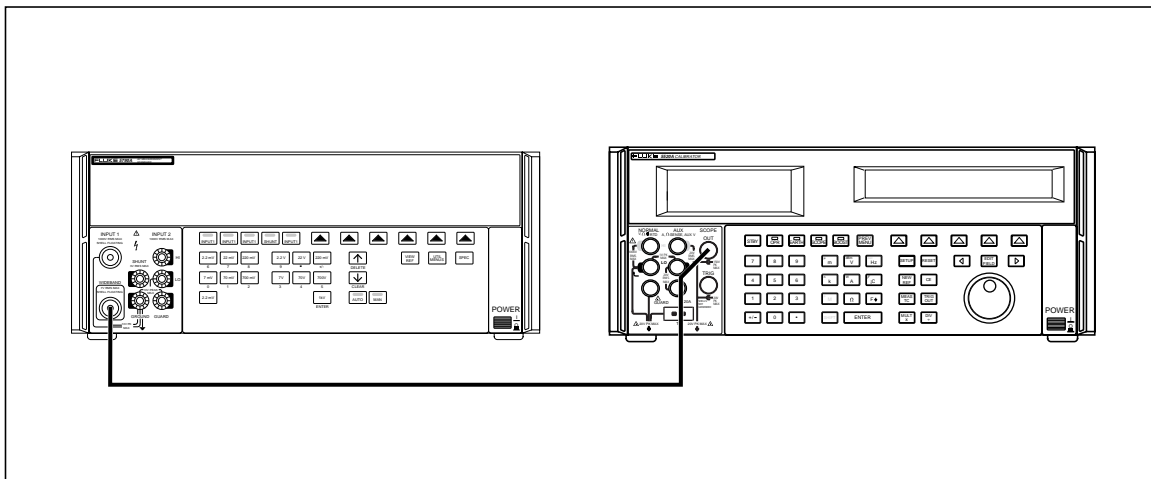
Leveled Sine Wave flatness verification is divided into two frequency bands: 50 kHz to 10 MHz (low frequency) and > 10 MHz to 600 MHz (high frequency). The equipment setups are different for each band. Leveled Sine Wave flatness is measured relative to 50 kHz. This is determined directly in the low frequency band. The high frequency band requires a “transfer” measurement be made at 10 MHz to calculate a flatness relative to 50 kHz.

6-61. Equipment Setup for Low Frequency Flatness

All low frequency flatness procedures use the following equipment.

- 5790A/03 AC Measurement Standard with Wideband option
- BNC(f) to Type N(m) adapter
- BNC cable supplied with the SC600

Connect the Calibrator Mainframe SCOPE connector to the 5790A WIDEBAND input with the BNC(f) to Type N(m) adapter as shown in Figure 6-10. Set the 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.



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Figure 6-10. Connecting the Calibrator Mainframe to the 5790A AC Measurement Standard

6-62. Equipment Setup for High Frequency Flatness

All high frequency flatness procedures use the following equipment.

- Hewlett-Packard 437B Power Meter
- Hewlett-Packard 8482A and 8481D Power Sensors
- BNC(f) to Type N(f) adapter
- BNC cable supplied with the Calibrator Mainframe

Note

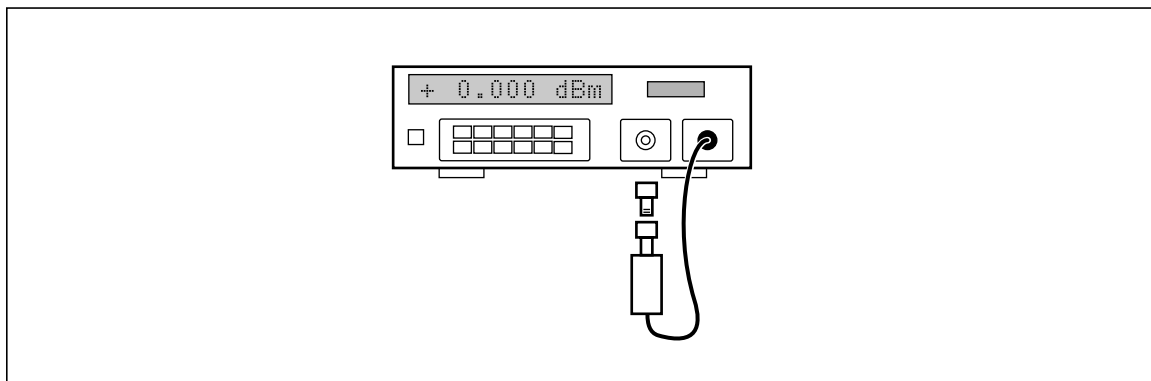
When high frequencies at voltages below 63 mV p-p are verified, use the 8481D Power Sensor. Otherwise, use the 8482A Power Sensor.

Connect the HP 437B Power Meter to either the 8482A or the 8481D Power Sensor as shown in Figure 6-11. For more information on connecting the two instruments, see the power meter and power sensor operators manuals.

Connect the power meter/power sensor combination to the SCOPE connector on the Calibrator Mainframe, as shown in Figure 6-12.

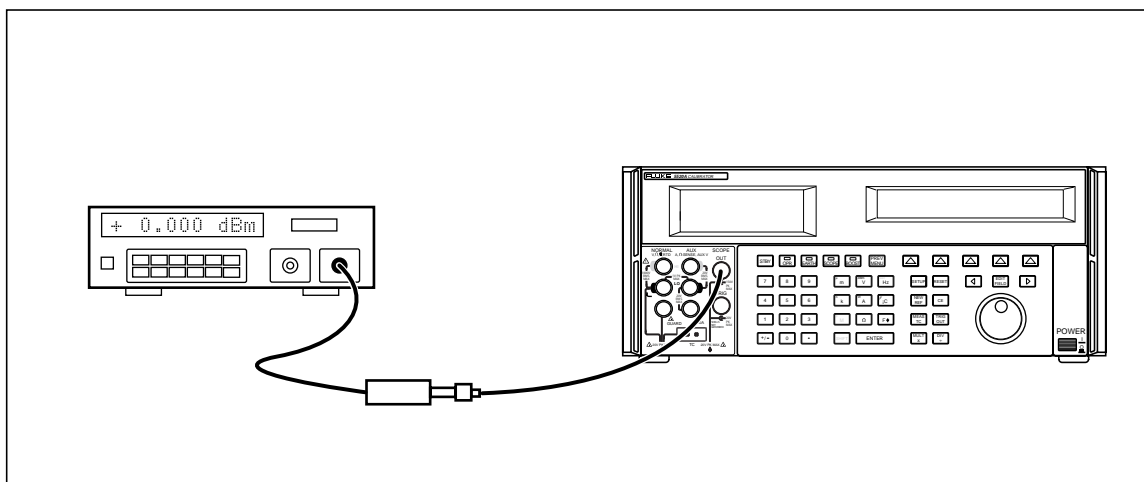
The Hewlett-Packard 437B Power Meter must be configured by setting the parameters listed below. Zero and self-calibrate the power meter with the power sensor being used. Refer to the Hewlett-Packard 437B operators manual for details.

- PRESET
- RESOLN 3
- AUTO FILTER
- WATTS
- SENSOR TABLE 0 (default)



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Figure 6-11. Connecting the HP 437B Power Meter to the HP 8482A or 8481D Power Sensor



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Figure 6-12. Connecting the Calibrator Mainframe to the HP Power Meter and Power Sensor

6-63. *Low Frequency Verification*

This procedure provides an example of testing low frequency flatness using a 5.5 V output. Follow the same procedure for testing other amplitudes, only compare results against the flatness specification listed in Table 6-32.

1. Program the Calibrator Mainframe for an output of 5.5 V @ 500 kHz. Press **OPR** on the Calibrator Mainframe to activate the output.
2. Allow the 5790A reading to stabilize. The 5790A should display approximately 1.94 V rms. Enter the 5790A reading in Column A of Table 6-32.
3. Enter 50 kHz into the Calibrator Mainframe. Allow the 5790A reading to stabilize, then enter the 5790A reading in Column B of Table 6-32.
4. Enter the next frequency listed in Table 6-32. Allow the 5790A reading to stabilize, then enter the reading into Column A of the table.
5. Enter 50 kHz into the Calibrator Mainframe. Allow the 5790A reading to stabilize, then enter the 5790A reading in Column B of Table 6-32.
6. Repeat steps 4 and 5 for all of frequencies listed in Table 6-32. Continue until you have completed Columns A and B.
7. When you have completed Columns A and B, press **STBY** to remove the Calibrator Mainframe's output. Complete Table 6-32 by performing the calculations for column C. Compare Column C to the specifications listed in the final column.

Table 6-32. Low Frequency Flatness Verification at 5.5 V

Calibrator Mainframe Frequency	A	B 50 kHz	C	Calibrator Mainframe Flatness Specification (%)
500 kHz				±1.50
1 MHz				±1.50
2 MHz				±1.50
5 MHz				±1.50
10 MHz				±1.50
Complete Columns A-C as follows:				
A Enter 5790A Reading (mV) for the present frequency.				
B Enter 5790A Reading (mV) for 50 kHz.				
C Compute and enter the Calibrator Mainframe Flatness Deviation (%): $100 * ((\text{Column A entry}) - (\text{Column B entry})) / (\text{Column B entry})$				

6-64. *High Frequency Verification*

This procedure provides an example of testing high frequency flatness using a 5.5 V output. Follow the same procedure for testing other amplitudes, only compare results against the flatness specification listed in Table 6-33. For this voltage range, you will use the model HP 8482A power sensor.

1. Program the Calibrator Mainframe for an output of 5.5 V @ 30 MHz. Press **OPR** on the Calibrator Mainframe to activate the output.
2. Allow the power meter reading to stabilize. The power meter should display approximately 75 mW. Enter the power meter's reading in Column A of Table 6-33.

3. Enter 10 MHz into the Calibrator Mainframe. Allow the power meter reading to stabilize, then enter the power meter's reading in Column B of Table 6-33.
4. Enter the next frequency listed in Table 6-33. Allow the power meter's reading to stabilize, then enter the reading into Column A of the table.
5. Enter 10 MHz into the Calibrator Mainframe. Allow the power meter reading to stabilize, then enter the power meter's reading in Column B of Table 6-33.
6. Repeat steps 4 and 5 for all of frequencies listed in Table 6-33. Continue until you have completed Columns A and B.
7. When you have completed Columns A and B, press **[STBY]** to remove the Calibrator Mainframe's output. Complete Table 6-33 by performing the calculations for each column. Compare Column G to the specifications listed in the final column.

Table 6-33. High Frequency Flatness Verification at 5.5 V

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	F	G	Calibrator Mainframe Flatness Spec. (%)
30								±1.50
70								±1.50
120								±2.00
290								±2.00
360								±4.00
390								±4.00
400								±4.00
480								±4.00
570								±4.00
580								±4.00
590								±4.00
600								±4.00
Complete Columns A-G as follows: A Enter the 437B present frequency Reading (W). B Enter the 437B 10 MHz Reading (W). C Apply power sensor correction factor for present frequency (W): $CF * (\text{Column A entry})$ D Apply power sensor correction factor for 10 MHz (W): $CF * (\text{Column B entry})$ E Compute and enter Error relative to 10 MHz (%): $100 * (\text{sqrt}(\text{Column A entry}) - \text{sqrt}(\text{Column B entry})) / \text{sqrt}(\text{Column B entry})$ F Enter the 10 MHz rms Error (%) for 5.5 V from Table 6-32, Column C. G Compute and enter the Calibrator Mainframe Flatness Deviation (%): $(\text{Column E entry}) + (\text{Column F entry})$								

6-65. Time Marker Verification

This procedure uses the following equipment:

- PM 6680 Frequency Counter with a prescaler for the Channel C input (Option PM 9621, PM 9624, or PM 9625) and ovenized timebase (Option PM 9690 or PM 9691)
- BNC(f) to Type N(m) adapter
- BNC cable supplied with the SC600

Refer to Figure 6-6 for the proper setup connections. Set the PM 6680's FUNCTION to measure frequency with auto trigger, measurement time set to 1 second or longer, and 50 Ω impedance.

Set the Calibrator Mainframe to SCOPE mode, with the Marker menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Then follow these steps to for each period listed in Table 6-34.

1. Program the Calibrator Mainframe to the output as listed in Table 6-34.
2. Using the BNC cable, connect the SCOPE connector on the Calibrator Mainframe to the PM 6680 at the channel indicated in Table 6-34. You will need the BNC-N adapter for the connection to Channel C.
3. Set the filter on the PM 6680 as indicated in the table. Allow the PM 6680 reading to stabilize, then record the PM 6680 reading for each frequency listed for the Calibrator Mainframe.
4. Invert the PM 6680's frequency reading to derive the period. For example, a reading of 1.000006345 kHz has a period of:

$$1/1.000006345 \text{ kHz} = 0.999993655 \text{ ms.}$$

Record the period in the table and compare to the tolerance column.

Table 6-34. Time Marker Verification

Calibrator Mainframe	PM 6680 Settings		PM 6680 Reading (Frequency)	¹ PM 6680 Reading	Tolerance
	Period	Channel		Filter	
5 s	A	On			0.3489454 s
2 s	A	On			0.0582996 s
50.0 ms	A	Off			3.872E-05 s
20.0 ms	A	Off			5E-08 s
10.0 ms	A	Off			2.5E-08 s
100 ns	A	Off			2.5E-13 s
50.0 ns	A	Off			1.25E-13 s
20.0 ns	A	Off			5E-14 s
10.0 ns	A	Off			2.5E-14 s
5.00 ns	A	Off			1.25E-14 s
2.00 ns	C	Off			5E-15 s

6-66. Wave Generator Verification

This procedure uses the following equipment:

- 5790A AC Measurement Standard

- BNC(f) to Double Banana adapter
- 50 Ω feedthrough termination
- BNC cable supplied with the Calibrator Mainframe

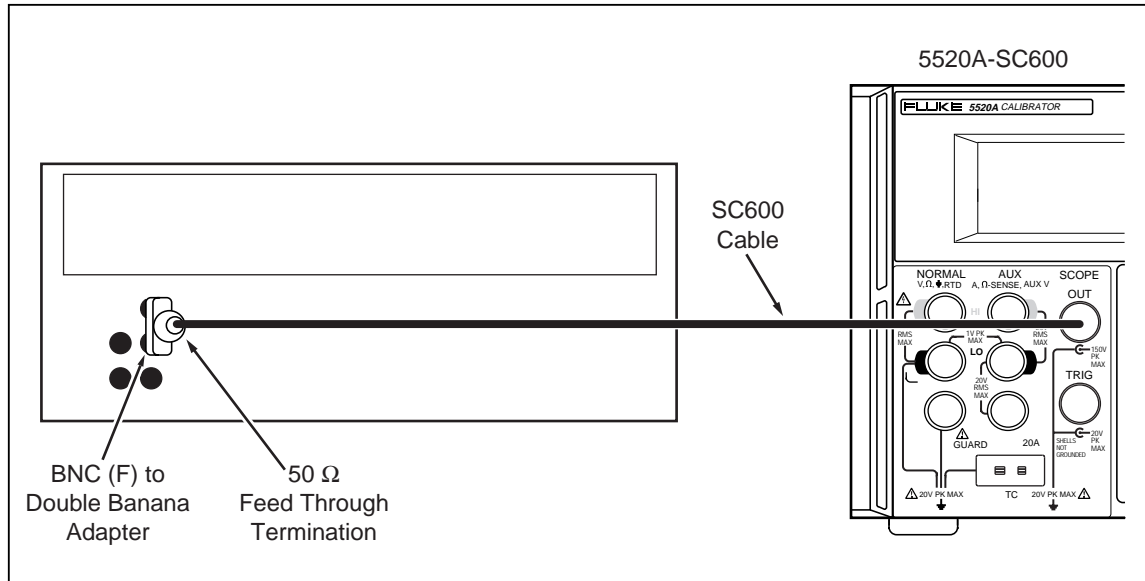


Figure 6-13. Wave Generator Verification Setup

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For wave generation verification procedures, refer to Figure 6-13 for the proper setup connections.

Set the Calibrator Mainframe to **SCOPE** mode, with the Wavegen menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Set the offset to 0 mV, and the frequency to 1 kHz. Then follow these steps to verify the wave generator function.

6-67. Verification at 1 M Ω

Set the Calibrator Mainframe impedance to 1 M Ω (The blue softkey under **SCOPE Z** toggles the impedance between 50 Ω and 1 M Ω).

1. Connect the BNC cable to the Calibrator Mainframe's **SCOPE** connector. Connect the other end of the BNC cable to the 5790A INPUT 2 using the BNC(f) to Double Banana adapter.
2. Set the 5790A to **AUTORANGE**, digital filter mode to **FAST**, restart fine, and Hi Res on.
3. Program the Calibrator Mainframe to output the wave type and voltage listed in Table 6-35.
4. Allow the 5790A reading to stabilize, then record the 5790A rms reading for each wave type and voltage in Table 6-35.
5. Multiply the rms reading by the conversion factor listed to convert it to the peak-to-peak value. Compare result to the tolerance column.

6-68. Verification at 50 Ω

Set the Calibrator Mainframe impedance to 50 Ω (The blue softkey under **SCOPE Z** toggles the impedance between 50 Ω and 1 M Ω).

1. Connect the BNC cable to the Calibrator Mainframe's SCOPE connector. Connect the other end of the BNC cable to the 50 Ω feedthrough termination then to the 5790A INPUT 2 using the BNC(f) to Double Banana adapter.
2. Set the 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.
3. Program the Calibrator Mainframe to output the wave type and voltage listed in Table 6-36.
4. Allow the 5790A reading to stabilize, then record the 5790A rms reading for each wave type and voltage in Table 6-36.
5. Multiply the rms reading by the conversion factor listed to convert it to the peak-to-peak value.

Multiply the peak-to-peak value by $(0.5 * (50 + R_{load}) / R_{load})$, where R_{load} = the actual feedthrough termination resistance, to correct for the resistance error. Compare result to the tolerance column.

Table 6-35. Wave Generator Verification at 1 MΩ

Calibrator Mainframe Wave Type	Calibrator Mainframe output (@ 10 kHz)	5790A Reading (V rms)	Conversion Factor	5790A Reading x Conversion Factor (V p-p)	Tolerance (V p-p)
square	1.8 mV		2.0000		0.000154 V
square	11.9 mV		2.0000		0.000457 V
square	21.9 mV		2.0000		0.00075 V
square	22.0 mV		2.0000		0.00076 V
square	56.0 mV		2.0000		0.00178 V
square	89.9 mV		2.0000		0.002797 V
square	90 mV		2.0000		0.0028 V
square	155 mV		2.0000		0.00475 V
square	219 mV		2.0000		0.00667 V
square	220 mV		2.0000		0.0067 V
square	560 mV		2.0000		0.0169 V
square	899 mV		2.0000		0.02707 V
square	0.90 V		2.0000		0.0271 V
square	3.75 V		2.0000		0.1126 V
square	6.59 V		2.0000		0.1978 V
square	6.6 V		2.0000		0.1981 V
square	30.8 V		2.0000		0.9241 V
square	55.0 V		2.0000		1.6501 V
sine	1.8 mV		2.8284		0.000154 V
sine	21.9 mV		2.8284		0.000757 V
sine	89.9 mV		2.8284		0.002797 V
sine	219 mV		2.8284		0.00667 V
sine	899 mV		2.8284		0.02707 V
sine	6.59 V		2.8284		0.1978 V
sine	55 V		2.8284		1.6501 V
triangle	1.8 mV		3.4641		0.000154 V
triangle	21.9 mV		3.4641		0.000757 V
triangle	89.9 mV		3.4641		0.002797 V
triangle	219 mV		3.4641		0.00667 V
triangle	899 mV		3.4641		0.02707 V
triangle	6.59 V		3.4641		0.1978 V
triangle	55 V		3.4641		1.6501 V

Table 6-36. Wave Generator Verification at 50 Ω

Calibrator Mainframe Wave Type	Calibrator Mainframe output (10 kHz)	5790A Reading (V rms)	Conversion Factor	5790A Rdg x Conversion Factor (V p-p)	V p-p value x correction	Tolerance (V p-p)
square	1.8 mV		2.0000			0.000154 V
square	6.4 mV		2.0000			0.000292 V
square	10.9 mV		2.0000			0.000427 V
square	11.0 mV		2.0000			0.00043 V
square	28.0 mV		2.0000			0.00094 V
square	44.9 mV		2.0000			0.001447 V
square	45 mV		2.0000			0.00145 V
square	78 mV		2.0000			0.00244 V
square	109 mV		2.0000			0.00337 V
square	110 mV		2.0000			0.0034 V
square	280 mV		2.0000			0.0085 V
square	449 mV		2.0000			0.01357 V
square	450 mV		2.0000			0.0136 V
square	780 mV		2.0000			0.0235 V
square	1.09 V		2.0000			0.0328 V
square	1.10 V		2.0000			0.0331 V
square	1.80 V		2.0000			0.0541 V
square	2.50 V		2.0000			0.0751 V
sine	1.8 mV		2.8284			0.000154 V
sine	10.9 mV		2.8284			0.000427 V
sine	44.9 mV		2.8284			0.001447 V
sine	109 mV		2.8284			0.00337 V
sine	449 mV		2.8284			0.01357 V
sine	1.09 V		2.8284			0.0328 V
sine	2.50 V		2.8284			0.0751 V
triangle	1.8 mV		3.4641			0.000154 V
triangle	10.9 mV		3.4641			0.000427 V
triangle	44.9 mV		3.4641			0.001447 V
triangle	109 mV		3.4641			0.00337 V
triangle	449 mV		3.4641			0.01357 V
triangle	1.09 V		3.4641			0.0328 V
triangle	2.50 V		3.4641			0.0751 V

6-69. Pulse Width Verification

The following equipment is used to verify the pulse width.

- High Frequency Digital Storage Oscilloscope: Tektronix 11801 with Tektronix SD-22/26 sampling head
- 3 dB attenuator, 3.5 mm (m/f)
- BNC(f) to 3.5 mm(m) adapter (2)
- BNC cable supplied with the SC600
- second BNC cable

Refer to Figure 6-7 for proper setup connections.

Connect the BNC cable supplied with the SC600 to the Calibrator Mainframe's SCOPE connector. Connect the other end of the BNC cable to one BNC(f) to 3.5 mm(m) adapter then to the DSO's sampling head through the 3 dB attenuator.

Using the second BNC(f) to 3.5 mm(m) adapter and BNC cable, connect the Calibrator Mainframe's TRIG OUT connector to the 11801's Trigger Input. The Calibrator Mainframe should be in SCOPE mode, with the Edge menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Press the softkey under TRIG to select the TRIG/1 External Trigger output.

Set the DSO to these parameters:

Digital Storage Oscilloscope Setup

- Main Time Base position (initial) 40 ns
- Vertical scale 200 mV/div
- Trigger source = ext; level = 0.5 V; ext atten = x10; slope = +; mode = auto
- Measurement Function positive width

1. Program the Calibrator Mainframe to output the pulse width and period at 1 V as listed in Table 6-37.
2. Change the horizontal scale of the DSO to the value listed in the table. Adjust the main time base position and vertical offset until the pulse signal is centered on the display. Record the width measurement. Compare to the tolerance column of Table 6-37.

Table 6-37. Pulse Width Verification

Calibrator Mainframe Output		DSO horizontal scale (time/div)	11801 Reading	Tolerance
Width	Period			
4.0 ns	200 ns	1 ns		0.700 ns
44.9 ns	200 ns	10 ns		2.745 ns
45 ns	200 ns	10 ns		6.250 ns
500 ns	1.25 us	100 ns		29.0 ns

6-70. Pulse Period Verification

This procedure uses the following equipment:

- PM 6680 Frequency Counter with an ovenized timebase (Option PM 9690 or PM 9691)
- BNC cable supplied with the SC600

Refer to Figure 6-6 for the proper setup connections. Set the Calibrator Mainframe to SCOPE mode, with the Pulse menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Then follow these steps to verify the Pulse period.

1. Set the PM 6680's FUNCTION to measure period on channel A with auto trigger, measurement time set to 1 second or longer, 50 Ω impedance, and filter off.
2. Using the BNC cable, connect the SCOPE connector on the Calibrator Mainframe to PM 6680 channel A.
3. Program the Calibrator Mainframe to output the pulse width and period (at 2.5 V) as listed in Table 6-38.
4. Allow the PM 6680 reading to stabilize, then record the PM 6680 reading for each period listed for the Calibrator Mainframe. Compare to the tolerance column of Table 6-38.

Table 6-38. Pulse Period Verification

Calibrator Mainframe Output		PM 6680 Reading	
Width	Period	(Period)	Tolerance
80 ns	200 ns		5E-13 s
500 ns	10 ms		2.5E-08 s
500 ns	20 ms		5.0E-08 s

6-71. MeasZ Resistance Verification

The MeasZ resistance function is verified by measuring resistors of known values. The measurement value is then compared to the resistor actual value.

The resistors must make a solid connection to a BNC(f) to enable a connection to the end of the BNC cable supplied with the SC600. The resistance values must be known at this BNC(f) connector. Fluke uses an HP 3458A DMM to make a 4-wire ohms measurement at the BNC(f) connector to determine the actual resistance values.

This procedure uses the following equipment:

- Resistors of known values: 1.5 MΩ, 1 MΩ, 60 Ω, 50 Ω, 40 Ω nominal
- adapters to connect resistors to BNC(f) connector
- BNC cable supplied with the SC600

Refer to Figure 6-17 for the proper setup connections.

Set the Calibrator Mainframe to SCOPE mode, with the MeasZ menu on the display. Then follow these steps to verify the MeasZ resistance function.

1. Set the Calibrator Mainframe MeasZ resistance range as indicated in Table 6-39. (The blue softkey under **MEASURE** toggles the MeasZ ranges).

2. Using the BNC cable, connect the SCOPE connector to the BNC(f) connector attached to the nominal resistance values indicated in Table 6-39. The 600 K Ω nominal value can be achieved by connecting the 1.5 M Ω and 1 M Ω resistors in parallel.
3. Allow the Calibrator Mainframe reading to stabilize, then record the Calibrator Mainframe resistance reading for each nominal value listed in Table 6-39. Compare the Calibrator Mainframe resistance readings to the actual resistance values and the tolerance column of Table 6-39.

Table 6-39. MeasZ Resistance Verification

Calibrator Mainframe MeasZ Range	Nominal Resistance Value	Calibrator Mainframe Resistance Reading	Actual Resistance Value	Tolerance
res 50 Ω	40 Ω			0.04 Ω
res 50 Ω	50 Ω			0.05 Ω
res 50 Ω	60 Ω			0.06 Ω
res 1M Ω	600 k Ω			600 Ω
res 1M Ω	1 M Ω			1 k Ω
res 1M Ω	1.5 M Ω			1.5 k Ω

6-72. MeasZ Capacitance Verification

The MeasZ capacitance function is verified by measuring capacitors of known values. The measurement value is then compared to the capacitor actual value.

The capacitors must make a solid connection to a BNC(f) to enable a connection to the end of the BNC cable supplied with the SC600. Due to the small capacitance values, care must be taken to know the actual capacitance at this BNC(f) connector. The capacitance values must be determined at a 10 MHz oscillator frequency. Fluke uses an HP 4192A Impedance Analyzer at 10 MHz to determine the actual capacitance values.

This procedure uses the following equipment:

- Adapters and capacitors to achieve 5 pF, 29 pF, 49 pF nominal values at the end of BNC(f) connector
- BNC cable supplied with the SC600

Refer to Figure 6-17 for the proper setup connections.

Set the Calibrator Mainframe to SCOPE mode, with the MeasZ menu on the display. Then follow these steps to verify the MeasZ capacitance function.

1. Set the Calibrator Mainframe MeasZ capacitance range to **cap**. (The blue softkey under **MEASURE** toggles the MeasZ ranges).
2. Connect the BNC cable to the Calibrator Mainframe SCOPE connector, but do not connect anything to the end of this cable.
3. Allow the Calibrator Mainframe reading to stabilize, then press the **SET OFFSET** blue softkey to zero the capacitance reading.
4. Connect the end of the BNC cable to the BNC(f) connector attached to the nominal capacitor values indicated in Table 6-40.

- Allow the Calibrator Mainframe reading to stabilize, then record the Calibrator Mainframe capacitance reading for each nominal value listed in Table 6-40. Compare the Calibrator Mainframe capacitance readings to the actual capacitance values and the tolerance column of Table 6-40.

Table 6-40. MeasZ Capacitance Verification

Nominal Capacitance Value	Calibrator Mainframe Capacitance Reading	Actual Capacitance Value	Tolerance
5 pF			0.75 pF
29 pF			1.95 pF
49 pF			2.95 pF

6-73. Overload Function Verification

This procedure uses the following equipment:

- 50 Ω feedthrough termination
- BNC cable supplied with the Calibrator Mainframe

Refer to Figure 6-14 for setup connections.

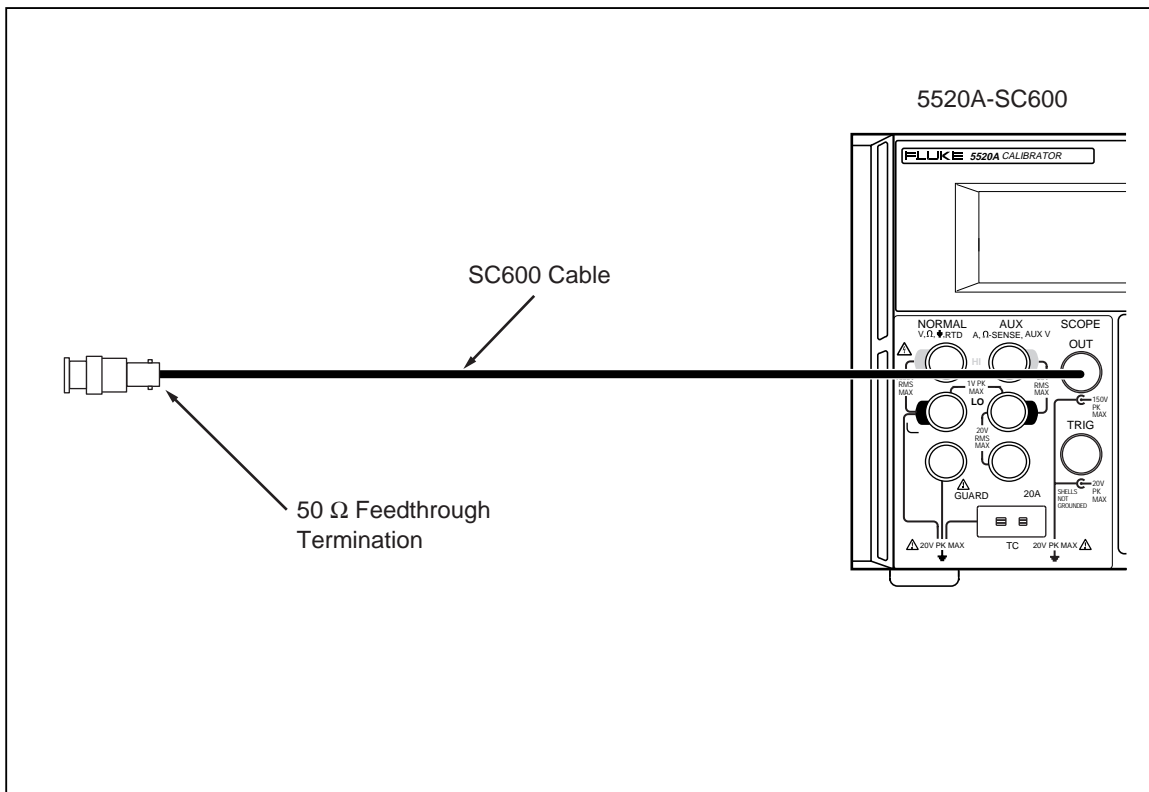


Figure 6-14. Overload Function Verification Setup

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Set the Calibrator Mainframe to SCOPE mode, with the Overload menu on the display. Connect the BNC cable to the Calibrator Mainframe SCOPE connector. Then follow these steps to verify the overload function.

1. Connect the 50 Ω feedthrough termination to the end of the BNC cable.
2. Program the Calibrator Mainframe output for 5.000 V, DC (**OUT VAL** blue softkey), and time limit = 60 s (**T LIMIT** blue softkey).
3. Press **OPR** on the Calibrator Mainframe to activate the output and verify that the **OPR** display timer increments.
4. Remove the 50 Ω feedthrough termination before 60 seconds and verify that Calibrator Mainframe goes to **STBY**.
5. Reconnect the 50 Ω feedthrough termination to the end of the BNC cable.
6. Program the Calibrator Mainframe output for 5.000 V, ac (**OUT VAL** blue softkey).
7. Press **OPR** on the Calibrator Mainframe to activate the output and verify that the **OPR** display timer increments.
8. Remove the 50 Ω feedthrough termination before 60 seconds and verify that Calibrator Mainframe goes to **STBY**.

6-74. SC600 Hardware Adjustments

Hardware adjustments must be made to the leveled sine and edge functions each time the SC600 is repaired. In addition to the adjustment procedures, this section provides lists of the required equipment and some recommendations on models that have the capabilities required by these procedures. Equivalent models can be substituted if necessary.

6-75. Equipment Required

The following equipment is necessary for performing the hardware adjustments described in this section. The models listed are recommended for providing accurate results.

- Standard adjustment tool for adjusting the pots and trimmer caps
- Extender Card
- Oscilloscope Mainframe and Sampling Head (Tektronix 11801 with SD-22/26 or Tektronix TDS 820 with 8 GHz bandwidth)
- 10 dB Attenuator (Weinschel 9-10 (SMA), or Weinschel 18W-10, or equivalent)
- Cable provided with SC600
- Spectrum Analyzer (Hewlett-Packard 8590A)

6-76. Adjusting the Leveled Sine Wave Function

There are two adjustment procedures that need to be made for the leveled sine wave function. The first procedure adjusts the balance out of the LO VCO so that the signal is balanced between the two VCOs. The second procedure adjusts the harmonics.

6-77. Equipment Setup

This procedure uses the spectrum analyzer. Before you begin this procedure, verify that the Calibrator Mainframe is in leveled sine wave mode (the Levsine menu is displayed), and program it to output 5.5 V p-p @ 600 MHz. Press **OPR** to activate the output.

Refer to Figure 6-9 for setup connections and connect the Calibrator Mainframe to the Spectrum Analyzer. Adjust the Spectrum Analyzer so that it displays one peak across its horizontal center line. The far right of the peak is fixed at the far right of the center line, as shown below.

6-78. Adjusting the Leveled Sine Wave VCO Balance

Once you have completed the setup described above, perform the following procedure to adjust the VCO balance for the leveled sine wave function.

1. Program the Calibrator Mainframe for an output of 5.5 V @ 600 MHz.
2. Set the Spectrum Analyzer to the parameters listed below.

Spectrum Analyzer Setup

Start Frequency	10 MHz
Stop Frequency	800 MHz
Resolution Bandwidth	30 kHz
Video Bandwidth	3 kHz
Reference Level	20 dBm

The Spectrum Analyzer will display a spur at 153 MHz. Refer to Figure 6-15 to identify the spur.

3. You need to adjust the wave until the spur is at a minimum. To do this, slowly rotate R1 (shown in the diagram) counterclockwise until the spur is at a minimum. As you adjust it, the spur will move down the waveform, towards the right. As soon as the spur is minimized, stop rotating R1. If you rotate it too far, the spur will reappear.

Once you have turned R1 to the point at which the spur is at a minimum, the signal is balanced between the VCOs, and you have completed the adjustment.

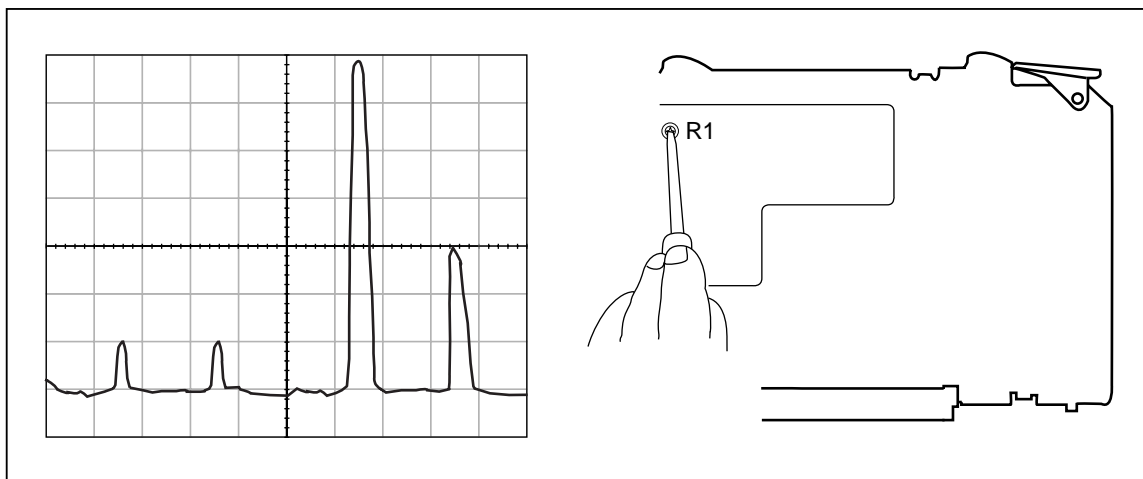


Figure 6-15. Adjusting the Leveled Sine Wave Balance

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6-79. Adjusting the Leveled Sine Wave Harmonics

The following procedure adjusts the harmonics for the leveled sine wave function.

Note

This procedure should only be used for adjusting the leveled sine wave harmonics. Do not use this procedure as a verification test. The specifications in this procedure are not valid for verification.

1. Set the Spectrum Analyzer to the parameters listed below.

Spectrum Analyzer Setup

Start Frequency	50 MHz
Stop Frequency	500 MHz
Resolution Bandwidth	3 MHz
Video Bandwidth	3 kHz
Reference Level	20 dBm

2. Use your Spectrum Analyzer's Peak Search function to find the desired reference signal. The Analyzer should show the fundamental, and second and third harmonics. The harmonics need to be adjusted so that the second harmonic is at 40 dBc and third harmonic should typically be at 50 dBc as shown in Figure 6-16.
3. To adjust the harmonics, adjust R8, as shown in Figure 6-16 until the peaks of the second and third harmonic are at the correct dB level. You may find that you can place the second harmonic at 40 dBc but the third harmonic is not at 50 dBc. If this is the case, continue adjusting R8. The second harmonic will fluctuate, but there is a point at which both harmonics will be at the correct decibel level.

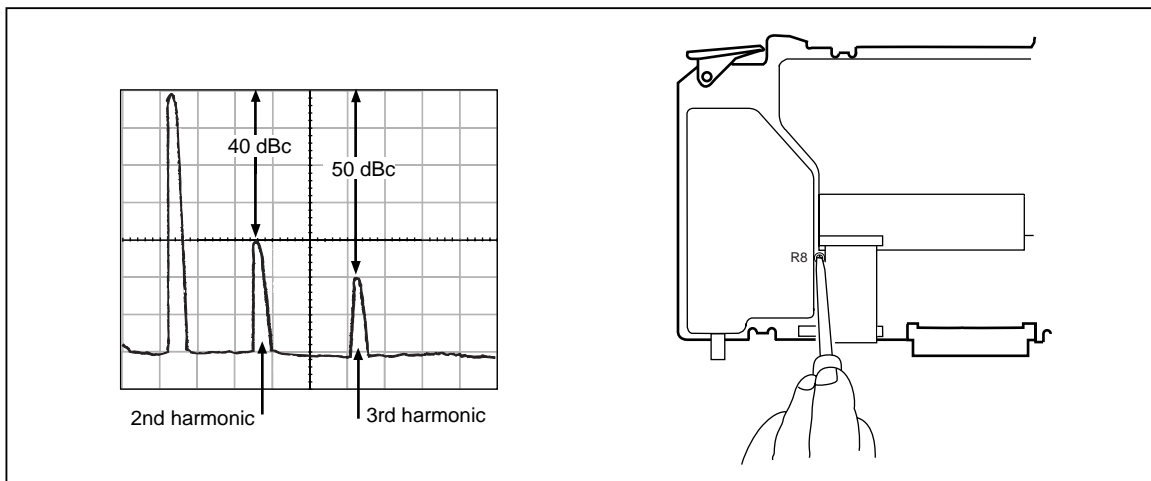


Figure 6-16. Adjusting the Leveled Sine Wave Harmonics

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6-80. Adjusting the Aberrations for the Edge Function

Adjustments need to be made after repair to the edge function to adjust the edge aberrations.

Note

To verify the edge aberrations back to national standards, you should send your Calibrator Mainframe to Fluke, or other facility that has established traceability for aberrations. Fluke, for example, has a reference pulse that is sent to the National Institute of Standards and Technology (NIST) for characterization. This information is then transferred to high speed sampling heads, which are used to adjust and verify the SC600.

6-81. *Equipment Setup*

The following equipment is needed for this procedure:

- Oscilloscope: Tektronix 11801 with SD22/26 input module or Tektronix TDS 820 with 8 GHz bandwidth.
- 10 dB Attenuator: Weinschel 9-10 (SMA) or Weinschel 18W-10 or equivalent
- Output cable provided with the SC600

Before you begin this procedure, verify that the SC600 is in the edge mode (the Edge menu is displayed), and program it to output 1 V p-p @ 1 MHz. Press **OPR** to activate the output.

Refer to Figure 6-7 for the proper setup connections and connect the Calibrator Mainframe to the oscilloscope. Set the oscilloscope vertical to 10 mV/div and horizontal to 1 ns/div. Set the oscilloscope to look at the 90% point of the edge signal; use this point as the reference level. Set the oscilloscope to look at the first 10 ns of the edge signal with the rising edge at the left edge of the oscilloscope display.

6-82. *Adjusting the Edge Aberrations*

Refer to Figure 6-17 while making the following adjustments:

1. Adjust A90R13 to set the edge signal at the right edge of oscilloscope display, at 10 ns, to the reference level set above.
2. Adjust A90R36 so the first overshoot is the same amplitude as the next highest aberration.
3. Adjust A90R35 so that the second and third overshoot aberrations are the same amplitude as the first aberration.
4. Adjust A90R12 to set the edge signal occurring between 2 ns and 10 ns to the reference level set above.
5. Readjust A90R36 and A90R35 to obtain equal amplitudes for the first, second, and third aberrations.
6. Adjust A90R13 to set the edge signal occurring between 0 ns and 2 ns to the reference point set above. Center any aberrations so the peaks are equal above and below the reference level.
7. Readjust A90R12 if necessary to keep the edge signal occurring between 2 ns and 10 ns at the reference level.
8. Readjust A90R13 if necessary to keep the edge signal occurring between 0 ns and 2 ns at the reference level.
9. Set the UUT output to 250 mV and the oscilloscope vertical to 2 mV/div. Check the aberrations.
10. Connect the 10 dB attenuator to the oscilloscope input. Connect the UUT to the attenuator and program the UUT output to 2.5 V.
11. Set the oscilloscope vertical to 5 mV/div. Check the aberrations.
12. Check for rise time < 300 ps at 250 mV, 1 V, and 2.5 V outputs.

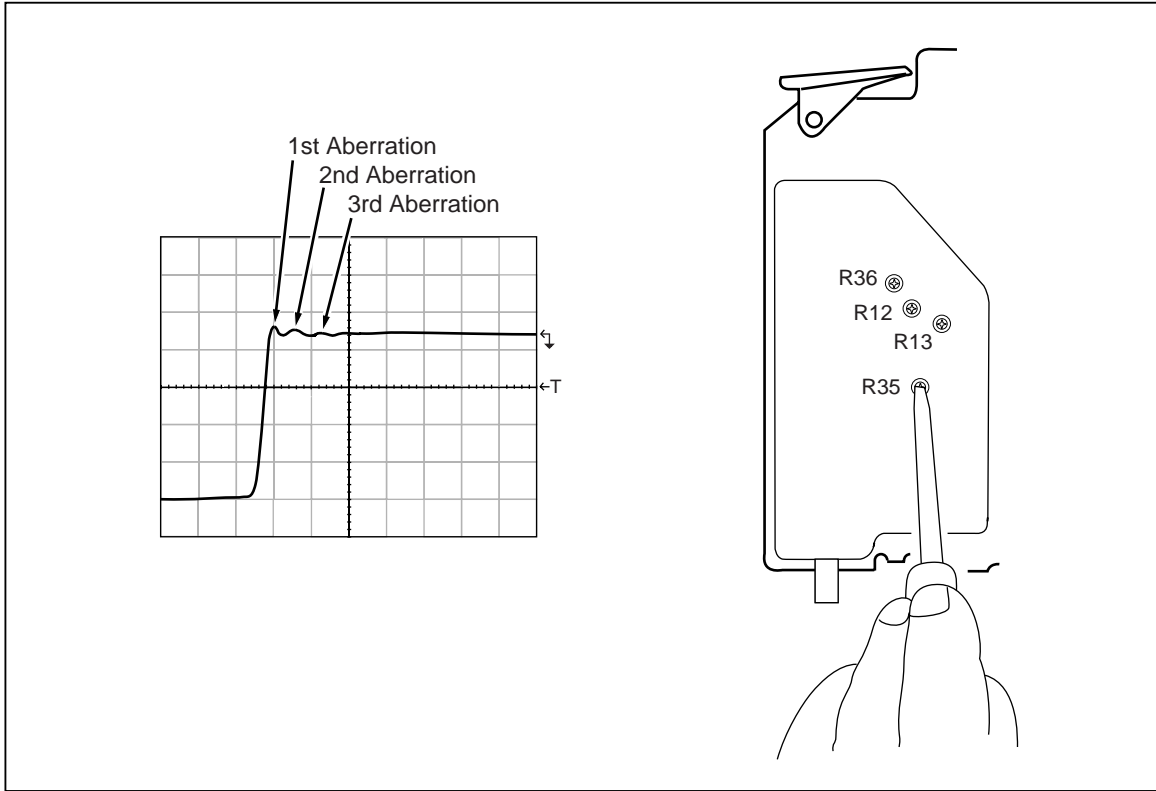


Figure 6-17. Adjusting Edge Aberrations

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Chapter 6

SC300 Option

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6-83. Introduction

This chapter contains the following information and service procedures for the SC300 Oscilloscope Calibration Option functions.

- Specifications
- Theory of Operation
- Calibration Procedures
- Verification Procedures
- Hardware Adjustments made after Repair

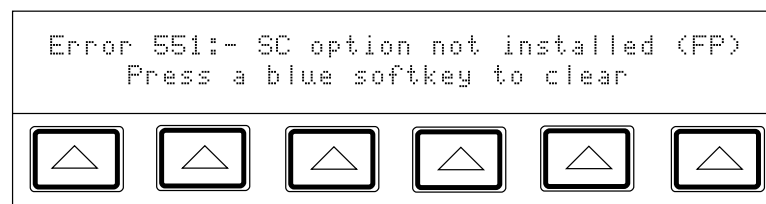
The calibration and verification procedures provide traceable results for all of the SC300 functions as long as they are performed using the recommended equipment. All of the required equipment along with the minimum specifications, are provided in Table 6-41 under “Equipment Required for Calibration and Verification.”

The calibration and verification procedures in this chapter are not the ones Fluke uses at the factory. These procedures have been developed to provide you with the ability to calibrate and verify the SC300 at your own site if necessary. You should review all of the procedures in advance to make sure you have the resources to complete them. It is strongly recommended that, if possible, you return your unit to Fluke for calibration and verification.

Hardware adjustments that are made after repair, at the factory or designated Fluke service centers, are provided in detail.

6-84. Maintenance

There are no maintenance techniques or diagnostic remote commands for the SC300 that are available to users. If your SC300 is not installed or not receiving power, the following error message appears on the display when you press **SCOPE** to access the oscilloscope calibration menus.



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If this message is displayed, and you have the SC300 installed in your Calibrator Mainframe, you must return the Calibrator Mainframe to Fluke for repair. If you wish to purchase the SC300, contact your Fluke sales representative.

6-85. SC300 Specifications

These specifications apply only to the SC300. General specifications that apply to the Calibrator Mainframe can be found in Chapter 1. The specifications are valid providing the Calibrator Mainframe is operated under the conditions specified in Chapter 1, and has completed a warm-up period of at least twice the length of time the calibrator was powered off, up to a maximum of 30 minutes. All SC300 specifications apply to the end of the cable (PN 945014) supplied with the Option.

6-86. Voltage Function Specifications

Voltage Function	DC Signal		AC Square Wave Signal	
	into 50 Ω	into 1 M Ω	into 50 Ω	into 1 M Ω
Amplitude Characteristics				
Range	0 V to ± 2.2 V	0 V to ± 33 V	1.8 mV to 2.2 V p-p	1.8 mV to 105 V p-p [1]
Resolution	< 100 V: 4 digits or 10 μ V, whichever is greater ≥ 100 V: 5 digits			
Adjustment Range	Continuous [1]			
1-Year Absolute Uncertainty, $t_{cal} \pm 5$ °C	$\pm (0.25\%$ of output + 100 μ V) [2]			
Sequence	1-2-5 (e.g., 10 mV, 20 mV, 50 mV)			
Square Wave Frequency Characteristics				
Range	10 Hz to 10 kHz [3]			
1-Year Absolute Uncertainty, $t_{cal} \pm 5$ °C	$\pm (25$ ppm of setting + 15 mHz)			
Typical Aberration within 20 μ s from leading edge	< (2% of output + 100 μ V)			
[1]	The square wave signal into 1 M Ω is a positive square wave from 1.8 mV to 55 V p-p. From 95 V to 105 V, its output is a square wave-like signal that alternates between the negative peak and the positive peak, with the centerline at -10 V. Signals between 55 V and 95 V p-p are not available.			
[2]	The uncertainty for 50 Ω loads does not include the input impedance uncertainty of the oscilloscope. Square wave signals below 4.5 mV p-p have an uncertainty of $\pm (0.25\%$ of output + 200 μ V). Signals from 95 to 105 V p-p have an uncertainty of 0.5% of output in the frequency range 100 Hz to 1 kHz. Typical uncertainty is 1.5% of output for 95 to 105 V p-p signals in the frequency range 10 Hz to 100 Hz, and 0.5% of output in the frequency range 1 kHz to 10 kHz.			
[3]	From 95 V to 105 V, the output is a square wave-type signal that alternates between the negative peak and the positive peak, with the centerline at -10 V. If the oscilloscope you are calibrating requires a fixed period for the square wave's peak-to-peak amplitude, you may need to adjust the Calibrator Mainframe's frequency output to accommodate for this waveform. For example, the Fluke ScopeMeter® has a calibration point at 1 kHz (1 ms), 100 V, peak-to-peak. To output a period of 1 ms at 100 V peak-to-peak, use a frequency of 356 Hz.			

6-87. Edge Function Specifications

Edge Characteristics into 50 Ω		1-Year Absolute Uncertainty, tcal ± 5 $^{\circ}\text{C}$
Amplitude		
Range (p-p)	4.5 mV to 2.75 V	\pm (2% of output + 200 μV)
Resolution	4 digits	
Adjustment Range	\pm 10% around each sequence value (indicated below)	
Sequence	5 mV, 10 mV, 25 mV, 50 mV, 100 mV, 250 mV, 500 mV, 1 V, 2.5 V	
Other Edge Characteristics		
Frequency Range	1 kHz to 1 MHz	\pm (25 ppm of setting + 15 mHz)
Rise Time	\leq 1 ns	
Leading Edge Aberrations	within 10 ns	< (2% of output + 2 mV)
	10 to 30 ns	< (1% of output + 2 mV)
	after 30 ns	< (0.5% of output + 2 mV)
Typical Duty Cycle	45% to 55%	

6-88. Leveled Sine Wave Function Specifications

Leveled Sine Wave Characteristics into 50 Ω	Frequency Range		
	50 kHz Reference	50 kHz to 100 MHz	100 to 300 MHz [1]
Amplitude Characteristics			
Range (p-p)	5 mV to 5.5 V [1]		
Resolution	< 100 mV: 3 digits ≥ 100 mV: 4 digits		
Adjustment Range	continuously adjustable		
1-Year Absolute Uncertainty, tcal \pm 5 °C	\pm (2% of output + 200 μ V)	\pm (3.5% of output + 300 μ V)	\pm (4% of output + 300 μ V)
Flatness (relative to 50 kHz)	not applicable	\pm (1.5% of output + 100 μ V)	\pm (2.0% of output + 100 μ V)
Short-term Stability	\leq 1% [2]		
Frequency Characteristics			
Resolution	10 Hz	10 kHz [3]	10 kHz
1-Year Absolute Uncertainty, tcal \pm 5 °C	\pm (25 ppm + 15 mHz)	\pm 25 ppm [4]	\pm 25 ppm
Distortion Characteristics			
2nd Harmonic	\leq -33 dBc		
3rd and Higher Harmonics	\leq -38 dBc		
<p>[1] Extended frequency range to 350 MHz is provided, but flatness is not specified. Amplitude is limited to 3 V for frequencies above 250 MHz.</p> <p>[2] Within one hour after reference amplitude setting, provided temperature varies no more than \pm 5°C.</p> <p>[3] At frequencies below 120 kHz, the resolution is 10 Hz. For frequencies between 120 kHz and 999.9 kHz, the resolution is 100 Hz.</p> <p>[4] \pm (25 ppm + 15 mHz) for frequencies of 1 MHz and below.</p>			

6-89. Time Marker Function Specifications

Time Marker into 50Ω	5s to 100 μs	50 μs to 2 μs	1 μs to 20 ns	10 ns to 2 ns
1-Year Absolute Uncertainty, tcal ± 5 °C	± (25 ppm + 1 mHz)	± (25 ppm + 15 mHz)	± 25 ppm	±25 ppm
Wave Shape	pulsed sawtooth	pulsed sawtooth	pulsed sawtooth	sine
Typical Output Level	> 1 V pk	> 1 V pk	> 1 V pk	> 2 V p-p [1]
Sequence	5-2-1 from 5s to 2 ns (e.g., 500 ms, 200 ms, 100 ms)			
Adjustment Range	At least ± 10% around each sequence value indicated above.			
Resolution	4 digits			
[1] The 2 ns time marker is typically > 0.5 p-p.				

6-90. Wave Generator Specifications

Wave Generator Characteristics	Square Wave, Sine Wave, and Triangle Wave into 50 Ω or 1 MΩ
Amplitude	
Range	into 1 MΩ: 1.8 mV to 55 V p-p into 50 Ω: 1.8 mV to 2.2 V p-p
1-Year Absolute Uncertainty, tcal ± 5 °C, 10 Hz to 10 kHz	± (3% of p-p output + 100 μV)
Sequence	1-2-5 (e.g., 10 mV, 20 mV, 50 mV)
Typical DC Offset Range	0 to ± (≥40% of p-p amplitude) [1]
Frequency	
Range	10 Hz to 100 kHz
Resolution	4 or 5 digits depending upon frequency
1-Year Absolute Uncertainty, tcal ± 5 °C	± (25 ppm + 15 mHz)
[1] The dc offset plus the wave signal must not exceed 30 V rms.	

6-91. Trigger Signal Specifications for the Time Marker Function

Time Marker Period	Division Ratio [1]	Amplitude into 50 Ω (p-p)	Typical Rise Time
5 to 50 ms	off/1	≥ 1 V	≤ 2 ns
20 ms to 100 ns	off/1/10/100	≥ 1 V	≤ 2 ns
50 to 10 ns	off/10/100	≥ 1 V	≤ 2 ns
5 to 2 ns	off/100	≥ 1 V	≤ 2 ns

6-92. Trigger Signal Specifications for the Edge Function

Edge Signal Frequency	Division Ratio	Amplitude into 50 Ω (p-p)	Typical Rise Time
1 kHz to 1 MHz	off/1	≥ 1 V	≤ 2 ns

6-93. Theory of Operation

The following discussion provides a brief overview of the following SC300 operating modes: voltage, edge, leveled sine wave, time marker and wave generator. This discussion will allow you to identify which of the main plug-in boards of the Calibrator Mainframe are defective. Figure 6-18 shows a block diagram of the SC300 Option, also referred to as the A50 board. Functions that are not depicted in the figure are generated from the DDS Assembly (A6 board). For a diagram of all Calibrator Mainframe board assemblies, refer to Figure 2-1.

6-94. Voltage Mode

All signals for the voltage function are generated from the A6 board and are passed to the A50 board via the SCOPE_HV signal line. The generated signal (ac or dc) is then passed from the A50 board to the A90, attenuator assembly, where range attenuation occurs. The signal is then passed to the SCOPE output BNC on the front panel.

6-95. Edge Mode

The edge clock originates on the A50 board. The signal is then shaped and split to generate the fast edge and external trigger signals. The edge signal is passed from the A50 board first to the attenuator assembly (where range attenuation occurs) and then to the SCOPE connector BNC on the front panel. If turned on, the trigger is connected to the Trig Out BNC on the front panel.

6-96. Leveled Sine Wave Mode

All of the leveled sine wave signals (from 50 kHz to 350 MHz) are produced on the A50 board. The leveled sine wave signal is passed from the A50 board to the on-board attenuator assembly. The attenuator assembly provides range attenuation and also contains a power detector which maintains amplitude flatness across the frequency range. The signal is then passed to the SCOPE connector BNC on the front panel.

6-97. Time Marker Mode

There are several “ranges” of time marker operation: 5 s to 50 ms, 20 ms to 100 ns, 50 ns to 20 ns, 10 ns and 5 to 2 ns.

The 5 s to 50 ms markers are generated on the A6 DDS board and are passed to the A50 board. The signal path is also split to drive the external trigger circuitry on the A50 board. If turned on, the trigger is connected to the Trig Out BNC on the front panel. The marker signal passing through the A50 board is connected up to the attenuator assembly. The signal is then passed to the SCOPE connector BNC on the front panel.

The 20 ms to 2 ns markers are generated on the A50 board. From 20 ms to 100 ns, a 20% duty cycle square wave is produced in addition to the spike and square wave markers. From 50 ns to 20 ns, only spike or square waves are produced. At 10 ns, the user can chose between the square wave or the leveled sine signal. The marker signal is passed from the A50 board to the attenuator assembly and then to the SCOPE connector BNC on the front panel.

The trigger signal is also generated on the A50 board. If the trigger is turned on, the signal is connected to the Trig Out BNC on the front panel.

6-98. Wave Generator Mode

All signals for the wavegen function are generated from the A6 board and are passed to the A50 board. They are then sent to the attenuator assembly, where range attenuation occurs. Wavegen signals are then sent to the SCOPE connector BNC on the front panel. The Wave Generator Square Wave is identical to the AC Square Wave Voltage.

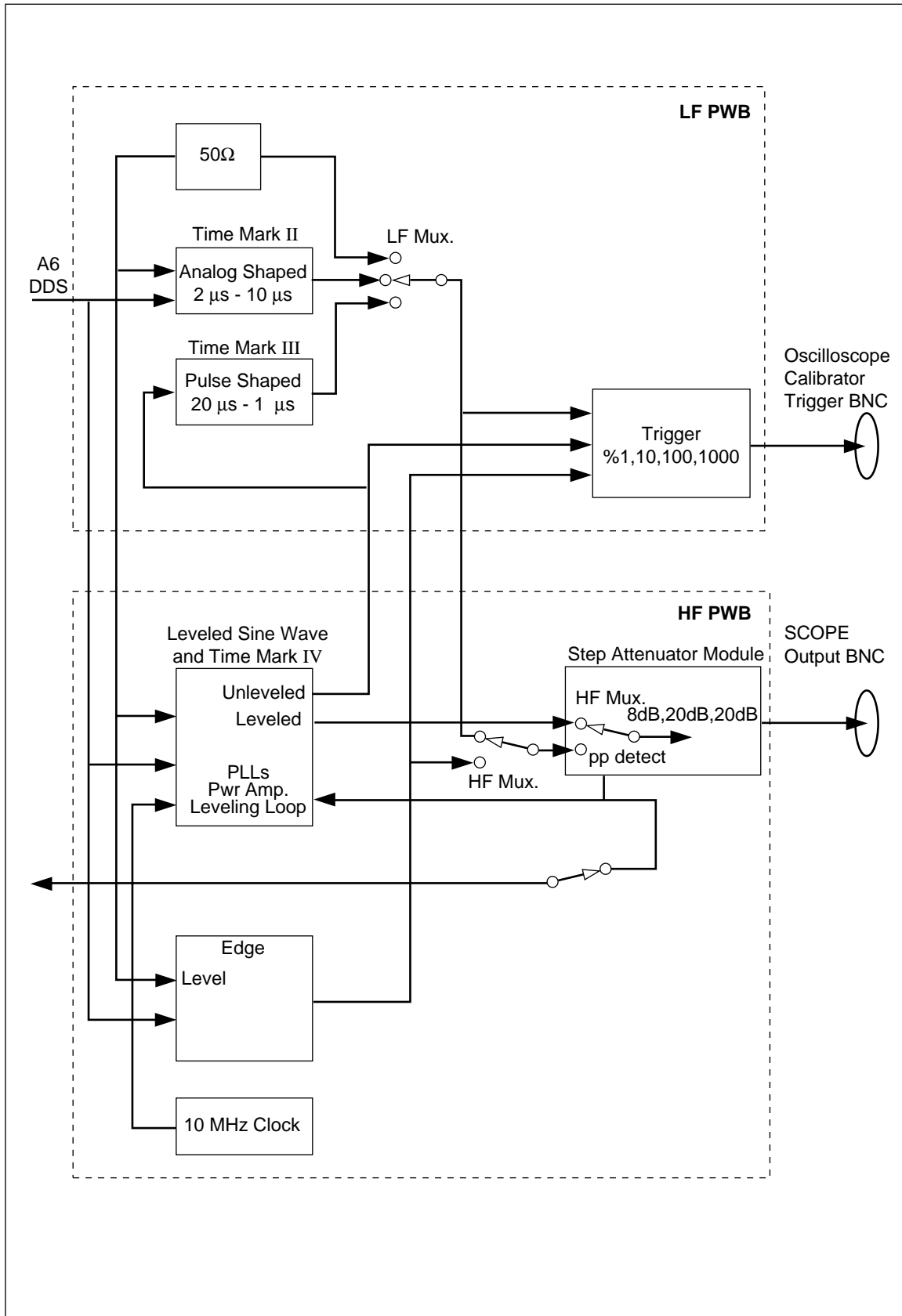


Figure 6-18. SC300 Block Diagram

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6-99. Equipment Required for Calibration and Verification

Table 6-41 lists the equipment, recommended models, and minimum specifications required for each calibration and verification procedure.

Table 6-41. SC300 Calibration and Verification Equipment

Instrument	Model	Minimum Use Specifications	
Wave Generator, Edge Amplitude Calibration, AC Voltage Verification			
Digital Multimeter	HP 3458A	Voltage	1.8 mV to ± 105 V p-p Uncertainty: 0.06%
		Edge	4.5 mV to 2.75 V p-p Uncertainty: 0.06%
Adapter	Pomona #1269	BNC(f) to Double Banana Plug	
Termination		Feedthrough $50 \Omega \pm 1\%$ (used with Edge Amplitude Calibration and AC Voltage Verification)	
BNC Cable	(supplied with SC300)		
Edge Rise Time and Aberrations Verification			
High-Frequency Digital Storage Oscilloscope	Tektronix 11801 with Tektronix SD-22/26 sampling head, or Tektronix TDS 820 with 8 GHz bandwidth	Frequency	2 GHz
		Resolution	4.5 mV to 2.75 V
Attenuator	Weinschel 9-10 (SMA) or Weinschel 18W-10 or equivalent	10 dB, 3.5 mm (m/f)	
Adapter		BNC(f) to 3.5 mm(m)	
BNC Cable	(supplied with SC300)		
Leveled Sine Wave Amplitude Calibration and Verification			
AC Measurement Standard	Fluke 5790A	Range	5 mV p-p to 5.5 V p-p
		Frequency	50 kHz
Adapter	Pomona #1269	BNC(f) to Double Banana Plug	
Termination		Feedthrough $50 \Omega \pm 1\%$	
BNC Cable	(supplied with SC300)		
DC and AC Voltage Calibration and Verification, DC Voltage Verification			
Digital Multimeter	HP 3458A		
Adapter	Pomona #1269	BNC(f) to Double Banana Plug	
Termination		Feedthrough $50 \Omega \pm 1\%$	
BNC Cable	(supplied with SC300)		

Table 6-41. SC300 Calibration and Verification Equipment (cont.)

Instrument	Model	Minimum Use Specifications	
Leveled Sine Wave Frequency Verification			
Frequency Counter	PM 6680 with option (PM 9621, PM 9624, or PM 9625) and (PM 9678)	50 kHz to 350 MHz, < 1.6 ppm uncertainty	
Adapter	Pomona #3288	BNC(f) to Type N(m)	
BNC Cable	(supplied with SC300)		
Leveled Sine Wave Flatness (Low Frequency) Calibration and Verification			
AC Measurement	Fluke 5790A	Range	5 mV p-p to 5.5 V p-p
Standard	with -03 option	Frequency	50 kHz to 10 MHz
Adapter	Pomona #3288	BNC(f) to Type N(m)	
BNC Cable	(supplied with SC300)		
Leveled Sine Wave Harmonics Verification			
Spectrum Analyzer	HP 8590A		
Adapter	Pomona #3288	BNC(f) to Type N(m)	
BNC Cable	(supplied with SC300)		
Edge Frequency, AC Voltage Frequency Verification			
Frequency Counter	PM 6680 with option (PM 9678)	20 ms to 150 ns, 10 Hz to 10 MHz: < 1.6 ppm uncertainty	
BNC Cable	(supplied with SC300)		
Edge Duty Cycle			
Frequency Counter	PM 6680		
BNC Cable	(supplied with SC300)		
Leveled Sine Wave Flatness (High Frequency) Calibration and Verification			
Power Meter	Hewlett-Packard 437B	Range	-42 to +5.6 dBm
		Frequency	10 - 300 MHz
Power Sensor	Hewlett-Packard 8482A	Range	-20 to +19 dBm
		Frequency	10 - 300 MHz
Power Sensor	Hewlett-Packard 8481D	Range	-42 to -20 dBm
		Frequency	10 - 300 MHz
30 dB Reference Attenuator	Hewlett-Packard 11708A (supplied with HP 8481D)	Range	30 dB
		Frequency	50 MHz
Adapter	Hewlett-Packard PN 1250-1474	BNC(f) to Type N(f)	
BNC Cable	(supplied with SC300)		

Table 6-41. SC300 Calibration and Verification Equipment (cont.)

Instrument	Model	Minimum Use Specifications	
Leveled Sine Wave Frequency, Time Marker Verification			
Frequency Counter	PM 6680 with option (PM 9621, PM 9624, or PM 9625) and (PM 9678)	2 ns to 5 s, 50 kHz to 500 MHz: < 1.6 ppm uncertainty	
Adapter	Pomona #3288	BNC(f) to Type N(m)	
BNC Cable	(supplied with SC300)		
Wave Generator Verification			
AC Measurement Standard	Fluke 5790A	Range	1.8 mV p-p to 55 V p-p
		Frequency	10 Hz to 100 kHz
Adapter	Pomona #1269	BNC(f) to Double Banana	
Termination		Feedthrough 50 Ω \pm 1%.	
BNC Cable	(supplied with SC300)		

6-100. SC300 Calibration Setup

The procedures in this manual have been developed to provide users the ability to calibrate the SC300 at their own site if they are required to do so. It is strongly recommended that, if possible, you return your unit to Fluke for calibration and verification. The unit should be returned with its cable. The Calibrator Mainframe must be fully calibrated prior to performing any of the SC300 calibration procedures.

The hardware adjustments are intended to be one-time adjustments performed in the factory, however, adjustment may be required after repair. Hardware adjustments must be performed prior to calibration. Calibration must be performed after any hardware adjustments. See “Hardware Adjustments” in this chapter.

The AC Square Wave Voltage function is dependent on the DC Voltage function. Calibration of the AC Voltage function is required after the DC Voltage is calibrated.

The Calibrator Mainframe must complete a warm-up period and the SC300 must be enabled for at least 5 minutes prior to calibration to allow internal components to thermally stabilize. The Calibrator Mainframe warm-up period is at least twice the length of time the calibrator was powered off, up to a maximum of 30 minutes. The SC300 is enabled by pressing the front panel **SCOPE** key. The green indicator on the **SCOPE** key will be illuminated when the SC300 is enabled.

Much of the SC300 can be calibrated interactively from the front panel. Enable the SC300 and wait at least 5 minutes. Enter Scope Cal mode by pressing the front panel **SETUP** key, **CAL** blue softkey, second **CAL** blue softkey, and **SCOPE CAL** blue softkey. Entering Scope Cal mode prior to having the SC300 enabled for at least 5 minutes will cause a warning message to be displayed.

All equipment specified for SC300 calibration must be calibrated, certified traceable if traceability is to be maintained, and operating within their normal specified operating environment. It is also important to ensure that the equipment has had sufficient time to warm up prior to its use. Refer to each equipment’s operating manual for details.

Before you begin calibration, you may wish to review all of the procedures in advance to ensure you have the resources to complete them.

The Calibrator Mainframe first prompts the user to calibrate the DC Voltage function. If another function is to be calibrated, alternately press the **OPTIONS** and **NEXT SECTION** blue softkeys until the desired function is reached.

6-101. Calibration and Verification of Square Wave Functions

The AC Voltage and Edge functions have square wave voltages that need to be calibrated and verified. The HP3458A digital multimeter can be programmed from either the front panel or over the remote interface to make these measurements.

6-102. Overview of HP3458A Operation

The Hewlett-Packard 3458A digital multimeter is setup as a digitizer to measure the peak-to-peak value of the signal. It is set to DCV, using various analog-to-digital integration times and triggering commands to measure the topline and baseline of the square wave signal.

6-103. Setup for Square Wave Measurements

By controlling the HP 3458A's integration and sample time, it can be used to make accurate, repeatable measurements of both the topline and baseline of the square wave signals up to 10 kHz.

The HP 3458A is triggered by a change in input level. The trigger level is set to 1% of the DCV range, with ac coupling of the trigger signal. The delay after the trigger event is also changed for the of AC Voltage Square Wave and Edge functions. See Table 6-42 and Figure 6-19.

Table 6-42. AC Square Wave Voltage and Edge Settings for the HP3458A

Voltage Input Frequency	HP 3458A Settings		
	NPLC	DELAY (topline)	DELAY (baseline)
10 Hz	1	.02 s	.07 s
100 Hz	.1	.002 s	.007 s
1 kHz	.01	.0002 s	.0007 s
5 kHz	.002	.00004 s	.00014 s
10 kHz	.001	.00002 s	.00007 s

Note

For this application, if making measurements of a signal > 1 kHz, the HP 3458A has been known to have .05% to .1% peaking in the 100 mV range. For these signals, lock the HP 3458A to the 1 V range.

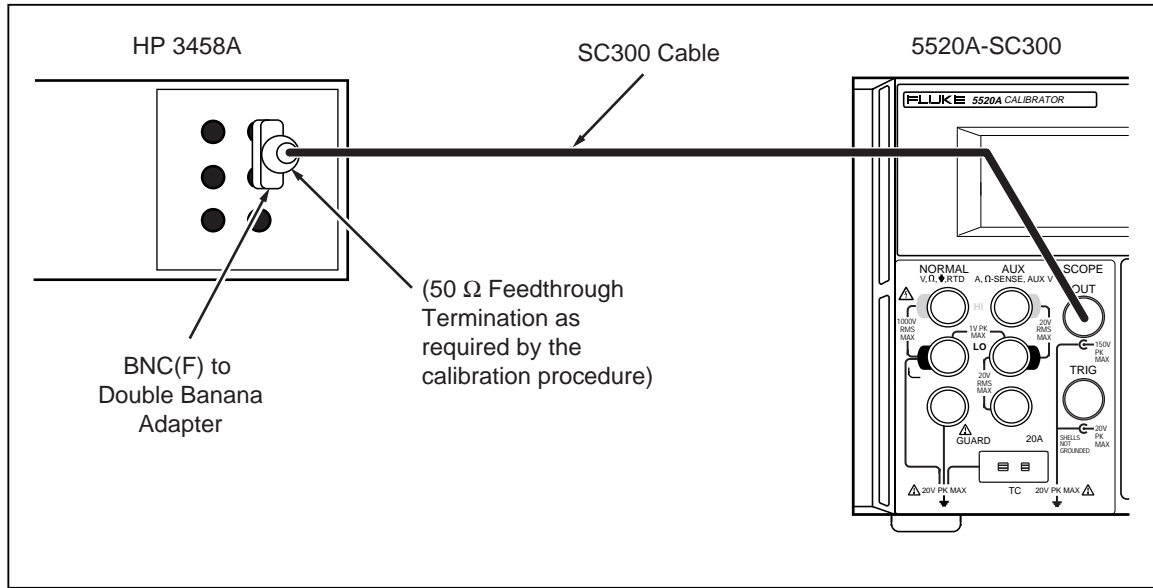


Figure 6-19. Equipment Setup for SC300 Square Wave Measurements.

For all measurements, the HP 3458A is in DCV, manual ranging, with level triggering enabled. A convenient method to make these measurements from the HP 3458A's front panel is to program these settings into several of the user defined keys on its front panel. For example, to make topline measurements at 1 kHz, you would set the DMM to "NPLC .01; LEVEL 1; DELAY .0002; TRIG LEVEL". To find the average of multiple readings, you can program one of the keys to "MATH OFF; MATH STAT" and then use the "RMATH MEAN" function to recall the average or mean value. Refer to Figure 6-19 for the proper connections.

6-104. DC Voltage Calibration

This procedure uses the following equipment:

- Hewlett-Packard 3458A Digital Multimeter
- 50 Ω feedthrough termination (as required in the calibration procedure)
- Shorted Dual Banana Connector
- BNC(f) to Double Banana adapter
- BNC cable supplied with the SC300

Note

Full calibration of the Voltage Function requires both dc and ac calibration.

Refer to Figure 6-19 for the proper setup connections.

Set the Calibrator Mainframe in Scope Cal mode, DC Voltage section. Follow these steps to calibrate DC Voltage:

1. Connect the Calibrator Mainframe's SCOPE connector to the HP 3458A input, using the BNC cable and the BNC(f) to Double Banana adapter.
2. Set the HP 3458A to DCV, Auto Range, NPLC = 10, FIXEDZ = on.
3. Press the **GO ON** blue softkey.

4. Ensure the HP 3458A reading is 0.0 V DC \pm 100 μ V.
5. Press the **GO ON** blue softkey.
6. Calibration voltages 33 V and greater will automatically put the Calibrator Mainframe output in standby. When this occurs, press **OPR** on the Calibrator Mainframe to activate the output. Allow the HP 3458A DC voltage reading to stabilize. Enter the reading via the Calibrator Mainframe front panel keypad, then press **ENTER**.

Note

The Calibrator Mainframe will warn when the entered value is out of bounds. If this warning occurs recheck the setup and carefully re-enter the reading insuring proper multiplier (i.e., m, μ , n, p). If the warning still occurs, repair may be necessary.

7. Repeat steps 6 until the Calibrator Mainframe display indicates that the next steps calibrate ac voltage. Press the **OPTIONS**, then **STORE CONSTS** blue softkeys to store the new calibration constants.

AC voltage must now be calibrated. Continue with the next section.

6-105. AC Square Wave Voltage Calibration

This procedure uses the same equipment and setup as DC Voltage calibration but requires different settings on the HP 3458A. See “Calibration and Verification of Square Wave Functions” earlier in this section for technical details on the procedure. DC voltages are measured and entered in the Calibrator Mainframe to calibrate the AC Voltage function.

Set up the Calibrator Mainframe to Cal ACV. Press **OPTIONS** and **NEXT SECTION** blue softkeys until the display reads “The next steps calibrate -SC300 ACV”. Then follow these steps to calibrate ac voltage:

1. Press the **GO ON** blue softkey.
2. Connect the Calibrator Mainframe’s SCOPE connector to the HP 3458A input, using the BNC cable and the BNC(f) to Double Banana adapter.
3. Set the HP 3458A to DCV, NPLC = .01, LEVEL 1, TRIG LEVEL, and the DELAY to .0002 for measuring the upper part of the wave form (i.e. topline), and the DELAY to .0007 for measuring the lower part of the wave form (i.e. baseline). Manually range lock the HP 3458A to the range that gives the most resolution for the topline measurements. Use this same range for the corresponding baseline measurements at each step.
4. For each calibration step, take samples for at least two seconds, using the HP 3458A MATH functions to retrieve the average or mean value. See “Setup for Square Wave Measurements” earlier in this chapter for more details.

The “true amplitude” of the wave form is the difference between the topline and baseline measurements, correcting for the load resistance error. To make this correction, multiply the readings by $(0.5 * (50 + Rload)/Rload)$, where Rload = actual feedthrough termination resistance if used.

Note

The Calibrator Mainframe will warn when the entered value is out of bounds. If this warning occurs recheck the setup and carefully re-enter the reading insuring proper multiplier (i.e., m, u, n, p). If the warning still occurs, repair may be necessary.

5. Repeat step 4 until the Calibrator Mainframe display indicates that WAVEGEN CAL is the next step. Press the **OPTIONS**, then **STORE CONSTS** blue softkeys to store the new calibration constants.

6-106. Edge Amplitude Calibration

This procedure uses the following equipment:

- Hewlett-Packard 3458A Digital Multimeter
- BNC(f) to Double Banana adapter
- BNC cable supplied with the SC300
- 50 Ω feedthrough termination

Refer to Figure 6-19 for the proper setup connections. Press the **OPTIONS** and **NEXT SECTION** blue softkeys until the display reads “Set up to measure fast edge amplitude”. Then follow these steps to calibrate edge amplitude:

1. Connect the Calibrator Mainframe’s SCOPE connector to the HP 3458A input, using the BNC cable and the BNC(f) to Double Banana.
2. Set the HP 3458A to DCV, NPLC = .01, LEVEL 1, TRIG LEVEL, and the DELAY to .0002 for measuring the upper part of the wave form (i.e. topline), and the DELAY to .0007 for measuring the lower part of the wave form (i.e. baseline). Manually lock the HP 3458A to the range that gives the most resolution for the baseline measurements. Use this same range for the corresponding baseline measurements at each step. Note that in the EDGE function, the topline is very near 0V, and the baseline is a negative voltage.
3. For each calibration step, take samples for at least two seconds, using the HP 3458A MATH functions to enter the average or mean value. See “Setup for Square Wave Measurements”, earlier in this section, for more details.

The “true amplitude” of the wave form is the difference between the topline and baseline measurements, correcting for the load resistance error. To make this correction, multiply the readings by $(0.5 * (50 + R_{load})/R_{load})$, where R_{load} = actual feedthrough termination resistance.

6-107. Leveled Sine Wave Amplitude Calibration

This procedure uses the following equipment:

- 5790A AC Measurement Standard
- BNC(f) to Double Banana Plug Adapter
- 50 Ω feedthrough termination
- BNC cable supplied with the SC300

Refer to Figure 6-20 for the proper connections.

Press the **OPTIONS** and **NEXT SECTION** blue softkeys until the display reads “Set up to measure leveled sine amplitude”. Then follow these steps to calibrate Leveled Sine Wave amplitude:

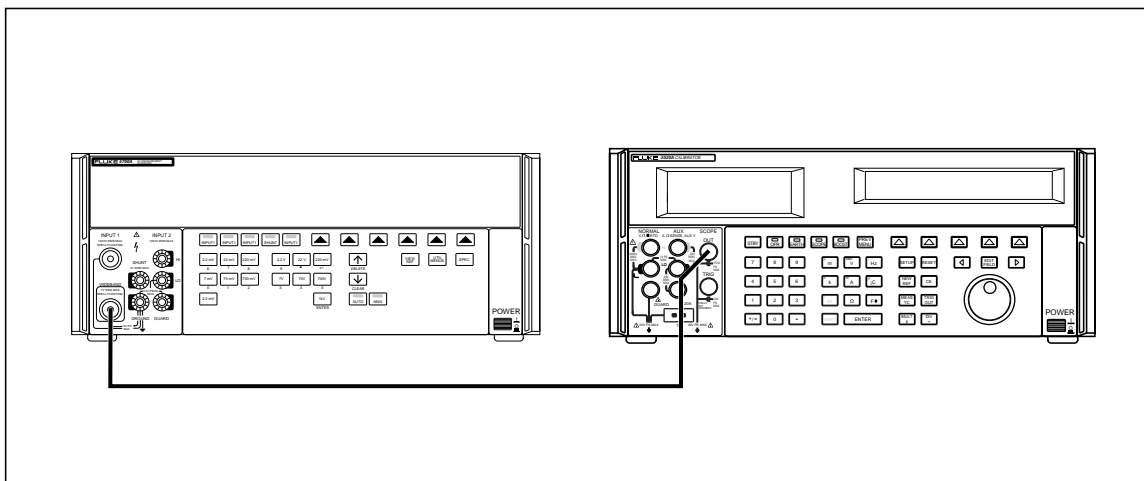
1. Connect the BNC cable to the Calibrator Mainframe’s SCOPE connector. Connect the other end of the BNC cable to the 50 Ω feedthrough termination then to the 5790A INPUT 2 using the BNC(f) to Double Banana adapter.
2. Set the 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.

3. Press the **GO ON** blue softkey.
4. Press **OPR** to activate operating mode on the Calibrator Mainframe.
5. Allow the 5790A rms reading to stabilize. Multiply the 5790A reading by $(0.5 * (50 + Rload) / Rload)$, where $Rload$ = the actual feedthrough termination resistance, to correct for the resistance error. Enter the corrected rms reading via the Calibrator Mainframe front panel keypad, then press **ENTER**.

Note

The Calibrator Mainframe will warn when the entered value is out of bounds. If this warning occurs recheck the setup and calculation and carefully re-enter the corrected rms reading insuring proper multiplier (i.e., m, u, n, p). If the warning still occurs, repair may be necessary.

6. Repeat step 5 until the Calibrator Mainframe display indicates that the next steps calibrate Leveled Sine flatness. Press the **OPTIONS**, then **STORE CONSTS** blue softkeys to store the new calibration constants.



yg034f.eps

Figure 6-20. Connecting the Calibrator Mainframe to the 5790A AC Measurement Standard

6-108. Leveled Sine Wave Flatness Calibration

Leveled Sine Wave flatness calibration is divided into two frequency bands: 50 kHz to 10 MHz (low frequency) and > 10 MHz to 300 MHz (high frequency). The equipment setups are different for each band. Flatness calibration of the low frequency band is made relative to 50 kHz. Flatness calibration of the high frequency band is made relative to 10 MHz.

Leveled Sine Wave flatness is calibrated at multiple amplitudes. Both low and high frequency bands are calibrated at each amplitude. Calibration begins with the low frequency band, then the high frequency band for the first amplitude, followed by the low frequency band, then the high frequency band for the second amplitude, and so on, until the flatness calibration is complete.

Press the **OPTIONS** and **NEXT SECTION** blue softkeys until the display reads “Set up to measure leveled sine flatness”.

6-109. Low Frequency Calibration

Connect the Calibrator Mainframe SCOPE connector to the 5790A WIDEBAND input as described under “Equipment Setup for Low Frequency Flatness”.

Follow these steps to calibrate low frequency Leveled Sine Wave flatness for the amplitude being calibrated:

1. Press the **GO ON** blue softkey.
2. Establish the 50 kHz reference:
 - Allow the 5790A rms reading to stabilize.
 - Press the 5790A **Set Ref** blue softkey. (Clear any previous reference by pressing the 5790A **Clear Ref** blue softkey prior to setting the new reference if required.)
3. Press the **GO ON** blue softkey.
4. Adjust the amplitude using the Calibrator Mainframe front panel knob until the 5790A reference deviation matches the 50 kHz reference within 1000 ppm.
5. Repeat steps 1 to 4 until the Calibrator Mainframe display indicates that the reference frequency is now 10 MHz. Continue with the high frequency calibration.

6-110. High Frequency Calibration

Connect the Calibrator Mainframe SCOPE connector to the power meter and power sensor as described in, “Equipment Setup for High Frequency Flatness” earlier in this section.

Follow these steps to calibrate high frequency Leveled Sine Wave flatness for the amplitude being calibrated.

1. Press the **GO ON** blue softkey.
2. Establish the 10 MHz reference:
 - Press the power meter **SHIFT** key, then **FREQ** key and use the arrow keys to enter the power sensor’s 10 MHz Cal Factor. Ensure that the factor is correct, then press the power meter **ENTER** key.
 - Allow the power meter reading to stabilize.
 - Press the Power meter **REL** key.
3. Press the **GO ON** blue softkey.
4. Press the power meter **SHIFT** key, then **FREQ** key and use the arrow keys to enter the power sensor’s Cal Factor for the frequency displayed on the Calibrator Mainframe. Ensure that the factor is correct, then press the power meter **ENTER** key.
5. Adjust the amplitude using the Calibrator Mainframe front panel knob until the power sensor reading matches the 10 MHz reference within 0.1%.
6. Repeat steps 1 to 5 until the Calibrator Mainframe display indicates that either the reference frequency is now 50 kHz or that the next steps calibrate pulse width. Repeat the low frequency calibration procedure for the next amplitude unless the Calibrator Mainframe display indicates that the next steps calibrate pulse width. Press the **OPTIONS**, then **STORE CONSTS** blue softkeys to store the new calibration constants.

6-111. Verification

All of the Oscilloscope Calibration functions should be verified at least once per year, or each time the SC300 is calibrated. The verification procedures in this section provide traceable results; however the factory uses different procedures and instruments of higher precision than those described here. The procedures in this manual have been developed to provide users the ability to verify the SC300 at their own site if they are required to do so. Fluke strongly recommends that, if possible, you return your unit to Fluke for calibration and verification.

All equipment specified for SC300 verification must be calibrated, certified traceable if traceability is to be maintained, and operating within their normal specified operating environment. It is also important to ensure that the equipment has had sufficient time to warm up prior to its use. Refer to each equipment's operating manual for details.

Before you begin verification, you may wish to review all of the procedures in advance to ensure you have the resources to complete them.

6-112. DC Voltage Verification

This procedure uses the following equipment:

- Hewlett-Packard 3458A Digital Multimeter
- BNC(f) to Double Banana adapter
- 50 Ω feedthrough termination (as required)
- BNC cable supplied with the SC300

For DC voltage verification, refer to Figure 6-19 for the proper setup connections.

Set the Calibrator Mainframe to SCOPE mode, with the Volt menu on the display. Then use the next sections to verify the DC Voltage function.

6-113. Verification at 1 M Ω

For the 1 M Ω verification, connect the Calibrator Mainframe's SCOPE connector to the HP 3458A input, using the cable and the BNC(f) to Double Banana adapter.

Make sure the Calibrator Mainframe impedance is set to 1 M Ω (The blue softkey under **Output Z** toggles the impedance between 50 Ω and 1 M Ω).

1. Set the HP 3458A to DCV, Auto Range, NPLC = 10, FIXEDZ = on.
2. Program the Calibrator Mainframe to output the voltage listed in Table 6-43. Press **OPR** on the Calibrator Mainframe to activate the output.
3. Allow the HP 3458A reading to stabilize, then record the HP 3458A reading for each voltage in Table 6-43.
4. Compare result to the tolerance column.

6-114. Verification at 50 Ω

For the 50 Ω verification, connect the SCOPE connector to the HP 3458A input, using the cable and the 50 Ω termination connected to the BNC to Banana Plug adapter.

Make sure the Calibrator Mainframe impedance is set to 50 Ω (The blue softkey under **Output Z** toggles the impedance between 50 Ω and 1 M Ω).

1. Set the HP 3458A to DCV, Auto Range, NPLC = 10, FIXEDZ = on.

2. Program the Calibrator Mainframe to output the voltage listed in Table 6-44. Press **OPR** on the Calibrator Mainframe to activate the output.
3. Allow the HP 3458A reading to stabilize, then record the HP 3458A reading for each voltage in Table 6-44.

Multiply the readings by $(0.5 * (50 + R_{load}) / R_{load})$, where R_{load} = the actual feedthrough termination resistance, to correct for the resistance error. Compare result to the tolerance (1-year spec.) column.

Table 6-43. DC Voltage Verification at 1 MΩ

Nominal Value (dc)	Measured Value (dc)	Deviation (mV)	1-Year Spec. (mV)
0.0 mV			0.10
5.0 mV			0.11
-5.0 mV			0.11
22.0 mV			0.15
-22.0 mV			0.15
25.0 mV			0.16
-25.0 mV			0.16
45.0 mV			0.21
-45.0 mV			0.21
50.0 mV			0.23
-50.0 mV			0.23
220.0 mV			0.65
-220.0 mV			0.65
250.0 mV			0.72
-250.0 mV			0.72
450.0 mV			1.22
-450.0 mV			1.22
500.0 mV			1.35
-500.0 mV			1.35
3.3 V			8.35
-3.3 V			8.35
4.0 V			10.10
-4.0 V			10.10
33.0 V			82.60
-33.0 V			82.60

Table 6-44. DC Voltage Verification at 50 Ω

Nominal Value (dc)	Measured Value (dc)	Deviation (mV)	1-Year Spec. (mV)
0.0 mV			0.10
5.0 mV			0.11
-5.0 mV			0.11
10.0 mV			0.12
-10.0 mV			0.12
22.0 mV			0.15
-22.0 mV			0.15
25.0 mV			0.16
-25.0 mV			0.16
55.0 mV			0.24
-55.0 mV			0.24
100.0 mV			0.35
-100.0 mV			0.35
220.0 mV			0.65
-220.0 mV			0.65
250.0 mV			0.72
-250.0 mV			0.72
550.0 mV			1.47
-550.0 mV			1.47
700.0 mV			1.85
-700.0 mV			1.85
2.2 V			5.60
-2.2 V			5.60

6-115. AC Voltage Amplitude Verification

This procedure uses the following equipment:

- Hewlett-Packard 3458A Digital Multimeter
- BNC(f) to Double Banana adapter
- 50 Ω feedthrough termination (as required)
- BNC cable supplied with the SC300

For ac voltage amplitude verification, refer to Figure 6-19 for the proper setup connections.

Set the Calibrator Mainframe to SCOPE mode, with the Volt menu on the display. Then proceed with the next sections to verify the AC Voltage function.

6-116. Verification at 1 M Ω

For the 1 M Ω verification, connect the Calibrator Mainframe's SCOPE connector to the HP 3458A input, using the cable supplied with the Calibrator Mainframe and the BNC(f) to Double Banana adapter. Connect the Calibrator Mainframe TRIG OUT connector to the HP 3458A Ext Trig connector located on the rear of that instrument.

Make sure the Calibrator Mainframe impedance is set to 1 M Ω . (The blue softkey under Output Z toggles the impedance between 50 Ω and 1 M Ω .)

1. When making measurements at 1 kHz, set the HP 3458A to the values shown in Table 6-42. Manually lock the HP 3458A to the range that gives the most resolution for the topline measurements. Use this same range for the corresponding baseline measurements at each step.
2. Measure the topline first. For each measurement, take samples for at least two seconds, using the HP 3458A MATH functions to determine the average or mean value. See "Setup Square Wave Measurements" earlier in this section for more details.
3. Measure the baseline of each output after the corresponding topline measurement. The peak-to-peak value is the difference between the topline and baseline measurements. Compare the result to the tolerance (1-year spec.) column.
4. When making measurements at the other frequencies, set up the HP 3458A (NPLC and topline and baseline DELAY) per Table 6-42.

Table 6-45. AC Voltage Verification at 1 MΩ

Nominal Value (p-p)	Frequency	Measured Value (p-p)	Deviation (mV)	1-Year Spec. (mV)
5.0 mV	10 Hz			0.11
5.0 mV	100 Hz			0.11
5.0 mV	1 kHz			0.11
5.0 mV	5 kHz			0.11
5.0 mV	10 kHz			0.11
10.0 mV	10 kHz			0.12
20.0 mV	100 Hz			0.15
20.0 mV	1 kHz			0.15
20.0 mV	10 kHz			0.15
50.0 mV	10 kHz			0.23
89.0 mV	10 Hz			0.32
89.0 mV	10 kHz			0.32
100.0 mV	10 kHz			0.35
200.0 mV	100 Hz			0.60
200.0 mV	1 kHz			0.60
200.0 mV	10 kHz			0.60
500.0 mV	10 kHz			1.35
890.0 mV	10 Hz			2.32
890.0 mV	10 kHz			2.32
1.0 V	100 Hz			2.60
1.0 V	1 kHz			2.60
1.0 V	10 kHz			2.60
2.0 V	10 kHz			5.10
5.0 V	10 Hz			12.60
5.0 V	10 kHz			12.60
10.0 V	10 kHz			25.10
20.0 V	10 kHz			50.10
50.0 V	10 Hz			125.10
50.0 V	100 Hz			125.10
50.0 V	1 kHz			125.10
50.0 V	10 kHz			125.10
105.0 V	100 Hz			262.60
105.0 V	1 kHz			262.60

6-117. Verification at 50 Ω

For the 50 Ω verification, connect the Calibrator Mainframe's SCOPE connector to the HP 3458A input, using the cable supplied with the Calibrator Mainframe, the external 50 Ω termination, and the BNC(f) to Double Banana adapter. (The 50 Ω termination is closest to the HP 3458A input.) Make sure the Calibrator Mainframe impedance is set to 50 Ω. (The blue softkey under **Output Z** toggles the impedance between 50 Ω and 1 MΩ). Proceed with the following steps:

1. Set the HP 3458A to the values shown in Table 6-42. Manually lock the HP 3458A to the range that gives the most resolution for the topline measurements. Use this same range for the corresponding baseline measurements at each step.
2. Measure the topline first, as indicated in Table 6-46. For each measurement, take samples for at least two seconds, using the HP 3458A MATH functions to determine the average or mean value. See "Setup for Square Wave Measurements" for more details.
3. Measure the baseline of each output after the corresponding topline measurement, as indicated in Table 6-46. The peak-to-peak value is the difference between the topline and baseline measurements. Multiply the readings by $(0.5 * (50 + R_{load}) / R_{load})$, where R_{load} = the actual feedthrough termination resistance, to correct for the resistance error. Compare the result to the tolerance column.

Table 6-46. AC Voltage Verification at 50 Ω

Nominal Value (p-p)	Frequency	Measured Value (p-p)	Deviation (mV)	1-Year Spec. (mV)
5.0 mV	10 Hz			0.11
5.0 mV	100 Hz			0.11
5.0 mV	1 kHz			0.11
5.0 mV	5 kHz			0.11
5.0 mV	10 kHz			0.11
10.0 mV	100 Hz			0.12
10.0 mV	1 kHz			0.12
10.0 mV	10 kHz			0.12
20.0 mV	10 kHz			0.15
44.9 mV	10 Hz			0.21
44.9 mV	10 kHz			0.21
50.0 mV	10 kHz			0.23
100.0 mV	100 Hz			0.35
100.0 mV	1 kHz			0.35
100.0 mV	10 kHz			0.35
200.0 mV	10 kHz			0.60
449.0 mV	10 Hz			1.22
449.0 mV	10 kHz			1.22

Table 6-46. AC Voltage Verification at 50 Ω (cont.)

Nominal Value (p-p)	Frequency	Measured Value (p-p)	Deviation (mV)	1-Year Spec. (mV)
500.0 mV	10 kHz			1.35
1.0 V	100 Hz			2.60
1.0 V	1 kHz			2.60
1.0 V	10 kHz			2.60
2.0 V	10 Hz			5.10
2.0 V	100 Hz			5.10
2.0 V	1 kHz			5.10
2.0 V	5 kHz			5.10
2.0 V	10 kHz			5.10

6-118. AC Voltage Frequency Verification

Refer to Figure 6-21 for the proper setup connections.

This procedure uses the following equipment:

- PM 6680 Frequency Counter with an TCXO timebase (Option PM 9678 or equivalent)
- BNC cable supplied with the SC300

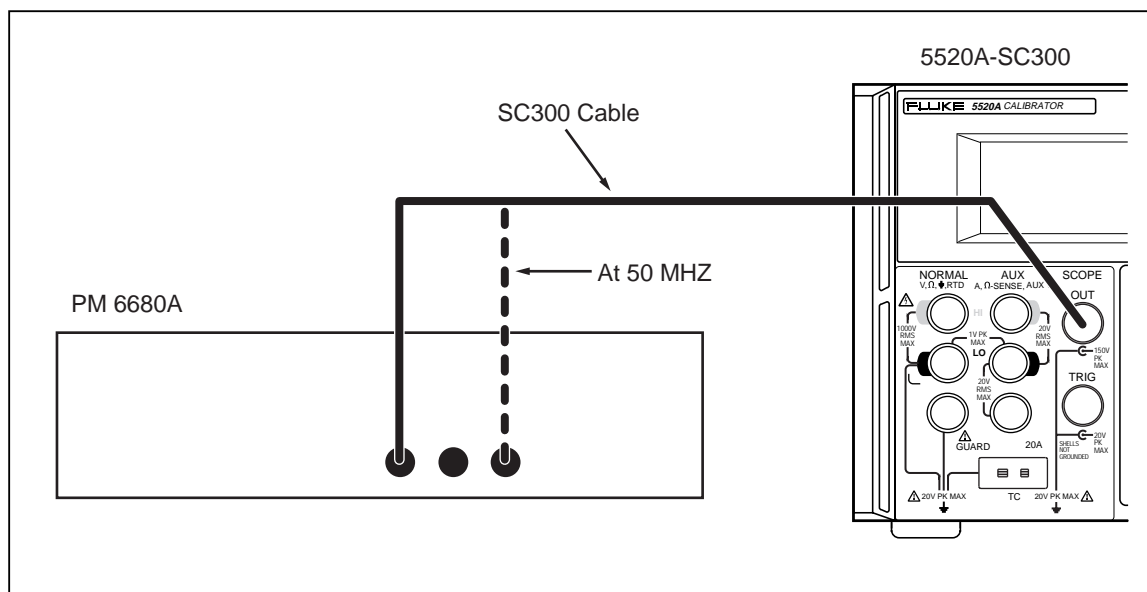


Figure 6-21. Frequency Verification Setup

Set the Calibrator Mainframe to SCOPE mode, with the Volt menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Then follow these steps to verify ac voltage frequency:

1. Set the PM 6680's FUNCTION to measure frequency on channel A with auto trigger, measurement time set to 1 second or longer, 1M Ω impedance, and filter off.
2. Using the BNC cable, connect the SCOPE connector on the Calibrator Mainframe to PM 6680 channel A.
3. Program the Calibrator Mainframe to output 2.1 V at each frequency listed in Table 6-47.
4. Allow the PM 6680 reading to stabilize, then record the PM 6680 reading for each frequency listed in Table 6-47. Compare to the tolerance column of Table 6-47.

Table 6-47. AC Voltage Frequency Verification

Calibrator Mainframe Frequency (output @ 2.1 V p-p)	PM 6680 Reading (Frequency)	Tolerance
10 Hz		0.00025 Hz
100 Hz		0.0025 Hz
1 kHz		0.025 Hz
10 kHz		0.25 Hz

6-119. Edge Amplitude Verification

For the Edge Amplitude verification, connect the Calibrator Mainframe's SCOPE connector to the HP 3458A input, using the cable supplied with the Calibrator Mainframe, the external 50 Ω termination, and the BNC(f) to Double Banana adapter. (The 50 Ω termination is closest to the HP 3458A input.)

1. For measurements of a 1 kHz signal, set the HP 3458A to DCV, NPLC = .01, LEVEL 1, TRIG LEVEL, and the DELAY to .0002 for measuring the upper part of the wave form (i.e. topline), and the DELAY to .0007 for measuring the lower part of the wave form (i.e. baseline). For measurements of a 10 kHz signal, set the HP 3458A to DCV, NPLC = .001, LEVEL 1, TRIG LEVEL, and the DELAY to .00002 for measuring the topline, and the DELAY to .00007 for measuring the baseline.
2. Manually lock the HP 3458A to the range that gives the most resolution for the baseline measurements. Use this same range for the corresponding baseline measurements at each step. Note that in the EDGE function, the topline is very near 0 V, and the baseline is a negative voltage. See Table 6-48.
3. For each calibration step, take samples for at least two seconds, using the HP 3458A MATH functions to enter the average or mean value. See "Setup for Square Wave Measurements" earlier in this section for more details.
4. The peak-to-peak value of the wave form is the difference between the topline and baseline measurements, correcting for the load resistance error. To make this correction, multiply the readings by $(0.5 * (50 + R_{load})/R_{load})$, where R_{load} = actual feedthrough termination resistance. Record each reading as indicated in Table 6-48.

Table 6-48. Edge Amplification Verification

Calibrator Mainframe Edge Output	HP 3458A Range	Topline Reading	Baseline Reading	Peak-to-Peak	Peak-to-Peak x Correction	Tolerance ($\pm V$)
100 mV, 1 kHz	100 mV dc					0.0022
1.00V, 1 kHz	1 V dc					0.0202
5 mV, 10 kHz	100 mV dc					0.0003
10 mV, 10 kHz	100 mV dc					0.0004
25 mV, 10 kHz	100 mV dc					0.0007
50 mV, 10 kHz	100 mV dc					0.0012
100 mV, 10 kHz	1 V dc					0.0022
500 mV, 10 kHz	1 V dc					0.0102
1.00 V, 10 kHz	1 V dc					0.0202
2.5 V, 10 kHz	10 V dc					0.0502

6-120. Edge Frequency Verification

This procedure uses the following equipment:

- PM 6680 Frequency Counter with an ovenized timebase (Option PM 9690 or PM 9691)
- BNC cable supplied with the SC300

Refer to Figure 6-21 for proper setup connections. Set the Calibrator Mainframe to SCOPE mode, with the Edge menu on the display. Press **[OPR]** on the Calibrator Mainframe to activate the output. Then follow these steps to verify Edge frequency:

1. Set the PM 6680's FUNCTION to measure frequency on channel A with auto trigger, measurement time set to 1 second or longer, 50 Ω impedance, and filter off.
2. Using the BNC cable, connect the SCOPE connector on the Calibrator Mainframe to PM 6680 channel A.
3. Program the Calibrator Mainframe to output 2.5 V at each frequency listed in Table 6-49.
4. Allow the PM 6680 reading to stabilize, then record the PM 6680 reading for each frequency listed in Table 6-49. Compare to the tolerance column of Table 6-49.

Table 6-49. Edge Frequency Verification

Calibrator Mainframe Frequency (output @ 2.5 V p-p)	PM 6680 Reading (Frequency)	Tolerance
1 kHz		0.025 Hz
10 kHz		0.25 Hz
100 kHz		2.50 Hz
1 MHz		25.0 Hz

6-121. Edge Duty Cycle Verification

This procedure uses the following equipment:

- PM 6680 Frequency Counter
- BNC cable supplied with the SC300

Refer to Figure 6-21 for proper setup connections. Set the Calibrator Mainframe to SCOPE mode, with the Edge menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Then follow these steps to verify Edge duty cycle.

1. Set the PM 6680's FUNCTION to measure duty cycle on channel A with auto trigger, measurement time set to 1 second or longer, 50 Ω impedance, and filter off.
2. Using the BNC cable, connect the SCOPE connector on the Calibrator Mainframe to PM 6680 channel A.
3. Program the Calibrator Mainframe to output 2.5 V at 1 MHz.
4. Allow the PM 6680 reading to stabilize. Compare the duty cycle reading to 50% \pm 5%.

6-122. Edge Rise Time Verification

This procedure tests the edge function's rise time. Aberrations are also checked with the Tektronix 11801 oscilloscope and SD-22/26 sampling head.

The following equipment is used to verify the edge rise time.

- High Frequency Digital Storage Oscilloscope: Tektronix 11801 with Tektronix SD-22/26 sampling head
- 3 dB attenuator, 3.5 mm (m/f)
- BNC(f) to 3.5 mm(m) adapter (2)
- BNC cable supplied with the SC300
- second BNC cable

Connect the BNC cable supplied with the SC300 to the Calibrator Mainframe's SCOPE connector. Connect the other end of the BNC cable to one BNC(f) to 3.5 mm(m) adapter then to the DSO's sampling head through the 3 dB attenuator.

Using the second BNC(f) to 3.5 mm(m) adapter and BNC cable, connect the Calibrator Mainframe's TRIG OUT connector to the 11801's Trigger Input. Refer to Figure 6-22.

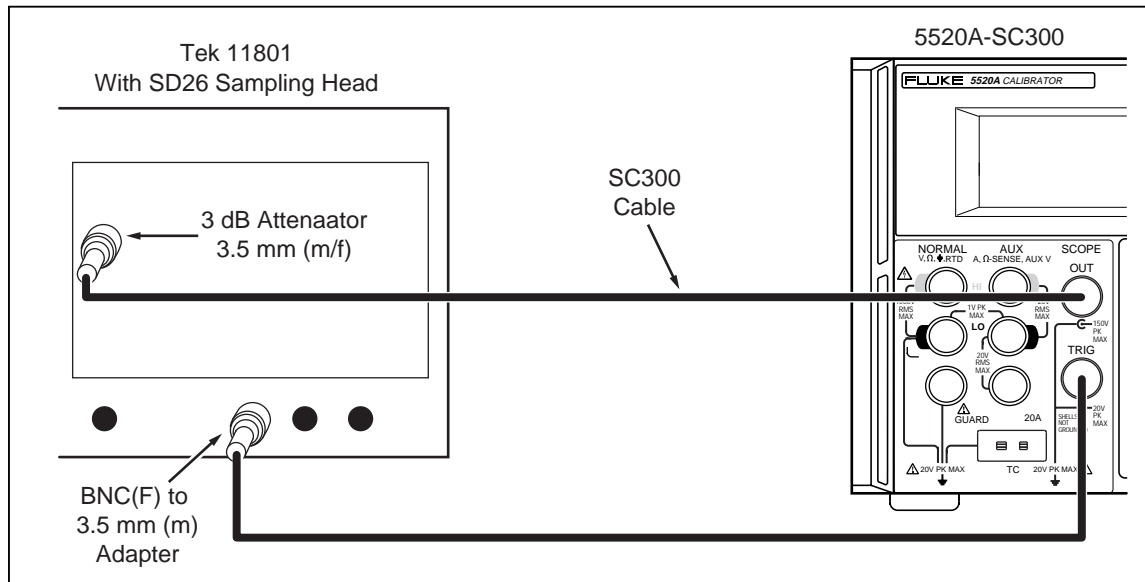


Figure 6-22. Edge Rise Time Verification Setup

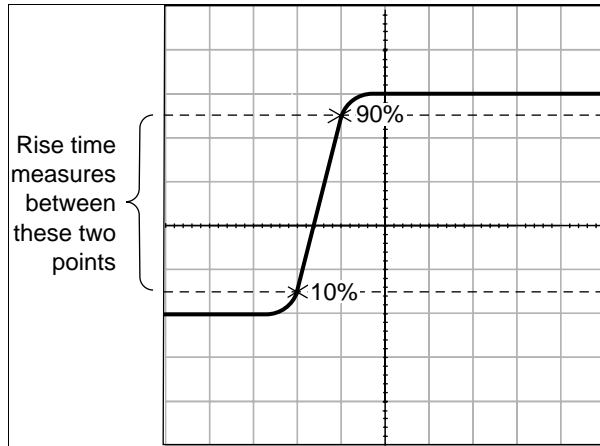
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The Calibrator Mainframe should be in SCOPE mode, with the Edge menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Press the softkey under TRIG to select the TRIG/1 External Trigger output. Program the Calibrator Mainframe to output 250 mV @ 1 kHz. Set the DSO to these parameters:

Digital Storage Oscilloscope Setup

Main Time Base position (initial)	40 ns
Horizontal scale	500 ps/div
Measurement Function	Rise Time

1. Program the Calibrator Mainframe to output the voltage and frequency listed in Table 6-50. Press **OPR** on the Calibrator Mainframe to activate the output.
2. Change the vertical scale of the DSO to the value listed in the table. Adjust the main time base position and vertical offset until the edge signal is centered on the display. Record the rise time measurement in column A of Table 6-50. Refer to Figure 6-23.
3. Correct the rise time measurement by accounting for the SD-22/26 sampling head's rise time. The SD-22/26 rise time is specified as < 28 ps. Column B = $\sqrt{(\text{Column A})^2 - (\text{SD-22/26 rise time})^2}$.
4. The edge rise time measured should be less than the time indicated in Table 6-50.



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Figure 6-23. Edge Rise Time

Table 6-50. Edge Rise Time Verification

Calibrator Mainframe Output		DSO Vertical Axis (mV/div)	A 11801 Reading	B Corrected Reading	Tolerance
Voltage	Frequency				
250 mV	1 kHz	20.0			< 1000 ps
250 mV	1 MHz	20.0			< 1000 ps
500 mV	1 kHz	50.0			< 1000 ps
500 mV	1 MHz	50.0			< 1000 ps
1 V	1 kHz	100.0			< 1000 ps
1 V	1 MHz	100.0			< 1000 ps
2.5 V	1 kHz	200.0			< 1000 ps
2.5 V	1 MHz	200.0			< 1000 ps

6-123. Edge Abberation Verification

The following equipment is needed for this procedure:

- Tektronix 11801 oscilloscope with SD22/26 sampling head
- Output cable provided with the SC300

Before you begin this procedure, verify that the 5520A-SC300 is in the edge mode (the Edge menu is displayed), and program it to output 1 V p-p @ 1 MHz. Press **OPR** to activate the output.

Connect the Calibrator Mainframe to the oscilloscope as in Figure 6-22. Set the oscilloscope vertical to 10 mV/div and horizontal to 1 ns/div. Set the oscilloscope to look at the 90% point of the edge signal; use this point as the reference level. Set the oscilloscope to look at the first 10 ns of the edge signal with the rising edge at the left edge of the oscilloscope display.

With these settings, each vertical line on the oscilloscope represents a 1% aberration. Determine that the SC300 falls within the typical specifications shown in Table 6-51.

Table 6-51. Edge Aberrations

Time from 50% of Rising Edge	Typical Edge Aberrations
0 - 10 ns	< 22 mV (2.2%)
10 - 30 ns	< 12 mV (1.2%)
> 30 ns	< 7 mV (0.7%)

6-124. Leveled Sine Wave Amplitude Verification

This procedure uses the following equipment:

- 5790A AC Measurement Standard
- BNC(f) to Double Banana Plug adapter
- 50Ω feedthrough termination
- BNC cable supplied with the SC300

Refer to Figure 6-20 for the proper setup connections.

Set the Calibrator Mainframe to SCOPE mode, with the Levsine menu on the display. Press **[OPR]** on the Calibrator Mainframe to activate the output. Then follow these steps to verify the leveled sine wave amplitude.

1. Connect the BNC cable to the Calibrator Mainframe's SCOPE connector. Connect the other end of the BNC cable to the 50Ω feedthrough termination then to the 5790A INPUT 2 using the BNC(f) to Double Banana adapter.
2. Set the 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.
3. Program the Calibrator Mainframe to output the voltage listed in Table 6-52.
4. Allow the 5790A reading to stabilize, then record the 5790A's rms reading for each voltage listed in Table 6-52.
5. Multiply the rms reading by the conversion factor of 2.8284 to convert it to the peak-to-peak value.
6. Multiply the peak-to-peak value by $(0.5 * (50 + Rload) / Rload)$, where Rload = the actual feedthrough termination resistance, to correct for the resistance error. Compare result to the tolerance column.

Table 6-52. Levelled Sine Wave Amplitude Verification

Calibrator Mainframe output (@ 50 kHz)	5790A Reading (V rms)	5790A Reading x 2.8284 (V p-p)	Tolerance (V p-p)
5.0 mV			0.4 mV
10.0 mV			0.5 mV
20.0 mV			0.7 mV
40.0 mV			1.1 mV
50.0 mV			1.3 mV
100.0 mV			2.3 mV
200.0 mV			4.3 mV
400.0 mV			8.3 mV
500.0 mV			10.3 mV
1.3 V			0.0263 V
2.0 V			0.0403 V
5.5 V			0.1103 V

6-125. Levelled Sine Wave Frequency Verification

This procedure uses the following equipment:

- PM 6680 Frequency Counter with a prescaler for the Channel C input (Option PM 9621, PM 9624, or PM 9625) and ovenized timebase (Option PM 9690 or PM 9691)
- BNC(f) to Type N(m) adapter
- BNC cable supplied with the SC300

Refer to 6-21 for the proper setup connections. Set the Calibrator Mainframe to SCOPE mode, with the Levsine menu on the display. Then follow these steps to verify the levelled sine wave amplitude.

1. Set the PM 6680's FUNCTION to measure frequency with auto trigger, measurement time set to 1 second or longer, and 50 Ω impedance.
2. Using the BNC cable, connect the SCOPE connector on the Calibrator Mainframe to the PM 6680 at the channel indicated in Table 6-53. You will need the BNC-N adapter for the connection to Channel C.
3. Set the filter on the PM 6680 as indicated in the table.
4. Program the Calibrator Mainframe to output as listed in Table 6-53. Press **OPR** on the Calibrator Mainframe to activate the output.
5. Allow the PM 6680 reading to stabilize, then record the PM 6680 reading for each frequency listed in Table 6-53.

Table 6-53. Leveled Sine Wave Frequency Verification

Calibrator Mainframe Frequency (output @ 5.5 V p-p)	PM 6680 Settings		PM 6680 Reading (Frequency)	Tolerance
	Channel	Filter		
50 kHz	A	On		1.25 Hz
500 kHz	A	Off		12.5 Hz
5 MHz	A	Off		125.0 Hz
50 MHz	A	Off		1250 Hz
500 MHz	C	Off		12500 Hz

6-126. Leveled Sine Wave Harmonics Verification

This procedure uses the following equipment:

- Hewlett-Packard 8590A Spectrum Analyzer
- BNC(f) to Type N(m) adapter
- BNC cable supplied with the SC300

Refer to Figure 6-24 for proper setup connections.

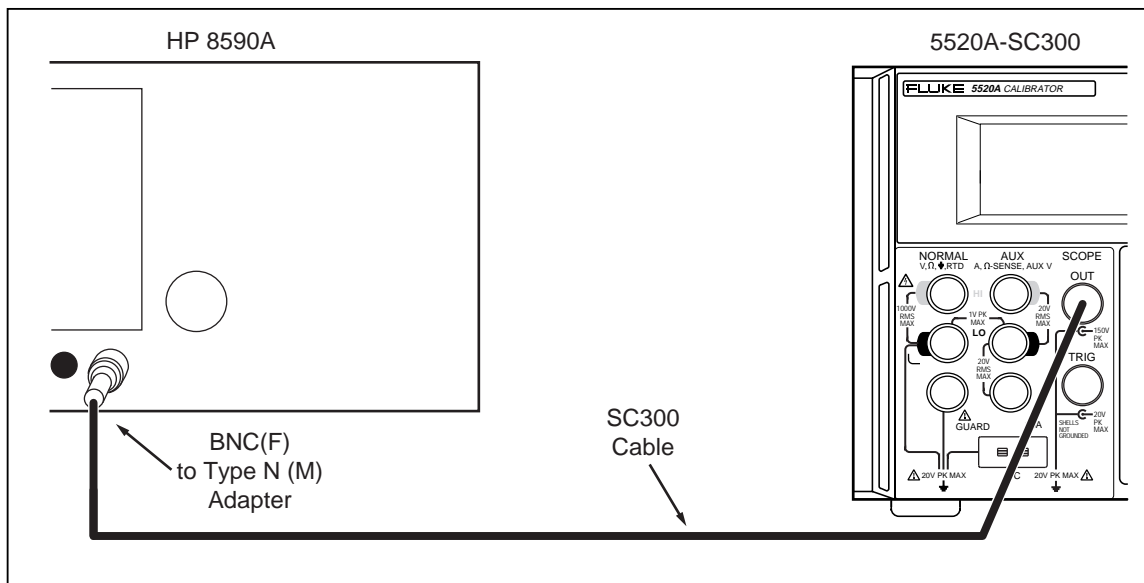


Figure 6-24. Leveled Sine Wave Harmonics Verification Setup

Set the Calibrator Mainframe to SCOPE mode, with the Levsine menu on the display. Then follow these steps to verify the leveled sine wave harmonics.

1. Using the BNC cable and BNC(f) to Type N(m) adapter, connect the SCOPE connector on the Calibrator Mainframe to the HP 8590A.
2. Program the Calibrator Mainframe to 5.5 V p-p at each frequency listed in Table 6-54. Press **OPR** on the Calibrator Mainframe to activate the output.

3. Set HP 8590A start frequency to the Calibrator Mainframe output frequency. Set HP 8590A stop frequency to 10 times the Calibrator Mainframe output frequency. Set the HP 8590A reference level at +19 dBm.
4. Record the harmonic level reading for each frequency and harmonic listed in Table 6-54. For harmonics 3, 4, and 5, record the highest harmonic level of the three measured. Harmonics should be below the levels listed in the tolerance column of Table 6-54.

Table 6-54. Leveled Sine Wave Harmonics Verification

Calibrator Mainframe Output Frequency (@ 5.5 V p-p)	Harmonic	HP 8590A Reading (dB)	Tolerance
50 kHz	2		-33 dB
50 kHz	3, 4, 5		-38 dB
100 kHz	2		-33 dB
100 kHz	3, 4, 5		-38 dB
200 kHz	2		-33 dB
200 kHz	3, 4, 5		-38 dB
400 kHz	2		-33 dB
400 kHz	3, 4, 5		-38 dB
800 kHz	2		-33 dB
800 kHz	3, 4, 5		-38 dB
1 MHz	2		-33 dB
1 MHz	3, 4, 5		-38 dB
2 MHz	2		-33 dB
2 MHz	3, 4, 5		-38 dB
4 MHz	2		-33 dB
4 MHz	3, 4, 5		-38 dB
8 MHz	2		-33 dB
8 MHz	3, 4, 5		-38 dB
10 MHz	2		-33 dB
10 MHz	3, 4, 5		-38 dB
20 MHz	2		-33 dB
20 MHz	3, 4, 5		-38 dB
40 MHz	2		-33 dB
40 MHz	3, 4, 5		-38 dB
80 MHz	2		-33 dB
80 MHz	3, 4, 5		-38 dB
100 MHz	2		-33 dB
100 MHz	3, 4, 5		-38 dB
200 MHz	2		-33 dB
200 MHz	3, 4, 5		-38 dB
250 MHz	2		-33 dB
250 MHz	3, 4, 5		-38 dB

6-127. Leveled Sine Wave Flatness Verification

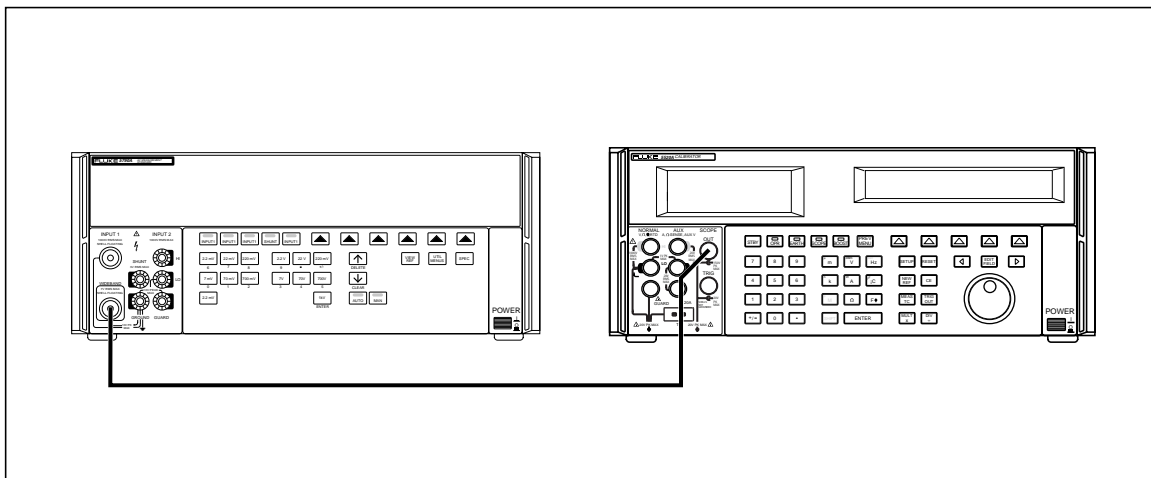
Leveled Sine Wave flatness verification is divided into two frequency bands: 50 kHz to 10 MHz (low frequency) and > 10 MHz to 300 MHz (high frequency). The equipment setups are different for each band. Leveled Sine Wave flatness is measured relative to 50 kHz. This is determined directly in the low frequency band. The high frequency band requires a “transfer” measurement be made at 10 MHz to calculate a flatness relative to 50 kHz.

6-128. Equipment Setup for Low Frequency Flatness

All low frequency flatness procedures use the following equipment:

- 5790A/03 AC Measurement Standard with Wideband option
- BNC(f) to Type N(m) adapter
- BNC cable supplied with the SC300

Connect the Calibrator Mainframe SCOPE connector to the 5790A WIDEBAND input with the BNC(f) to Type N(m) adapter as shown in Figure 6-25. Set the 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.



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Figure 6-25. Connecting the Calibrator Mainframe to the 5790A AC Measurement Standard

6-129. Equipment Setup for High Frequency Flatness

All high frequency flatness procedures use the following equipment:

- Hewlett-Packard 437B Power Meter
- Hewlett-Packard 8482A and 8481D Power Sensors
- BNC(f) to Type N(f) adapter
- BNC cable supplied with the Calibrator Mainframe

Note

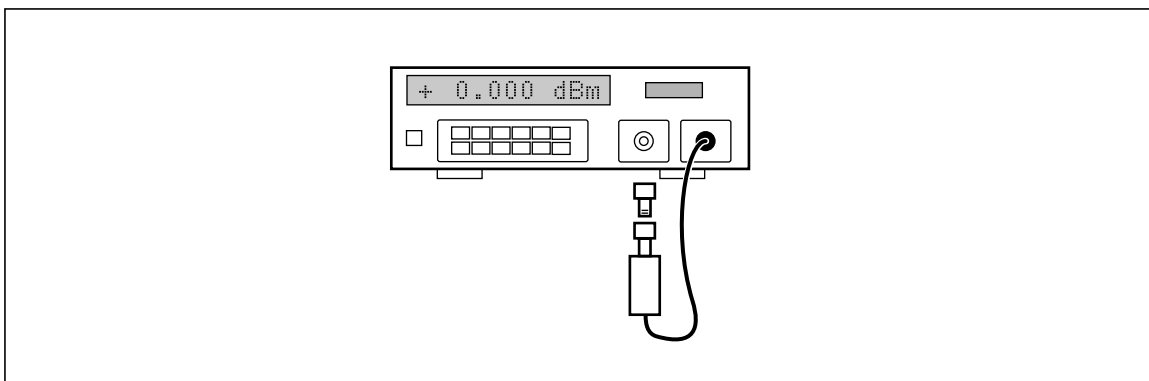
When high frequencies at voltages below 63 mV p-p are verified, use the 8481D Power Sensor. Otherwise, use the 8482A Power Sensor.

Connect the HP 437B Power Meter to either the 8482A or the 8481D Power Sensor as shown in Figure 6-26. For more information on connecting the two instruments, see the power meter and power sensor operators manuals.

Connect the power meter/power sensor combination to the SCOPE connector on the Calibrator Mainframe, as shown in Figure 6-27.

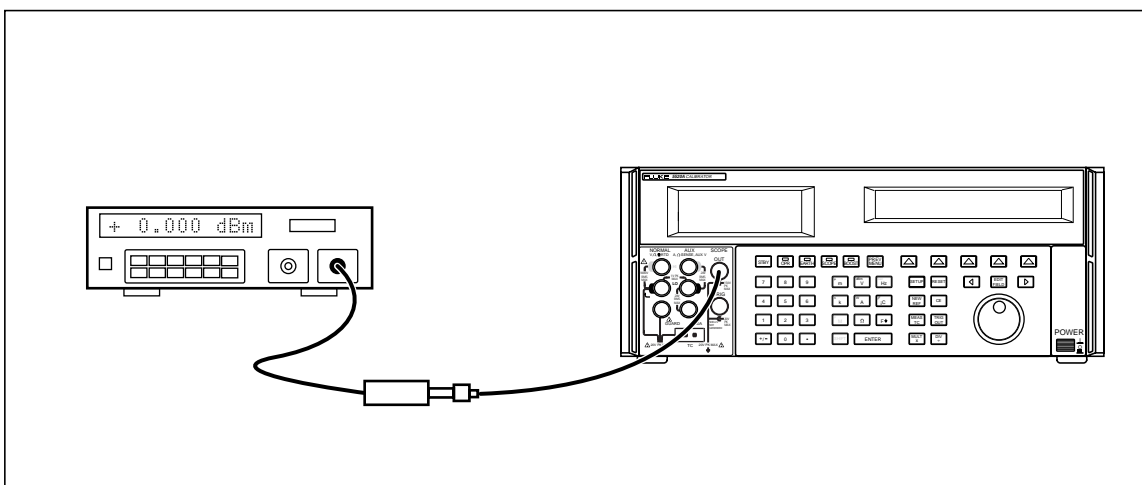
The Hewlett-Packard 437B Power Meter must be configured by setting the parameters listed below. Zero and self-calibrate the power meter with the power sensor being used. Refer to the Hewlett-Packard 437B operators manual for details.

- PRESET
- RESOLN 3
- AUTO FILTER
- WATTS
- SENSOR TABLE 0 (default)



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Figure 6-26. Connecting the HP 437B Power Meter to the HP 8482A or 8481D Power Sensor



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Figure 6-27. Connecting the Calibrator Mainframe to the HP Power Meter and Power Sensor

6-130. Low Frequency Verification

This procedure provides an example of testing low frequency flatness using a 5.5 V output. Follow the same procedure for testing other amplitudes, only compare results against the flatness specification listed in Table 6-55.

1. Program the Calibrator Mainframe for an output of 5.5 V @ 500 kHz. Press **OPR** on the Calibrator Mainframe to activate the output.
2. Allow the 5790A reading to stabilize. The 5790A should display approximately 1.94 V rms. Enter the 5790A reading in Column A of Table 6-55.
3. Enter 50 kHz into the Calibrator Mainframe. Allow the 5790A reading to stabilize, then enter the 5790A reading in Column B of Table 6-55.
4. Enter the next frequency listed in Table 6-55. Allow the 5790A reading to stabilize, then enter the reading into Column A of the table.
5. Enter 50 kHz into the Calibrator Mainframe. Allow the 5790A reading to stabilize, then enter the 5790A reading in Column B of Table 6-55.
6. Repeat steps 4 and 5 for all of frequencies listed in Table 6-55. Continue until you have completed Columns A and B.
7. When you have completed Columns A and B, press **STBY** to remove the Calibrator Mainframe's output. Complete Table 6-55 by performing the calculations for column C. Compare Column C to the specifications listed in the final column.

Table 6-55. Low Frequency Flatness Verification at 5.5 V

Calibrator Mainframe Frequency	A	B 50 kHz	C	Calibrator Mainframe Flatness Specification (%)
500 kHz				$\pm 1.50 + 100 \mu\text{V}$
1 MHz				$\pm 1.50 + 100 \mu\text{V}$
2 MHz				$\pm 1.50 + 100 \mu\text{V}$
5 MHz				$\pm 1.50 + 100 \mu\text{V}$
10 MHz				$\pm 1.50 + 100 \mu\text{V}$
Complete Columns A-C as follows:				
	A Enter 5790A Reading (mV) for the present frequency.			
	B Enter 5790A Reading (mV) for 50 kHz.			
	C Compute and enter the Calibrator Mainframe Flatness Deviation (%): $100 * ((\text{Column A entry}) - (\text{Column B entry})) / (\text{Column B entry})$			

6-131. High Frequency Verification

This procedure provides an example of testing high frequency flatness using a 5.5 V output. Follow the same procedure for testing other amplitudes, only compare results against the flatness specification listed in Table 6-56. For this voltage range, you will use the model HP 8482A power sensor.

1. Program the Calibrator Mainframe for an output of 5.5 V @ 30 MHz. Press **OPR** on the Calibrator Mainframe to activate the output.
2. Allow the power meter reading to stabilize. The power meter should display approximately 75 mW. Enter the power meter's reading in Column A of Table 6-56.

3. Enter 10 MHz into the Calibrator Mainframe. Allow the power meter reading to stabilize, then enter the power meter's reading in Column B of Table 6-56.
4. Enter the next frequency listed in Table 6-56. Allow the power meter's reading to stabilize, then enter the reading into Column A of the table.
5. Enter 10 MHz into the Calibrator Mainframe. Allow the power meter reading to stabilize, then enter the power meter's reading in Column B of Table 6-56.
6. Repeat steps 4 and 5 for all of frequencies listed in Table 6-56. Continue until you have completed Columns A and B.
7. When you have completed Columns A and B, press **[STBY]** to remove the Calibrator Mainframe's output. Complete Table 6-56 by performing the calculations for each column. Compare Column G to the specifications listed in the final column.

Table 6-56. High Frequency Flatness Verification at 5.5 V

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	F	G	Calibrator Mainframe Flatness Spec. (%)
20								± 1.50 +100 uV
50								± 1.50 +100 uV
100								± 1.50 +100 uV
125								± 2.00 + 100 uV
160								± 2.00 + 100 uV
200								± 2.00 + 100 uV
220								± 2.00 + 100 uV
235								± 2.00 + 100 uV
250								± 2.00 + 100 uV
300								± 2.00 + 100 uV
<p>Complete Columns A-G as follows:</p> <p>A Enter the 437B present frequency Reading (W).</p> <p>B Enter the 437B 10 MHz Reading (W).</p> <p>C Apply power sensor correction factor for present frequency (W): CF * (Column A entry)</p> <p>D Apply power sensor correction factor for 10 MHz (W): CF * (Column B entry)</p> <p>E Compute and enter Error relative to 10 MHz (%): $100 * (\text{sqrt}(\text{Column A entry}) - \text{sqrt}(\text{Column B entry})) / \text{sqrt}(\text{Column B entry})$</p> <p>F Enter the 10 MHz rms Error (%) for 5.5 V from Table 6-55, Column C.</p> <p>G Compute and enter the Calibrator Mainframe Flatness Deviation (%): (Column E entry) + (Column F entry)</p>								

6-132. Time Marker Verification

This procedure uses the following equipment:

- PM 6680 Frequency Counter with a prescaler for the Channel C input (Option PM 9621, PM 9624, or PM 9625) and ovenized timebase (Option PM 9690 or PM 9691)
- BNC(f) to Type N(m) adapter
- BNC cable supplied with the SC300

Refer to Figure 6-21 for the proper setup connections. Set the PM 6680's FUNCTION to measure frequency with auto trigger, measurement time set to 1 second or longer, and 50 Ω impedance.

Set the Calibrator Mainframe to SCOPE mode, with the Marker menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Then follow these steps to for each period listed in Table 6-57.

1. Program the Calibrator Mainframe to the output as listed in Table 6-57.
2. Using the BNC cable, connect the SCOPE connector on the Calibrator Mainframe to the PM 6680 at the channel indicated in Table 6-57. You will need the BNC-N adapter for the connection to Channel C.
3. Set the filter on the PM 6680 as indicated in the table. Allow the PM 6680 reading to stabilize, then record the PM 6680 reading for each frequency listed for the Calibrator Mainframe.
4. Invert the PM 6680's frequency reading to derive the period. For example, a reading of 1.000006345 kHz has a period of:

$$1/1.000006345 \text{ kHz} = 0.999993655 \text{ ms.}$$

Record the period in the table and compare to the tolerance column.

Table 6-57. Time Marker Verification

Calibrator Mainframe	PM 6680 Settings			PM 6680 Reading (Frequency)	1/(PM 6680 Reading) (Period)	Tolerance
	Period	Channel	Impedance			
	4.979 s	A	50 Ω	On		25.12 ms
	2.002 s	A	50 Ω	On		4.050 ms
	0.999 s	A	50 Ω	On		1.0300 ms
	500 ms	A	50 Ω	On		262.500 μs
	200 ms	A	50 Ω	On		45.000 μs
	100 ms	A	50 Ω	Off		12.500 μs
	50.0 ms	A	50 Ω	Off		3.750 μs
	20.0 ms	A	50 Ω	Off		900.00 ns
	10.0 ms	A	50 Ω	Off		350.00 ns
	5.00 ms	A	50 Ω	Off		150.00 ns
	2.00 ms	A	50 Ω	Off		54.00 ns
	1.00 ms	A	50 Ω	Off		26.00 ns
	500 μs	A	50 Ω	Off		12.750 ns
	200 μs	A	50 Ω	Off		5.040 ns

Table 6-57. Time Marker Verification (cont.)

Calibrator Mainframe	PM 6680 Settings			PM 6680 Reading (Frequency)	1/(PM 6680 Reading) (Period)	Tolerance
	Channel	Impedance	Filter			
100 μ s	A	50 Ω	Off			2.650 ns
50.0 μ s	A	50 Ω	Off			1.287 ns
20.0 μ s	A	50 Ω	Off			506.000 ps
10.0 μ s	A	50 Ω	Off			252.000 ps
5.00 μ s	A	50 Ω	Off			125.400 ps
2.00 μ s	A	50 Ω	Off			50.060 ps
1.00 μ s	A	50 Ω	Off			25.000 ps
500 ns	A	50 Ω	Off			13.000 ps
200 ns	A	50 Ω	Off			5.000 ps
100 ns	A	50 Ω	Off			2.500 ps
50.0 ns	A	50 Ω	Off			1.250 ps
20.0 ns	A	50 Ω	Off			0.5000 ps
10.0 ns	A	50 Ω	Off			0.2500 ps
5.00 ns	A	50 Ω	Off			0.1250 ps
2.00 ns	C	50 Ω	Off			0.0500 ps

6-133. Wave Generator Verification

This procedure uses the following equipment:

- 5790A AC Measurement Standard
- BNC(f) to Double Banana adapter
- 50 Ω feedthrough termination
- BNC cable supplied with the Calibrator Mainframe

For wave generation verification procedures, refer to Figure 6-28 for the proper setup connections.

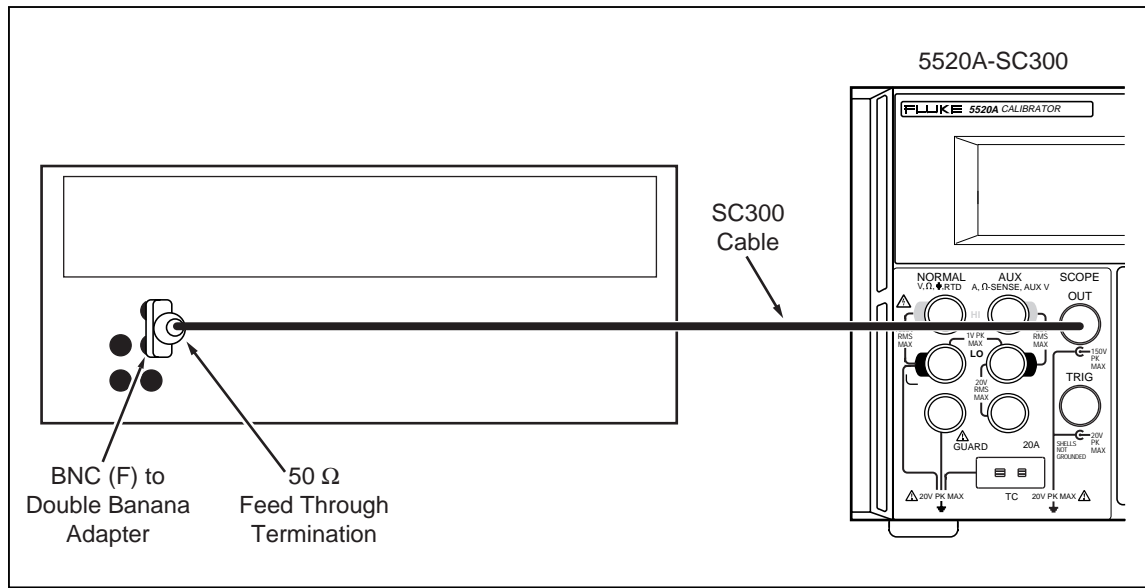


Figure 6-28. Wave Generator Verification Setup

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Set the Calibrator Mainframe to **SCOPE** mode, with the Wavegen menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Set the offset to 0 mV, and the frequency to 1 kHz. Then follow these steps to verify the wave generator function.

6-134. Verification at 1 MΩ

1. Set the Calibrator Mainframe impedance to 1 MΩ (The blue softkey under SCOPE Z toggles the impedance between 50 Ω and 1 MΩ).
2. Connect the BNC cable to the Calibrator Mainframe's SCOPE connector. Connect the other end of the BNC cable to the 5790A INPUT 2 using the BNC(f) to Double Banana adapter.
3. Set the 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.
4. Program the Calibrator Mainframe to output the wave type and voltage listed in Table 6-58.
5. Allow the 5790A reading to stabilize, then record the 5790A rms reading for each wave type and voltage in Table 6-58.
6. Multiply the rms reading by the conversion factor listed to convert it to the peak-to-peak value. Compare result to the tolerance column.

6-135. Verification at 50 Ω

1. Set the Calibrator Mainframe impedance to 50 Ω (The blue softkey under SCOPE Z toggles the impedance between 50 Ω and 1 MΩ).
2. Connect the BNC cable to the Calibrator Mainframe's SCOPE connector. Connect the other end of the BNC cable to the 50 Ω feedthrough termination then to the 5790A INPUT 2 using the BNC(f) to Double Banana adapter.
3. Set the 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.

4. Program the Calibrator Mainframe to output the wave type and voltage listed in Table 6-59.
5. Allow the 5790A reading to stabilize, then record the 5790A rms reading for each wave type and voltage in Table 6-59.
6. Multiply the rms reading by the conversion factor listed to convert it to the peak-to-peak value.
7. Multiply the peak-to-peak value by $(0.5 * (50 + R_{load}) / R_{load})$, where R_{load} = the actual feedthrough termination resistance, to correct for the resistance error. Compare result to the tolerance column.

Table 6-58. Wave Generator Verification at 1 M Ω

Calibrator Mainframe Wave Type	Calibrator Mainframe output (@ 10 kHz)	5790A Reading (V rms)	Conversion Factor	5790A Reading x Conversion Factor (V p-p)	Tolerance (V p-p)
square	5.0 mV		2.0000		250.00 μ V
square	20.0 mV		2.0000		700.00 μ V
square	89 mV		2.0000		2.770 mV
square	219 mV		2.0000		6.670 mV
square	890 mV		2.0000		26.8 mV
square	6.5 V		2.0000		195.1 mV
square	55 V		2.0000		1.65 V
sine	5.0 mV		2.8284		250.00 μ V
sine	20.0 mV		2.8284		700.00 μ V
sine	89 mV		2.8284		2.770 mV
sine	219 mV		2.8284		6.670 mV
sine	890 mV		2.8284		26.8 mV
sine	6.5 V		2.8284		195.1 mV
sine	55 V		2.8284		1.65 V
triangle	5.0 mV		3.4641		250.00 μ V
triangle	20.0 mV		3.4641		700.00 μ V
triangle	89 mV		3.4641		2.770 mV
triangle	219 mV		3.4641		6.670 mV
triangle	890 mV		3.4641		26.8 mV
triangle	6.5 V		3.4641		195.1 mV
triangle	55 V		3.4641		1.65 V

Table 6-59. Wave Generator Verification at 50 Ω

Calibrator Mainframe Wave Type	Calibrator Mainframe output (@ 10 kHz)	5790A Reading (V rms)	Conversion Factor	5790A Reading x Conversion Factor (V p-p)	Tolerance (V p-p)
square	5.0 mV		2.0000		250.00 μV
square	10.9 mV		2.0000		430.00 μV
square	45 mV		2.0000		1.450 mV
square	109 mV		2.0000		3.370 mV
square	0.45V		2.0000		13.570 mV
square	1.09V		2.0000		32.500 mV
square	2.20V		2.0000		66.100 mV
sine	5.0 mV		2.8284		250.00 μV
sine	10.9 mV		2.8284		430.00 μV
sine	45 mV		2.8284		1.450 mV
sine	109 mV		2.8284		3.370 mV
sine	0.45 V		2.8284		13.570 mV
sine	1.09 V		2.8284		32.500 mV
sine	2.20 V		2.8284		66.100 mV
triangle	5.0 mV		3.4641		250.00 μV
triangle	10.9 mV		3.4641		430.00 μV
triangle	45 mV		3.4641		1.450 mV
triangle	109 mV		3.4641		3.370 mV
triangle	0.45 V		3.4641		13.570 mV
triangle	1.09 V		3.4641		32.500 mV
triangle	2.20 V		3.4641		66.100 mV

6-136. SC300 Hardware Adjustments

Hardware adjustments must be made to the leveled sine and edge functions each time the SC300 is repaired. In addition to the adjustment procedures, this section provides lists of the required equipment and some recommendations on models that have the capabilities required by these procedures. Equivalent models can be substituted if necessary.

6-137. Equipment Required

The following equipment is necessary for performing the hardware adjustments described in this section. The models listed are recommended for providing accurate results.

- Standard adjustment tool for adjusting the pots and trimmer caps
- Extender Card (pn 661865, 5800A-7006K, Extender Kit)

- Oscilloscope Mainframe and Sampling Head (Tektronix 11801 with SD-22/26 or Tektronix TDS 820 with 8 GHz bandwidth)
- 10 dB Attenuator (Weinschel 9-10 (SMA), or Weinschel 18W-10, or equivalent)
- Cable provided with SC300
- Spectrum Analyzer (Hewlett-Packard 8590A)

6-138. Adjusting the Leveled Sine Wave Function

There is one adjustment procedure that need to be made for the leveled sine wave function. The procedure adjusts the harmonics.

6-139. Equipment Setup

This procedure uses the spectrum analyzer. Before you begin this procedure, verify that the Calibrator Mainframe is in leveled sine wave mode (the Levsine menu is displayed), and program it to output 5.5 V p-p @ 50 MHz. Press **OPR** to activate the output.

Refer to Figure 6-24 for setup connections and connect the Calibrator Mainframe to the Spectrum Analyzer. Adjust the Spectrum Analyzer so that it displays one peak across its horizontal centerline. The far right of the peak is fixed at the far right of the centerline, as shown below.

6-140. Adjusting the Leveled Sine Wave Harmonics

Note

This procedure should only be used for adjusting the leveled sine wave harmonics. Do not use this procedure as a verification test. The specifications in this procedure are not valid for verification.

Set the Spectrum Analyzer to the parameters listed below.

Spectrum Analyzer Setup

Start Frequency	50 MHz
Stop Frequency	500 MHz
Resolution Bandwidth	3 MHz
Video Bandwidth	3 kHz
Reference Level	20 dBm

Use your Spectrum Analyzer's Peak Search function to find the desired reference signal. The Analyzer should show the fundamental, and second and third harmonics. The harmonics need to be adjusted so that the second harmonic is at -34 dBc and third harmonic should typically be greater than or equal to -39 dBc as shown in Figure 6-29.

To adjust the harmonics, adjust R8, as shown in Figure 6-29 until the peaks of the second and third harmonic are at the correct dB level. You may find that you can place the second harmonic at -34 dBc but the third harmonic is less than -39 dBc. If this is the case, continue adjusting R8 until the third harmonic is at -39dBc and the second harmonic is greater than or equal to -34dBc The second harmonic will fluctuate, but there is a point at which both harmonics will be at the correct decibel level.

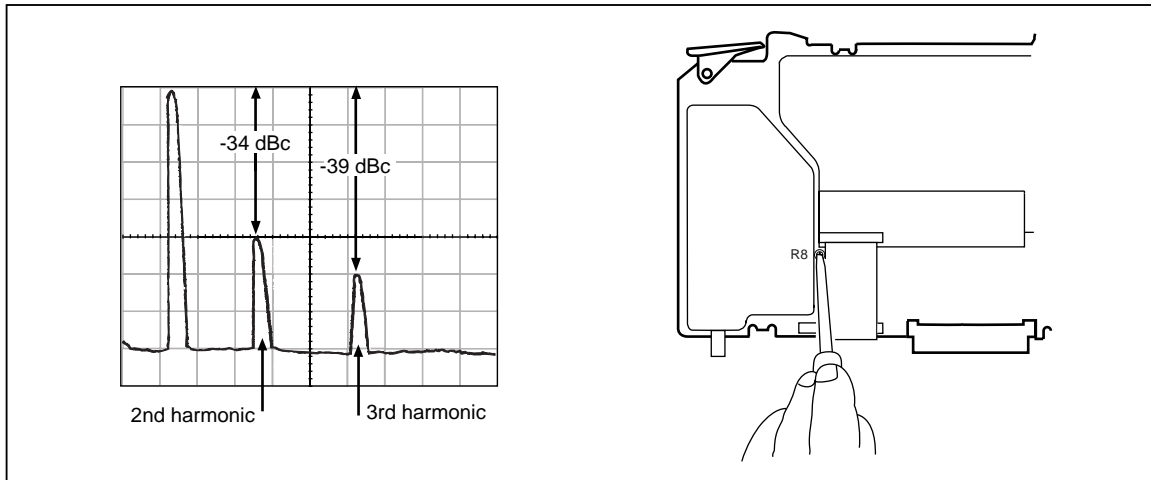


Figure 6-29. Adjusting the Leveled Sine Wave Harmonics

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6-141. Adjusting the Aberrations for the Edge Function

Adjustments need to be made after repair to the edge function to adjust the edge aberrations.

6-142. Equipment Setup

The following equipment is needed for this procedure:

- Oscilloscope: Tektronix 11801 with SD22/26 input module or Tektronix TDS 820 with 8 GHz bandwidth.
- 20 dB Attenuator: Weinschel 9-20 (SMA) or Weinschel 18W-20 or equivalent
- Output cable provided with the SC300

Before you begin this procedure, verify that the SC300 is in the edge mode (the Edge menu is displayed), and program it to output 1 V p-p @ 1 MHz. Press **OPR** to activate the output.

Refer to Figure 6-22 for the proper setup connections and connect the Calibrator Mainframe to the oscilloscope. Set the oscilloscope vertical to 1 mV/div and horizontal to 1 ns/div. Set the oscilloscope to look at the first 10 ns of the edge signal with the rising edge at the left edge of the oscilloscope display.

6-143. Adjusting the Edge Aberrations

Refer to Figure 6-30 while making the following adjustments:

1. Set the oscilloscope to display the 90% point of the edge signal. Note this voltage (or set to center of the display) as it will be used as the reference for the following adjustments.
2. Set the oscilloscope to display the leading edge and the first 10 ns of the edge signal. Adjust A90R13 to set the edge signal at the 10 ns point to the reference level.
3. Adjust A90R12 to flatten out the edge signal. Readjust A90R13 if necessary to keep the edge signal at the reference level.
4. Adjust A90R35 so the first overshoot is the same amplitude as the second aberration.
5. Readjust A90R36 to center the first two aberrations about reference level.

6. Readjust A90R13 if necessary to keep the edge signal at 10 ns to be at the reference level.
7. Readjust A90R36 ,A90R35 or A90R12 to obtain equal amplitudes of the aberrations displayed during the first 10 ns to be equally above and below the reference level. Check the aberrations , compare with specifications. It may be necessary to slow the rise time(A90R35) to reduce the amplitude of the aberrations.
8. Set the UUT output to 2.5 V and the oscilloscope vertical to 2 mV/div. Check the aberrations.
9. Remove the 20 dB attenuator from the oscilloscope input. Connect the UUT to the scope input and program the UUT output to 250 mV.
10. Set the oscilloscope vertical to 5 mV/div. Check the aberrations.
11. Check for rise time $< 950 \text{ ps} \pm 25 \text{ ps}$ at 250 mV, 1 V, and 2.5 V outputs.

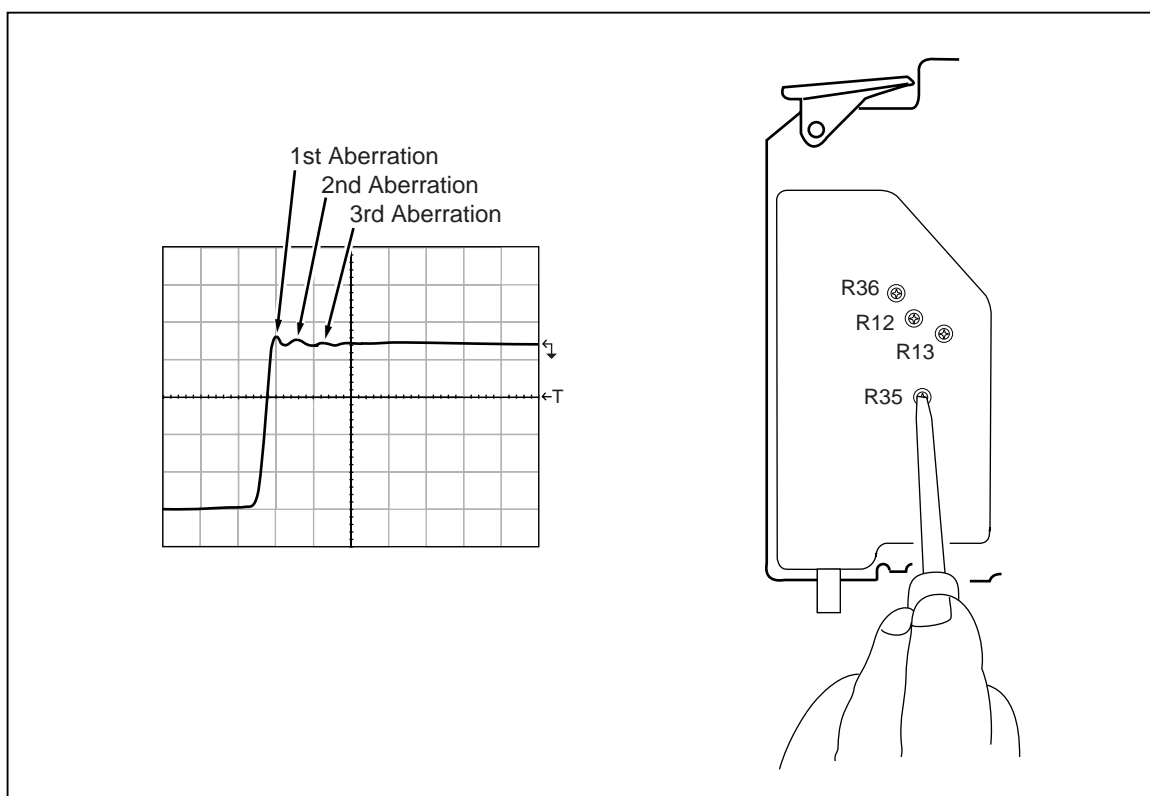


Figure 6-30. Adjusting Edge Aberrations

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