

FLUKE®

5500A

Multi-Product Calibrator

Service Manual

PN 105798

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Chapter 1

Introduction and Specifications

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1-1. Introduction

The Fluke Model 5500A Multi-Product Calibrator (Figure 1-1) is a precise instrument that calibrates a wide variety of electrical measuring instruments. With the 5500A Calibrator, you can calibrate precision multimeters that measure ac or dc voltage, ac or dc current, ac or dc power, resistance, capacitance, and temperature. With the Oscilloscope Calibration option, you can use the 5500A Calibrator to calibrate analog and digital oscilloscopes. Specifications for the standard 5500A are provided at the end of this chapter. Specifications for the Oscilloscope Option are in Chapter 6.

Warning

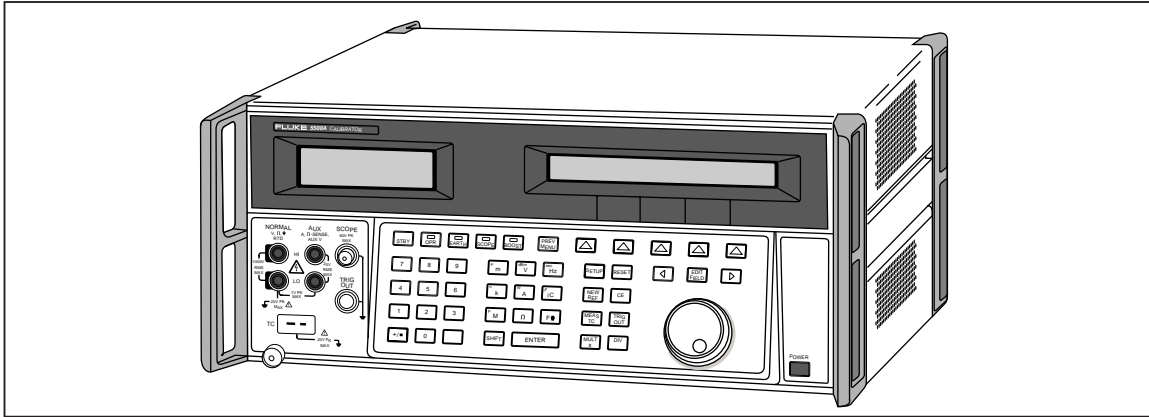
If the 5500A Calibrator is operated in any way not specified by the 5500A Operators Manual or other documentation provided by Fluke, protection provided by the 5500A may be impaired.

The 5500A Calibrator is a fully programmable precision source of the following:

- DC voltage from 0 V to ± 1020 V.
- AC voltage from 1 mV to 1020 V, with output from 10 Hz to 500 kHz.
- AC current from 0.01 μ A to 11.0 A, with output from 10 Hz to 10 kHz.
- DC current from 0 to ± 11.0 A.
- Resistance values from a short circuit to 330 M Ω .
- Capacitance values from 330 pF to 1100 μ F.
- Simulated output for three types of Resistance Temperature Detectors (RTDs).
- Simulated output for nine types of thermocouples.

Features of the 5500A Calibrator include the following:

- Automatic meter error calculation using a simple output adjust knob.
- Keys that multiply and divide the output value by 10 to simplify work on meters with calibration points at decade multiples.
- Programmable entry limits to restrict levels that may be keyed into the 5500A, to prevent calling up a level that may be harmful to equipment or personnel.
- Simultaneous output of voltage and current, up to 11 kW.
- Simultaneous output of two voltages.
- Extended bandwidth mode outputs multiple waveforms down to 0.01 Hz, and sine waves to 2 MHz.
- Variable phase signal output.
- Standard IEEE-488 (GPIB) interface, complying with ANSI/IEEE Standards 488.1-1987 and 488.2-1987.
- EIA Standard RS-232-C serial data interface for printing, displaying, or transferring internally stored calibration constants, and for remote control of the 5500A.
- Pass-through RS-232-C serial data interface for communicating with the Unit Under Test (UUT).
- Extensive automatic internal self-testing and diagnostics of analog and digital functions.



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Figure 1-1. 5500A Multi-Product Calibrator

1-2. 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.

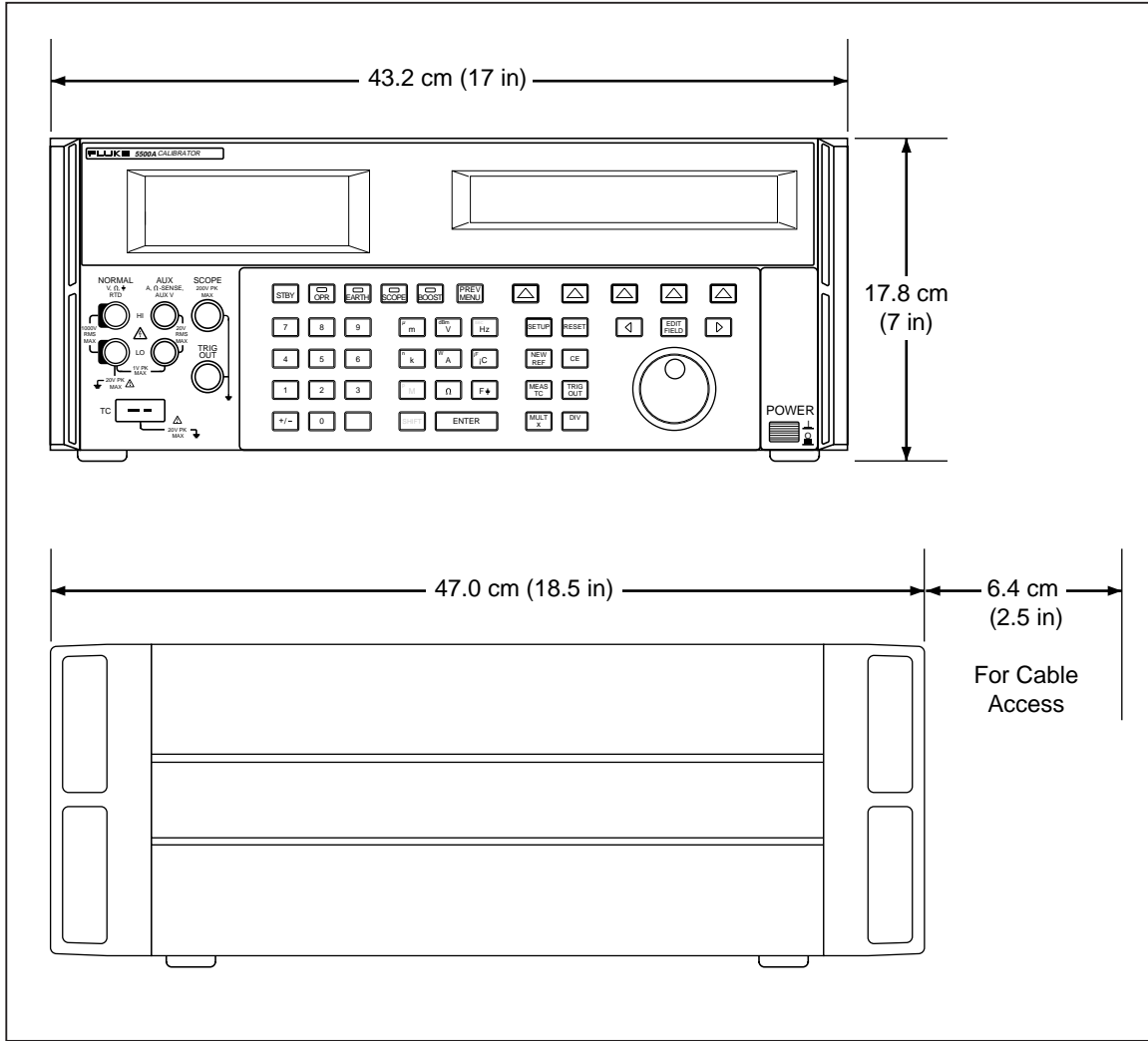
This service manual provides instructions for verification of performance, calibration, and maintenance. If you choose to repair a malfunction, information in this manual can help you to determine which module (printed circuit assembly) has a fault. See Chapter 5 for cautions about handling the internal components.

1-3. Specifications

The following paragraphs detail specifications for the 5500A Calibrator. The specifications are valid after allowing a warm-up period of 30 minutes, or twice the time the 5500A has been turned off. For example, if the 5500A 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 5500A was calibrated), the temperature coefficient is less than 0.1 times the 90-day specifications per $^{\circ}\text{C}$ (limited to $0\text{ }^{\circ}\text{C}$ to $50\text{ }^{\circ}\text{C}$). These specifications also assume the 5500A Calibrator is zeroed every seven days or when the ambient temperature changes more than $5\text{ }^{\circ}\text{C}$. (See “Zeroing the Calibrator” in Chapter 4.)

Also see additional specifications later in this chapter for information on extended specifications for ac voltage and current. The dimensional outline for the 5500A Calibrator is shown in Figure 1-2.



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Figure 1-2. 5500A Calibrator Dimensional Outline

1-4. 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, 5725A Amplifier
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 +5 °C is 0.1X/°C of the 90-day specification (or 1-year, as applicable) per °C.
Relative Humidity [1]	<ul style="list-style-type: none"> • Operating: <80% to 30 °C, <70% to 40 °C, <40% to 50 °C • Storage: <95%, non-condensing
Altitude	<ul style="list-style-type: none"> • Operating: 3,050 m (10,000 ft) maximum • Non-operating: 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	Designed to comply with FCC Rules Part 15; VFG 243/1991. If used in areas with Electromagnetic fields of 1 to 3 V/m, resistance outputs have a floor adder of 0.508 Ω. Performance not specified above 3 V/m. This instrument may be susceptible to electro-static discharge (ESD) from direct contact to the binding posts. Good static aware practices should be followed when handling this and other pieces of electronic equipment.
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: ±10% about line voltage setting
Power Consumption	5500A Calibrator, 300 VA; 5725A Amplifier, 750 VA
Dimensions	<p>5500A Calibrator:</p> <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 <p>5725A Amplifier:</p> <ul style="list-style-type: none"> • Height, 13.3 cm (5.25 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, 63.0 cm (24.8 inches) overall.
Weight (without options)	5500A Calibrator, 22 kg (49 lb); 5725A Amplifier 32 kg (70 pounds)
Absolute Uncertainty Definition	The 5500A specifications include stability, temperature coefficient, linearity, line and load regulation, and the traceability of the external standards used for calibration. You do not need to add anything to determine the total specification of the 5500A for the temperature range indicated.
Specification Confidence Interval	99%
[1] After long periods of storage at high humidity, a drying out period (with the power on) of at least one week may be required.	

1-5. DC Voltage Specifications

Ranges	Absolute Uncertainty, tcal ± 5 °C ± (% of output + μV)				Stability 24 hours, ± 1 °C ± (ppm output + μV)	Reso- lution	Maximum Burden [1]
	90 days		1 year				
0 to 329.9999 mV	0.005%	3 μV	0.006%	3 μV	5 ppm + 1 μV	0.1 μV	50 Ω
0 to 3.299999 V	0.004	5	0.005	5	4 + 3	1	10 mA
0 to 32.99999 V	0.004	50	0.005	50	4 + 30	10	10 mA
30 to 329.9999 V	0.0045	500	0.0055	500	4.5 + 300	100	5 mA
100 to 1020.000 V	0.0045	1500	0.0055	1500	4.5 + 900	1000	5 mA
Auxiliary Output (dual output mode only) [2]							
0 to 329.999 mV	0.03	350	0.04	350	30 + 100	1	5 mA
0.33 to 3.3 V	0.03	350	0.04	350	30 + 100	10	5 mA

[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.
[2] Two channels of dc voltage output are provided.

Ranges	Noise	
	Bandwidth 0.1 to 10 Hz p-p ± (ppm output + μV)	Bandwidth 10 to 10 kHz rms
0 to 329.9999 mV	1 μV	4 μV
0 to 3.299999 V	10 μV	50 μV
0 to 32.99999 V	100 μV	600 μV
30 to 329.9999 V	10 ppm + 1 mV	20 mV
100 to 1020.000 V	10 ppm + 5 mV	20 mV
Auxiliary Output (dual output mode only) [1]		
0 to 329.999 mV	5 μV	20 μV
0.33 to 3.3 V	20 μV	200 μV

[1] Two channels of dc voltage output are provided.

1-6. DC Current Specifications

Ranges	Absolute Uncertainty, tcal $\pm 5^\circ\text{C}$ \pm (% of output + μA)				Resolution	Compliance Voltage	Maximum Inductive Load
	90 days		1 year				
0 to 3.29999 mA	0.010%	0.05 μA	0.013%	0.05 μA	0.01 μA	4.5 V	1 μH
0 to 32.9999 mA	0.008	0.25	0.01	0.25	0.1	4.5 V	200 μH
0 to 329.999 mA	0.008	3.3	0.01	3.3	1	4.5 to 3.0 V [1]	200 μH
0 to 2.19999 A	0.023	44	0.03	44	10	4.5 to 3.4 V [2]	200 μH
0 to 11 A	0.038	330	0.06	330	100	4.5 to 2.5 V [3]	200 μH
5725A Amplifier							
0 to 11 A	0.03	330	0.04	330	100	4 V	400 μH
<p>[1] The actual voltage compliance (V_c) is a function of current output (I_o), and is given by the formula: $V_c = -5.05 \cdot I_o + 4.67$. The highest compliance voltage is limited to 4.5 V.</p> <p>[2] The actual voltage compliance (V_c) is a function of current output (I_o), and is given by the formula: $V_c = -0.588 \cdot I_o + 4.69$. The highest compliance voltage is limited to 4.5 V.</p> <p>[3] The actual voltage compliance (V_c) is a function of current output (I_o), and is given by the formula: $V_c = -0.204 \cdot I_o + 4.75$. The highest compliance voltage is limited to 4.3 V.</p>							

Ranges	Noise	
	Bandwidth 0.1 to 10 Hz p-p	Bandwidth 10 to 10 kHz rms
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 2.19999 A	20 μA	1 mA
0 to 11 A	200 μA	10 mA
5725A Amplifier		
0 to 11 A	± 25 ppm of output + 200 nA	2 mA

1-7. Resistance Specifications

Ranges [1]	Absolute Uncertainty, tcal ± 5 °C ± (% of output + Ω) [2]				Resolution	Allowable Current [4]
	90 days		1 year			
0 to 10.99 Ω	0.009%	0.008 Ω [3]	0.012%	0.008 Ω [3]	0.001 Ω	1 to 125 mA
11 to 32.999 Ω	0.009	0.015 [3]	0.012	0.015 [3]	0.001	1 to 125 mA
33 to 109.999 Ω	0.007	0.015 [3]	0.009	0.015 [3]	0.001	1 to 70 mA
110 to 329.999 Ω	0.007	0.015 [3]	0.009	0.015 [3]	0.001	1 to 40 mA
330Ω to 1.09999 kΩ	0.007	0.06	0.009	0.06	0.01	250 μA to 18 mA
1.1 to 3.29999 kΩ	0.007	0.06	0.009	0.06	0.01	250 μA to 5 mA
3.3 to 10.9999 kΩ	0.007	0.6	0.009	0.6	0.1	25 μA to 1.8 mA
11 to 32.9999 kΩ	0.007	0.6	0.009	0.6	0.1	25 μA to 0.5 mA
33 to 109.999 kΩ	0.008	6	0.011	6	1	2.5 μA to 0.18 mA
110 to 329.999 kΩ	0.009	6	0.012	6	1	2.5 μA to 0.05 mA
330k to 1.09999 MΩ	0.011	55	0.015	55	10	250 nA to 0.018 mA
1.1 to 3.29999 MΩ	0.011	55	0.015	55	10	250 nA to 5 μA
3.3 to 10.9999 MΩ	0.045	550	0.06	550	100	25 nA to 1.8 μA
11 to 32.9999 MΩ	0.075	550	0.1	550	100	25 nA to 0.5 μA
33 to 109.999 MΩ	0.4	5.5k	0.5	5.5k	1000	2.5 nA to 0.18 μA
110 to 330 MΩ	0.4	16.5k	0.5	16.5k	1000	2.5 nA to 0.06 μA

- [1] Continuously variable from 0 to 330 MΩ.
 [2] Applies for COMP OFF (to the 5500A Calibrator front panel NORMAL terminals) and 2-wire and 4-wire compensation.
 [3] The floor adder is improved to 0.006 Ω (0 to 10.99 Ω range) and 0.010 Ω (11 to 329.999 Ω) if the 5500A Calibrator is zeroed (ohms zero or instrument zero) within 8 hours and temperature is ±1 °C of zeroing ambient temperature.
 [4] Do not exceed the largest current for each range. For currents lower than shown, the floor adder increases by $Floor_{(new)} = Floor_{(old)} \times I_{min}/I_{actual}$. For example, a 100 μA stimulus measuring 100 Ω has a floor uncertainty of $0.01\Omega \times 1 \text{ mA}/100 \mu\text{A} = 0.1\Omega$.

Ranges	Maximum Voltage [1]	Maximum Lead Resistance [2]
0 to 10.99 Ω	1.37 V	<3.2 Ω
11 to 32.999 Ω	4.12	<3.2
33 to 109.999 Ω	7.7	<3.2
110 to 329.999 Ω	13.2	<3.2
330 Ω to 1.09999 kΩ	19.8	<6
1.1 to 3.29999 kΩ	16.5	<6
3.3 to 10.9999 kΩ	19.8	<6
11 to 32.9999 kΩ	16.5	<6
33 to 109.999 kΩ	19.8	<6
110 to 329.999 kΩ	16.5	(n/a 110 kΩ and above)
330 kΩ to 1.09999 MΩ	19.8	"
1.1 to 3.29999 MΩ	16.5	"
3.3 to 10.9999 MΩ	19.8	"
11 to 32.9999 MΩ	16.5	"
33 to 109.999 MΩ	19.8	"
110 to 330 MΩ	19.8	"

- [1] This is for the largest resistance for each range. The maximum voltage for other values is I_{max} (highest value of Allowable Current above) multiplied by R_{out} .
 [2] Maximum lead resistance for no additional error in 2-wire COMP.

1-8. AC Voltage (Sinewave) Specifications

Ranges	Frequency	Absolute Uncertainty, tcal ± 5 °C \pm (% of output + μ V)				Res- olution	Max Burden [1]
		90 days		1 year			
1.0 to 32.999 mV	10 to 45 Hz	0.26%	20 μ V	0.35%	20 μ V	1 μ V	50 Ω
	45 Hz to 10 kHz	0.11	20	0.15	20		
	10 to 20 kHz	0.15	20	0.2	20		
	20 to 50 kHz	0.19	20	0.25	20		
	50 to 100 kHz	0.26	33	0.35	33		
	100 to 500 kHz	0.75	60	1	60		
33 to 329.999 mV	10 to 45 Hz	0.19	50	0.25	50	1 μ V	50 Ω
	45 Hz to 10 kHz	0.04	20	0.05	20		
	10 to 20 kHz	0.08	20	0.1	20		
	20 to 50 kHz	0.12	40	0.16	40		
	50 to 100 kHz	0.17	170	0.24	170		
	100 to 500 kHz	0.53	330	0.7	330		
0.33 to 3.29999 V	10 to 45 Hz	0.11	250	0.15	250	10 μ V	10 mA
	45 Hz to 10 kHz	0.02	60	0.03	60		
	10 to 20 kHz	0.06	60	0.08	60		
	20 to 50 kHz	0.10	300	0.14	300		
	50 to 100 kHz	0.17	1700	0.24	1700		
	100 to 500 kHz	0.38	3300	0.5	3300		
3.3 to 32.9999 V	10 to 45 Hz	0.11	2500	0.15	2500	100 μ V	10 mA
	45 Hz to 10 kHz	0.03	600	0.04	600		
	10 to 20 kHz	0.06	2600	0.08	2600		
	20 to 50 kHz	0.14	5000	0.19	5000		
	50 to 100 kHz	0.17	17000	0.24	17000		
33 to 329.999 V	45 Hz to 1 kHz	0.04	6.6 mV	0.05	6.6 mV	1 mV	5 mA, except 20 mA for 45 to 65 Hz
	1 to 10 kHz	0.06	15	0.08	15		
	10 to 20 kHz	0.07	33	0.09	33		
330 to 1020 V	45 Hz to 1 kHz	0.04	80 mV	0.05	80 mV	10 mV	2 mA, except 6 mA for 45 to 65 Hz
	1 to 5 kHz	0.15	100	0.20	100		
	5 to 10 kHz	0.15	500	0.20	500		

AC Voltage (Sinewave) Specifications (cont.)

Ranges	Frequency	Absolute Uncertainty, tcal $\pm 5^\circ\text{C}$ \pm (% of output + μV)				Resolution	Maximum Burden [1]
		90 days		1 year			
5725A Amplifier							
100 to 1020 V	45 Hz to 1 kHz	0.04	80 mV	0.05	80 mV	10 mV	50 mA
	1 to 20 kHz	0.06	100	0.08	100	10 mV	70 mA
	20 to 30 kHz	0.08	100	0.10	100	10 mV	70 mA
100 to 750 V	30 to 100 kHz	0.38	500	0.5	500	10 mV	70 mA
Auxiliary Output [dual output mode only] [2]							
10 to 329.999 mV	10 to 20 Hz	0.15	370	0.2	370	1 μV	5 mA
	20 to 45 Hz	0.08	370	0.1	370		
	45 Hz to 1 kHz	0.08	370	0.1	370		
	1 to 5 kHz	0.15	450	0.2	450		
	5 to 10 kHz	0.3	450	0.4	450		
0.33 to 3.29999 V	10 to 20 Hz	0.15	450	0.2	450	10 μV	5 mA
	20 to 45 Hz	0.08	450	0.1	450		
	45 Hz to 1 kHz	0.07	450	0.09	450		
	1 to 5 kHz	0.15	1400	0.2	1400		
	5 to 10 kHz	0.3	1400	0.4	1400		
<p>[1] Remote sensing is not provided. Output resistance is $< 5\text{ m}\Omega$ for outputs $\geq 0.33\text{ V}$. The AUX output resistance is $< 1\ \Omega$. The maximum load capacitance is 500 pF, subject to the maximum burden current limits.</p> <p>[2] There are two channels of voltage output. The maximum frequency of the dual output is 10 kHz.</p>							

AC Voltage (Sinewave) Specifications (cont.)

Ranges	Frequency	Maximum Distortion and Noise 10 Hz to 5 MHz Bandwidth
		± (% output + μV)
1.0 to 32.999 mV	10 to 45 Hz	0.15% + 90 μV
	45 Hz to 10 kHz	0.035 + 90
	10 to 20 kHz	0.06 + 90
	20 to 50 kHz	0.15 + 90
	50 to 100 kHz	0.25 + 90
	100 to 500 kHz	0.3 + 90
33 to 329.999 mV	10 to 45 Hz	0.15% + 90 μV
	45 Hz to 10 kHz	0.035 + 90
	10 to 20 kHz	0.06 + 90
	20 to 50 kHz	0.15 + 90
	50 to 100 kHz	0.20 + 90
	100 to 500 kHz	0.20 + 90
0.33 to 3.29999 V	10 to 45 Hz	0.15% + 200 μV
	45 Hz to 10 kHz	0.035 + 200
	10 to 20 kHz	0.06 + 200
	20 to 50 kHz	0.15 + 200
	50 to 100 kHz	0.20 + 200
	100 to 500 kHz	0.20 + 200
3.3 to 32.9999 V	10 to 45 Hz	0.15% + 2 mV
	45 Hz to 10 kHz	0.035 + 2
	10 to 20 kHz	0.08 + 2
	20 to 50 kHz	0.2 + 2
	50 to 100 kHz	0.5 + 2
33 to 329.999 V	45 Hz to 1 kHz	0.15% + 10 mV
	1 to 10 kHz	0.05 + 10
	10 to 20 kHz	0.6 + 10
330 to 1000 V	45 Hz to 1 kHz	0.15% + 30 mV
	1 to 10 kHz	0.07 + 30
5725A Amplifier		
100 to 1000 V	45 Hz to 1 kHz	0.07%
	1 to 20 kHz	0.15%
	20 to 30 kHz	0.3%
100 to 750 V	30 to 100 kHz	0.4%
Auxiliary Output [dual output mode only] 10 Hz to 100 kHz Bandwidth		
10 to 329.999 mV	10 to 20 Hz	0.2% + 200 μV
	20 to 45 Hz	0.06 + 200
	45 Hz to 1 kHz	0.08 + 200
	1 to 5 kHz	0.3 + 200
	5 to 10 kHz	0.6 + 200
0.33 to 3.29999 V	10 to 20 Hz	0.2% + 200 μV
	20 to 45 Hz	0.06 + 200
	45 Hz to 1 kHz	0.08 + 200
	1 to 5 kHz	0.3 + 200
	5 to 10 kHz	0.6 + 200

1-9. AC Current (Sinewave) Specifications

Ranges	Frequency	Absolute Uncertainty, tcal ± 5 °C ± (% of output + μA)				Res- olution	Com- pliance Voltage	Max Induc- tive Load
		90 days		1 year				
0.029 to 0.32999 mA	10 to 20 Hz	0.19%	0.15 μA	0.25%	0.15 μA	0.01 μA	3.0 V rms	1 μH
	20 to 45 Hz	0.09	0.15	0.12	0.15			
	45 Hz to 1 kHz	0.09	0.25	0.12	0.25			
	1 to 5 kHz	0.30	0.15	0.4	0.15			
	5 to 10 kHz	0.94	0.15	1.25	0.15			
0.33 to 3.2999 mA	10 to 20 Hz	0.15	0.3	0.2	0.3	0.01	3.0 V rms	1 μH
	20 to 45 Hz	0.08	0.3	0.1	0.3			
	45 Hz to 1 kHz	0.08	0.3	0.1	0.3			
	1 to 5 kHz	0.15	0.3	0.2	0.3			
	5 to 10 kHz	0.45	0.3	0.6	0.3			
3.3 to 32.999 mA	10 to 20 Hz	0.15	3	0.2	3	0.1	3.0 V rms	200 μH, 10 to 500 Hz 1 μH, 500 Hz to 10 kHz
	20 to 45 Hz	0.08	3	0.1	3			
	45 Hz to 1 kHz	0.07	3	0.09	3			
	1 to 5 kHz	0.15	3	0.2	3			
	5 to 10 kHz	0.45	3	0.6	3			
33 to 329.99 mA	10 to 20 Hz	0.15	30	0.2	30	1	3.0 to 2.0 V rms [1]	200 μH, 10 to 500 Hz 5 μH, 500 Hz to 10 kHz
	20 to 45 Hz	0.08	30	0.1	30			
	45 Hz to 1 kHz	0.07	30	0.09	30			
	1 to 5 kHz	0.15	30	0.2	30			
	5 to 10 kHz	0.45	30	0.6	30			
0.33 to 2.19999A	10 to 45 Hz	0.15	300	0.2	300	10	3.0 to 2.0 V rms [2]	200 μH, 45 to 500 Hz 5 μH, 500 Hz to 5 kHz
	45 Hz to 1 kHz	0.08	300	0.1	300			
	1 to 5 kHz	0.7	300	0.75	300			
2.2 to 11A	45 to 65 Hz	0.05	2000	0.06	2000	100	2.8 to 1.25 V rms [3]	200 μH, 45 to 65 Hz 1 μH, 65 Hz to 1 kHz
	65 to 500 Hz	0.08	2000	0.10	2000			
	500 Hz to 1 kHz	0.25	2000	0.33	2000			

AC Current (Sinewave) Specifications (cont.)

Ranges	Frequency	Absolute Uncertainty, tcal $\pm 5^\circ\text{C}$ \pm (% of output + μA)				Res- olution	Com- pliance Voltage	Max Induc- tive Load
		90 days		1 year				
5725A Amplifier								
1.5 to 11 A	45 to 1 kHz	0.08	100	0.1	100	100	3	400 μH
	1 to 5 kHz	0.19	5000	0.25	5000			
	5 to 10 kHz	0.75	10000	1	10000			
<p>[1] The actual voltage compliance (V_c) is a function of current output (I_o), and is given by the formula: $V_c = -3.37 \cdot I_o + 3.11$. The highest compliance voltage is limited to 3.0 V.</p> <p>[2] The actual voltage compliance (V_c) is a function of current output (I_o), and is given by the formula: $V_c = -0.535 \cdot I_o + 3.18$. The highest compliance voltage is limited to 3.0 V.</p> <p>[3] The actual voltage compliance (V_c) is a function of current output (I_o), and is given by the formula: $V_c = -0.176 \cdot I_o + 3.19$. The highest compliance voltage is limited to 2.8 V.</p>								

Ranges	Frequency	Maximum Distortion and Noise 10 Hz to 100 kHz Bandwidth \pm (% output + μA)
0.02 to 0.32999 mA	10 to 20 Hz	0.15% + 1.0 μA
	20 to 45 Hz	0.1 + 1.0
	45 Hz to 1 kHz	0.05 + 1.0
	1 to 5 kHz	0.5 + 1.0
	5 to 10 kHz	1.0 + 1.0
0.33 to 3.2999 mA	10 to 20 Hz	0.15% + 1.5 μA
	20 to 45 Hz	0.06 + 1.5
	45 Hz to 1 kHz	0.02 + 1.5
	1 to 5 kHz	0.5 + 1.5
	5 to 10 kHz	1.2 + 1.5
3.3 to 32.999 mA	10 to 20 Hz	0.15% + 5 μA
	20 to 45 Hz	0.05 + 5
	45 Hz to 1 kHz	0.07 + 5
	1 to 5 kHz	0.3 + 5
	5 to 10 kHz	0.7 + 5
33 to 329.99 mA	10 to 20 Hz	0.15% + 50 μA
	20 to 45 Hz	0.05 + 50
	45 Hz to 1 kHz	0.07 + 50
	1 to 5 kHz	0.2 + 50
	5 to 10 kHz	0.4 + 50
0.33 to 2.19999 A	10 to 45 Hz	0.2% + 500 μA
	45 Hz to 1 kHz	0.1 + 500
	1 to 5 kHz	1.4 + 500
2.2 to 11 A	45 to 65 Hz	0.2% + 3 mA
	65 to 500 Hz	0.1 + 3
	500 Hz to 1 kHz	0.4 + 3
5725A Amplifier		
1.5 to 11 A	45 Hz to 1 kHz	0.05% + 1 mA
	1 to 5 kHz	0.12 + 1
	5 to 10 kHz	0.5 + 1

1-10. Capacitance Specifications

Ranges	Absolute Uncertainty, tcal $\pm 5^\circ\text{C}$ \pm (% of output + nF)				Resolution	Frequency	
	90 days		1 year			Allowed	Typical for <1% Error
0.33 to 0.4999 nF	0.38%	0.01 nF	0.5%	0.01 nF	0.1 pF	50 to 1000 Hz	10 kHz
0.5 to 1.0999 nF	0.38	0.01	0.5	0.01	0.1 pF	50 to 1000 Hz	10 kHz
1.1 to 3.2999 nF	0.38	0.01	0.5	0.01	0.1 pF	50 to 1000 Hz	10 kHz
3.3 to 10.999 nF	0.38	0.01	0.5	0.01	1 pF	50 to 1000 Hz	10 kHz
11 to 32.999 nF	0.19	0.1	0.25	0.1	1 pF	50 to 1000 Hz	10 kHz
33 to 109.99 nF	0.19	0.1	0.25	0.1	10 pF	50 to 1000 Hz	10 kHz
110 to 329.99 nF	0.19	0.3	0.25	0.3	10 pF	50 to 1000 Hz	10 kHz
0.33 to 1.0999 μF	0.19	1	0.25	1	100 pF	50 to 1000 Hz	5 kHz
1.1 to 3.2999 μF	0.26	3	0.35	3	100 pF	50 to 1000 Hz	2 kHz
3.3 to 10.999 μF	0.26	10	0.35	10	1 nF	50 to 400 Hz	1.5 kHz
11 to 32.999 μF	0.30	30	0.40	30	1 nF	50 to 400 Hz	800 Hz
33 to 109.99 μF	0.38	100	0.50	100	10 nF	50 to 200 Hz	400 Hz
110 to 329.99 μF	0.50	300	0.70	300	10 nF	50 to 100 Hz	200 Hz
330 to 1.1 mF	1	300	1	300	100 nF	50 to 100 Hz	150 Hz

Specifications apply to both dc charge/discharge capacitance meters and ac RCL meters.

The output is continuously variable from 330 pF to 1.1 mF.

For all ranges, the maximum charge and discharge current is 150 mA pk or 30 mA rms. The peak voltage is 4 V, except the 330 μF to 1.1 mF range is limited to 1 V. The maximum lead resistance for no additional error in 2-wire COMP mode is 10 Ω .

1-11. Temperature Calibration (Thermocouple) Specifications

TC Type	Range (°C)	Absolute Uncertainty Source/Measure, tcal ± 5 °C, ± (°C) [1]		TC Type	Range (°C)	Absolute Uncertainty Source/Measure, tcal ± 5 °C, ± (°C) [1]		
		90 days	1 year			90 days	1 year	
B	600 °C to 800 °C	0.42 °C	0.44 °C	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		
E	1800 to 2316	0.63	0.84	R	0 to 250	0.48	0.57	
	J	-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		
K	-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		
U	-200 to -100	0.25	0.33		120 to 400	0.10	0.14	
	-100 to -25	0.14	0.18	-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					

The 10 µV/°C linear output mode has the same uncertainty as the 300 mV dc range.

Applies to both simulated thermocouple output and thermocouple measurement.

[1] Temperature standard ITS-90 or IPTS-68 is selectable.

[2] Resolution is 0.01 °C.

[3] Does not include thermocouple error.

1-12. Temperature Calibration (RTD) Specifications

RTD Type	Range (°C) [1]		Absolute Uncertainty, tcal ± 5 °C, ± (°C) [2]	
	Minimum	Maximum	90 days	1 year
Pt 385, 100Ω	-200 °C	-80 °C	0.04 °C	0.05 °C
	-80	0	0.05	0.05
	0	100	0.07	0.07
	100	300	0.08	0.09
	300	400	0.09	0.10
	400	630	0.10	0.12
	630	800	0.21	0.23
Pt 3926, 100 Ω	-200	-80	0.04	0.05
	-80	0	0.05	0.05
	0	100	0.07	0.07
	100	300	0.08	0.09
	300	400	0.09	0.10
	400	630	0.10	0.12
Pt 3916, 100 Ω	-200	-190	0.25	0.25
	-190	-80	0.04	0.04
	-80	0	0.05	0.05
	0	100	0.06	0.06
	100	260	0.06	0.07
	260	300	0.07	0.08
	300	400	0.08	0.09
	400	600	0.08	0.10
Pt 385, 200 Ω	-200	-80	0.03	0.04
	-80	0	0.03	0.04
	0	100	0.04	0.04
	100	260	0.04	0.05
	260	300	0.11	0.12
	300	400	0.12	0.13
	400	600	0.12	0.14
	600	630	0.14	0.16

Temperature Calibration (RTD) Specifications (cont.)

Pt 385, 500 Ω	-200	-80	0.03	0.04
	-80	0	0.04	0.05
	0	100	0.05	0.05
	100	260	0.06	0.06
	260	300	0.07	0.08
	300	400	0.07	0.08
	400	600	0.08	0.09
	600	630	0.09	0.11
Pt 385, 1000 Ω	-200	-80	0.03	0.03
	-80	0	0.03	0.03
	0	100	0.03	0.04
	100	260	0.04	0.05
	260	300	0.05	0.06
	300	400	0.05	0.07
	400	600	0.06	0.07
	600	630	0.22	0.23
PtNi 385, 120 Ω (Ni120)	-80	0	0.06	0.08
	0	100	0.07	0.08
	100	260	0.13	0.14
Cu 427, 10 Ω [3]	-100	260	0.3	0.3
<p>[1] Resolution is 0.003 °C.</p> <p>[2] Applies for COMP OFF (to the 5500A Calibrator front panel NORMAL terminals) and 2-wire and 4-wire compensation.</p> <p>[3] Based on MINCO Application Aid No. 18.</p>				

1-13. DC Power Specification Summary

	Voltage Range	5500A Calibrator Current Range			
		3.3 to 8.999 mA	9 to 32.999 mA	33 to 89.99 mA	90 to 329.99 mA
		Absolute Uncertainty, tcal $\pm 5^{\circ}\text{C}$, \pm (% of watts output)			
90 days	33 mV to 1020 V	0.03%	0.02%	0.03%	0.02%
1 year	33 mV to 1020 V	0.04%	0.03%	0.04%	0.03%

	Voltage Range	5500A Calibrator Current Range			
		0.33 to 0.8999 A	0.9 to 2.1999 A	2.2 to 4.4999 A	4.5 to 11 A
		Absolute Uncertainty, tcal $\pm 5^{\circ}\text{C}$, \pm (% of watts output)			
90 days	33 mV to 1020 V	0.07%	0.05%	0.08%	0.06%
1 year	33 mV to 1020 V	0.08%	0.06%	0.12%	0.09%

	Voltage Range	5725A Amplifier Current Range	
		1.5 to 4.4999 A	4.5 to 11 A
		Absolute Uncertainty, tcal $\pm 5^{\circ}\text{C}$, \pm (% of watts output)	
90 days	33 mV to 1020 V	0.09%	0.07%
1 year	33 mV to 1020 V	0.10%	0.08%

Note

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

1-14. AC Power (45 Hz to 65 Hz) Specification Summary, PF=1

		5500A Calibrator Current Range			
		3.3 to 8.999 mA	9 to 32.999 mA	33 to 89.99 mA	90 to 329.99 mA
		Absolute Uncertainty, tcal ± 5 °C, ± (% of watts output)			
5500A Calibrator					
90 days	33 to 329.999 mV	0.30%	0.20%	0.25%	0.20%
	330 mV to 1020 V	0.20	0.12	0.20	0.12
1 year	33 to 329.999 mV	0.40	0.25	0.35	0.25
	330 mV to 1020 V	0.25	0.15	0.25	0.15
5725A Amplifier					
90 days	100 to 1020 V	0.20	0.12	0.20	0.12
1 year	100 to 1020 V	0.25	0.15	0.25	0.15

		5500A Calibrator Current Range			
		0.33 to 0.8999 A	0.9 to 2.1999 A	2.2 to 4.4999 A	4.5 to 11 A
		Absolute Uncertainty, tcal ± 5 °C, ± (% of watts output)			
5500A Calibrator					
90 days	33 to 329.999 mV	0.25%	0.20%	0.25%	0.20%
	330 mV to 1020 V	0.20	0.12	0.18	0.12
1 year	33 to 329.999 mV	0.35	0.25	0.35	0.25
	330 mV to 1020 V	0.25	0.15	0.20	0.15
5725A Amplifier					
90 days	100 to 1020 V	0.20	0.12	0.18	0.12
1 year	100 to 1020 V	0.25	0.15	0.20	0.15

		5725A Amplifier Current Range	
		1.5 to 4.4999 A	4.5 to 11 A
		Absolute Uncertainty, tcal ± 5 °C, ± (% of watts output)	
5500A Calibrator			
90 days	33 to 329.999 mV	0.25%	0.20%
	330 mV to 1020 V	0.15	0.12
1 year	33 mV to 1020 V	0.35	0.25
	330 mV to 1020 V	0.20	0.15

Note

1. To determine uncertainty with more precision, see “Calculating Power Uncertainty.”

1-15. Power and Dual Output Limit Specifications

Frequency	Voltages (NORMAL)	Currents	Voltages (AUX)	Power Factor (PF)
DC	0 to \pm 1020 V	0 to \pm 11 A	0 to \pm 3.3 V	—
10 to 45 Hz	33 mV to 32.9999 V	3.3 mA to 2.19999 A	10 mV to 3.3 V	0 to 1
45 to 65 Hz	33 mV to 1020 V	3.3 mA to 11 A	10 mV to 3.3 V	0 to 1
65 to 500 Hz	330 mV to 1020 V	33 mA to 2.19999 A	100 mV to 3.3 V	0 to 1
65 to 500 Hz	3.3 V to 1020 V	33 mA to 11 A	100 mV to 3.3 V	0 to 1
500 Hz to 1 kHz	330 mV to 1020 V	33 mA to 11 A	100 mV to 3.3 V	1
1 to 5 kHz	3.3 V to 1020 V [1]	33 mA to 2.19999 A	100 mV to 3.3 V [1]	1
5 to 10 kHz	3.3 V to 1020 V [2]	33 mA to 329.99 mA	1 V to 3.3 V [2]	1

[1] In dual volts, voltage is limited to 3.3 to 500 V in the NORMAL output.
 [2] In dual volts, voltage is limited to 3.3 to 250 V in the NORMAL output.

- The range of voltages and currents shown in “DC Voltage Specifications,” DC Current Specifications,” “AC Voltage (Sinewaves) 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 degrees. The phase resolution for dual ac outputs is 0.02 degree.

1-16. 5500A Phase Specifications

1-Year Absolute Uncertainty, $t_{cal} \pm 5^\circ\text{C}$, ($\Delta\Phi$ degrees)				
10 to 65 Hz	65 to 500 Hz	500 to 1 kHz	1k to 5 kHz	5k to 10 kHz
0.15° [1]	0.9° [2]	2.0° [3]	6°	10°

[1] For 33 to 1000 V output, burden current <6 mA. For 6 to 20 mA burden current (33 to 330 V), the phase uncertainty is 0.4°.
 [2] For 33 to 1000 V output, burden current <2 mA. For 2 to 5 mA burden current (33 to 330 V), the phase uncertainty is 1.5°.
 [3] For 33 to 1000 V output, burden current <2 mA. For 2 to 5 mA burden current (33 to 330 V), the phase uncertainty is 5°.

5500A Phase Specifications (cont.)

Phase (Φ) Watts	Phase (Φ) VARs	PF	Power Uncertainty Adder due to Phase Error				
			10 to 65 Hz	65 to 500 Hz	500 to 1 kHz	1 to 5 kHz	5k to 10 kHz
0 degrees	90 degrees	1.000	0.00%	0.01%	0.06%	0.55%	1.52%
5	85	0.996	0.02	0.15	—	—	—
10	80	0.985	0.05	0.29	—	—	—
15	75	0.966	0.07	0.43	—	—	—
20	70	0.940	0.10	0.58	—	—	—
25	65	0.906	0.12	0.74	—	—	—
30	60	0.866	0.15	0.92	—	—	—
35	55	0.819	0.18	1.11	—	—	—
40	50	0.766	0.22	1.33	—	—	—
45	45	0.707	0.26	1.58	—	—	—
50	40	0.643	0.31	1.88	—	—	—
55	35	0.574	0.37	2.26	—	—	—
60	30	0.500	0.45	2.73	—	—	—
65	25	0.423	0.56	3.38	—	—	—
70	20	0.342	0.72	4.33	—	—	—
75	15	0.259	0.98	5.87	—	—	—
80	10	0.174	1.49	8.92	—	—	—
85	5	0.087	2.99	17.97	—	—	—
90	0	0.000	—	—	—	—	—

To calculate exact ac watts power adders due to phase uncertainty for values not shown, use the following formula: $Adder(\%) = 100(1 - \frac{\cos(\Phi + \Delta\Phi)}{\cos(\Phi)})$. For example: for a PF of .9205 ($\Phi = 23$) and a phase uncertainty of $\Delta\Phi = 0.15$, the ac watts power adder is:

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

1-17. 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 ($\Phi=0$)

Voltage Uncertainty Uncertainty for 100 V at 60 Hz is 0.04% + 6.6 mV, totaling:
100 V x .0004 = 40 mV added to 6.6 mV = 46.6 mV. Expressed in percent:
46.6 mV/100 V x 100 = 0.047% (see “AC Voltage (Sinewave) Specifications”).

Current Uncertainty Uncertainty for 1 A is 0.08% + 300 μ A, totaling:
1 A x .0008 = 800 μ A added to 300 μ A = 1.1 mA. Expressed in percent:
1.1 mA/1 A x 100 = 0.11% (see “AC Current (Sinewaves) Specifications”).

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

$$\text{Total Watts Output Uncertainty} = U_{\text{power}} = \sqrt{0.047^2 + 0.11^2 + 0^2} = 0.12\%$$

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 0.04% + 6.6 mV, totaling:
100 V x .0004 = 40 mV added to 6.6 mV = 46.6 mV. Expressed in percent:
46.6 mV/100 V x 100 = 0.047% (see “AC Voltage (Sinewave) Specifications”).

Current Uncertainty Uncertainty for 1 A is 0.08% + 300 μ A, totaling:
1 A x .0008 = 800 μ A added to 300 μ A = 1.1 mA. Expressed in percent:
1.1 mA/1 A x 100 = 0.11% (see “AC Current (Sinewave) Specifications”).

PF Adder Watts Adder for PF = 0.5 ($\Phi=60$) at 400 Hz is 2.73% (see “Phase Specifications”).

$$\text{Total Watts Output Uncertainty} = U_{\text{power}} = \sqrt{0.047^2 + 0.11^2 + 2.73^2} = 2.73\%$$

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 = 0.0872 ($\Phi=85$)

Voltage Uncertainty Uncertainty for 100 V at 60 Hz is 0.04% + 6.6 mV, totaling:
100 V x .0004 = 40 mV added to 6.6 mV = 46.6 mV. Expressed in percent:
46.6 mV/100 V x 100 = 0.047% (see “AC Voltage (Sinewave) Specifications”).

Current Uncertainty Uncertainty for 1 A is 0.08% + 300 μ A, totaling:
1 A x .0008 = 800 μ A added to 300 μ A = 1.1 mA. Expressed in percent:
1.1 mA/1 A x 100 = 0.11% (see “AC Current (Sinewave) Specifications”).

VARs Adder VARs Adder for $\Phi=85$ at 60 Hz is 0.02% (see “Phase Specifications”).

$$\text{Total VARs Output Uncertainty} = U_{\text{VARs}} = \sqrt{0.047^2 + 0.11^2 + 0.02^2} = 0.12\%$$

1-18. Additional Specifications

The following paragraphs provide additional specifications for the 5500A 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 5500A 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. (See Chapter 4, Front Panel Operations.)

1-19. Frequency Specifications

Frequency Range	Resolution	1-Year Absolute Uncertainty, tcal ± 5°C	Jitter
.01 - 119.99 Hz	.01 Hz	25 ppm, ± 1 mHz	2 μs
120.0 - 1199.9	0.1 Hz	25 ppm, ± 1 mHz	2 μs
1.200k - 11.999k	1.0 Hz	25 ppm, ± 1 mHz [1]	2 μs
12.00k - 119.99k	10 Hz	25 ppm, ± 15 mHz	140 ns
120.0k - 1199.9k	100 Hz	25 ppm, ± 15 mHz	140 ns
1.200M - 2.000M	1 kHz	25 ppm, ± 15 mHz	140 ns
[1] ± (25 ppm + 15 mHz) above 10 kHz			

1-20. Harmonics (2nd to 50th) Specifications

Fundamental Frequency [1]	Voltages NORMAL Terminals	Currents	Voltages AUX Terminals	Amplitude Uncertainty
10 to 45 Hz	33 mV to 32.9999 V	3.3 mA to 2.19999 A	10 mV to 3.3 V	Same % of output as the equivalent single output, but twice the floor adder.
45 to 65 Hz	33 mV to 1020 V	3.3 mA to 11 A	10 mV to 3.3 V	
65 to 500 Hz	33 mV to 1020 V	33 mA to 11 A	100 mV to 3.3 V	
500 to 1 kHz	330 mV to 1020 V	33 mA to 11 A	100 mV to 3.3 V	
1k to 5 kHz	3.3 V to 1020 V	33 mA to 2.19999 A	100 mV to 3.3 V	
<p>Phase uncertainty for harmonic outputs is 1 degree, 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 degrees (from “Phase Specifications”). Another example, the phase uncertainty of a 60 Hz fundamental output and a 400 Hz harmonic output is 1 degree.</p> <p>[1] The maximum frequency of the harmonic output is 10 kHz. For example, if the fundamental output is 5 kHz, the maximum selection is the 2nd harmonic (10 kHz). All harmonic frequencies (2nd to 50th) are available for fundamental outputs between 10 and 200 Hz.</p>				

Example of Determining Amplitude Uncertainty in a Dual Output Harmonic Mode

What are the amplitude uncertainties for the following dual outputs?

NORMAL (Fundamental) Output: 100 V, 100 Hz

From “AC Voltage (Sinewave) Specifications” the single output specification for 100 V, 100 Hz, is 0.04% + 6.6 mV. For the dual output in this example, the specification is 0.04% + 13.2 mV as the 0.04% is the same and the floor is twice the value (2 x 6.6 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).

1-21. AC Voltage (Sinewave) Extended Bandwidth Specifications

Ranges	Frequency	1-Year Absolute Uncertainty, tcal ± 5 °C, ± (% of output + % of range)		Maximum Voltage Resolution
		%Output	%Range	
Normal Channel (Single Output Mode)				
1.0 to 33 mV	0.01 to 10 Hz	5.0%	0.5%	Two digits, e.g., 25 mV
34 to 330 mV				Three digits
0.4 to 3.3 V				Two digits
4 to 33 V				Two digits
	10 to 500 kHz	(See AC Voltage (Sinewaves) Specifications)		
0.3 to 3.3 V	500 kHz to 1 MHz	-8 dB at 1 MHz, typical		Two digits
	1 to 2 MHz	-32 dB at 2 MHz, typical		
Auxiliary Output (Dual Output Mode)				
10 to 330 mV	0.01 to 10 Hz	5.0%	0.5%	Three digits
0.4 to 3.3 V				Two digits
	10 to 10 kHz	(See AC Voltage (Sinewave) Specifications)		

1-22. AC Voltage (Non-Sinewave) Specifications

Trianglewave & Truncated Sine Ranges p-p [1]	Frequency	1-Year Absolute Uncertainty, $t_{cal} \pm 5\text{ }^{\circ}\text{C}$, \pm (% of output + % of range) [2]		Maximum Voltage Resolution
		%Output	%Range	
Normal Channel (Single Output Mode)				
2.9 to 92.999 mV	0.01 to 10 Hz	5.0%	0.5%	Two digits on each range
93 to 929.999 mV	10 to 45 Hz	0.25	0.5	Six digits on each range
0.93 to 9.29999 V	45 Hz to 1 kHz	0.25	0.25	
9.3 to 92.9999 V	1 to 20 kHz	0.5	0.25	
	20 to 100 kHz ^[3]	5.0	0.5	
Auxiliary Output (Dual Output Mode)				
93 to 929.999 mV 0.93 to 9.29999 V	0.01 to 10 Hz	5.0%	0.5%	Two digits on each range
	10 to 45 Hz	0.25	0.5	Six digits on each range
	45 Hz to 1 kHz	0.25	0.25	
	1 to 10 kHz	5.0	0.5	
[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. [2] Uncertainty is stated in p-p. Amplitude is verified using an rms-responding DMM. [3] Uncertainty for truncated sine outputs is typical over this frequency band.				
Squarewave Ranges p-p [1]	Frequency	1-Year Absolute Uncertainty, $t_{cal} \pm 5\text{ }^{\circ}\text{C}$, \pm (% of output + % of range) [2]		Maximum Voltage Resolution
		%Output	%Range	
Normal Channel (Single Output Mode)				
2.9 to 65.999 mV	0.01 to 10 Hz	5.0%	0.5%	Two digits on each range
66 to 659.999 mV	10 to 45 Hz	0.25	0.5	Six digits on each range
0.66 to 6.59999 V	45 Hz to 1 kHz	0.25	0.25	
6.6 to 65.9999 V	1 to 20 kHz	0.5	0.25	
	20 to 100 kHz	5.0	0.5	
Auxiliary Output (Dual Output Mode)				
66 to 659.999 mV 0.66 to 6.59999 V	0.01 to 10 Hz	5.0%	0.5%	Two digits on each range
	10 to 45 Hz	0.25	0.5	Six digits on each range
	45 Hz to 1 kHz	0.25	0.25	
	1 to 10 kHz	5.0	0.5	
[1] To convert p-p to rms for squarewave, multiply the p-p value by .5000000. [2] Uncertainty is stated in p-p. Amplitude is verified using an rms-responding DMM.				

1-23. AC Voltage, DC Offset Specifications

Range [1] (Normal Channel)	Offset Range [2]	Maximum pk Signal	1-Year Absolute Offset Uncertainty, tcal ± 5 °C [3]
			± (% Output (dc) + μV)
Sinewaves			
3.3 to 32.999 mV	0 to 50 mV	80 mV	0.1% + 33 μV
33 to 329.999 mV	0 to 500 mV	800 mV	0.1 + 330
0.33 to 3.29999 V	0 to 5 V	8 V	0.1 + 3300
3.3 to 32.9999 V	0 to 50 V	55 V	0.1 + 33 mV
Trianglewaves and Truncated Sinewaves			
9.3 to 92.999 mV p-p	0 to 50 mV	80 mV	0.1% + 93 μV
93 to 929.999 mV p-p	0 to 500 mV	800 mV	0.1 + 930
0.93 to 9.29999 V p-p	0 to 5 V	8 V	0.1 + 9300
9.3 to 92.9999 V p-p	0 to 50 V	55 V	0.1 + 93 mV
Squarewaves			
6.6 to 65.999 mV p-p	0 to 50 mV	80 mV	0.1% + 66 μV
66 to 659.999 mV p-p	0 to 500 mV	800 mV	0.1 + 660
0.66 to 6.59999 V p-p	0 to 5 V	8 V	0.1 + 6600
6.6 to 65.9999 V p-p	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 squarewave 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 to 10 Hz, and 500 kHz to 2 MHz, the offset uncertainty is 5% of output, ± 1% of the offset range.</p>			

1-24. AC Voltage, Squarewave Characteristics

Risetime @ 1 kHz Typical	Settling Time @ 1 kHz Typical	Overshoot @ 1 kHz Typical	Duty Cycle Range	Duty Cycle Uncertainty [1]
<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 (0.8% of period +140 ns) for frequencies >10 kHz; + (0.8% of period + 2 μ s) for frequencies \leq 10 kHz.
[1] For duty cycles of 10.00% to 90.00%.				

1-25. 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

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

Ranges	Frequency	1-Year Absolute Uncertainty, $t_{cal} \pm 5^\circ\text{C}$, \pm (% of output + % of range) [2]		Maximum Current Resolution
		%Output	%Range	
All current ranges, <330 mA	0.01 to 10 Hz	5.0%	0.5%	2 digits each range
	10 to 10 kHz	(See AC Current (Sinewave) Specifications)		

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

Trianglewave & Truncated Sinewave Ranges [1]	Frequency	1-Year Absolute Uncertainty, tcal ± 5 °C, ± (% of output + % of range) [2]		Maximum Current Resolution
		%Output	%Range	
2.9 to 92.999 mA	0.01 to 10 Hz	5.0%	0.5%	Two digits, e.g., 75 mA
	10 to 45 Hz	0.25	0.5	Six digits on each range
	45 Hz to 1 kHz	0.25	0.25	
	1 to 10 kHz	0.25	0.5	
93 to 929.999 mA	0.01 to 10 Hz	5.0%	0.5%	Two digits
	10 to 45 Hz	0.25	0.5	Six digits on each range
	45 Hz to 1 kHz	0.25	0.5	
	1 to 10 kHz	5.0	1.0	
0.93 to 2.19 A	10 to 45 Hz	5.0%	1.0%	Two digits
	45 Hz to 1 kHz	0.5	0.5	Six digits on each range
	1 to 5 kHz	5.0	1.0	
2.2 to 11 A	45 to 500 Hz	2.0%	0.5%	Two digits on each range
	500 Hz to 1 kHz	5.0	1.0	Six digits on each range
2.9 to 65.999 mA	0.01 to 10 Hz	5.0 %	0.5%	Two digits, e.g., 50 mA
	10 to 45 Hz	0.25	0.5	Six digits on each range
	45 Hz to 1 kHz	0.25	0.25	
	1 to 10 kHz	0.25	0.5	
66 to 659.999 mA	0.01 to 10 Hz	5.0%	0.5%	Two digits
	10 to 45 Hz	0.25	0.5	Six digits on each range
	45 Hz to 1 kHz	0.25	0.5	
	1 to 10 kHz	5.0	1.0	
0.66 to 2.19 A	10 to 45 Hz	5.0%	1.0%	Two digits
	45 Hz to 1 kHz	0.5	0.5	Six digits on each range
	1 to 5 kHz	5.0	1.0	
2.2 to 11 A	45 to 500 Hz	2.0%	0.5%	Two digits on each range
	500 Hz to 1 kHz	5.0	1.0	Six digits on each range

[1] All waveforms are p-p output ranges.
[2] Uncertainty is stated in p-p. Amplitude is verified using an rms-responding DMM.

1-28. AC Current, Squarewave Characteristics (typical)

Range	Risetime	Settling Time	Overshoot
I<4.4 A @ 400 Hz	25 μ s	40 μ s to 1% of final value	<10% for loads <100 Ω

1-29. 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

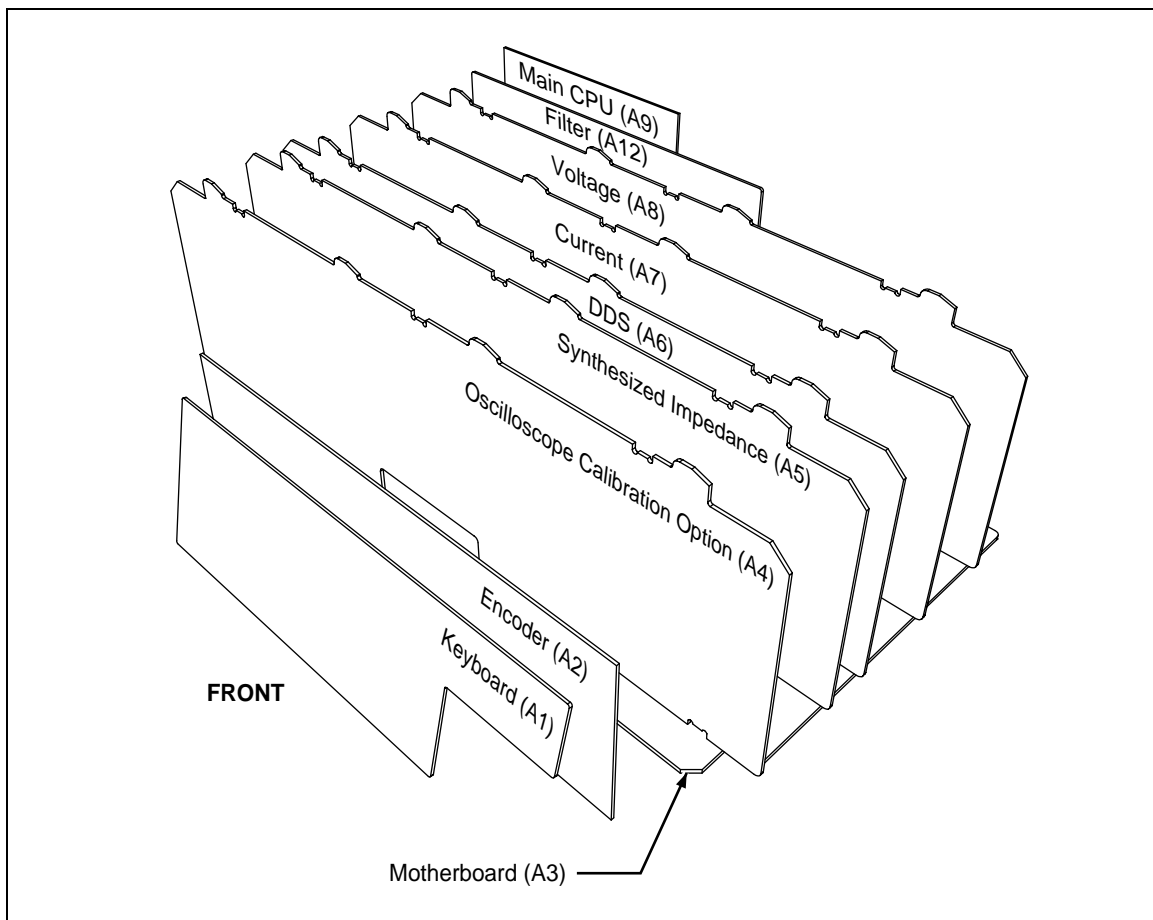
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2-1. Introduction

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 5500A. The Oscilloscope Calibration Option is described in the Options chapter.

The 5500A 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 11.0 A, with output from 10 Hz to 10 kHz.
- DC current from 0 to ± 11.0 A.
- Resistance values from a short circuit to 330 M Ω .
- Capacitance values from 330 pF to 1100 μ F.
- Simulated output for three types of Resistance Temperature Detectors (RTDs).
- Simulated output for nine types of thermocouples.



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Figure 2-1. 5500A Internal Layout

2-2. Encoder Assembly (A2)

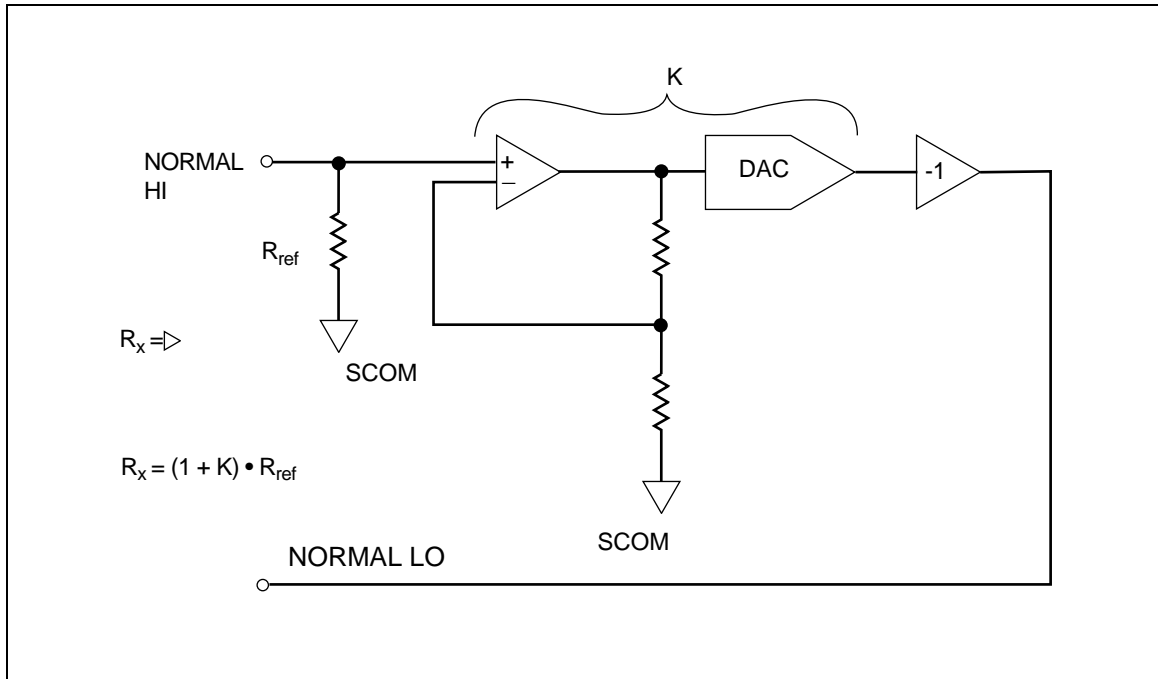
The Encoder assembly (A2) has its own microprocessor and is in communication with the Main CPU (A9) on the Rear Panel through a serial link. Memory for the Encoder assembly is contained in EPROM. The Encoder assembly handles the interface to the Keyboard assembly (A1).

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

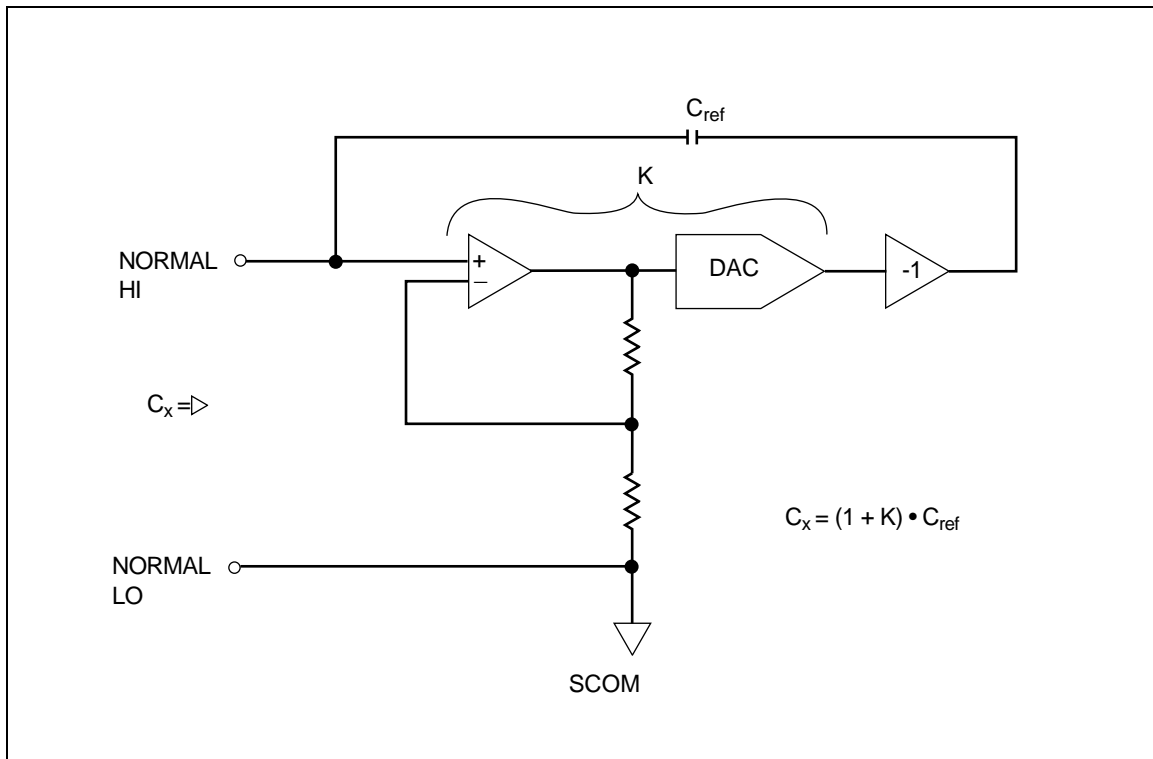


Figure 2-3. Synthesized Capacitance Function

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).
- Inguard CPU that controls relays and latches throughout the analog assemblies.

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, 2.2 A, and 11 A) and two voltage ranges (330 mV and 3.3 V) to the AUX outputs. The 330 μ A range is only available in ac. If a 5725A Amplifier is attached, 5500A current can also be sourced through the 5725A binding posts.

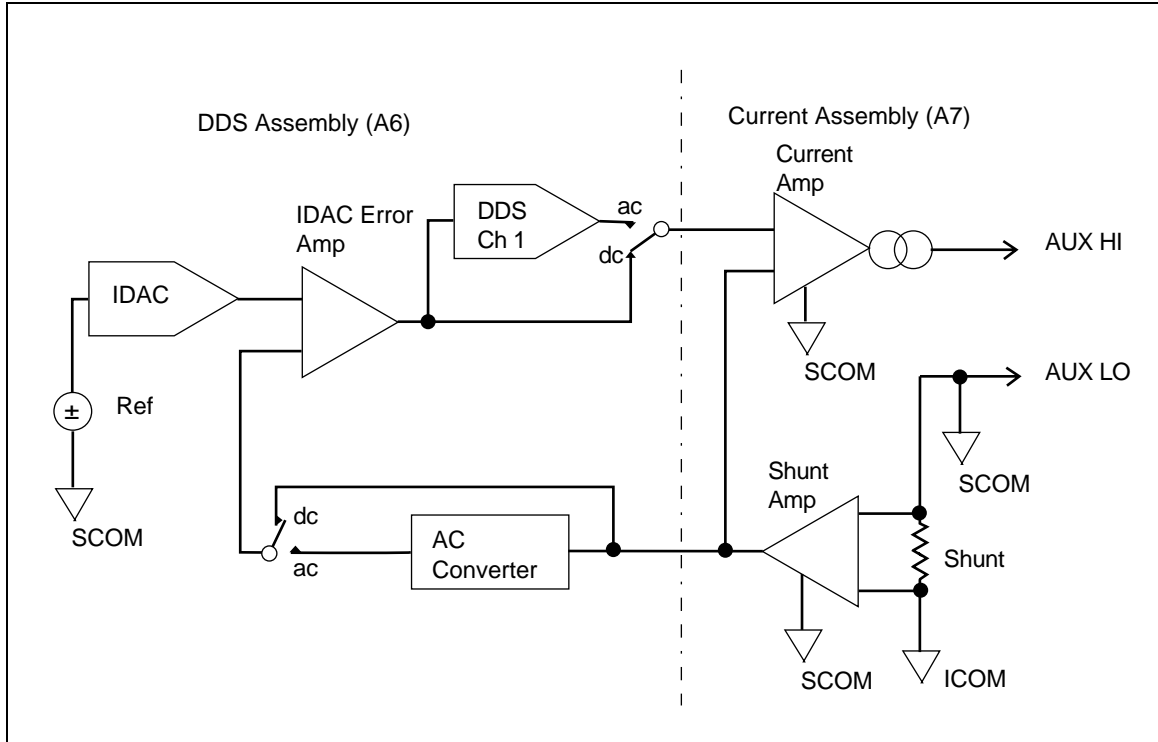
The Current assembly works together with the DDS (A6) assembly. The Filter (A12) assembly provides the high current power supplies.

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

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.

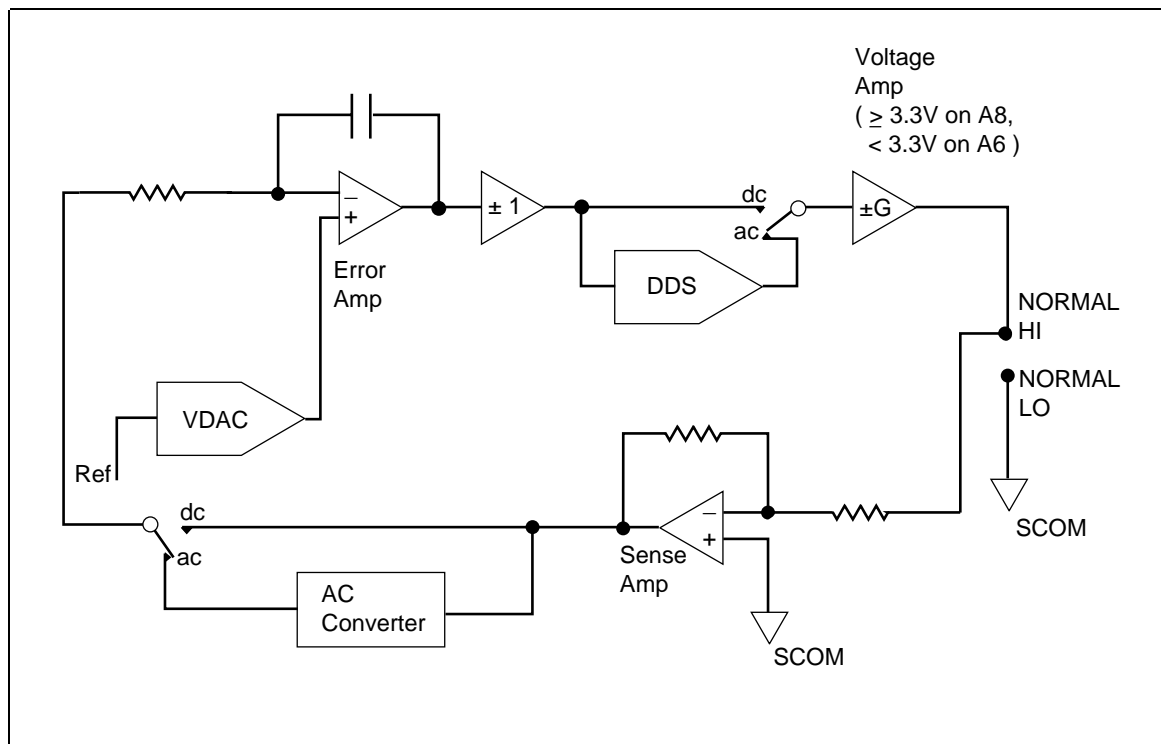


Figure 2-5. Voltage Function

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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.

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 supplies are fused on the motherboard. It is unlikely the fuses will blow unless there is another fault since the regulators will current limit below the fuse ratings. 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 transformer connections (inguard SCOM referenced) are connected to the Motherboard (A3) via J209. Fuses for each of the supplies are located on the Motherboard. It is unlikely the fuses will blow unless there is another fault since the regulators will current limit below the fuse 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

Use this chapter as a guide to calibration and for verification of the 5500A's performance to specifications. 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.

3-2. Calibration

The standard 5500A has no internal hardware adjustments. The Oscilloscope Option has hardware adjustments; see Chapter 7. All calibration is done with the covers on, using software calibration constants. A calibration routine that prompts you through the entire procedure is built into the 5500A. Calibration occurs in the following major steps:

1. The 5500A sources specific output values and you measure the outputs using traceable measuring instruments of higher accuracy.
2. You enter the measured results either manually through the front panel keyboard or remotely with an external terminal or computer.
3. The 5500A computes a software correction factor and stores it in volatile memory.
4. 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 at the end of this chapter.

3-3. Equipment Required for Calibration and Verification

The equipment listed in Table 3-1 is required to calibrate and verify performance of the 5500A. If a specified instrument is not available, you can substitute an instrument that assures a 4:1 Test Uncertainty Ratio.

Table 3-1. Required Equipment for Calibration and Verification

Equipment	Recommended Model	Purpose
Test Lead Kit	Fluke 5500A/Leads	Provides test cables, esp. TC leads
8-1/2 digit DMM	HP 3458A	DC volts, resistance
Mercury Thermometer	ASTM 56C	Temperature reference
100 mV dc source	Fluke 5500A, 5700A, 5440B, or 5100B	Source for thermocouple measurements (characterize w/ the DMM, if necessary)
Phase Meter	Clarke-Hess 6000	Phase
LCR Meter	Fluke PM6304C with PM9540/BAN test lead set	Capacitance
Counter/Timer	Fluke PM6666	Frequency
AC Measurement Standard	Fluke 5790A	ACV and ACI w/ shunts
Shunt	Fluke Y5020	10 A dc
Resistance Standard	Fluke 742A-1	300 mA dc
Resistance Standard	Fluke 742A-10	30 mA dc
Resistance Standard	Fluke 742A-100	3 mA dc
Resistance Standard	Fluke 742A-10M	Resistance at 320 MΩ
Current Shunt Adapter	Fluke 792A-7004	Assures compatibility w/ A40 shunts
AC Shunts	Fluke A40 (10 mA, 30 mA, 300 mA, 3 A) and A40A-10	ACI
Interconnect cable for A40A	Fluke A45-4004	Cable adapter for A40A
Precision metal film resistors	1 kΩ, 1%, 100 ppm/°C or better	Current shunt for <330 μA (Determine value w/ the DMM)

3-4. Starting Calibration

From the front panel, you start calibration by pressing the **SETUP** key, followed by the CAL softkey twice, then 5500A CAL. The CALIBRATION SWITCH on the 5500A 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.

3-5. How the Calibration Procedure Works

The calibration procedure is self-prompting, with a chance to ABORT and DISCARD any changes after each function is calibrated. After you press the 5500A CAL softkey, the procedure works as follows:

1. The 5500A automatically programs the outputs listed in the following tables and prompts you to make external connections to appropriate measurement instruments.
2. The 5500A then goes into Operate, or asks you to place it into Operate.

3. You are then prompted to enter into the 5500A the value read on the measurement instrument.

Note

Intermixed with these "output and measure" procedures are internal 5500A calibration procedures that require no action by the operator.

3-6. DC Volts

Measure the 5500A output using a precision DMM, and enter into the 5500A each of the measured values listed in Table 3-2 when prompted to do so.

Table 3-2. DC Volts Calibration Steps

Step	5500A Output (NORMAL)
1	+3.00 V
2	-3.00 V
3	+300 mV
4	+3.00 V
5	+30 V
6	+300 V
7	+1000 V

3-7. AC Volts

Measure the 5500A output using a precision ac voltmeter, and enter into the 5500A each of the measured values listed in Table 3-3 when prompted to do so.

Table 3-3. AC Volts Calibration Steps

Step	5500A Output (NORMAL)	Frequency
1	3.2999 V	100 Hz
2	0.330 V	100 Hz
3	3.00 V	500 kHz
4	3.00 V	9.99 Hz
5	30 mV	100 Hz
6	30 mV	500 kHz
7	300 mV	100 Hz
8	30 V	100 Hz
9	30 V	100 kHz
10	300 V	100 kHz
11	300 V	20 kHz
12	1000 V	100 Hz
13	1000 V	7 kHz

3-8. Thermocouple Measuring

This procedure calibrates the temperature measuring capability of the 5500A by externally measuring a known temperature. The connections are shown in Figure 3-1.

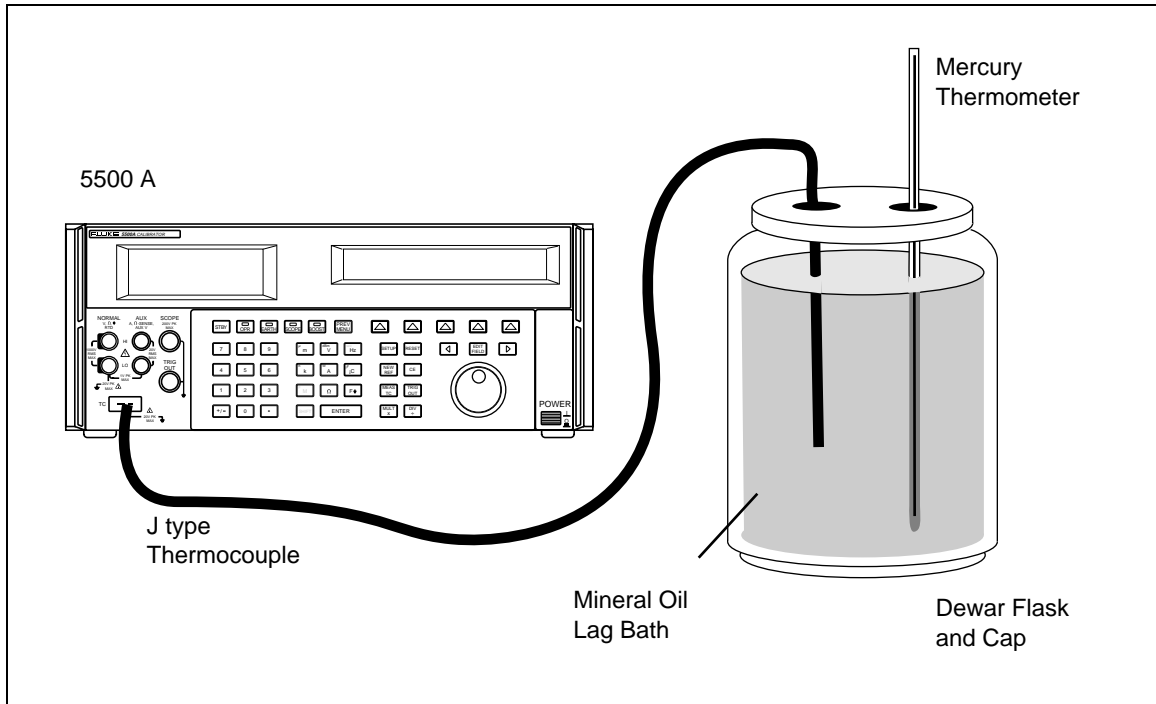


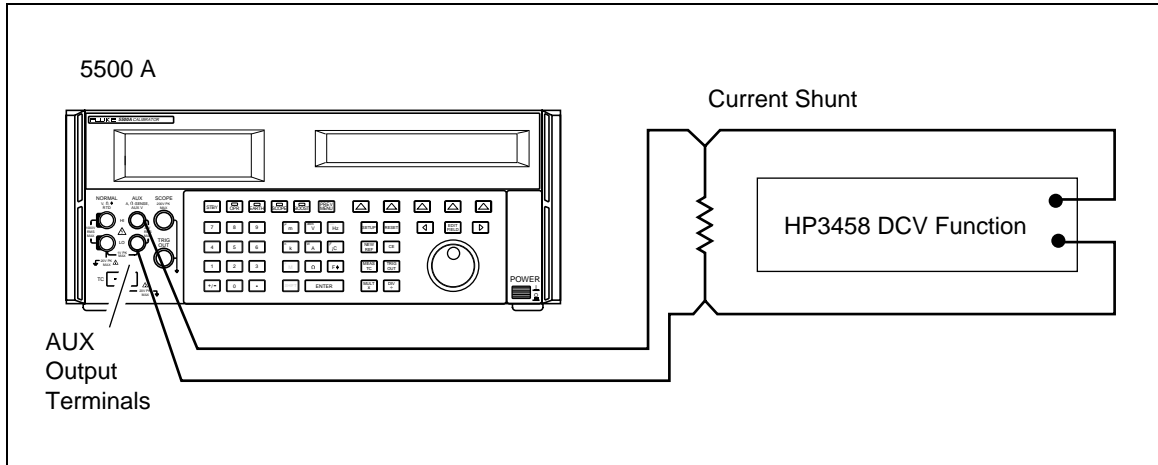
Figure 3-1. Connections for Calibrating TC Measure

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1. Apply a copper short to the TC terminals. Allow the temperature of the short to stabilize for 3 minutes.
2. Perform the "zero" calibration as indicated on the 5500A front panel.
3. Remove the copper short as instructed on the 5500A front panel.
4. Perform the "gain" CAL as follows: Plug a J thermocouple into the TC terminals as Figure 3-1 shows. Allow the temperature to stabilize for 3 minutes. Measure a lag bath that is within $\pm 2^{\circ}\text{C}$ of ambient temperature. Compare this reading with a precision temperature standard and enter the reading into the 5500A when prompted to do so.

3-9. DC Current

Use a precision DMM and appropriate precision shunts to measure the 5500A output as Figure 3-2 shows. Enter into the 5500A each of the measured values listed in Table 3-4 when prompted to do so.



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Figure 3-2. Connections for Calibrating DC Current

Table 3-4. DC Current Calibration Steps

Step	5500A Output (AUX)	Shunt Value
1	3 mA	742A-100 Ω
2	30 mA	742A-10 Ω
3	300 mA	742A-1 Ω
4	2 A	Y5020, 0.01 Ω
5	10 A	Y5020, 0.01 Ω

3-10. AC Current

Use a Fluke 5790A or equivalent with the appropriate precision shunts and adapter to measure the 5500A output. Refer to the 5790A Operator Manual for operating instructions and connections. Enter into the 5500A each of the measured values listed in Table 3-5 when prompted to do so.

Table 3-5. AC Current Calibration Steps

Step	5500A Output (AUX)	Frequency	Shunt Value
1	3.2999 mA	100 Hz	A40-10mA
2	0.330 mA	100 Hz	1 k Ω Metal Film
3	3 mA	5 kHz	A40-10mA
4	3 mA	10 kHz	A40-10mA
5	300 μ A	100 Hz	1 k Ω Metal Film
6	300 μ A	5 kHz	1 k Ω Metal Film
7	300 μ A	10 kHz	1 k Ω Metal Film
8	30 mA	100 Hz	A40-30mA
9	30 mA	5 kHz	A40-30mA
10	30 mA	10 kHz	A40-30mA
11	300 mA	100 Hz	A40-300mA
12	300 mA	5 kHz	A40-300mA
13	300 mA	10 kHz	A40-300mA
14	2 A	100 Hz	A40-3A
15	2 A	1000 Hz	A40-3A
16	2 A	5 kHz	A40-3A
17	10 A	100 Hz	Y5020, 0.01 Ω
18	10 A	500 Hz	Y5020, 0.01 Ω
19	10 A	1000 Hz	Y5020, 0.01 Ω

3-11. AUX DC Volts

Measure the AUX output using a precision DMM. Enter into the 5500A the measured values of each step listed in Table 3-6 when prompted to do so.

Table 3-6. AUX DC Volts Calibration Steps

Step	NORMAL Output	AUX output
1	+300 mV	+300 mV
2	+3 V	+3 V

3-12. AUX AC Volts

Measure the AUX output using a precision AC Voltmeter. Enter into the 5500A the measured values of each step listed in Table 3-7 when prompted to do so.

Table 3-7. AUX AC Volts Calibration Steps

Step	NORMAL Output	AUX output	Frequency
1	1.1 V	300 mV	100 Hz
2	1.1 V	300 mV	5 kHz
3	1.1 V	300 mV	10 kHz
4	1.1 V	3 V	100 Hz
5	1.1 V	3 V	5 kHz
6	1.1 V	3 V	10 kHz
7	1.1 V	3 V	9.99 Hz

3-13. Resistance

Use a precision DMM to measure the resistance output. Figure 3-3 shows the four-wire connections. Enter into the 5500A the measured values of each step listed in Table 3-8 when prompted to do so.

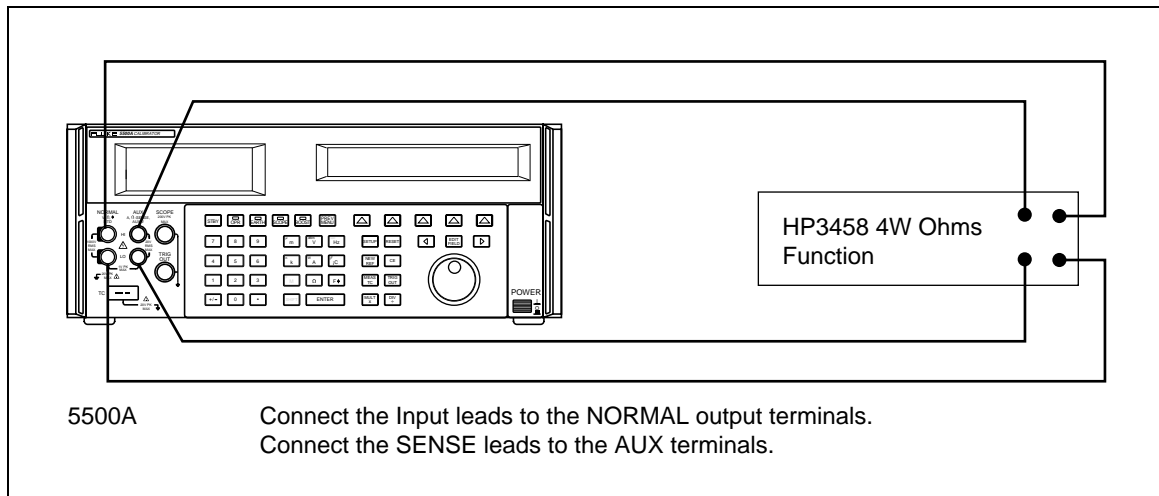


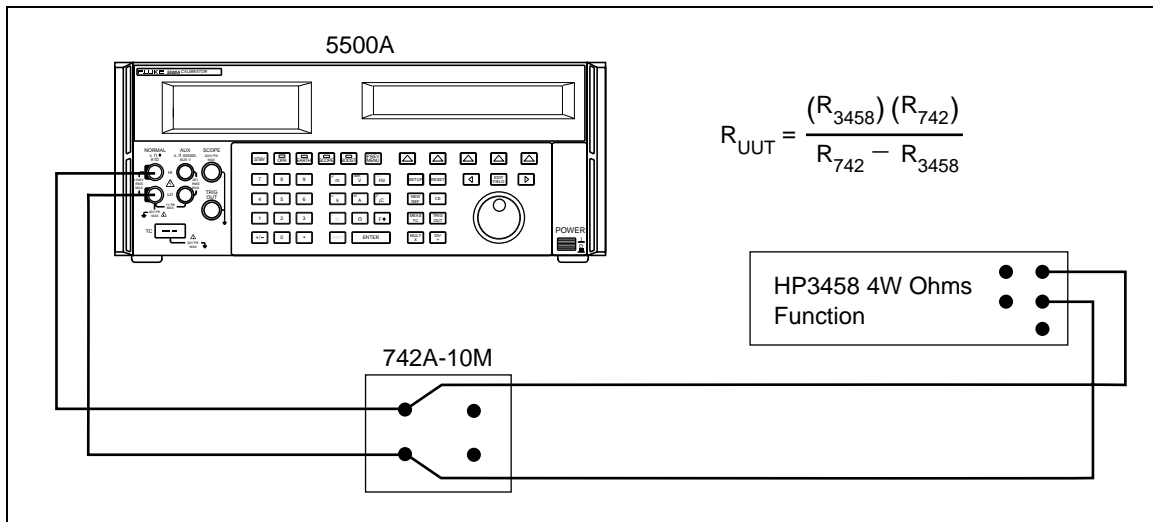
Figure 3-3. Connections for Calibrating Four-Wire Ohms

Table 3-8. Resistance Calibration Steps

Step	5500A Output	Comments
1	1 Ω	Make a four-wire measurement
2	10 Ω	“
3	11 Ω	“
4	32 Ω	“
5	35 Ω	“
6	100 Ω	“
7	110 Ω	“
8	320 Ω	“
9	0.35 k Ω	“
10	1 k Ω	“
11	1.1 k Ω	“
12	3.2 k Ω	“
13	3.5 k Ω	“
14	10 k Ω	“
15	11 k Ω	“
16	32 k Ω	“
17	35 k Ω	“
18	100 k Ω	“
19	110 k Ω	Make a two-wire measurement
20	320 k Ω	“
21	0.35 M Ω	“
22	1 M Ω	“
23	1.1 M Ω	“
24	3.2 M Ω	“
25	3.5 M Ω	“
26	10 M Ω	“
27	11 M Ω	“
28	32 M Ω	“
29	35 M Ω	“
30	100 M Ω	“
31	110 M Ω	“

Table 3-8. Resistance Calibration Steps (cont.)

Step	5500A Output	Comments
32	320 MΩ [1]	Make a two-wire measurement
<p>[1] Perform this test using the HP 3458A in the 10 MΩ range and the Fluke 742A-10M in parallel with the 5500A output. Using exactly 10 MΩ, the nominal value displayed on the HP 3458A is 9.66667 MΩ. Figure 3-4 shows the connections and the equation you use to calculate actual resistance. Enter the calculated actual resistance, R_{UUT}, into the HP 3458A. In the equation, R_{3458} is the reading of the HP 3458A, R_{742} is the printed value of the 742A-10M, and R_{UUT} is the actual 5500A output.</p>		



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Figure 3-4. High End Resistance Connections with Equation

3-14. Capacitance

Use the Fluke 6304C LCR Meter with PM9540/BAN output cable as shown in Figure 3-5. This cable eliminates the need for a four-wire connection. Using the PM6304C LCR meter, HI LEVEL is 2 V and NORMAL LEVEL is 1 V. The 5500A is automatically set to **COMP off**. Enter into the 5500A the measured values of each step listed in Table 3-9 when prompted to do so.

Note

Make sure there are no other connections to the 5500A, especially the SCOPE BNC. Connecting any additional grounds to the 5500A can cause erroneous capacitance outputs.

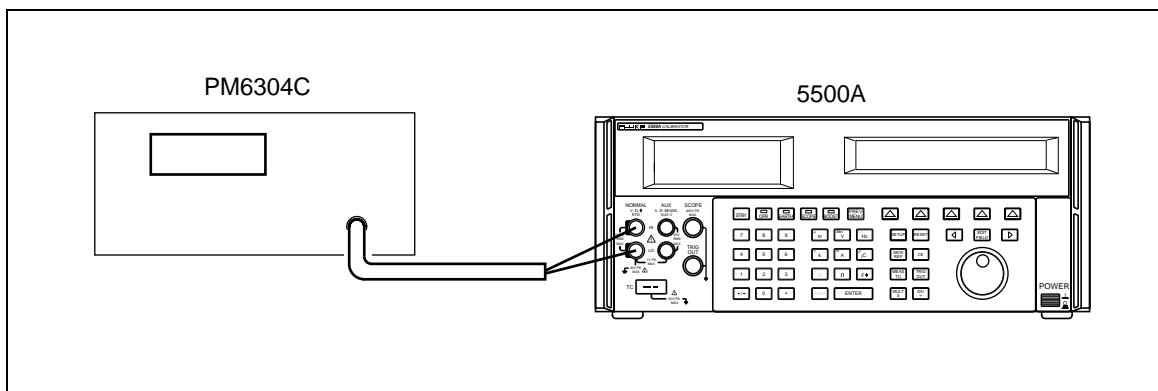


Figure 3-5. LCR Meter Connections

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Table 3-9. Capacitance Calibration Steps

Step	5500A Output (NORMAL)	Recommended Stimulus
1	330 pF	2 V rms at 1 kHz
2	499 pF	“
3	0.5 nF	“
4	1.00 nF	“
5	1.10 nF	“
6	3.2 nF	“
7	3.5 nF	“
8	10 nF	“
9	11 nF	“
10	32 nF	“
11	35 nF	“
12	100 nF	“
13	110 nF	“
14	320 nF	1 V rms at 1 kHz
15	0.35 μF	1 V rms at 100 Hz
16	1 μF	“
17	1.1 μF	“
18	3.2 μF	“
19	3.5 μF	“
20	10 μF	“
21	11 μF	“
22	32 μF	“
23	35 μF	“
24	100 μF	“
25	110 μF	“
26	320 μF	“
27	350 μF	1 V rms at 50 Hz
28	600 μF	“

3-15. Capacitance, Four-Wire Comp

This step measures the internal capacitance between the 5500A AUX HI and NORMAL LO terminals to give the best COMP four-wire operation in Capacitance.

Refer to Figure 3-6. Connect the LCR meter INPUT/SENSE HI to the 5500A AUX HI; connect the LCR meter INPUT/SENSE LO to the 5500A NORMAL LO. Enter the LCR reading into the 5500A when prompted. The LCR meter should nominally read 400 pF with a 1 kHz, 2 V rms stimulus.

Note

Make sure there are no other connections to the 5500A, especially the SCOPE BNC. Connecting any additional grounds to the 5500A can cause erroneous capacitance outputs.

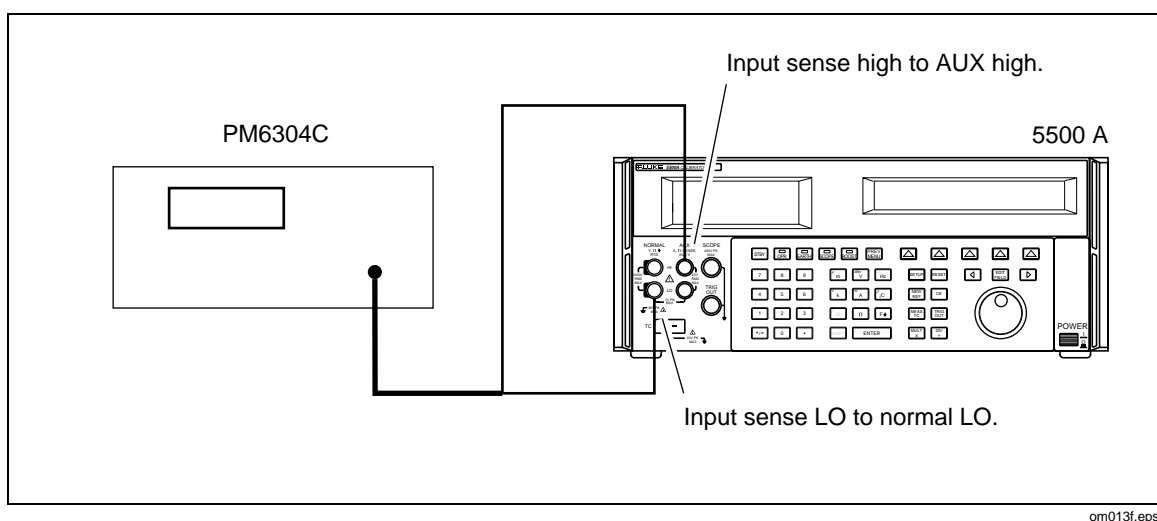


Figure 3-6. Connections for Four-Wire Compensated Capacitance

Note

The remaining steps in the calibration procedure are not necessary unless the 5500A has been repaired. They are called "Factory Cal," and are accessible only via the remote interface.

3-16. Frequency

Frequency calibration is only accessible by remote command. See "Remote Commands for 5500A Calibration," later in this chapter. In remote, you can jump to Frequency calibration by sending the command:

```
CAL_START FACTORY
```

In Frequency calibration, the 5500A outputs 3 V, 500 kHz. Measure the frequency with a precision counter. Enter the frequency reading into the 5500A when prompted by the 5500A.

3-17. NORMAL Volts and AUX Volts Phase

NORMAL volts and AUX volts phase calibration is only accessible by remote command. See “Remote Commands for 5500A 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 phase meter of suitable accuracy as shown in Figure 3-7. Enter into the 5500A the measured values when prompted.

The 5500A outputs the voltages shown in Table 3-10. The 5500A is automatically set to LOs open.

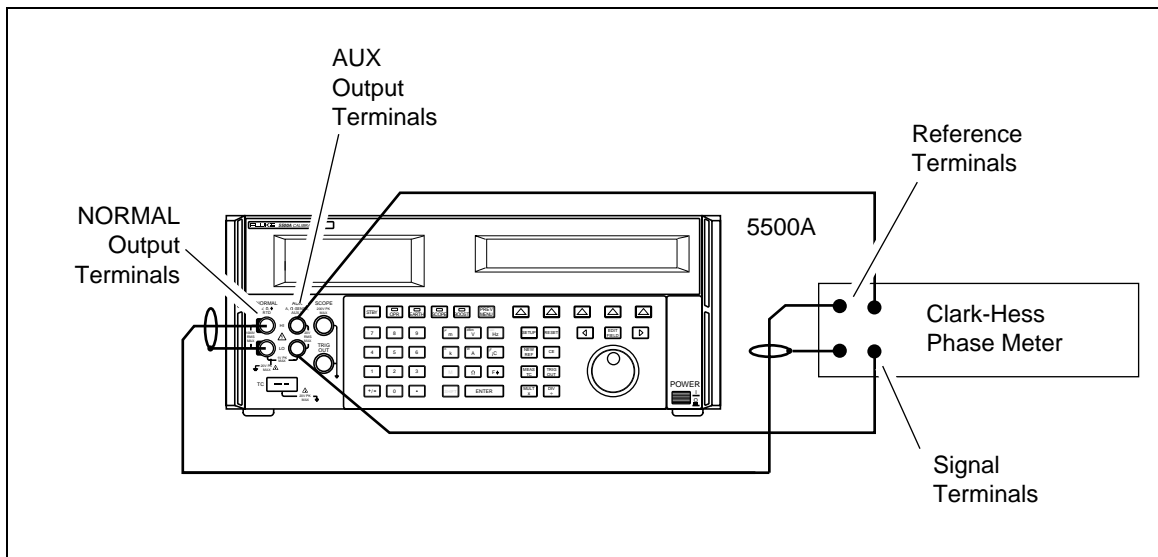


Figure 3-7. Normal Volts and AUX Volts Phase Calibration

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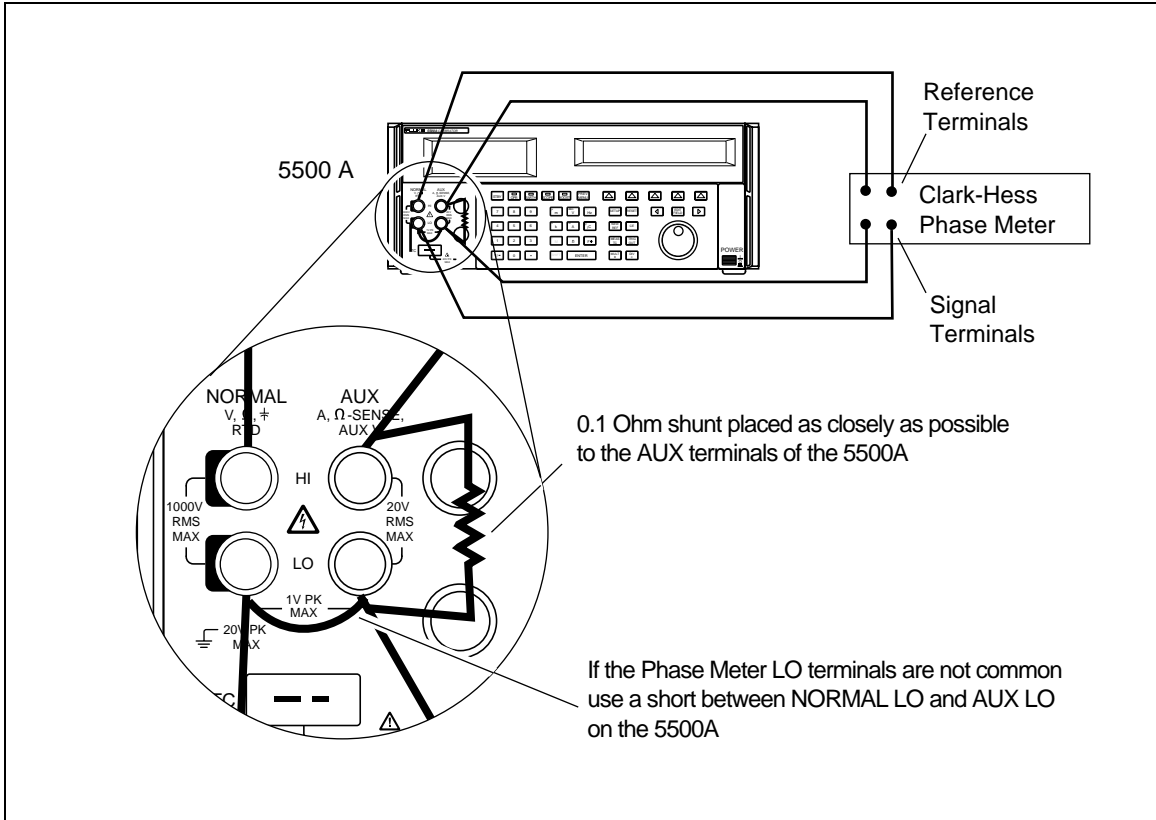
Table 3-10. Normal Volts and AUX Volts Phase Calibration Steps

Step	Reference	Signal	
	NORMAL Output	AUX output	Frequency (0° φ)
1	3.00 V	300 mV	10 kHz
2	3.00 V	3.00 V	10 kHz

3-18. Volts and AUX Current Phase

The 5500A outputs the voltages and currents shown in Figure 3-8. The 5500A 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. Table 3-11 shows the steps in this procedure. In remote, you can jump to NORMAL volts and AUX current phase calibration by sending the command:

```
CAL_START FACTORY , IPHASE
```



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Figure 3-8. Volts and Current Phase Calibration

Table 3-11. Volts and Current Phase Calibration Steps

Step	Reference	Signal	
	NORMAL Output (Volts)	Current Output (Amps)	Frequency (Hz) (0° phase)
1	3.00E+00	300E-03	500E+000
2	3.00E+00	300E-03	10E+3
3	3.00E+00	2.00E+00	500E+00
4	3.00E+00	2.00E+00	5.0E+03
5	3.00E+00	3.00E+00	64E+00
6	3.00E+00	3.00E+00	1.0E+03

3-19. Remote Commands for 5500A Calibration

Calibration of the 5500A using remote commands is simple. To access calibration steps described in paragraphs 3-6 through 3-15, simply send the command:

```
CAL_START MAIN
```

To access calibration steps described in paragraphs 3-16 through 3-18, 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 3-12.

Table 3-12. 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 5500A 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 5500A.
3. Press . At the prompt, type the desired calibration command, e.g., CAL_START FACTORY.

3-20. Generating a Calibration Report

Three different calibration reports are available from the 5500A, 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 three types of report are as follows:

- “**stored**,” which is a comparison of the most recent calibration shifts to those from the previous calibration.
- “**active**,” which is a comparison of the active calibration shifts to those from the most recent calibration. (These shifts are all zero unless you have just done a new calibration, but not saved the constants yet.)
- “**consts**,” which is a listing of the active set of raw calibration constant values.

The following examples show the first few lines of calibration shifts and calibration constants reports, in both printout and spreadsheet formats. The 90-day specification is shown in these examples because a 90-day interval was selected in the REPORT SETUP menu.

3-21. Calibration Shifts Report, Printout Format

FLUKE CORPORATION 5500A OUTPUT SHIFTS, ACTIVE VS. STORED 5500A S/N 0

Report string =
Cal dates: Active = 0, Stored = 0, Old = 0

DC Voltage (DCV)

RANGE AND VALUE	OUTPUT	SHIFT	90 DAY SPEC	% OF SPEC
DC330MV +329.9999 mV	+0.000	uV +0.00000%	0.00591%	+0.0%
DC330MV -329.9999 mV	+0.000	uV +0.00000%	0.00591%	+0.0%
DC3_3V +3.299999 V	+0.00000	mV +0.00000%	0.00420%	+0.0%
DC3_3V -3.299999 V	+0.00000	mV +0.00000%	0.00420%	+0.0%
DC33V +32.99999 V	+0.0000	mV +0.00000%	0.00400%	+0.0%
DC33V -32.99999 V	+0.0000	mV +0.00000%	0.00400%	+0.0%
DC330V +329.9999 V	+0.000	mV +0.00000%	(NO SPEC)	----
DC330V +30.0000 V	+0.000	mV +0.00000%	0.01000%	+0.0%
DC330V -30.0000 V	+0.000	mV +0.00000%	0.01000%	+0.0%
DC330V -329.9999 V	+0.000	mV +0.00000%	(NO SPEC)	----
DC1000V +1000.000 V	+0.00	mV +0.00000%	(NO SPEC)	----
DC1000V +100.000 V	+0.00	mV +0.00000%	(NO SPEC)	----
DC1000V -100.000 V	+0.00	mV +0.00000%	(NO SPEC)	----
DC1000V -1000.000 V	+0.00	mV +0.00000%	(NO SPEC)	----

Secondary DC Voltage (DCV_DCV)

RANGE AND VALUE	OUTPUT	SHIFT	90 DAY SPEC	% OF SPEC
DC330MV_S +329.999 mV	+0.00	uV +0.00000%	0.13610%	+0.0%
DC330MV_S -329.999 mV	+0.00	uV +0.00000%	0.13610%	+0.0%

(continued)

3-22. Calibration Shifts Report, Spreadsheet Format

```
ACTIVE=,0,STORED=,0,OLD=,0
DC330MV,+329.9999 mV, 0.00 Hz,+0e+00,V,+0.00000,0.00006
DC330MV,-329.9999 mV, 0.00 Hz,+0e+00,V,+0.00000,0.00006
DC3_3V,+3.299999 V, 0.00 Hz,+0e+00,V,+0.00000,0.00004
DC3_3V,-3.299999 V, 0.00 Hz,+0e+00,V,+0.00000,0.00004
DC33V,+32.99999 V, 0.00 Hz,+0e+00,V,+0.00000,0.00004
DC33V,-32.99999 V, 0.00 Hz,+0e+00,V,+0.00000,0.00004
DC330V,+329.9999 V, 0.00 Hz,+0e+00,V,+0.00000,0.00000
DC330V,+30.0000 V, 0.00 Hz,+0e+00,V,+0.00000,0.00010
DC330V,-30.0000 V, 0.00 Hz,+0e+00,V,+0.00000,0.00010
DC330V,-329.9999 V, 0.00 Hz,+0e+00,V,+0.00000,0.00000
DC1000V,+1000.000 V, 0.00 Hz,+0e+00,V,+0.00000,0.00000
DC1000V,+100.000 V, 0.00 Hz,+0e+00,V,+0.00000,0.00000
DC1000V,-100.000 V, 0.00 Hz,+0e+00,V,+0.00000,0.00000
DC1000V,-1000.000 V, 0.00 Hz,+0e+00,V,+0.00000,0.00000
DC330MV_S,+329.999 mV, 0.00 Hz,+0e+00,V,+0.00000,0.00136
DC330MV_S,-329.999 mV, 0.00 Hz,+0e+00,V,+0.00000,0.00136
DC3_3V_S,+3.30000 V, 0.00 Hz,+0e+00,V,+0.00000,0.00041
DC3_3V_S,-3.30000 V, 0.00 Hz,+0e+00,V,+0.00000,0.00041
(continued)
```

3-23. Calibration Constant Report, Printout Format

```
FLUKE CORPORATION      5500A CALIBRATION CONSTANT VALUES      5500A S/N      0
```

NAME	ACTIVE	STORED	OLD	DEFAULT
SL40MV_F8	1.2800001E-01	1.2800001E-01	1.2800001E-01	1.2800001E-01
SL40MV_F9	1.5000001E-01	1.5000001E-01	1.5000001E-01	1.5000001E-01
SL40MV_FA	2.0000000E-01	2.0000000E-01	2.0000000E-01	2.0000000E-01
SL40MV_FB	2.5000000E-01	2.5000000E-01	2.5000000E-01	2.5000000E-01
SL40MV_FC	3.0000001E-01	3.0000001E-01	3.0000001E-01	3.0000001E-01
SL100MV_G	1.4230000E+01	1.4230000E+01	1.4230000E+01	1.4230000E+01
SL100MV_F1	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
SL100MV_F2	6.5000001E-03	6.5000001E-03	6.5000001E-03	6.5000001E-03
SL100MV_F3	1.6000001E-02	1.6000001E-02	1.6000001E-02	1.6000001E-02
SL100MV_F4	3.7999999E-02	3.7999999E-02	3.7999999E-02	3.7999999E-02
SL100MV_F5	7.5000003E-02	7.5000003E-02	7.5000003E-02	7.5000003E-02
SL100MV_F6	9.7999997E-02	9.7999997E-02	9.7999997E-02	9.7999997E-02
SL100MV_F7	1.1800000E-01	1.1800000E-01	1.1800000E-01	1.1800000E-01
SL100MV_F8	1.2800001E-01	1.2800001E-01	1.2800001E-01	1.2800001E-01
SL100MV_F9	1.5000001E-01	1.5000001E-01	1.5000001E-01	1.5000001E-01
SL100MV_FA	2.0000000E-01	2.0000000E-01	2.0000000E-01	2.0000000E-01
SL100MV_FB	2.5000000E-01	2.5000000E-01	2.5000000E-01	2.5000000E-01
SL100MV_FC	3.0000001E-01	3.0000001E-01	3.0000001E-01	3.0000001E-01
SL400MV_G	5.6669998E+00	5.6669998E+00	5.6669998E+00	5.6669998E+00
SL400MV_F1	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
SL400MV_F2	6.5000001E-03	6.5000001E-03	6.5000001E-03	6.5000001E-03

(continued)

3-24. Calibration Constants Report, Spreadsheet Format

```
ACTIVE= , 0 , STORED= , 0 , OLD= , 0
    VDAC_Z1, 4.0950000E+03, 4.0950000E+03, 4.0950000E+03, 4.0950000E+03
    VDAC_Z2, 6.7770000E+03, 6.7770000E+03, 6.7770000E+03, 4.0960000E+03
VDAC_RATIO, 6.3140000E+03, 6.3140000E+03, 6.3140000E+03, 6.7550000E+03
    VDAC_G, 5.8708777E+02, 5.8708777E+02, 5.8708777E+02, 5.8700000E+02
    VDAC_N, 5.8709972E+02, 5.8709972E+02, 5.8709972E+02, 5.8700000E+02
    IDAC_Z1, 4.0950000E+03, 4.0950000E+03, 4.0950000E+03, 4.0950000E+03
    IDAC_Z2, 6.4480000E+03, 6.4480000E+03, 6.4480000E+03, 4.0960000E+03
IDAC_RATIO, 5.9950000E+03, 5.9950000E+03, 5.9950000E+03, 6.7550000E+03
    IDAC_G, 5.8719214E+02, 5.8719214E+02, 5.8719214E+02, 5.8700000E+02
    IDAC_N, 5.8720334E+02, 5.8720334E+02, 5.8720334E+02, 5.8700000E+02
```

(continued)

3-25. Performance Verification Tests

The following tests are used to verify the performance of the 5500A 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 5500A Calibrator before testing by completing “Zeroing the Calibrator” as described next.

The performance tests have reserved columns for recording the Measured Value and Deviation (%).

3-26. 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 5500A Calibrator ambient temperature changes by more than 5°C. Zeroing is particularly important when your calibration workload has 1 mΩ and 1 mV resolution, and when there are significant temperature changes in the 5500A Calibrator work environment. There are two zeroing functions: total instrument zero (ZERO) and ohms-only zero (OHMS ZERO).

Complete the following procedure to zero the calibrator. (Note: The 5500A 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 copper short circuit in the front panel TC connector (total instrument zero only).
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 5500A Calibrator; press the OHMS ZERO softkey to zero only the ohms function. After the zeroing routine is complete (several minutes), press the **RESET** key to reset the calibrator.

3-27. DC Voltage Amplitude Accuracy (NORMAL)

The DC Voltage Amplitude Accuracy test verifies the accuracy of dc voltage at the 5500A Calibrator front panel NORMAL terminals. Table 3-13 shows the test points.

Table 3-13. DC Voltage Accuracy Test

Range	Nominal Value	Measured Value (NORMAL)	Deviation %	90-Day Spec. (μV or %)
330 mV	0.0000 mV			3.0 μV
330 mV	329 mV			0.0059%
330 mV	-329 mV			0.0059%
3.3 V	0.000 mV			5 μV
3.3 V	3.29 V			0.0042%
3.3 V	-3.29 V			0.0042%
30 V	0.00 mV			50 μV
30 V	32.9 V			0.0042%
30 V	-32.9 V			0.0042%
300 V	50 V			0.0055%
300 V	329 V			0.0047%
300 V	-50 V			0.0055%
300 V	-329 V			0.0047%
1000 V	334 V			0.0049%
1000 V	900 V			0.0047%
1000 V	-334 V			0.0049%
1000 V	-900 V			0.0047%

3-28. DC Voltage Amplitude Accuracy (AUX)

The DC Voltage Amplitude Accuracy test verifies the accuracy of dc voltage at the 5500A Calibrator front panel AUX terminals in the presence of a lower voltage at the NORMAL terminals. Table 3-14 shows the test points.

Table 3-14. DC Voltage Amplitude Accuracy Test

Nominal Value (NORMAL)	Nominal Value (AUX)	Measured Value (V) (AUX)	Deviation %	90-Day Spec. (% or mV)
3 V	0 mV			0.350 mV
3 V	329 mV			0.1365%
3 V	-329 mV			0.1365%
3 V	0.33 V			0.1361%
3 V	3.29 V			0.0407%
3 V	-3.29 V			0.0407%

3-29. DC Current Amplitude Accuracy

The DC Voltage Amplitude Accuracy test verifies the accuracy of dc current at the 5500A Calibrator front panel AUX terminals. See Figure 3-2 and Table 3-4 for test equipment connection instructions. Table 3-15 shows the test points.

Table 3-15. DC Current Amplitude Accuracy Test

Range	Nominal Value	Measured Value (A) (AUX)	Deviation %	90-Day Spec. (% or mA)
3.3 mA	0 mA			0.00005 mA
3.3 mA	0.19 mA			0.036%
3.3 mA	-0.19 mA			0.036%
3.3 mA	1.9 mA			0.013%
3.3 mA	-1.9 mA			0.013%
3.3 mA	3.29 mA			0.012%
3.3 mA	-3.29 mA			0.012%
33 mA	0 mA			0.00025 mA
33 mA	19 mA			0.009%
33 mA	-19 mA			0.009%
33 mA	32.9 mA			0.009%
33 mA	-32.9 mA			0.009%
330 mA	0 mA			0.0033 mA
330 mA	190 mA			0.010%
330 mA	-190 mA			0.010%
330 mA	329 mA			0.009%
330 mA	-329 mA			0.009%
2.2 A	0 A			0.000044 A
2.2 A	2.19 A			0.025%
2.2 A	-2.19 A			0.025%
11 A	0 A			0.00033 A
11 A	11 A			0.041%
11 A	-11 A			0.041%

3-30. Resistance Accuracy

The Resistance Accuracy test verifies the accuracy of synthesized resistance at the 5500A Calibrator front panel NORMAL terminals. See Figure 3-3 for test equipment connection instructions. For resistances of less than 110 k Ω , use the four-wire COMP option. For resistances of 110 k Ω or higher, the COMP option is automatically turned off. Table 3-16 shows the test points.

Table 3-16. Resistance Accuracy Test

Nominal Value	Measured Value (Ohms)	Deviation %	90-Day Spec. (m Ω or %)
0 Ω			6 m Ω
2 Ω			0.309%
10.9 Ω			0.064%
11.9 Ω			0.135%
19 Ω			0.088%
30 Ω			0.059%
33 Ω			0.052%
109 Ω			0.021%
119 Ω			0.020%
190 Ω			0.015%
300 Ω			0.012%
330 Ω			0.025%
1.09 k Ω			0.012%
1.19 k Ω			0.012%
1.9 k Ω			0.010%
3 k Ω			0.009%
3.3 k Ω			0.025%
10.9 k Ω			0.012%
11.9 k Ω			0.012%
19 k Ω			0.010%
30 k Ω			0.009%
33 k Ω			0.026%
109 k Ω			0.013%
119 k Ω			0.014%
190 k Ω			0.012%

Table 3-16. Resistance Accuracy Test (cont.)

Nominal Value	Measured Value (Ohms)	Deviation %	90-Day Spec. (mΩ or %)
300 kΩ			0.011%
330 kΩ			0.028%
1.09 MΩ			0.016%
1.19 MΩ			0.016%
1.9 MΩ			0.014%
3 MΩ			0.013%
3.3 MΩ			0.062%
10.9 MΩ			0.050%
11.9 MΩ			0.080%
19 MΩ			0.078%
30 MΩ			0.077%
33 MΩ			0.415%
109 MΩ			0.406%
119 MΩ			0.413%
290 MΩ [1]			0.403%

[1] Perform this test using the HP 3458A in the 10 MΩ range and the Fluke 742A-10M in parallel with the 5500A output. Using exactly 10 MΩ, the nominal value is 9.66667 MΩ. Figure 3-4 shows the connections and the equation you use to calculate actual resistance.

3-31. Resistance DC Offset Measurement

The Resistance DC Offset Measurement test checks the dc offset of the amplifiers used in synthesizing resistance. Prior to performing this test, make sure you zero the 5500A Calibrator following the “Zeroing the Calibrator” procedure described earlier in this chapter. Set the output to 100 ohms, COMP OFF, and measure the NORMAL terminals with a dc millivoltmeter. Table 3-17 shows the test point.

Table 3-17. Resistance DC Offset Measurement Test

Range	Nominal Value	Measured Value (V) (NORMAL)	Deviation %	8-Hour Spec.
100 Ω	0.000 mV			0.010 mV

3-32. AC Voltage Amplitude Accuracy (NORMAL)

The AC Voltage Amplitude Accuracy test verifies the accuracy of ac voltage at the 5500A Calibrator front panel NORMAL terminals. Table 3-18 shows the test points.

Table 3-18. AC Voltage Amplitude Accuracy Test (NORMAL)

Nominal Value	Frequency	Measured Value (V) (NORMAL)	Deviation %	90-Day Spec. (%)
30 mV	9.5 Hz			5.550
30 mV	10 Hz			0.327
30 mV	45 Hz			0.177
30 mV	1 kHz			0.177
30 mV	10 kHz			0.177
30 mV	20 kHz			0.217
30 mV	50 kHz			0.257
30 mV	100 kHz			0.370
30 mV	450 kHz			0.950
300 mV	9.5 Hz			5.550
300 mV	10 Hz			0.207
300 mV	45 Hz			0.047
300 mV	1 kHz			0.047
300 mV	10 kHz			0.047
300 mV	20 kHz			0.087
300 mV	50 kHz			0.133
300 mV	100 kHz			0.227
300 mV	500 kHz			0.640
3 V	9.5 Hz			5.550
3 V	10 Hz			0.118
3 V	45 Hz			0.022
3 V	1 kHz			0.022
3 V	10 kHz			0.022
3 V	20 kHz			0.062
3 V	50 kHz			0.110
3 V	100 kHz			0.227
3 V	450 kHz			0.490

Table 3-18. AC Voltage Amplitude Accuracy Test (NORMAL) (cont.)

Nominal Value	Frequency	Measured Value (V) (NORMAL)	Deviation %	90-Day Spec. (%)
30 V	9.5 Hz			5.550
30 V	10 Hz			0.118
30 V	45 Hz			0.032
30 V	1 kHz			0.032
30 V	10 kHz			0.032
30 V	20 kHz			0.069
30 V	50 kHz			0.157
30 V	90 kHz			0.227
300 V	45 Hz			0.042
300 V	1 kHz			0.042
300 V	10 kHz			0.065
300 V	18 kHz			0.081
1000 V	45 Hz			0.048
1000 V	1 kHz			0.048
1000 V	5 kHz			0.160
1000 V	8 kHz (10 kHz optional)			0.200

3-33. AC Voltage Amplitude Accuracy (AUX)

The AC Voltage Amplitude Accuracy test verifies the accuracy of ac voltage at the 5500A Calibrator front panel AUX terminals in the presence of a voltage at the NORMAL terminals. Leave the NORMAL terminals disconnected. Table 3-19 shows the test points.

Table 3-19. AC Voltage Amplitude Accuracy Test (AUX)

Nominal Value (NORMAL)	Nominal Value (AUX)	Frequency	Measured Value (V) (AUX)	Deviation %	90-Day Spec. (%)
300 mV	10 mV	45 Hz			3.780%
300 mV	10 mV	1 kHz			3.780
300 mV	10 mV	5 kHz			4.650
300 mV	10 mV	10 kHz			4.800
300 mV	300 mV	9.5 Hz			5.550
300 mV	300 mV	10 Hz			0.273
300 mV	300 mV	45 Hz			0.203
300 mV	300 mV	1 kHz			0.203
300 mV	300 mV	5 kHz			0.300
300 mV	300 mV	10 kHz			0.450
300 mV	3 V	9.5 Hz			5.550
300 mV	3 V	10 Hz			0.165
300 mV	3 V	45 Hz			0.085
300 mV	3 V	1 kHz			0.085
300 mV	3 V	5 kHz			0.197
300 mV	3 V	10 kHz			0.347
1000 V	10 mV	45 Hz			3.780
1000 V	100 mV	1 kHz			0.450
500 V	100 mV	5 kHz			0.600
250 V	1 V	10 kHz			0.440

3-34. AC Current Amplitude Accuracy

The AC Voltage Amplitude Accuracy test verifies the accuracy of ac current at the 5500A Calibrator front panel AUX terminals. Use a Fluke 5790A with the appropriate precision shunts and adapter to measure the 5500A output. Refer to the 5790A Operator Manual for operating instructions and connections. See Figure 3-2 for connections, and see Table 3-5 for shunt information. Table 3-20 shows the test points.

Table 3-20. AC Current Amplitude Accuracy Test

Nominal Value	Frequency	Measured Value (A) (AUX)	Deviation %	90-Day Spec. (%)
33 μ A	1 kHz			0.848%
33 μ A	10 kHz			1.395
190 μ A	45 Hz			0.169
190 μ A	1 kHz			0.222
190 μ A	10 kHz			1.019
329 μ A	10 Hz			0.236
329 μ A	45 Hz			0.136
329 μ A	1 kHz			0.166
329 μ A	5 kHz			0.346
329 μ A	10 kHz			0.986
0.33 mA	1 kHz			0.171
0.33 mA	5 kHz			0.241
1.9 mA	1 kHz			0.096
1.9 mA	10 kHz			0.466
3.29 mA	10 Hz			0.159
3.29 mA	45 Hz			0.089
3.29 mA	1 kHz			0.089
3.29 mA	5 kHz			0.159
3.29 mA	10 kHz			0.459
3.3 mA	1 kHz			0.161
3.3 mA	5 kHz			0.241
19 mA	1 kHz			0.086
19 mA	10 kHz			0.466
32.9 mA	10 Hz			0.159
32.9 mA	45 Hz			0.079
32.9 mA	1 kHz			0.079

Table 3-20. AC Current Amplitude Accuracy Test (cont.)

Nominal Value	Frequency	Measured Value (A) (AUX)	Deviation %	90-Day Spec. (%)
32.9 mA	5 kHz			0.159
32.9 mA	10 kHz			0.459
33 mA	1 kHz			0.161
33 mA	5 kHz			0.241
190 mA	1 kHz			0.086
190 mA	10 kHz			0.466
329 mA	10 Hz			0.159
329 mA	45 Hz			0.080
329 mA	1 kHz			0.080
329 mA	5 kHz			0.159%
329 mA	10 kHz			0.459
0.33 A	1 kHz			0.171
0.33 A	5 kHz			0.791
2.19 A	45 Hz			0.094
2.19 A	1 kHz			0.094
2.19 A	5 kHz			0.714
2.2 A	500 Hz			0.171
2.2 A	1 kHz			0.471
11 A	45 Hz			0.068
11 A	500 Hz			0.098
11 A	1 kHz			0.268

3-35. Capacitance Accuracy

The Capacitance Accuracy test verifies the accuracy of the synthesized capacitance output at the 5500A Calibrator front panel AUX terminals. Table 3-21 shows the test points. Use the Fluke 6304C LCR Meter with PM9540/BAN output cable as shown in Figure 3-5. This cable eliminates the need for a four-wire connection.

Note

Make sure there are no other connections to the 5500A, especially the SCOPE BNC. Connecting any additional grounds to the 5500A can cause erroneous capacitance outputs. To overcome a noise problem, increase the meter's signal current by increasing the voltage or frequency.

Table 3-21. Capacitance Accuracy Test

Nominal Value	LCR Stimulus Frequency	Measured Value (F) (NORMAL)	Deviation %	90-Day Spec. (%)
0.35 η F	1 kHz			3.23%
0.48 η F	1 kHz			2.46
0.6 η F	1 kHz			2.05
1 η F	1 kHz			1.38
1.2 η F	1 kHz			1.22
3 η F	1 kHz			0.71
3.3 η F	1 kHz			0.68
10.9 η F	1 kHz			0.47
12 η F	1 kHz			1.03
30 η F	1 kHz			0.52
33 η F	1 kHz			0.49
109 η F	1 kHz			0.28
120 η F	1 kHz			0.44
300 η F	1 kHz			0.29
330 η F	100 Hz			0.49
1.09 μ F	100 Hz			0.28
1.2 μ F	100 Hz			0.51
3 μ F	100 Hz			0.36
3.3 μ F	100 Hz			0.56
10.9 μ F	100 Hz			0.35
12 μ F	100 Hz			0.55
30 μ F	100 Hz			0.40
33 μ F	100 Hz			0.68
109 μ F	100 Hz			0.47
120 μ F	100 Hz			0.75
300 μ F	100 Hz			0.60
330 μ F	50 Hz			1.09
1.1 mF	50 Hz			1.03

3-36. Thermocouple Measurement Accuracy

The Thermocouple Measurement Accuracy test checks the internal temperature reference. To perform this test, measure a lag bath temperature within ± 2 °C of the 5500A. Set the 5500A to Internal Reference, J thermocouple type. Make connections with J-type thermocouple wire as shown in Figure 3-1. Table 3-22 shows the test points.

Table 3-22. Thermocouple Measurement Accuracy Test

Nominal Value (°C)	5500A Reads (°C)	Deviation °C	90-Day Spec. (°C)
Lag bath temperature			0.1

3-37. Thermocouple Sourcing Accuracy

The Thermocouple Sourcing Accuracy test checks the accuracy of the thermocouple measuring circuitry. For this test, measure the dc output at the 5500A front panel TC connector with a dc meter (observe polarity on the TC connector). Select External Reference and the linear output 10 $\mu\text{V}/^\circ\text{C}$ as the thermocouple “type.” Use all copper wires for these connections. The Fluke 5500A/Leads test lead kit contains a copper TC plug and wire for this purpose. Table 3-23 shows the test points.

Table 3-23. Thermocouple Sourcing Accuracy Test

Nominal Value (°C)	Equivalent Value (mV)	Measured Value (mV) (TC connector)	Deviation %	90-Day Spec. (mV or %)
0	0.000 mV			0.003 mV
100	1.000			0.305%
-100	-1.000			0.305%
1000	10.000			0.035%
-1000	-10.000			0.035%
10000	100.000			0.008%
-10000	-100.000			0.008%

3-38. Thermocouple Measuring Accuracy

The Thermocouple Measuring Accuracy test checks the accuracy of the thermocouple measuring circuitry. For this test, input a dc voltage into the 5500A front panel TC terminals using copper plugs and wire (observe polarity on the TC connector), select External Reference, and select the linear output 10 $\mu\text{V}/^\circ\text{C}$ as the thermocouple “type.” The Fluke 5500A/Leads test lead kit contains a copper TC plug and wire for this purpose. Table 3-24 shows the test points.

(Optional: You can also source a known temperature from a temperature calibrator using a J-type thermocouple connection and Internal Reference. Source 0 °C, 100 °C, 1000 °C, and -200 °C.)

Table 3-24. Thermocouple Measuring Accuracy Test

Input Value	Nominal Reading (°C)	Actual Reading (mV) (TC connector)	Deviation %	90-Day Spec. (mV or %)
0 V	0.00			0.003 mV
100 mV	10,000.00			0.008%
-100 mV	-10,000.00			0.008%

3-39. DC Power Amplitude Accuracy (NORMAL)

The DC Power Amplitude Accuracy (NORMAL) test checks the amplitude accuracy of the dc volts at the NORMAL terminals in the presence of DC I at the AUX terminals. Apply a short to the AUX terminals to provide a low-impedance path for current. Table 3-25 shows the test points.

Table 3-25. DC Power Amplitude Accuracy Test (NORMAL)

Nominal Value (NORMAL)	Nominal Value (A) (AUX)	Measured Value (V) (NORMAL)	Deviation %	90-Day Spec. (%)
20 mV	2.19 A			0.020%
20 mV	11 A			0.020%

3-40. DC Power Amplitude Accuracy (AUX)

The DC Power Amplitude Accuracy (AUX) test checks the amplitude accuracy of the dc current output at the AUX terminals in the presence of dc voltage at the NORMAL terminals. Use the connections shown in Figure 3-2. Table 3-26 shows the test points.

Table 3-26. DC Power Amplitude Accuracy Test (AUX)

Nominal Value (NORMAL)	Nominal Value (AUX)	Measured Value (A) (AUX)	Deviation %	90-Day Spec. (%)
1000 V	100 μ A			0.06%
1000 V	1 mA			0.015
329 V	2.19 A			0.025
1000 V	11 A			0.041

3-41. AC Power Amplitude Accuracy (High Voltage)

The AC Power Amplitude Accuracy (High Voltage) test checks the current outputs at the AUX terminals in the presence of a high voltage. Use the 5790A, A40 and A40A shunts, and the shunt adapter, as described in the 5790A Operator Manual. Table 3-27 shows the test points.

Table 3-27. AC Power Amplitude Accuracy Test (High Voltage)

Nominal Value (NORMAL)	Nominal Value (AUX)	Frequency	Phase (degrees)	Measured Value (A) (AUX)	Deviation %	90-Day Spec. (%)
1000 V	3.3 mA	65 Hz	0			0.161%
1000 V	3.3 mA	65 Hz	90			0.161
1000 V	33 mA	500 Hz	0			0.161
1000 V	33 mA	500 Hz	90			0.161
1000 V	33 mA	1 kHz	0			0.161
1000 V	33 mA	5 kHz	0			0.241
1000 V	33 mA	7 kHz (10 kHz optional)	0			0.541
(Optional) 800 V	33 mA	10 kHz				0.541

3-42. AC Power Amplitude Accuracy (High Current)

The AC Power Amplitude Accuracy (High Current) test checks the voltage outputs at the NORMAL terminals in the presence of a high current. Apply a short to the AUX terminals to provide a low-impedance path for current. Table 3-28 shows the test points.

Table 3-28. AC Power Amplitude Accuracy Test (High Current)

Nominal Value (NORMAL)	Nominal Value (AUX)	Frequency	Phase (degrees)	Measured Value (V) (NORMAL)	Deviation %	90-Day Spec. (%)
33 mV	11 A	65 Hz	0			0.101%
33 mV	11 A	65 Hz	90			0.101
330 mV	11 A	1 kHz	0			0.038
3.3 V	2.19 A	5 kHz	0			0.048
3.3 V	329 mA	10 kHz	0			0.048

3-43. AC Power Amplitude Accuracy (High Power)

The AC Power Amplitude Accuracy (High Power) test checks the accuracy of the ac power output at high power levels. Apply a short to the AUX terminals to provide a low-impedance path for current. Table 3-29 shows the test points.

Table 3-29. AC Power Amplitude Accuracy Test (High Power)

Nominal Value (NORMAL)	Nominal Value (AUX)	Frequency	Phase (degrees)	Measured Value (V) (NORMAL)	Deviation %	90-Day Spec. (%)
329 V	2.19 A	5 kHz	0			0.065%
1 kV	11 A	1 kHz	0			0.048

3-44. Phase and Frequency Accuracy

The Phase and Frequency Accuracy test checks the accuracy of the phase between signals at the NORMAL output and the AUX inputs, and the accuracy of the frequency. For the volts-volts phase test, ac couple the input to the phase meter as shown in Figure 3-7. For the volts-current phase, measure the phase across a noninductive resistor as shown in Figure 3-8. Table 3-30 shows the test points for phase. Table 3-31 shows the test points for frequency.

Table 3-30. Phase Accuracy Test

Output Voltage (NORMAL)	Output Voltage (AUX)	Frequency	Nominal Phase (degrees)	Measured Value (degrees)	Deviation %	1-Year Spec. (degrees)
3 V	1 V	60 Hz	0			0.15 degrees
3 V	1 V	400 Hz	0			0.9
3 V	1 V	1 kHz	0			2
3 V	1 V	5 kHz	0			6
3 V	1 V	10 kHz	0			10
3 V	1 V	60 Hz	60			0.15
3 V	1 V	400 Hz	60			0.9
3 V	1 V	1 kHz	60			2
3 V	1 V	5 kHz	60			6
3 V	1 V	10 kHz	60			10
3 V	1 V	60 Hz	90			0.15
3 V	1 V	400 Hz	90			0.9

Table 3-30. Phase Accuracy Test (cont.)

Output Voltage (NORMAL)	Output Voltage (AUX)	Frequency	Nominal Phase (degrees)	Measured Value (degrees)	Deviation %	1-Year Spec. (degrees)
3 V	1 V	1 kHz	90			2
3 V	1 V	5 kHz	90			6
3 V	1 V	10 kHz	90			10
Output Voltage (NORMAL)	Output Current (AUX)	Frequency	Nominal Phase (degrees)	Measured Value (degrees)	Deviation %	1-Year Spec. (degrees)
33 V	300 mA	65 Hz	0			0.15
33 V	2 A	65 Hz	0			0.15
33 V	5 A	65 Hz	0			0.15
33 V	5 A	400 Hz	0			0.9

Table 3-31. Frequency Accuracy Test

Output Voltage (NORMAL)	Frequency	Measured Value (Hz)	Deviation ppm	1-Year Spec. (ppm)
3 V	119.00 Hz			42
3 V	120.0 Hz			42
3 V	1000.0 Hz			27
3 V	100.00 kHz			25

3-45. AC Voltage Amplitude Accuracy, Squarewave (NORMAL)

The AC Voltage Amplitude Accuracy, Squarewave (NORMAL) test checks the amplitude accuracy at the NORMAL terminals. For this test, use the Fluke 5790A. Refer to the 5790A Operator Manual for operating instructions and connections. For squarewaves, the measured value (in rms) should be exactly 1/2 the nominal value in peak-to-peak. Table 3-32 shows the test points.

Table 3-32. AC Voltage Amplitude Accuracy, Squarewave (NORMAL)

Nominal Value (p-p)	Frequency	Measured Value (V rms) (NORMAL)	Deviation %	1-Year Spec. (%)
30 mV (15 mV rms)	10 Hz			1.350
30 mV	1 kHz			0.800
30 mV	20 kHz			1.050
30 mV	100 kHz			6.100
300 mV (150 mV rms)	10 Hz			1.350
300 mV	1 kHz			0.800
300 mV	20 kHz			1.050
300 mV	100 kHz			6.100
3 V (1.5 V rms)	10 Hz			1.350
3 V	1 kHz			0.800
3 V	20 kHz			1.050
3 V	100 kHz			6.100
30 V (15 V rms)	10 Hz			1.350
30 V	1 kHz			0.800
30 V	20 kHz			1.050
30 V	100 kHz			6.100

3-46. AC Voltage Amplitude Accuracy, Squarewave (AUX)

The AC Voltage Amplitude Accuracy, Squarewave (AUX) test checks the amplitude accuracy at the AUX terminals. For this test, use the Fluke 5790A. Refer to the 5790A Operator Manual for operating instructions and connections. For squarewaves, the measured value (in rms) should be exactly 1/2 the nominal value in peak-to-peak. Table 3-33 shows the test points.

Table 3-33. AC Voltage Amplitude Accuracy, Squarewave (AUX)

Nominal Value (p-p, NORMAL)	Nominal Value (p-p, AUX)	Frequency	Measured Value (V rms, AUX)	Deviation %	1-Year Spec. (%)
3 V	300 mV	10 Hz			1.350
3 V	300 mV	1 kHz			0.800
3 V	300 mV	5 kHz			6.100
3 V	300 mV	10 kHz			6.100
3 V	3 V	10 Hz			1.350
3 V	3 V	1 kHz			0.800
3 V	3 V	5 kHz			6.100
3 V	3 V	10 kHz			6.100

3-47. AC Voltage Harmonic Amplitude Accuracy (NORMAL)

The AC Voltage Harmonic Amplitude Accuracy (NORMAL) tests the accuracy of the harmonics from the NORMAL terminals. For this test, set the 5500A output to sinewave. Table 3-34 shows the test points.

Table 3-34. AC Voltage Harmonic Amplitude Accuracy (NORMAL)

Nominal Value (NORMAL)	Nominal Value (AUX)	Frequency (AUX)	Harmonic (NORMAL)	Frequency (NORMAL)	Measured Value (V) (NORMAL)	Deviation %	90-Day Spec. (%)
30 mV	300 mV	20 Hz	50th	1 kHz			0.243%
30 mV	300 mV	100 Hz	50th	5 kHz			0.243
30 mV	300 mV	200 Hz	50th	10 kHz			0.243
300 mV	300 mV	20 Hz	50th	1 kHz			0.053
300 mV	300 mV	100 Hz	50th	5 kHz			0.053
300 mV	300 mV	200 Hz	50th	10 kHz			0.053
3 V	3 V	20 Hz	50th	1 kHz			0.024
3 V	3 V	100 Hz	50th	5 kHz			0.024
3 V	3 V	200 Hz	50th	10 kHz			0.024
30 V	3 V	20 Hz	50th	1 kHz			0.034
30 V	3 V	100 Hz	50th	5 kHz			0.034
30 V	3 V	200 Hz	50th	10 kHz			0.034
300 V	3 V	50 Hz	20th	1 kHz			0.044
300 V	3 V	100 Hz	50th	5 kHz			0.070
300 V	3 V	200 Hz	50th	10 kHz			0.070
1000 V	3 V	50 Hz	20th	1 kHz			0.056
1000 V	3 V	100 Hz	50th	5 kHz			0.170
800 V	3 V	200 Hz	50th	10 kHz			0.275
Optional: 1000 V	3 V	200 Hz	50th	10 kHz			0.250

3-48. AC Voltage Harmonic Amplitude Accuracy (AUX)

The AC Voltage Harmonic Amplitude Accuracy (AUX) tests the accuracy of the 50th harmonic from the AUX terminals. For this test, set the 5500A output to sinewave. Table 3-35 shows the test points.

Table 3-35. AC Voltage Harmonic Amplitude Accuracy (AUX)

Nominal Value (NORMAL)	Nominal Value (AUX)	Frequency (AUX)	Frequency (NORMAL)	Measured Value (V) (AUX)	Deviation %	90-Day Spec (%)
100 mV	329 mV	1 kHz	20 Hz			0.305%
100 mV	329 mV	5 kHz	100 Hz			0.424
100 mV	329 mV	10 kHz	200 Hz			0.574
100 mV	3.29 V	1 kHz	20 Hz			0.097
100 mV	3.29 V	5 kHz	100 Hz			0.235
100 mV	3.29 V	10 kHz	200 Hz			0.385

3-49. DC Voltage Offset Accuracy

The DC Voltage Offset Accuracy test the accuracy of the dc offset function for an ac sinewave output on the NORMAL terminals. Table 3-36 shows the test points.

Table 3-36. DC Voltage Offset Accuracy Test

Nominal ACV Value	Nominal DC Value	Frequency	Measured Value (V DC) (NORMAL)	Deviation %	1-Year Spec. (μV or %)
10 mV	0 V	1 kHz			33 μV
10 mV	50 mV	1 kHz			0.166%
100 mV	0 V	1 kHz			330 μV
100 mV	500 mV	1 kHz			0.166%
1 V	0 V	1 kHz			3.3 mV
1 V	5 V	1 kHz			0.166%
3.3 V	0 V	1 kHz			33 mV
3.3 V	45 V	1 kHz			0.173%

3-50. AC Voltage Accuracy with a DC Offset

The AC Voltage Accuracy with a DC Offset tests the accuracy of the ac output in the presence of a dc offset. For this test, be sure to ac couple the input to the meter. Table 3-37 shows the test points.

Table 3-37. AC Voltage Accuracy with a DC Offset

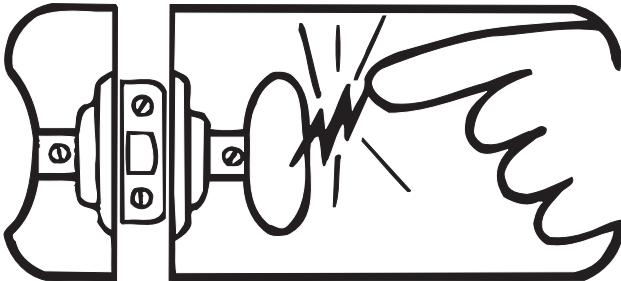
Nominal ACV Value	Nominal DC Value	Frequency	Measured (V AC) (NORMAL)	Deviation %	90-Day Spec. (%)
3.3 mV	50 mV	1 kHz			0.716%
33 mV	500 mV	1 kHz			0.101
330 mV	5 V	1 kHz			0.038
3.3 V	45 V	1 kHz			0.048



static awareness



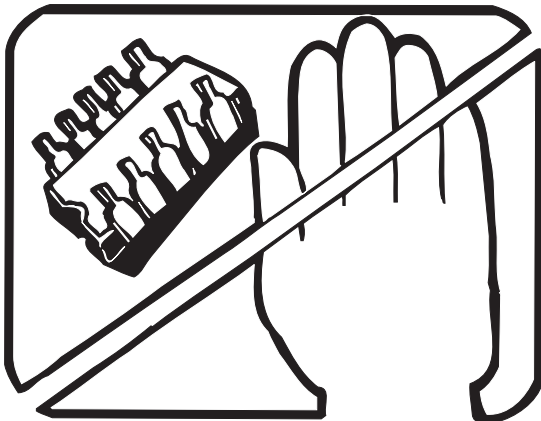
A Message From
Fluke Corporation



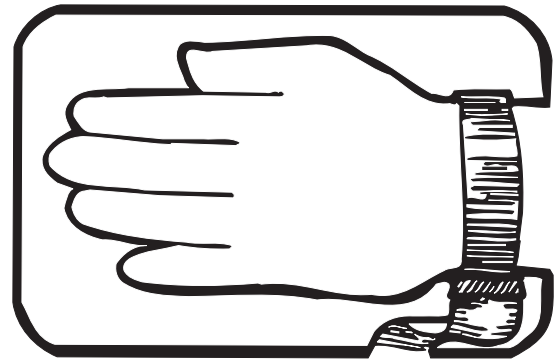
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

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

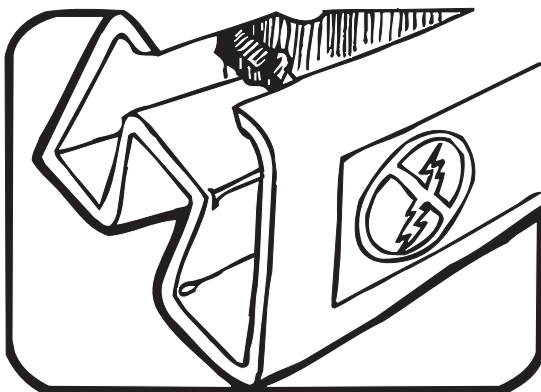
The following practices should be followed to minimize damage to S.S. (static sensitive) devices.



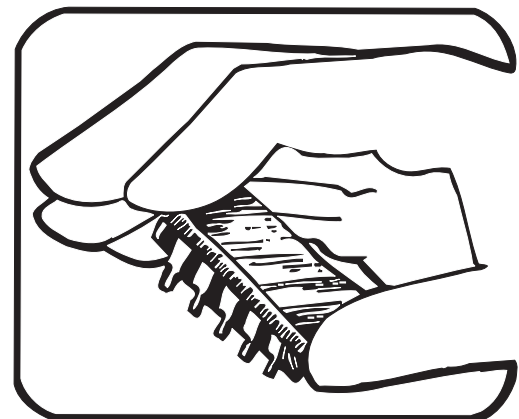
1. MINIMIZE HANDLING



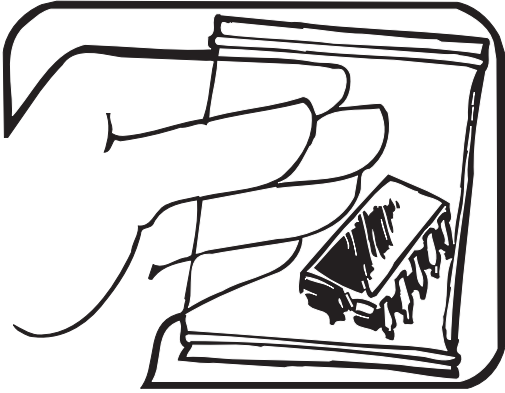
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



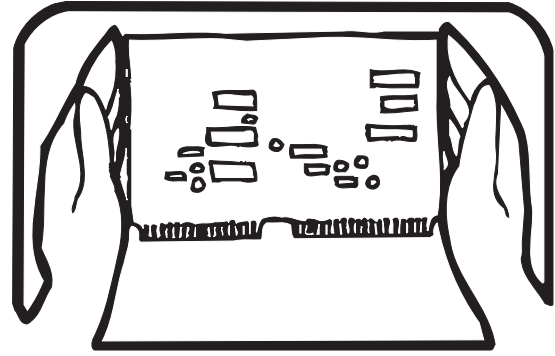
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



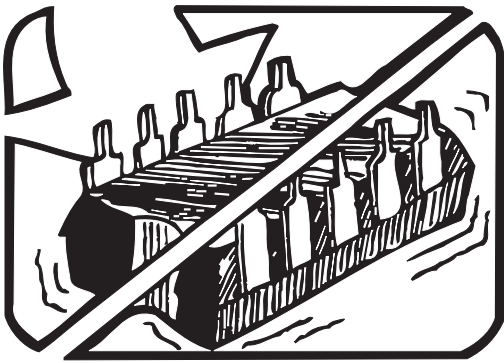
4. HANDLE S.S. DEVICES BY THE BODY.



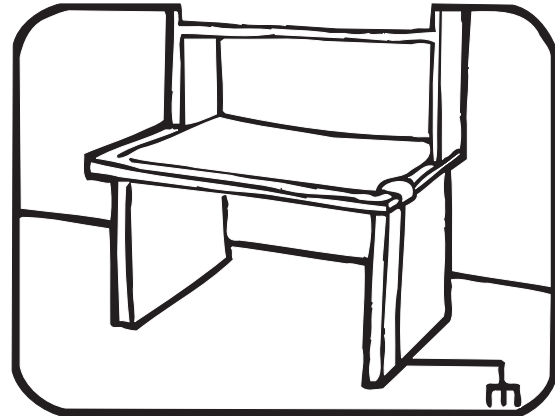
5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT.



8. WHEN REMOVING PLUG-IN ASSEMBLIES HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR HELPS PROTECT INSTALLED S.S. DEVICES.



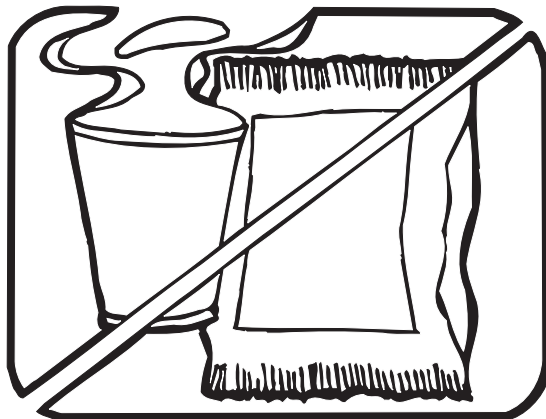
6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION.

10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

11. ONLY GROUNDED-TIP SOLDERING IRONS SHOULD BE USED.



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

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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.

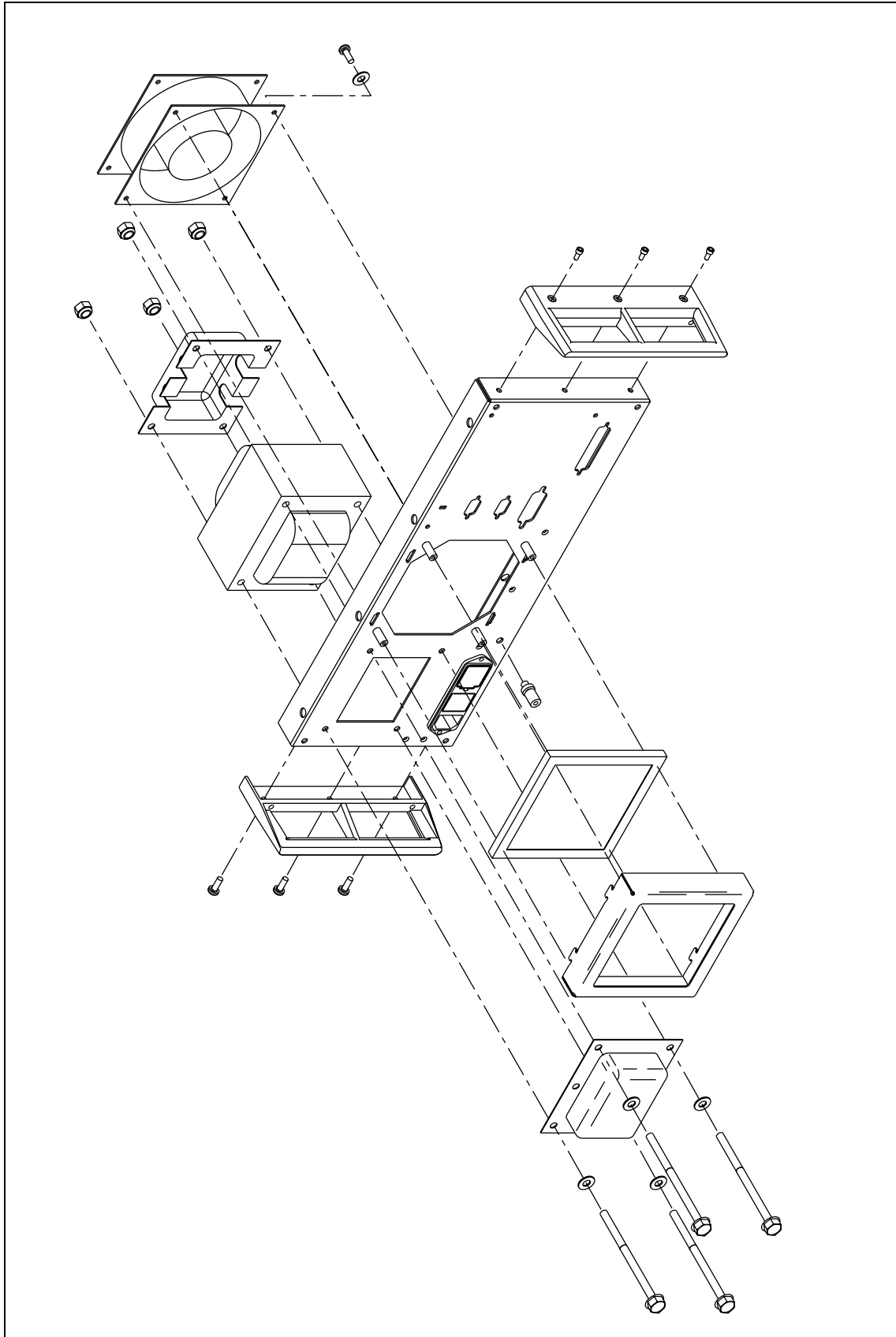


Figure 4-1. Exploded View of Rear Panel Assemblies

om016f.eps

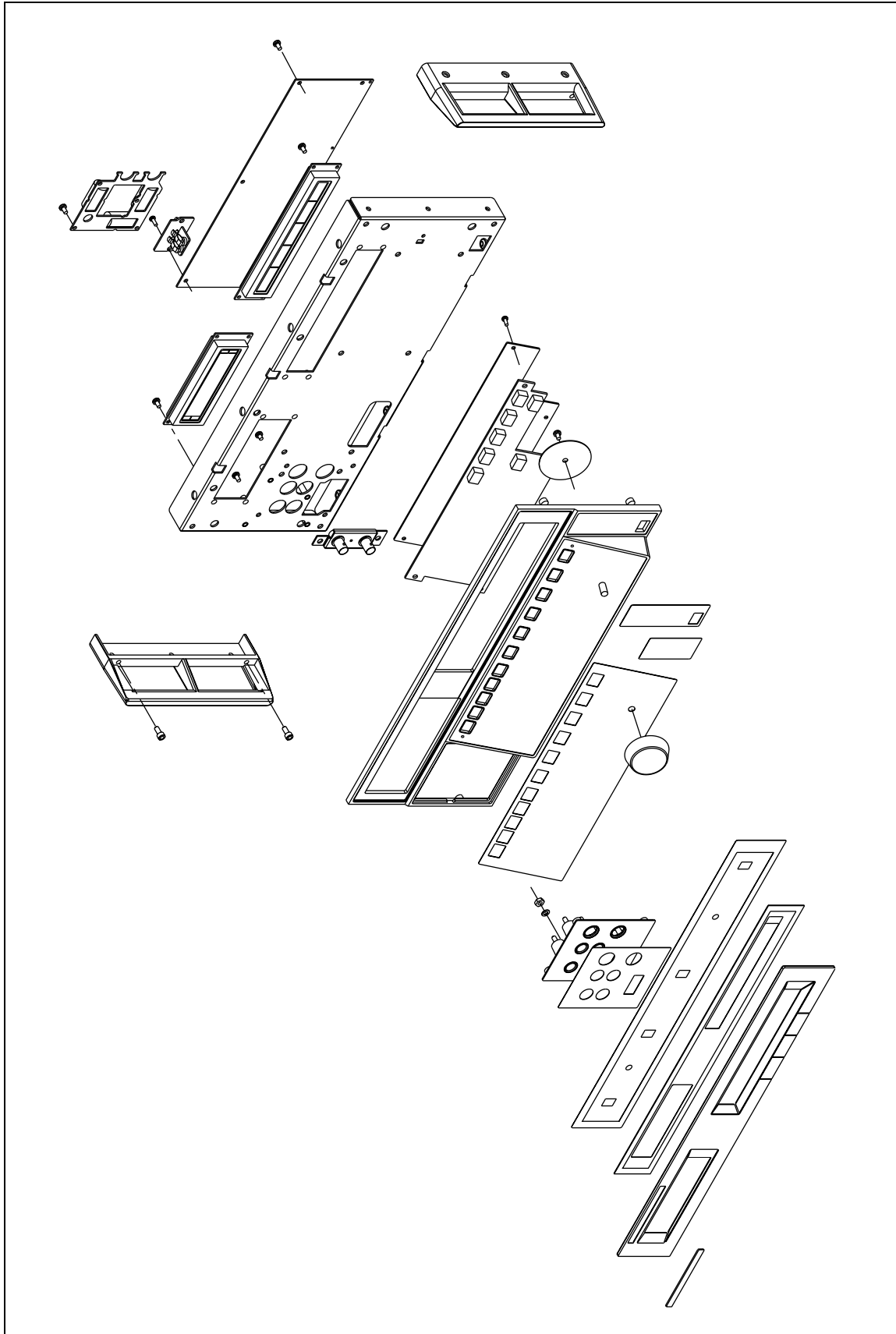


Figure 4-2. Exploded View of Front Panel Assemblies

om017f.eps

4-9. Diagnostic Testing

5500A 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 5500A 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:

- PSEUDO CAL -- Runs all the internal gains calibration steps, but does not save the updated constants. This is useful to check for error messages.
- 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 5500A prompts you to remove all cables from the front panel outputs.

4-11. Sequence of Diagnostics Tests

After you press the GO NO softkey, an automatic sequence of tests begins. Diagnostics runs the following tests:

- General and DDS assembly (A6) diagnostics (23 steps)
- Current assembly (A7) diagnostics (24 steps)
- Synthesized Impedance assembly (A5) diagnostics (26 steps)
- Voltage assembly (A8) diagnostics (16 steps)

4-12. Diagnostics Error Messages

If an error message appears during diagnostics, check the following annotated list to determine which assembly, and what circuit, is suspect. You should perform the diagnostics in proper sequence. Each diagnostic test builds on the successful pass of the previous diagnostic test in order to properly diagnose a faulty subcircuit. The assembly named in the error message is almost always the assembly that has the fault.

1006 (DDE:FR) A6 DCI loop fault

Suspects include U57, U31, and U33 on the A6 assembly.

1007 (DDE:FR) A6 ACI loop fault

Suspects include U3, U14, U34, U37, U38, U44, U47, U84, and U90 on the A6 assembly.

1010 (DDE:FR) A6 ACV loop fault

Assuming the dc voltage tests pass, there are a number of A6 ICs associated with ac voltage that could be suspect. These include U5, U55, U61, U62, U13, U4, U35, U32, U49, U25, U96, U40, U20, U39, U84 and U3.

1011 (DDE:FR) A6 33 mV divider fault

Suspects on the A6 assembly are resistor network Z8 and relay K7.

1012 (DDE:FR) A6 330 mV DC fault

Suspects on the A6 assembly are resistor network Z8 and relay K7.

1013 (DDE:FR) A6 +3.3V DC fault

Suspect ICs on the A6 assembly are U21, U57, U15, U60, U87, U48, and U42. These ICs are tested in previous test near 0 V. This test exposes failures at full scale positive.

1014 (DDE:FR) A6 -3.3V DC fault

Suspect ICs on the A6 assembly are U21, U57, U15, U60, U87, U48 and U42. These ICs are tested in previous test near 0 V. This test exposes failures at full scale negative.

1015 (DDE:FR) A8 33V DC fault

Suspect components on the A8 assembly include U1, Q1 through Q4, Q6, Q16, Q17, R10, R13, and R17 through R19.

1016 (DDE:FR) A6 33 mV AC fault

Suspects include U41, U57, U21, and Z8 on the A6 assembly.

1017 (DDE:FR) A6 330 mV AC fault

Suspects include U41, U57, U21, and Z8 on the A6 assembly.

1018 (DDE:FR) A6 3.3V AC fault

Assuming the ACV LOOP test passes, suspect ICs include U41, U57, U21, and U87.

1019 (DDE:FR) A8 33V AC fault

Suspect components on the A8 assembly include U1, Q1 through Q4, Q6, Q16, Q17, R10, R13, and R17 through R19.

1020 (DDE:FR) A6 vloop error amp fault

The primary suspect IC is U60. Other possible suspects include U15 and U48, all on the A6 assembly.

1021 (DDE:FR) A6 3.3V amp fault

The primary suspect IC is U42. Another suspect is U48, both on the A6 assembly.

1022 (DDE:FR) A6 polarity inverter fault

The primary suspect IC is U87 on the A6 assembly.

1023 (DDE:FR) A6 3.3V sense buffer fault

Suspect ICs are U21, U57, and U26 on the A6 assembly. If one of these ICs is bad, it will cause faults on the other *A6 sense buffer* tests as well. Other suspects on the A6 assembly include relay K3 and resistor network Z5.

1024 (DDE:FR) A6 33V sense buffer fault

Assuming the *A6 sense buffer (3.3 V)* test passed, suspects are relay K2 and resistor network Z5.

1025 (DDE:FR) A6 330V sense buffer fault

Assuming previous *A6 sense buffer* tests passed, suspects are relay K1 and resistor network Z5.

1026 (DDE:FR) A6 1000V sense buffer fault

Assuming previous *A6 sense buffer* tests passed, the suspect IC is U60.

1027 (DDE:FR) A6 trim DAC 0 (3.3V) fault

Suspects include U17, U4, U25, U42, R3, R45, R51, R50, R22, and C133 on the A6 assembly.

1028 (DDE:FR) A6 trim DAC 0 (33V) fault

Suspects include U17, U4, U25, U42, R3, R45, R51, R50, R22, and C133 on the A6 assembly.

1029 (DDE:FR) A6 trim DAC 1 fault

Suspects include U18, U34, R131, R142, R143, and C126 on the A6 assembly.

1030 (DDE:FR) A8 33V DC offset fault

The primary suspect IC is U1 on the A8 assembly.

1031 (DDE:FR) A8 330V AC low F fault

Suspects include transformer T3, U16, and U13.

1032 (DDE:FR) A8 330V AC high F fault

Suspects include transformer T2 and U4.

1033 (DDE:FR) A8 330V DC fault

Suspects include CR4 through 6, CR16, CR19, CR20, C2, and C24 on the A8 assembly.

1034 (DDE:FR) A8 1000V AC low F fault

Suspects include transformer T3, U16, and U13 on the A8 assembly.

1035 (DDE:FR) A8 1000V AC high F fault

Suspects include transformer T2 and U4 on the A8 assembly.

1036 (DDE:FR) A8 1000V DC fault

Suspects include CR4 through 6, CR16, CR19, CR20, C2, and C24 on the A8 assembly.

1040 (DDE:FR) A5 interface fault

Is the A5 assembly installed? If so, suspect circuitry includes A5 digital ICs U14, U12, or CMOS switch U7, relay K15, and driver IC U15.

1041 (DDE:FR) A5 X1 input amp fault

Suspect ICs on the A5 assembly include U34, U20, U8, U7, Q4, and Q3, as well as the +17, and -17 V supplies and their associated circuitry.

1042 (DDE:FR) A5 lo comp amp fault

Suspect ICs on the A5 assembly include U3, U37, U4, U5, and U7.

1043 (DDE:FR) A5 coarse ZDAC fault

Suspect ICs on the A5 assembly include U25, U1, U24, U39, and U4.

1044 (DDE:FR) A5 fine ZDAC fault

Suspect ICs on the A5 assembly include U22, or U23, and U4.

1045 (DDE:FR) A5 inverting amp fault

Suspect ICs on the A5 assembly include U24, U1, and relay K16 (and respective relay driver U30).

1046 (DDE:FR) A5 X2.45 input amp fault

Suspect ICs on the A5 assembly include U20, Q3, Q4, and noninverting amp U34 in X2.45 gain mode, as well as U3, and U10.

1047 (DDE:FR) A5 X3 input amp fault

Suspect ICs on the A5 assembly include U20, Q3, Q4, and noninverting amp U34 in X3.08 gain.

1048 (DDE:FR) A5 X13.1 input amp fault

Suspect ICs on the A5 assembly include U20, Q3, Q4, and noninverting amp U34 in X13.1 gain mode.

1049 (DDE:FR) A5 input leakage fault

Suspect ICs on the A5 assembly include Q3, Q4, U34, and analog MUXs U26, U27, and U29.

1050 (DDE:FR) A5 offset comp fault

Suspect components on the A5 assembly are IC U4 and resistor R17.

1051 (DDE:FR) A5 input voltage detect fault

On the A5 assembly, suspect circuits are the +/- 17 V supplies (Zener diodes VR4 and VR3 may be regulating too low but may be within tolerance). Suspect ICs are U16 and U5. Check the voltage threshold levels on U16.

1052 (DDE:FR) A5 12.75 ohm reference fault

Suspect components on the A5 assembly are relay driver ICs U2, U15, U28, U30, and R30 or Z2.

1053 (DDE:FR) A5 33.25 ohm reference fault

Suspect components on the A5 assembly are relay driver IC U2 and resistor network Z2.

1054 (DDE:FR) A5 100 ohm reference fault

Suspect components on the A5 assembly are relay driver IC U2 and resistor network Z2.

1055 (DDE:FR) A5 325 ohm reference fault

Suspect components on the A5 assembly are relay driver IC U2 and resistor network Z2.

1056 (DDE:FR) A5 1 kohm reference fault

Suspect components on the A5 assembly are relay driver IC U2 and resistor network Z2.

1057 (DDE:FR) A5 3.25 kohm reference fault

Suspect components on the A5 assembly are relay driver IC U2 and resistor network Z2.

1058 (DDE:FR) A5 10 kohm reference fault

Suspect components on the A5 assembly are relay driver IC U2 and resistor network Z2.

1059 (DDE:FR) A5 33 kohm reference fault

Suspect components on the A5 assembly are relay driver IC U2 and resistor network Z1.

1060 (DDE:FR) A5 100 kohm reference fault

Suspect components on the A5 assembly are relay driver IC U2 and resistor network Z1.

1061 (DDE:FR) A5 325 kohm reference fault

Suspect components on the A5 assembly are IC U26, relay driver U2, and Z1.

1062 (DDE:FR) A5 1 Mohm reference fault

Suspect components on the A5 assembly are IC U26, relay driver U2, and Z1.

1063 (DDE:FR) A5 2W comp open ckt fault

Suspect components on the A5 assembly are protection FETs Q13, Q14, Q15, and Q16, R77, and power supply U33.

1064 (DDE:FR) A5 2W comp fault

Suspect components on the A5 assembly are Q1, Q2, U40, and U35.

1065 (DDE:FR) A7 Shunt amp fault (2.2A)

Suspects include Q33,U20,U24,U6 and Z5 on the A7 Assembly. Also suspect is U31 on the A6 assembly.

- 1066 (DDE:FR) A7 Shunt amp fault (3.3 mA)**
Suspects include U6 and Z2 on the A7 assembly.
- 1067 (DDE:FR) A7 Shunt amp fault (33 mA)**
Suspects include U6 and Z2 on the A7 assembly.
- 1068 (DDE:FR) A7 Shunt amp fault (330 mA)**
Suspects include U6 and Z2 on the A7 assembly.
- 1069 (DDE:FR) A7 Shunt amp fault (11A)**
Suspects include K14, K15, U5, R12, R17, R47, R53, and R59 on the A7 assembly.
- 1070 (DDE:FR) A7 Leakage current fault**
Suspects include U5-U8,U16,U19-U20 and U23 on the A7 assembly.
- 1071 (DDE:FR) A7 Output amp leakage fault**
Suspects include Q2, Q3, Q4, Q6, Q7, Q10, U10, U11, U13, U14, and U17 on the A7 assembly. On the A97 SIP assembly, suspects include Q6, Q9, Q18, Q19, U2, and U3.
- 1072 (DDE:FR) A7 Undercurrent fault +3.3 mA**
Suspects include U19, U21, and the A97 SIP assembly on the A7 assembly.
- 1073 (DDE:FR) A7 Overcurrent fault +3.3 mA**
Suspects include U19, U21, and the A97 SIP assembly on the A7 assembly.
- 1074 (DDE:FR) A7 Undercurrent fault -3.3 mA**
Suspects include R7, R13, Q6, and U3 on the A97 assembly.
- 1075 (DDE:FR) A7 Overcurrent fault -3.3 mA**
Suspects include R7, R13, Q6, and U3 on the A97 assembly.
- 1076 (DDE:FR) A7 Undercurrent fault +33 mA**
Suspects include K5, R27, R30, Q19, and U2 on the A97 assembly.
- 1077 (DDE:FR) A7 Overcurrent fault +33 mA**
The primary suspect is R30 on the A97 assembly.
- 1078 (DDE:FR) A7 Undercurrent fault -33 mA**
Suspects include R27, Q18, and U3 on the A97 assembly.
- 1079 (DDE:FR) A7 Overcurrent fault -33 mA**
Suspects include R27, Q18, and U3 on the A97 assembly.
- 1082 (DDE:FR) A7 Undercurrent fault +330 mA**
Suspects include K18, R88, R92, R102, R105, Q10, Q1, and U13 on the A7 assembly.

1083 (DDE:FR) A7 Overcurrent fault +330 mA

Suspects include K16, K17, R88, and R92 on the A7 assembly.

1080 (DDE:FR) A7 Undercurrent fault -330 mA

Suspects include R102, R105, Q2, Q8, and U13 on the A7 assembly.

1081 (DDE:FR) A7 Overcurrent fault -330 mA

Suspects include R102, R105, Q2, Q8, and U13 on the A7 assembly.

1086 (DDE:FR) A7 Undercurrent fault +2.2A

Suspects include R24 and R34 on the A7 assembly.

1087 (DDE:FR) A7 Overcurrent fault +2.2A

The primary suspect is R34 on the A97 assembly.

1084 (DDE:FR) A7 Undercurrent fault -2.2A

The primary suspect is R24 on the A7 assembly.

1085 (DDE:FR) A7 Overcurrent fault -2.2A

The primary suspect is R24 on the A7 assembly.

1088 (DDE:FR) A7 Aux amp fault

Suspects include R6, R7, R44, R46, and U8 on the A7 assembly.

1089 (DDE:FR) A7 Monitor fault (+DC)

Suspects include R18, R38, R43, R48, R52, R57, C67, CR11, and U22 on the A7 assembly.

1090 (DDE:FR) A7 Monitor fault (-DC)

Suspects include CR9 and U22 on the A7 assembly.

4-13. 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.

4-14. Internal Fuse Replacement

In addition to the operator-replaceable line fuse (see “Replacing the Line Fuse”), there are additional fuses mounted on printed circuit assemblies (PCAs) internal to the 5500A Calibrator. The location of the internal fuses are summarized in Table 4-1.

Table 4-1. Internal Fuse Locations

Fuse Description	Printed Circuit Assembly	Reference	Quantity	Part Number
△ 0.125 A, 250 V, Slow Blow	A5 Synthesized Impedance	A5F2, A5F3	2	832261
△ 0.5 A, 250 V, Slow Blow	A12 Filter	A12F1, A12F2	2	831990
△ 2 A, 250 V, Slow Blow	A3 Motherboard	A3F1 to A3F10	10	806331

4-15. Complete List of Error Messages

The following is a list of the 5500A Calibrator error messages. The error message format is shown in Table 4-2.

Table 4-2. 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	Up to 36 text characters
	DDE Device-Specific Error, caused by the 5500A 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 5500A 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

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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
201 (DDE:FR D) 5725A ROM failure
202 (DDE:FR D) 5725A RAM failure
203 (DDE:FR D) 5725A EEPROM failure
204 (DDE:FR D) 5725A data bus failure
205 (DDE:FR D) 5725A CLAMPS circuit failure
206 (DDE:FR D) 5725A HVCLR circuit failure
207 (DDE:FR D) 5725A DAC failure
208 (DDE:FR D) 5725A watchdog timer fault
209 (DDE:FR D) 5725A I heatsink too hot
210 (DDE:FRS ) Output tripped to standby
211 (DDE:FR D) 5725A compliance V exceeded
212 (DDE:FRS ) 5725A compliance V exceeded
213 (DDE:FR D) 5725A +400V did not shut off
214 (DDE:FR D) 5725A -400V did not shut off
215 (DDE:FR D) 5725A V heatsink too hot
216 (DDE:FRS ) 5725A V heatsink too hot
217 (DDE:FR D) 5725A +400V supply too small
218 (DDE:FR D) 5725A +400V supply too large
219 (DDE:FR D) 5725A -400V supply too large
220 (DDE:FR D) 5725A -400V supply too small
221 (DDE:FR D) 5725A +400V supply overI
222 (DDE:FRS ) Output tripped to standby
223 (DDE:FR D) 5725A -400V supply overI
224 (DDE:FRS ) Output tripped to standby
225 (DDE:FR D) 5725A fan not working
226 (DDE:FR D) 5725A CLAMPS fault
227 (DDE:FRS ) Output tripped to standby
228 (DDE:FR D) 5725A software TRAP
229 (DDE:FR D) 5725A cable was off
230 (DDE:FR D) 5725A RESET
231 (DDE:FR D) 5725A guard-crossing timeout
232 (DDE:FR D) 5725A illegal command
233 (DDE:FR D) 5725A non-maskable interrupt
234 (DDE:FR D) 5725A HVCLEAR tripped
235 (DDE:FRS ) Output tripped to standby
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
    
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316 (DDE:FR ) Open thermocouple for RJ cal
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
404 (DDE:FR D) Queue from 5725A full
405 (DDE:FR ) Message over display R side
406 (DDE:FR ) Unmappable character #%d [%d is an ASCII character]
407 (DDE:FR ) Encoder did not reset
408 (DDE:FR ) Encoder got invalid command
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 works only for 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
524 (DDE: ) Can't turn on the boost
525 (DDE: ) Can't turn off the boost
526 (DDE: ) Limit too small or large
527 (DDE: ) No changes except RESET now
528 (DDE:FR D) 5725A went away while in use
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

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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: ) -SC option not installed
600 (DDE:FR D) Outguard watchdog timeout
601 (DDE: ) 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 [%s is serial port]
801 (DDE:FR ) Serial framing error %s [%s is serial port]
802 (DDE:FR ) Serial overrun error %s [%s is serial port]
803 (DDE:FR ) Serial characters dropped %s [%s is serial port]
900 (DDE:FR ) Report timeout - aborted
1000 (DDE:FR ) Sequence failed during diag
1001 (DDE:FR ) Guard xing link diag fail
1002 (DDE:FR ) Inguard bus r/w diag fail
1003 (DDE:FR ) A6 A/D comm fault
1004 (DDE:FR ) A6 A/D or DAC fault
1005 (DDE:FR ) A6 DAC fine channel fault
1006 -1091 See "Diagnostic Error Messages"
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

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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
1500 (DDE:FRS) Compliance voltage exceeded
1501 (DDE:FRS) Shunt amp over or underload
1502 (DDE:FRS) Heat sink too hot
1503 (DDE:FRS) Output current lim exceeded
1504 (DDE:FRS) Input V or A limit exceeded
1600 (DDE:FR D) OPM transition error
1601 (DDE:FR D) TC measurement failure
1800 (DDE:FR) Unknown boost command
1801 (DDE:FR) BX not responding
65535 (DDE:FR) Unknown error %d [%d is unknown error number]

Chapter 5
List of Replaceable Parts

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5-2.	How to Obtain Parts.....	5-3
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5-1. Introduction

This chapter contains an illustrated list of replaceable parts for the **5500A Multi-Product Calibrator to the module level only**. 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. The parts lists give the following information:

- Reference designator
- An indication if the part is subject to damage by static discharge
- 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

Electrical components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the Fluke Corporation and its authorized representatives by using the part number under the heading FLUKE STOCK NO. To order components directly from Fluke Corporation, call (toll-free) 800-526-4731. Parts price information is available from the Fluke Corporation or its representatives.

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

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

5-3. How to Contact Fluke

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

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

Canada: 1-800-36-FLUKE (1-800-363-5853)

Europe: +31 402-675-200

Japan: +81-3-3434-0181

Singapore: +65-738-5655

Anywhere in the world: +1-425-446-5500

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



This instrument may contain a Nickel-Cadmium battery. Do not mix with the solid waste stream. Spent batteries should be disposed of by a qualified recycler or hazardous materials handler. Contact your authorized Fluke service center for recycling information.

5-4. Parts Lists

The following tables list the replaceable parts for the **5500A 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. The parts lists give the following information:

- Reference designator
- An indication if the part is subject to damage by static discharge
- 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.

Table 5-1. Chassis Assembly

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
A3	* MOTHERBOARD PCA	937375	1	
A5	* SYNTHESIZED IMPEDANCE PCA	937388	1	
A6	* DDS PCA	937391	1	
A7	* CURRENT PCA	937396	1	
A7A1	* LOW CURRENT AMPLIFIER PCA	945332	1	
A8	* VOLTAGE PCA	937404	1	
A12	* FILTER PCA	945337	1	
H1	SCREW,CAP,SCKT,SS,8-32,.375	295105	12	
H13	SCREW,FHU,P,LOCK,SS,6-32,.250	320093	20	
H58	SCREW,PH,P,LOCK,SS,6-32,.500	320051	12	
H70	SCREW,PH,P,LOCK,STL,6-32,.250	152140	38	
MP1	ASSEMBLY, CHASSIS, RIVETED	945175	1	
MP2	COVER, INSTRUMENT, TOP	937073	1	
MP3	COVER, INSTRUMENT, BOTTOM	937078	1	
MP4	COVER, ANALOG, TOP	937086	1	
MP6	EXTRUSION, SIDE	937271	2	
MP8	INSERT, PLASTIC SIDE	937276	2	
MP10	PUSH ROD	945241	1	
MP14	BOTTOM FOOT, MOLDED, GRAY #	868786	4	
MP25	AIDE,PCB PULL	541730	1	
MP26	LABEL,CALIB, CERTIFICATION SEAL	802306	1	
MP27	CABLE ACC,CLAMP,.187 ID,SCREW MOUNT	101345	1	
MP28	CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	1	

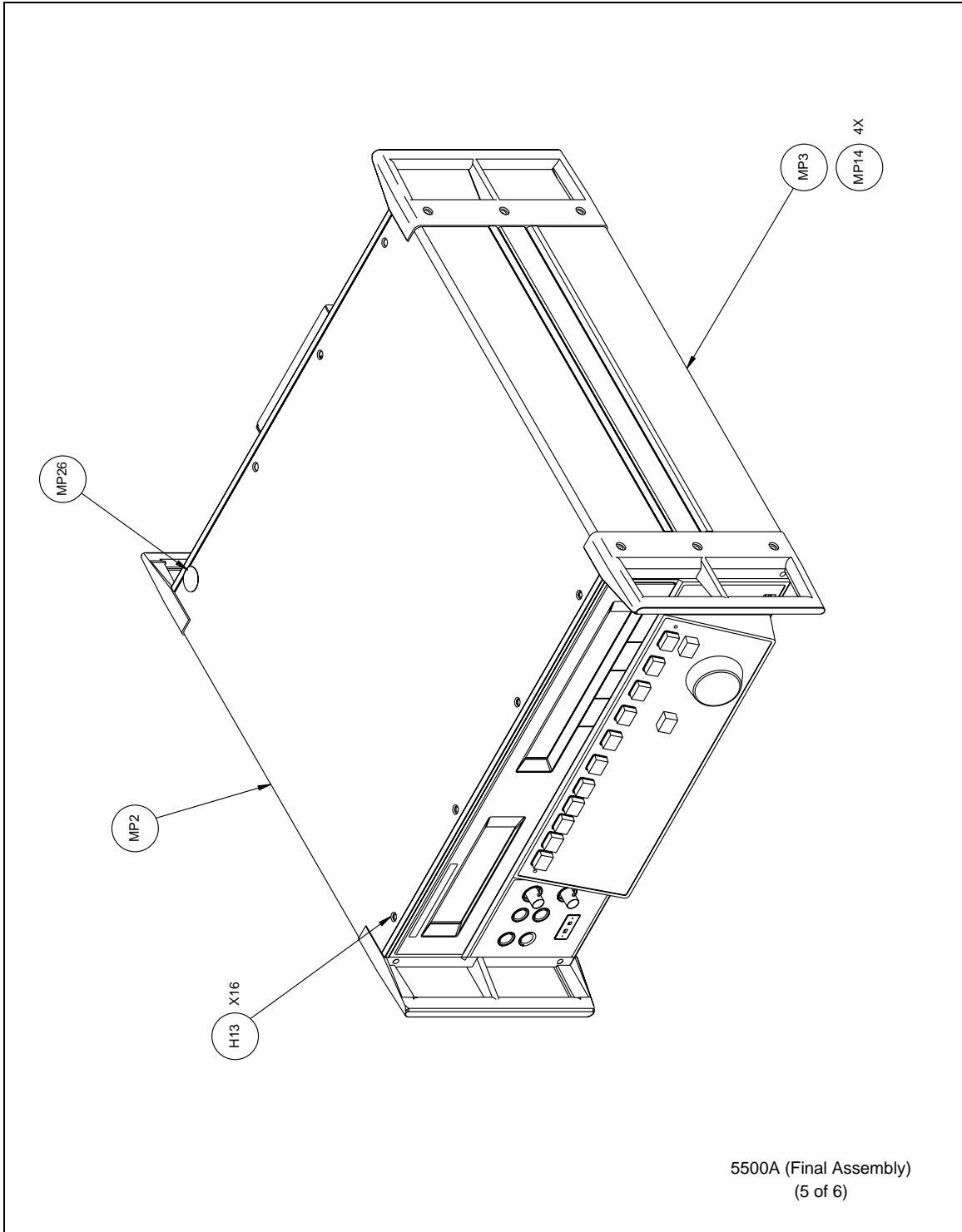
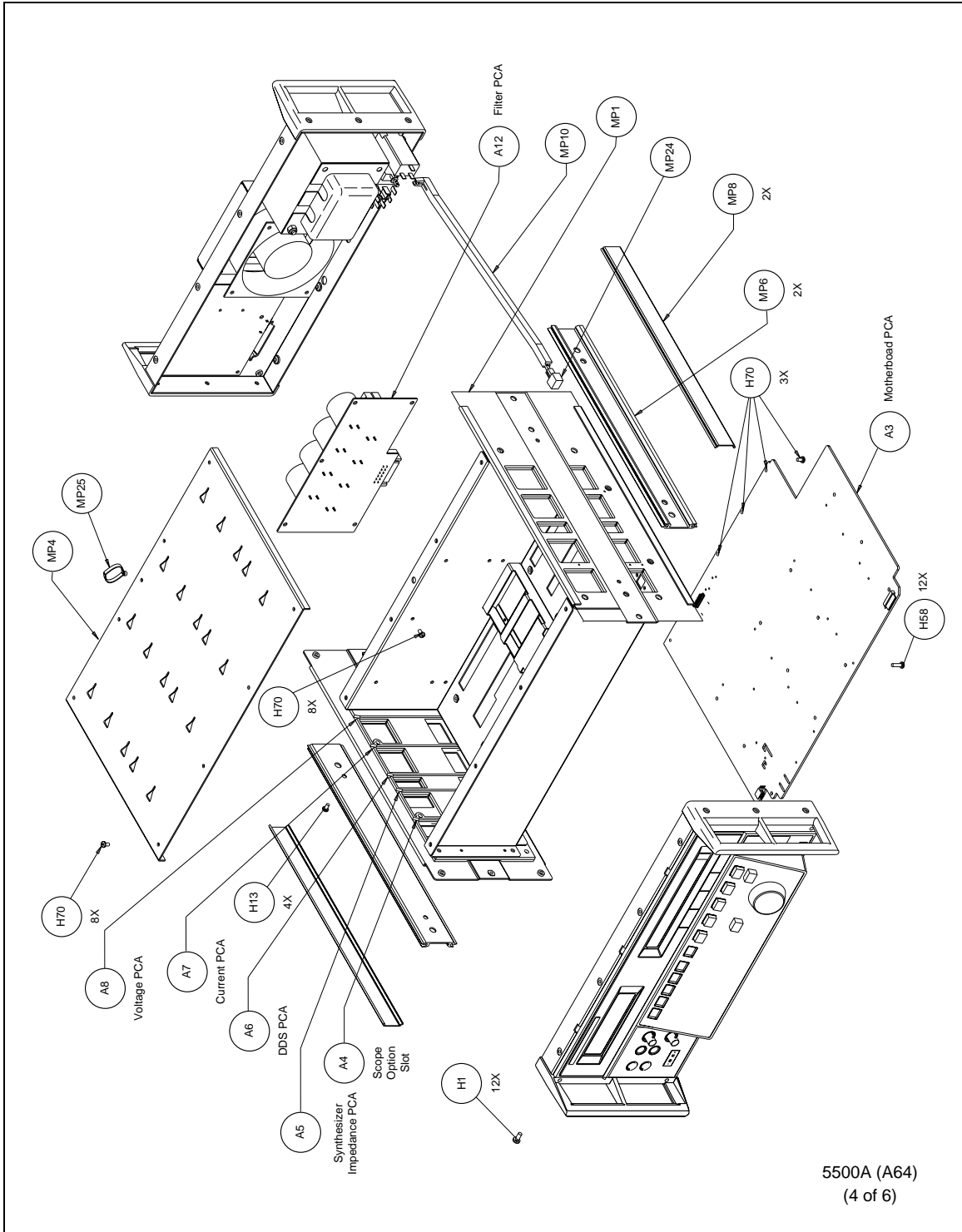


Figure 5-1. Chassis Assembly

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Figure 5-1. Chassis Assembly (cont)

Table 5-2. Front Panel Assembly

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
A1	* KEYBOARD PCA	761049	1	
A2	* ENCODER PCA	937370	1	
A10	* TC BUTTON PCA	945308	1	
A11	* TC CONNECTION PCA	945485	1	
TM2	PRINT MATL,REGISTRATION,CAL PROD,ENG	944822	1	
TM1	OPERATOR MANUAL	945159	1	
H1-14	SCREW,PH,P,LOCK,STL,6-32,.250	152140	19	
H15	SCREW,CAP,SCKT,SS,8-32,.375	295105	4	
H19	SCREW,PH,P,THD FORM,STL,5-20,.312	494641	11	
H34	SCREW,PH,P,LOCK,STL,8-32,.187	944785	2	
H38	WASHER, LOW THERMAL #8	859939	4	
H42	NUT, #8 LOW THERMAL	850334	4	
H46	SCREW,PH,P,LOCK,STL,6-32,.625	152181	4	
J1, J2	CONN,COAX,BNC(F),CABLE	412858	2	
MP1	FRONT PANEL, MODIFIED	937284	1	
MP2	PANEL, FRONT	883160	1	
MP3	HANDLE,INSTRUMENT, GRAY #7	886333	2	
MP4	GROMMET,EXTRUDED,POLYETHYLENE, .085	854351	1	
MP5	BEZEL, FRONT PANEL	945238	1	
MP6	OUTPUT BLOCK	945266	1	
MP8	DECAL, OUTPUT BLOCK	937263	1	
MP9	LENS, BEZEL	945246	1	
MP11	ADHESIVE, BEZEL	945258	1	
MP12	NAMEPLATE, ELECTROFORM	945261	1	
MP13	LCD MODULE,16X2 CHAR,TRANSMISSIVE	929179	1	
MP14	LCD MODULE,40X2 CHAR,TRANSMISSIVE	929182	1	
MP18	DECAL, POWER ON/OFF	886312	1	
MP19	CALIBRATION CERTIFICATION DECAL	891718	1	
MP20	DECAL, KEYPAD	886304	1	
MP21	ENCODER WHEEL	764548	1	
MP22	KNOB, ENCODER, GREY	868794	1	
MP23	BRACKET, BNC	945451	1	
MP24	POWER BUTTON, ON/OFF	775338	1	
MP25	CABLE ACCESS,TIE,4.00L, .10W, .75 DIA	172080	3	
S7	KEYPAD, ELASTOMERIC	1586654	1	
W1	CORD,LINE,5-15/IEC,3-18AWG,SVT,7.5 FT	284174	1	
W17	CABLE, OUTPUT BLOCK TO MOTHER BOARD	945365	1	

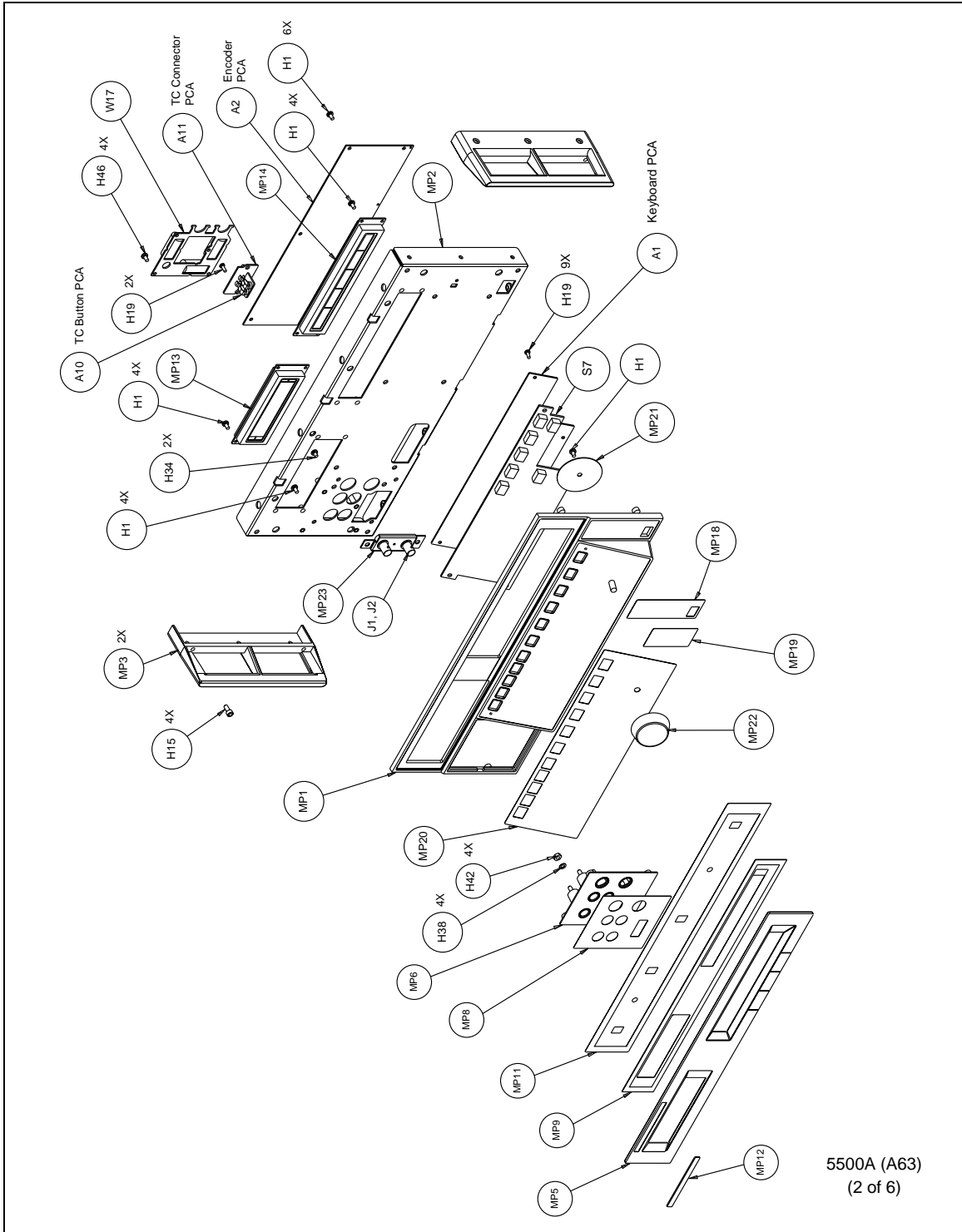
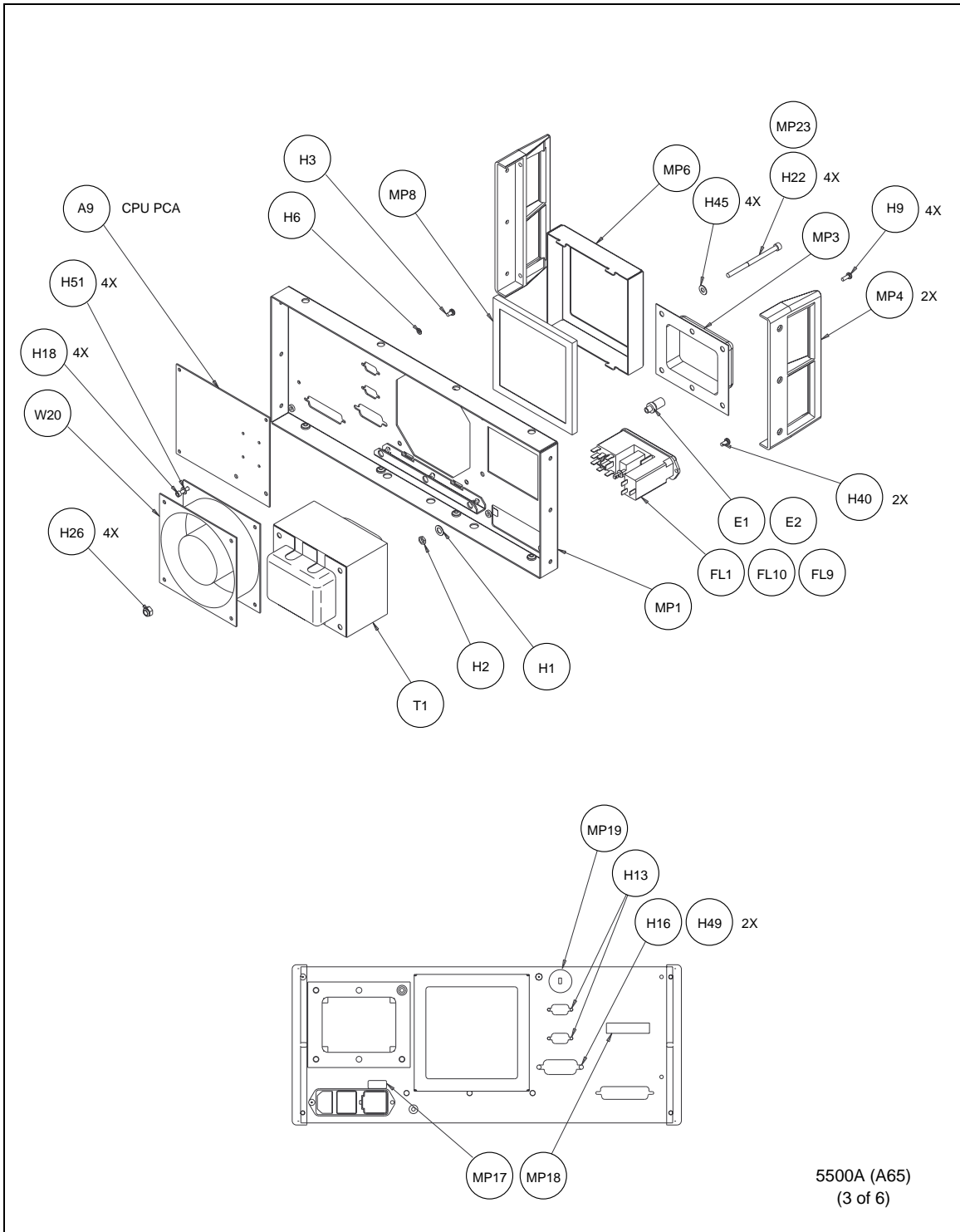


Figure 5-2. Front Panel Assembly

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Table 5-3. Rear Panel Assembly

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
A9	* CPU PCA	937409	1	
E1	BINDING HEAD, PLATED	102889	1	
E2	BINDING POST, STUD, PLATED	102707	1	
△F1	FUSE,.25X1.25,2.5A,250V,SLOW	851931	1	1
△F2, F3	FUSE,.25X1.25,1.25A,250V,SLOW	851936	2	2
FL1	FILTER,LINE,250VAC,4A,W/ENTRY MODULE	944269	1	
FL9	FILTER,LINE,PART,VOLTAGE SELECTOR	944272	1	
FL10	FILTER,LINE,PART,FUSE DRWR W/SHRT BAR	944277	1	
H1	WASHER,LOCK,INTRNL,STL,.267ID	110817	1	
H2	NUT,HEX,BR,1/4-28	110619	1	
H3	SCREW,PH,P,LOCK,STL,6-32,.250	152140	3	
H6	WASHER,FLAT,STL,.160,.281,.010	111005	3	
H9	SCREW,CAP,SCKT,SS,8-32,.375	295105	4	
H13	CONN ACC,D-SUB,JACKSCREW KIT,.250 L	944715	2	
H16	CONN ACC,MICRO-RIBBON,SCREW LOCK	854737	2	
H18	SCREW,CAP,SCKT,STL,LOCK,6-32,.750	944772	4	
H22	SCREW,HHI,H,SS,10-32,3.25	944459	4	
H26	NUT,HEX,ELASTIC STOP,STL,10-32,.375	944350	4	
H40	SCREW,FHU,P,SS,6-32,.312	867234	2	
H45	WASHER,FLAT,STL,.203,.434,.031	110262	4	
H49	WASHER,FLAT,STL,.191,.289,.010	111047	2	
H51	WASHER,FLAT,STL,.170,.375,.031	110288	4	
MP1	PANEL, REAR	883165	1	
MP3	COVER, TRANSFORMER	104353	1	
MP4	HANDLE,INSTRUMENT, GRAY #7	886333	2	
MP6	HOUSING, AIR FILTER	937107	1	
MP8	AIR FILTER	945287	1	
MP17	DECAL, CSA	864470	1	
MP18	LABEL,ADHES,VINYL,1.500,.312	844712	1	
MP19	LABEL,CALIB, CERTIFICATION SEAL	802306	1	
MP20	CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	2	
MP22	LABEL,MYLAR,GROUND SYMBOL	911388	1	
MP23	SLEEV,POLYOL,SHRINK,.187-.093ID,BLACK	113852	1	
T1	TRANSFORMER, POWER, MAIN	937128	1	
W20	FAN ASSEMBLY	881789	1	
W22	WIRE, GROUND	945456	1	
Notes				
1. For 100V and 120V units only.				
2. For 240V units only.				



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Figure 5-3. Rear Panel Assembly

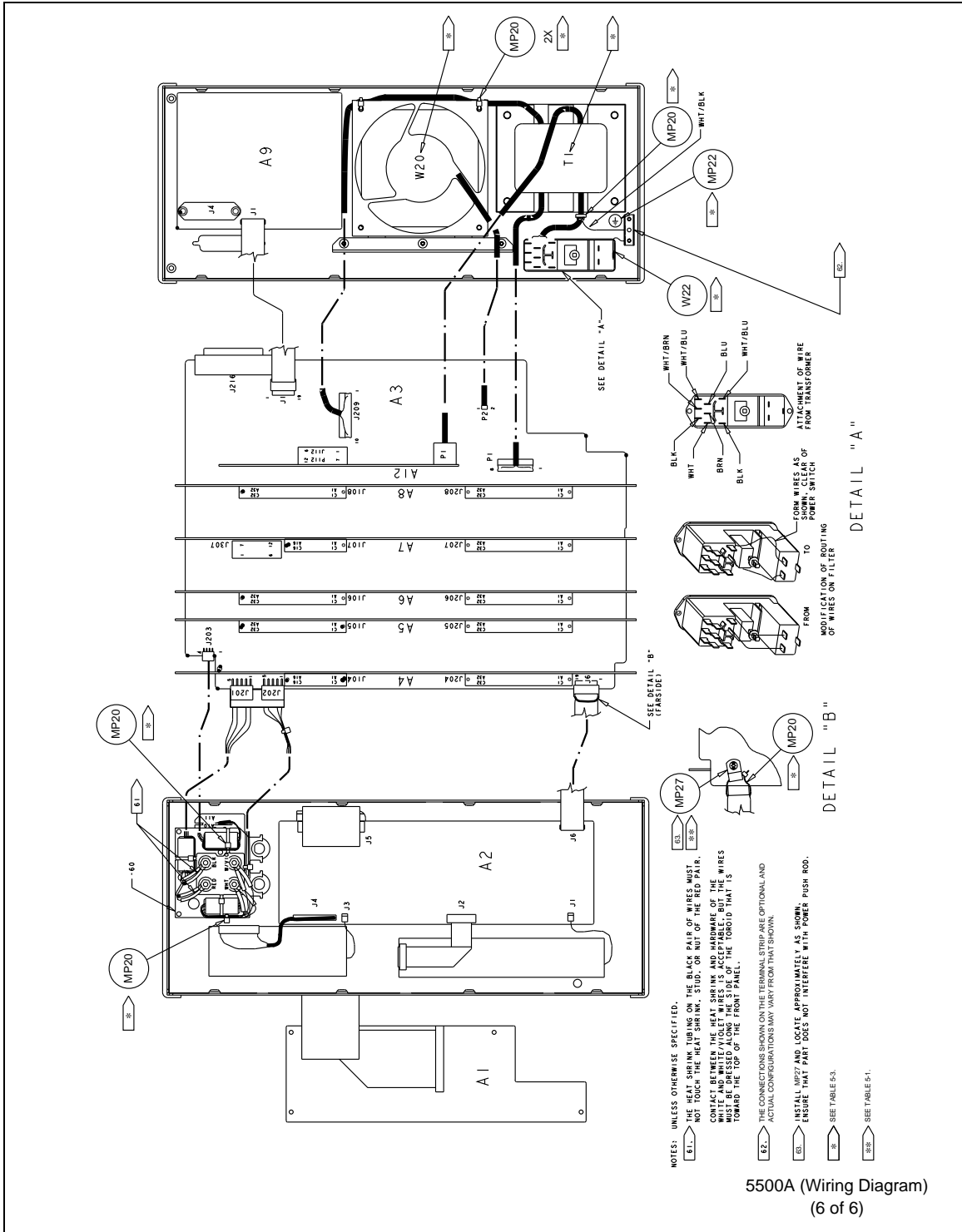


Figure 5-4. Wiring Diagram

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Chapter 6

Oscilloscope Calibration Options

- Option 5500A-SC600: see page 6-3.
- Option 5500A-SC300: see page 6-65.

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

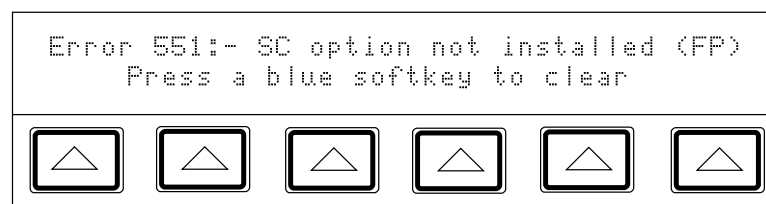
The calibration and verification procedures provide traceable results for all of the SC600 functions as long as they are performed using the recommended equipment. All of the required equipment along with the minimum specifications, are provided in Table 6-15 under “Equipment Requirements for Calibration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



OM0301.EPS

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 MΩ Load	50 Ω Load	1 MΩ 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 μV 10 μV 100 μV 1 mV 10 mV	
Adjustment Range	Continuously adjustable			
1-Year Absolute Uncertainty, tcal ± 5 °C	± (0.25% of output + 40 μV)	± (0.05% of output + 40 μV)	± (0.25% of output + 40 μV)	± (0.1% of output + 40 μV) [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 °C	± (2.5 ppm of setting)			
Typical Aberration within 4 μs from 50% of leading/trailing edge	< (0.5% of output + 100 μV)			
[1] Selectable positive or negative, zero referenced square wave.				
[2] For square wave frequencies above 1 kHz, ± (0.25% of output + 40 μV).				

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 50 Ω	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 $\pm 5^\circ\text{C}$	\pm (2% of output + 300 μV)	\pm (3.5% of output + 300 μV)	\pm (4% of output + 300 μV)	\pm (6% of output + 300 μV)
Flatness (relative to 50 kHz)	not applicable	\pm (1.5% of output + 100 μV)	\pm (2% of output + 100 μV)	\pm (4% of output + 100 μV)
Short-Term Amplitude Stability	$\leq 1\%$ [1]			
Frequency Characteristics				
Resolution	10 kHz			
1-Year Absolute Uncertainty, tcal $\pm 5^\circ\text{C}$	± 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 $\pm 5^\circ\text{C}$.				

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 [3]	±(25 + t * 1000) ppm [1]	± 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 [2]	> 1 V p-p [2]	> 1 V p-p [2]	>1 V p-p [2]	> 1 V p-p
Typical Jitter (rms)	<10 ppm	< 1 ppm	< 1 ppm	<1 ppm	<1 ppm
Sequence (cardinal points)	5-2-1 from 5 s to 2 ns (e.g., 500 ms, 200 ms, 100 ms)				
Adjustment Range	At least ± 10% around each cardinal points.				
Amplitude Resolution	4 digits				
[1] t is time in seconds. Examples: At 5 s the uncertainty is 5,025 ppm; At 50 ms the uncertainty is 75 ppm. [2] Typical rise time of square wave and 20%-pulse (20% duty cycle pulse) is < 1.5 ns. [3] Away from the cardinal points, add ±50 ppm to uncertainty.					

6-8. Wave Generator Specifications

Table 6-5. Wave Generator Specifications

Wave Generator Characteristics	Square Wave, Sine Wave, and Triangle Wave into 50Ω 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 50Ω (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	50 Ω	1 MΩ
Measurement Range	40 Ω to 60 Ω	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. Pulse Generator Modes 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)

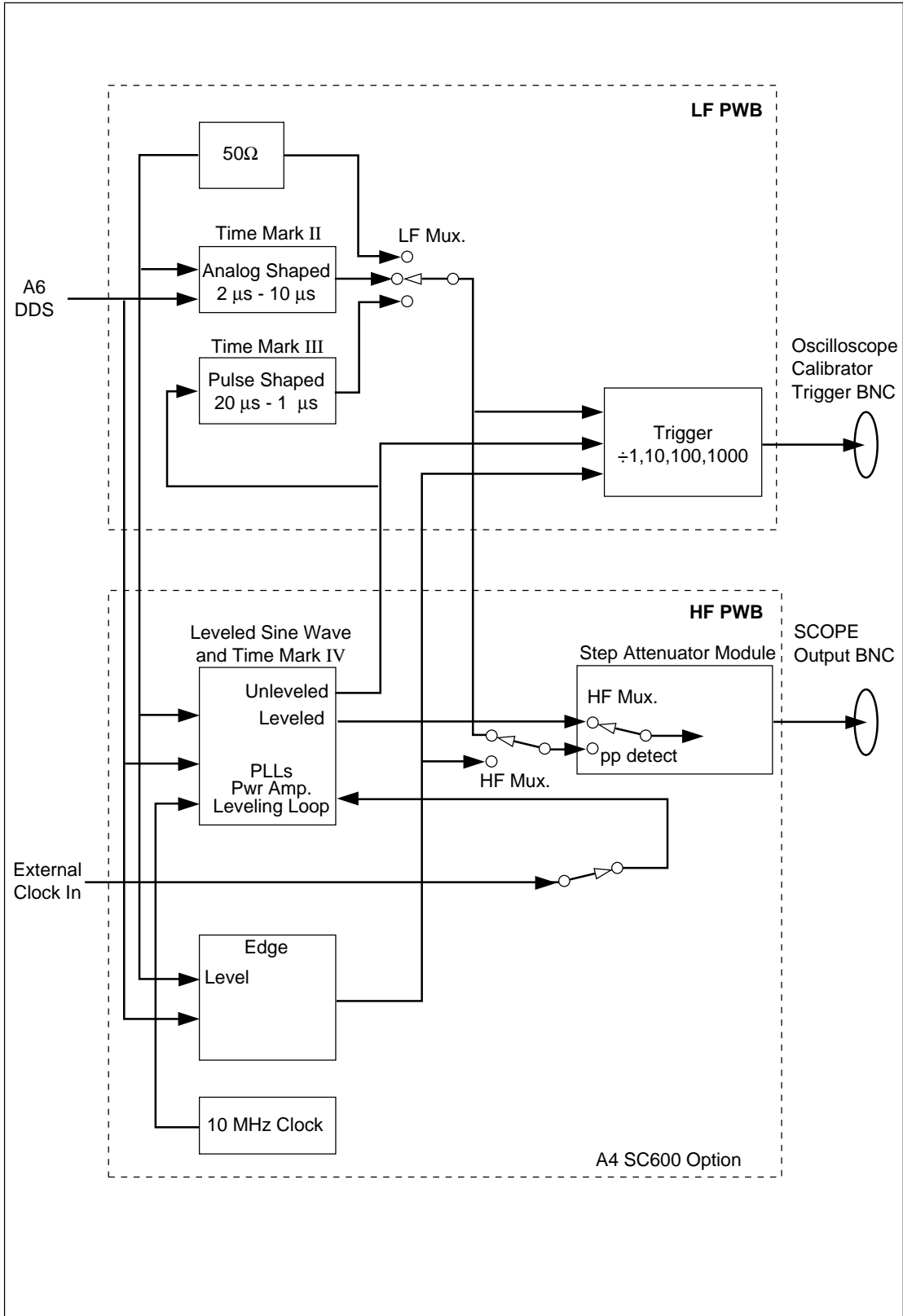
The reference resistors for this mode are on the A50 board, while the DCV reference signal and measuring signals are on the A6 DDS board.

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.



om031f.eps

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 Standard	Fluke 5790A with -03 option	Range	5 mV p-p to 5.5 V p-p
		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 E4418A	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. For these signals, lock the HP 3458A to the 1V range.

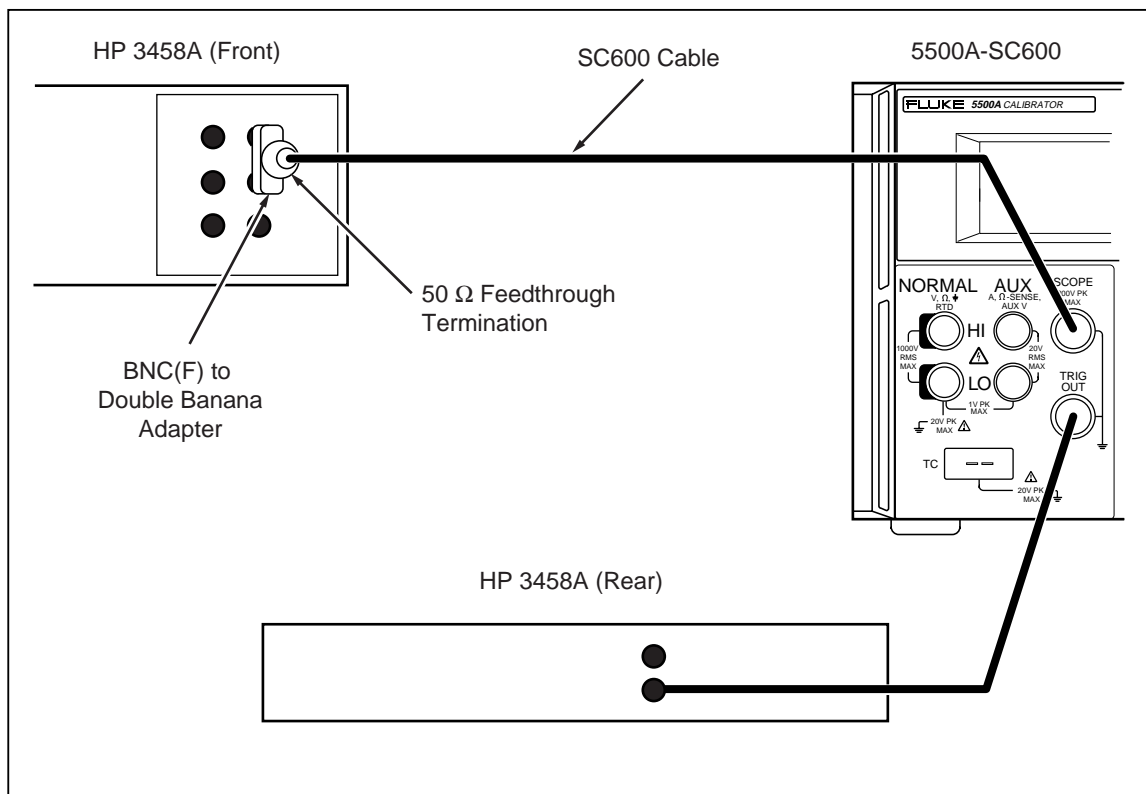


Figure 6-2. Equipment Setup for SC600 Voltage Square Wave Measurements

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

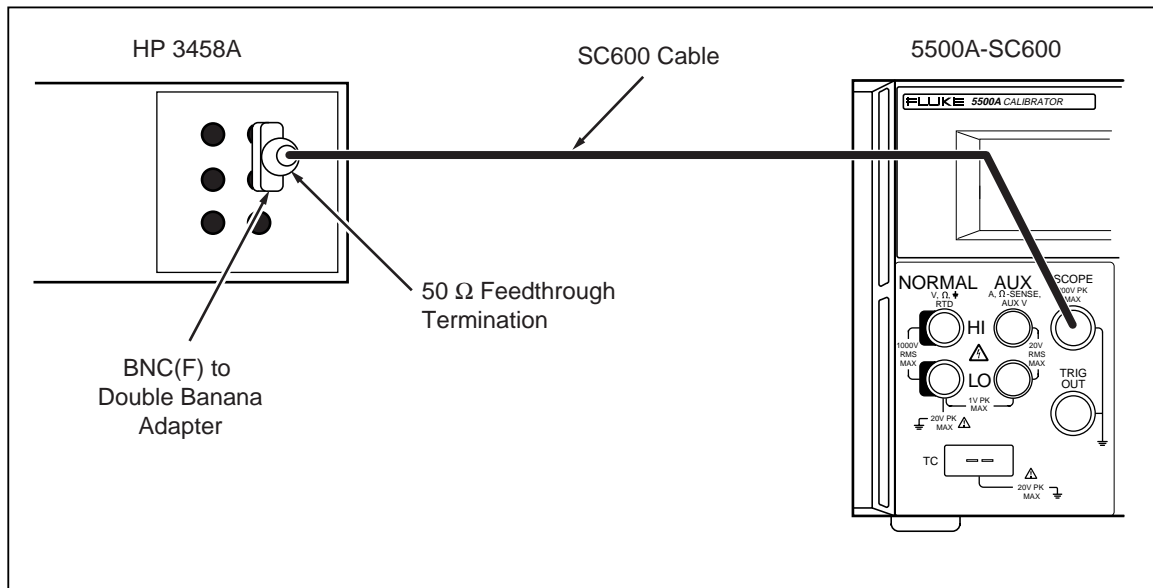


Figure 6-3. Equipment Setup for SC600 Edge and Wave Gen Square Wave Measurements.

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. R121 is a square, single-turn pot and is marked on the board located near Q29.
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
- 50Ω 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 0 V, 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

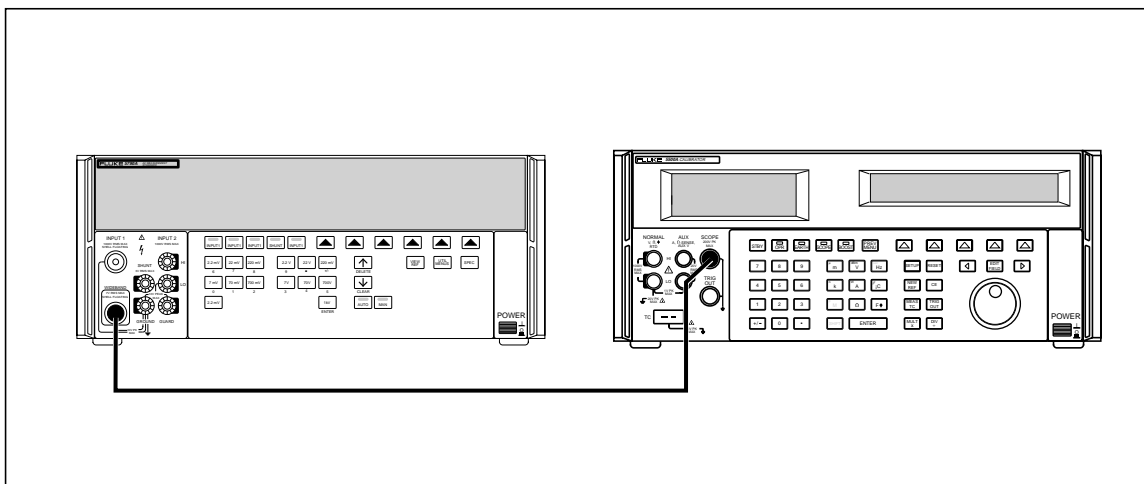
Press the **OPTIONS** and **NEXT SECTION** blue softkeys until the display reads “Set up to measure leveled sine amplitude”. Then follow these steps to calibrate Leveled Sine Wave amplitude.

1. Connect the BNC cable to the Calibrator Mainframe’s SCOPE connector. Connect the other end of the BNC cable to the 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. 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.

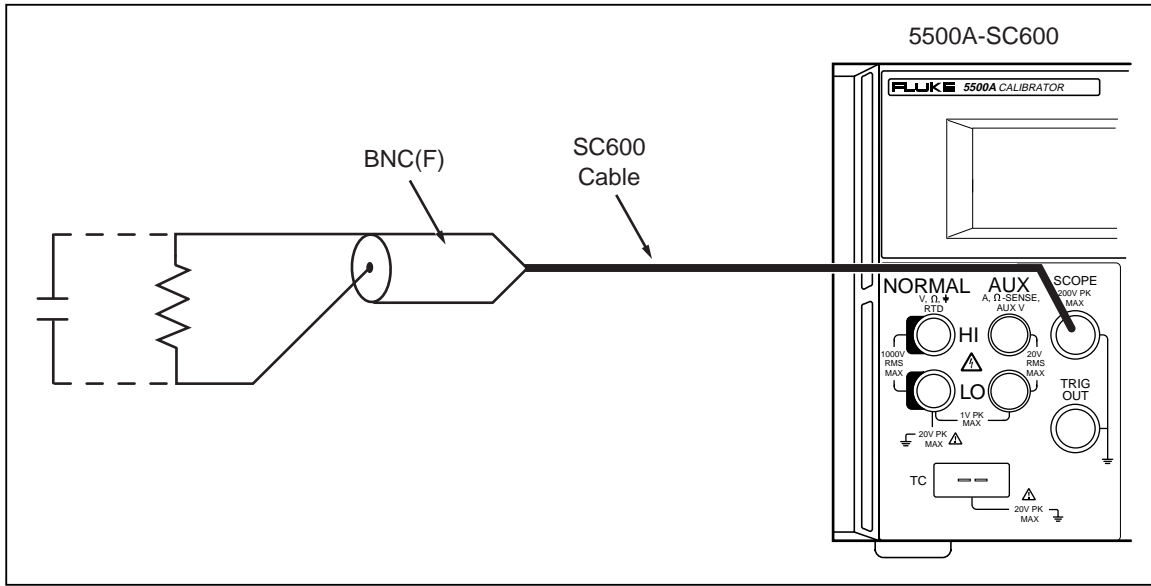


Figure 6-5. MeasZ Function Calibration Setup

Set the Calibrator Mainframe in Scope Cal mode at the prompt to connect a 50Ω 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 $(0.5 * (50 + Rload) / Rload)$, where Rload = 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 50Ω

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 MΩ

For the 1 MΩ 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 MΩ. (The blue softkey under Output @ toggles the impedance between 50 Ω and 1 MΩ.)

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 M Ω

Calibrator Mainframe Output (1 kHz, or as noted)	HP 3458A Range	Topline Reading	Baseline Reading	Peak-to-Peak	Tolerance (\pm 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 50Ω

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

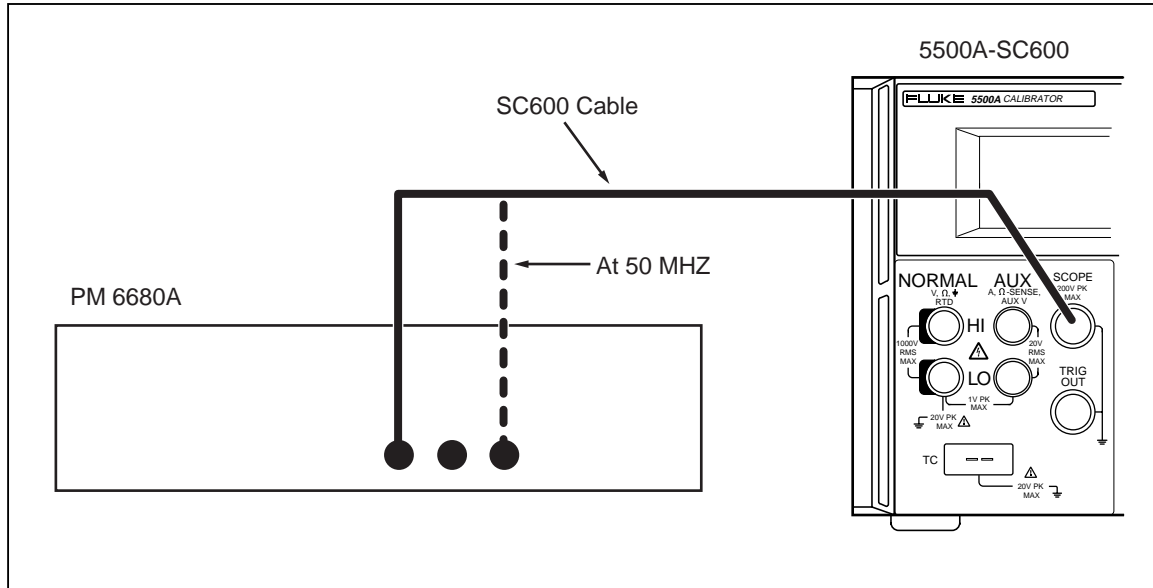


Figure 6-6. AC Voltage Frequency Verification Setup

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, 50Ω 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% ± 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.

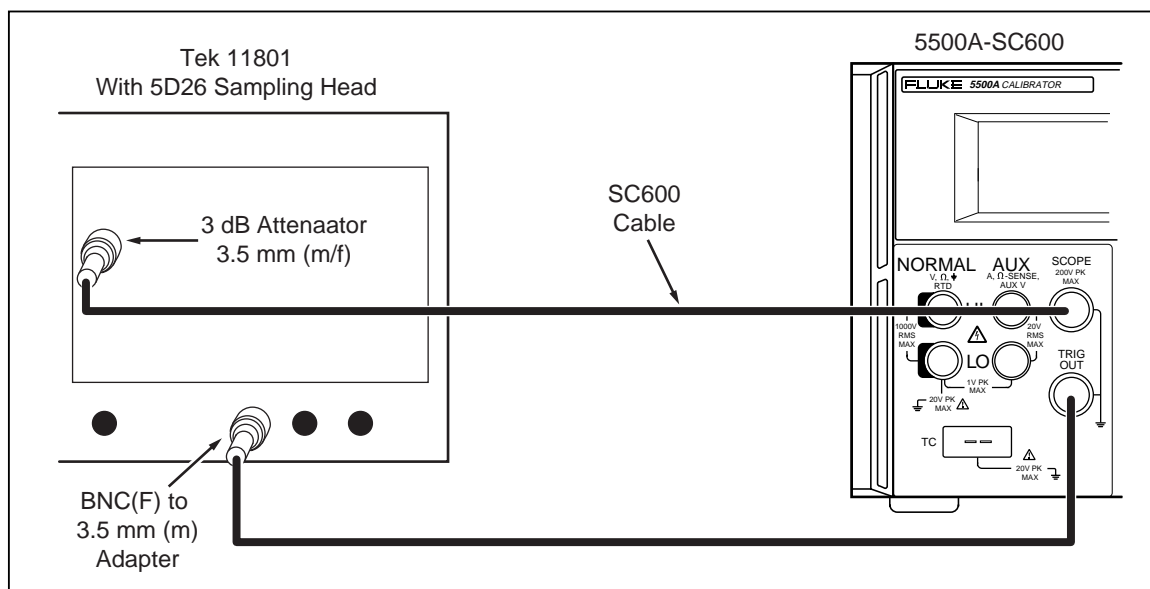


Figure 6-7. Edge Rise Time Verification Setup

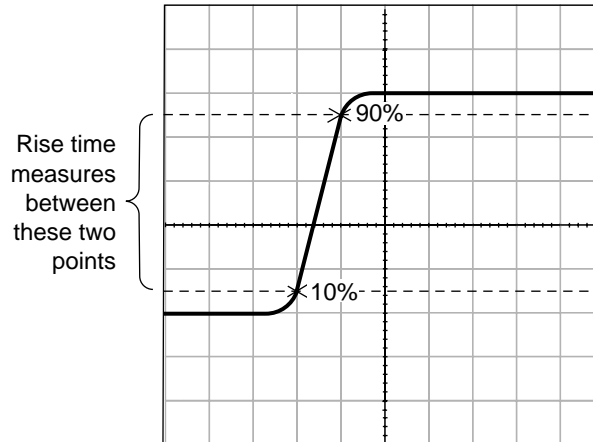
The Calibrator Mainframe should be in SCOPE mode, with the Edge menu on the display. Press **OPR** on the Calibrator Mainframe to activate the output. Press the softkey under TRIG to select the TRIG/1 External Trigger output. Program the Calibrator Mainframe to output 250 mV @ 1 kHz. Set the DSO to these 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 MHz	20.0			<300 ps
250 mV	10 MHz	20.0			<350 ps
500 mV	1 MHz	50.0			<300 ps
500 mV	10 MHz	50.0			<350 ps
1 V	1 MHz	100.0			<300 ps
1 V	10 MHz	100.0			<350 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 5500A-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 50Ω 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.

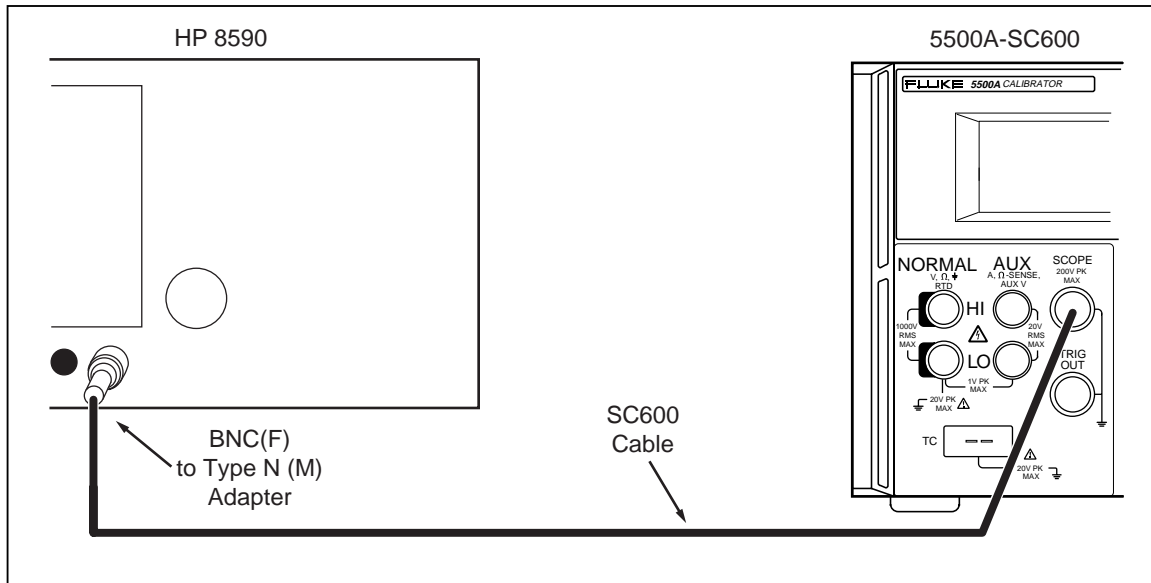


Figure 6-9. Leveled Sine Wave Harmonics Verification Setup

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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

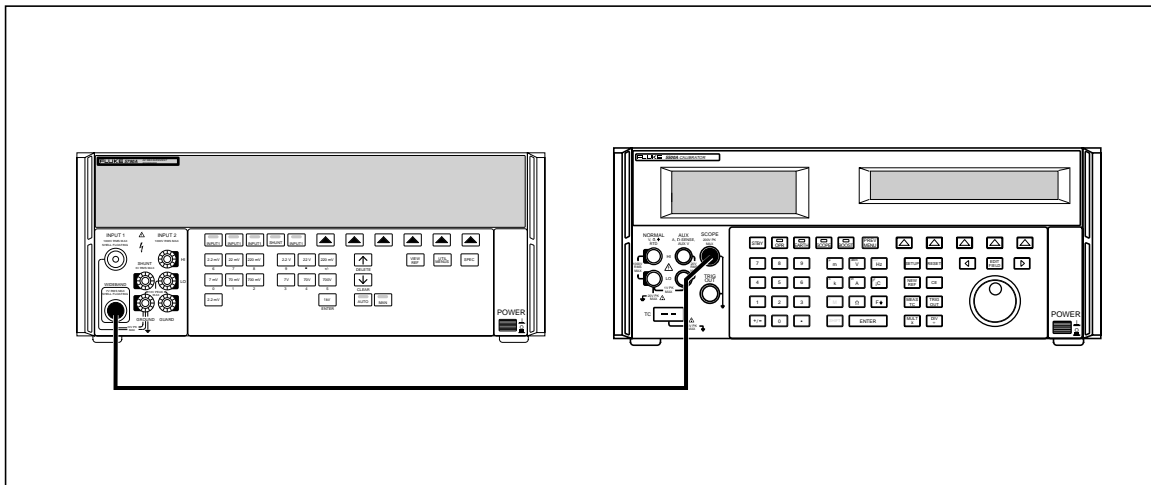
Leveled Sine Wave flatness verification is divided into two frequency bands: 50 kHz to 10 MHz (low frequency) and >10 MHz to 600 MHz (high frequency). The equipment setups are different for each band. Leveled Sine Wave flatness is measured relative to 50 kHz. This is determined directly in the low frequency 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 E4418A Power Meter
- Hewlett-Packard 8482A and 8481D Power Sensors
- BNC(f) to Type N(f) adapter
- BNC cable supplied with the Calibrator Mainframe

Note

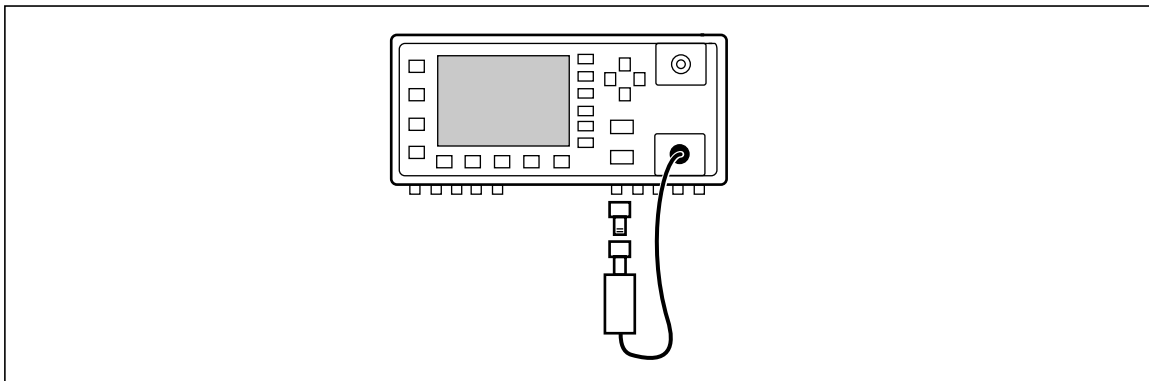
When high frequencies at voltages below 63 mV p-p are verified, use the 8481D Power Sensor. Otherwise, use the 8482A Power Sensor.

Connect the HP E4418A 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.

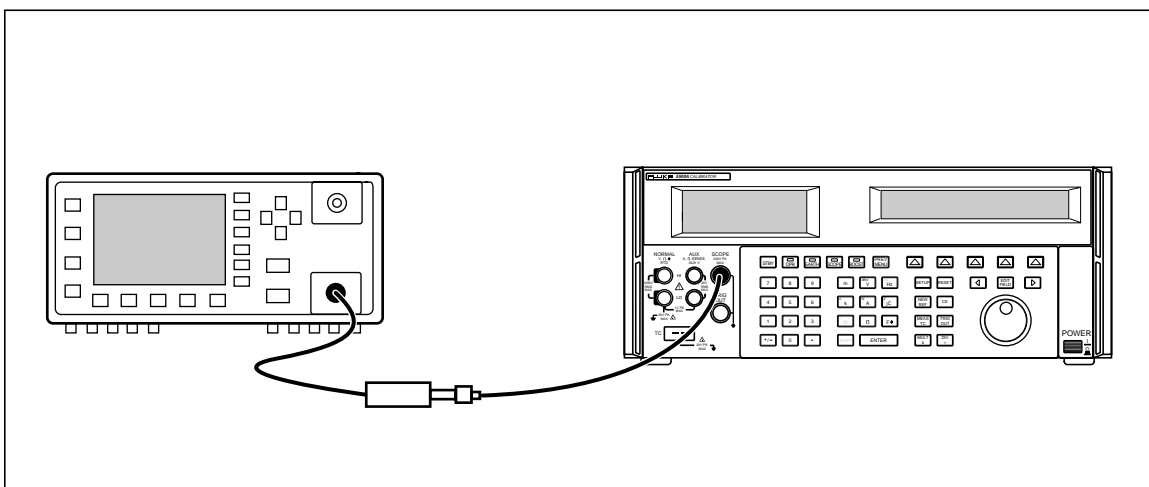
The Hewlett-Packard E4418A Power Meter must be configured by setting the parameters listed below. Zero and self-calibrate the power meter with the power sensor being used. Refer to the Hewlett-Packard E4418A operators manual for details.

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



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Figure 6-11. Connecting the HP E4418A 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 E 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	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-E as follows: A Enter the E4418A present frequency Reading (W). B Enter the E4418A 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 (%): $100 * (\text{sqrt}(\text{Column C entry}) - \text{sqrt}(\text{Column D entry})) / \text{sqrt}(\text{Column D entry})$.						

Table 6-34. High Frequency Flatness Verification at 7.5 mV

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	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-E as follows: A Enter the E4418A present frequency Reading (W). B Enter the E4418A 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 (%): $100 * (\sqrt{\text{Column C entry}} - \sqrt{\text{Column D entry}}) / \sqrt{\text{Column D entry}}$.						

Table 6-35. High Frequency Flatness Verification at 25 mV

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	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-E as follows: A Enter the E4418A present frequency Reading (W). B Enter the E4418A 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 (%): $100 * (\sqrt{\text{Column C entry}} - \sqrt{\text{Column D entry}}) / \sqrt{\text{Column D entry}}$.						

Table 6-36. High Frequency Flatness Verification at 70 mV

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	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-E as follows: A Enter the E4418A present frequency Reading (W). B Enter the E4418A 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 (%): $100 * (\text{sqrt}(\text{Column C entry}) - \text{sqrt}(\text{Column D entry})) / \text{sqrt}(\text{Column D entry})$.						

Table 6-37. High Frequency Flatness Verification at 250 mV

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	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-E as follows: A Enter the E4418A present frequency Reading (W). B Enter the E4418A 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 (%): $100 * (\text{sqrt}(\text{Column C entry}) - \text{sqrt}(\text{Column D entry})) / \text{sqrt}(\text{Column D entry})$.						

Table 6-38. High Frequency Flatness Verification at 800 mV

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	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-E as follows: A Enter the E4418A present frequency Reading (W). B Enter the E4418A 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 (%): $100 * (\text{sqrt}(\text{Column C entry}) - \text{sqrt}(\text{Column D entry})) / \text{sqrt}(\text{Column D entry})$.						

Table 6-39. High Frequency Flatness Verification at 3.4 V

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	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-E as follows: A Enter the E4418A present frequency Reading (W). B Enter the E4418A 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 (%): $100 * (\text{sqrt}(\text{Column C entry}) - \text{sqrt}(\text{Column D entry})) / \text{sqrt}(\text{Column D entry})$.						

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 50Ω 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 6-40.

1. Program the Calibrator Mainframe to the output as listed in Table 6-40.
2. Using the BNC cable, connect the SCOPE connector on the Calibrator Mainframe to the PM 6680 at the channel indicated in Table 6-40. 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 6-40. Time Marker Verification

Calibrator Mainframe Period	PM 6680 Settings		PM 6680 Reading (Frequency)	1	Tolerance
	Channel	Filter		PM 6680 Reading (Period)	
4.979 s	A	On			24.91E-3 s
2.002 s	A	On			4.06E-3 s
50.0 ms	A	Off			3.75E-6 s
20.0 ms	A	Off			50E-09 s
10.0 ms	A	Off			25E-09 s
50.0 μs	A	Off			125E-12 s
20.0 μs	A	Off			50E-12 s
10.0 μs	A	Off			25E-12 s
50.0 ns	A	Off			125E-15 s
20.0 ns	A	Off			50E-15 s
10.0 ns	A	Off			25E-15 s
5.00 ns	A	Off			12.5E-15 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

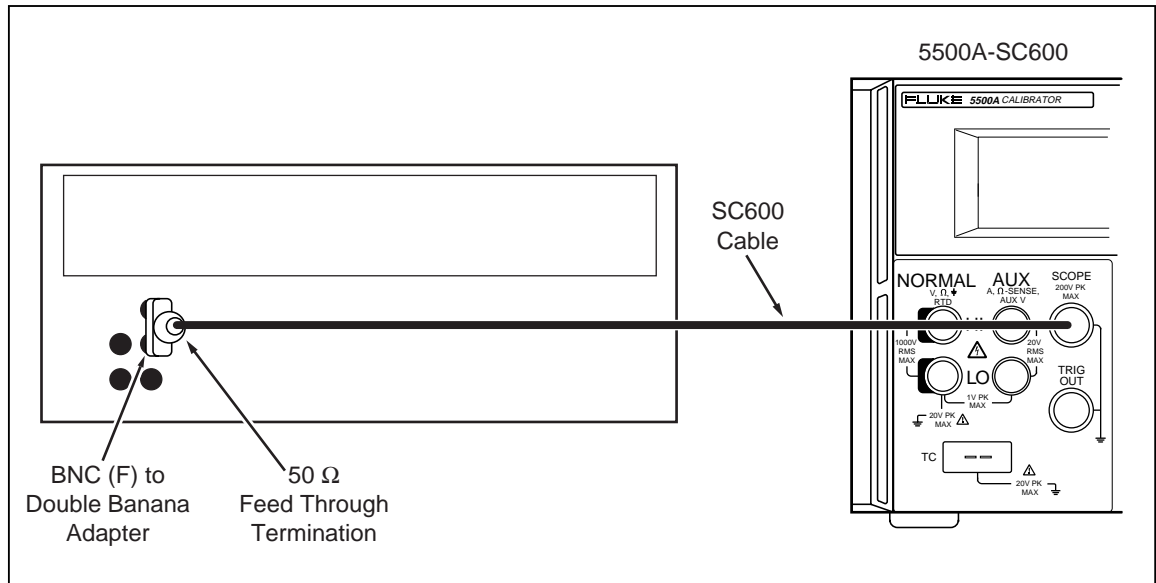


Figure 6-13. Wave Generator Verification Setup

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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 6-41.
4. Allow the 5790A reading to stabilize, then record the 5790A rms reading for each wave type and voltage in Table 6-41.

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 6-42.
4. Allow the 5790A reading to stabilize, then record the 5790A rms reading for each wave type and voltage in Table 6-42.
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 $(0.5 * (50 + Rload) / Rload)$, where Rload = the actual feedthrough termination resistance, to correct for the resistance error. Compare result to the tolerance column.

Table 6-41. 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	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 6-42. 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 6-43.
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 6-43.

Table 6-43. 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 6-44.
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 6-44.

Table 6-44. 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 6-45. (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 6-45. 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 6-45. Compare the Calibrator Mainframe resistance readings to the actual resistance values and the tolerance column of Table 6-45.

Table 6-45. 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 6-46.

- Allow the Calibrator Mainframe reading to stabilize, then record the Calibrator Mainframe capacitance reading for each nominal value listed in Table 6-46. Compare the Calibrator Mainframe capacitance readings to the actual capacitance values and the tolerance column of Table 6-46.

Table 6-46. 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.

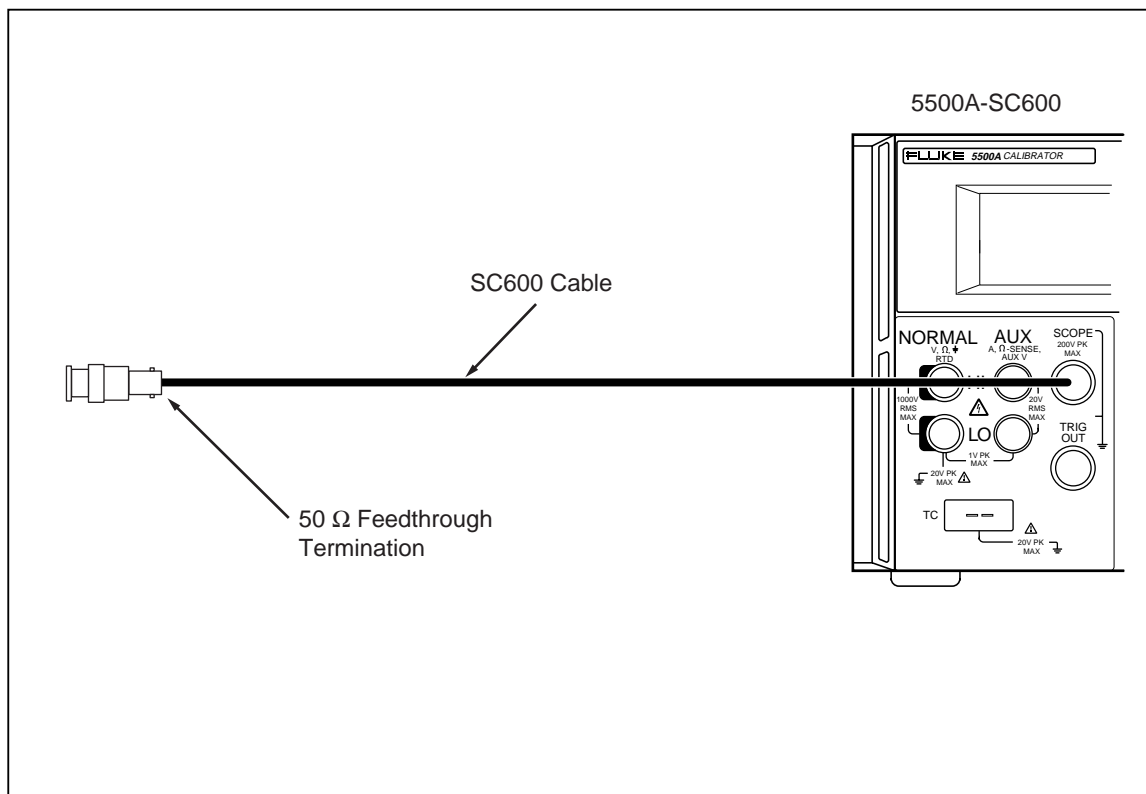


Figure 6-14. Overload Function Verification Setup

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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.

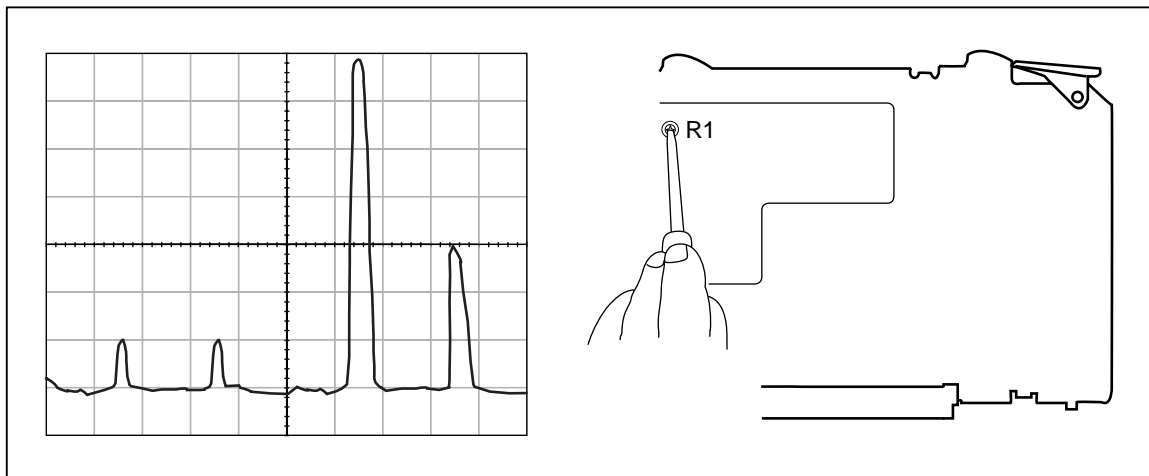


Figure 6-15. Adjusting the Leveled Sine Wave Balance

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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.

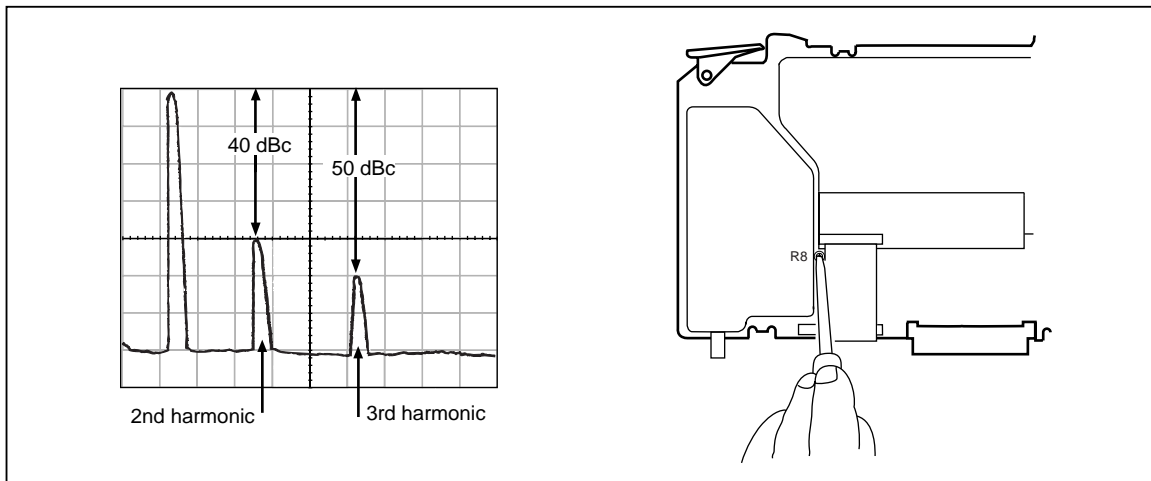


Figure 6-16. Adjusting the Leveled Sine Wave Harmonics

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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 <math><300\text{ ps}</math> at 250 mV, 1 V, and 2.5 V outputs.

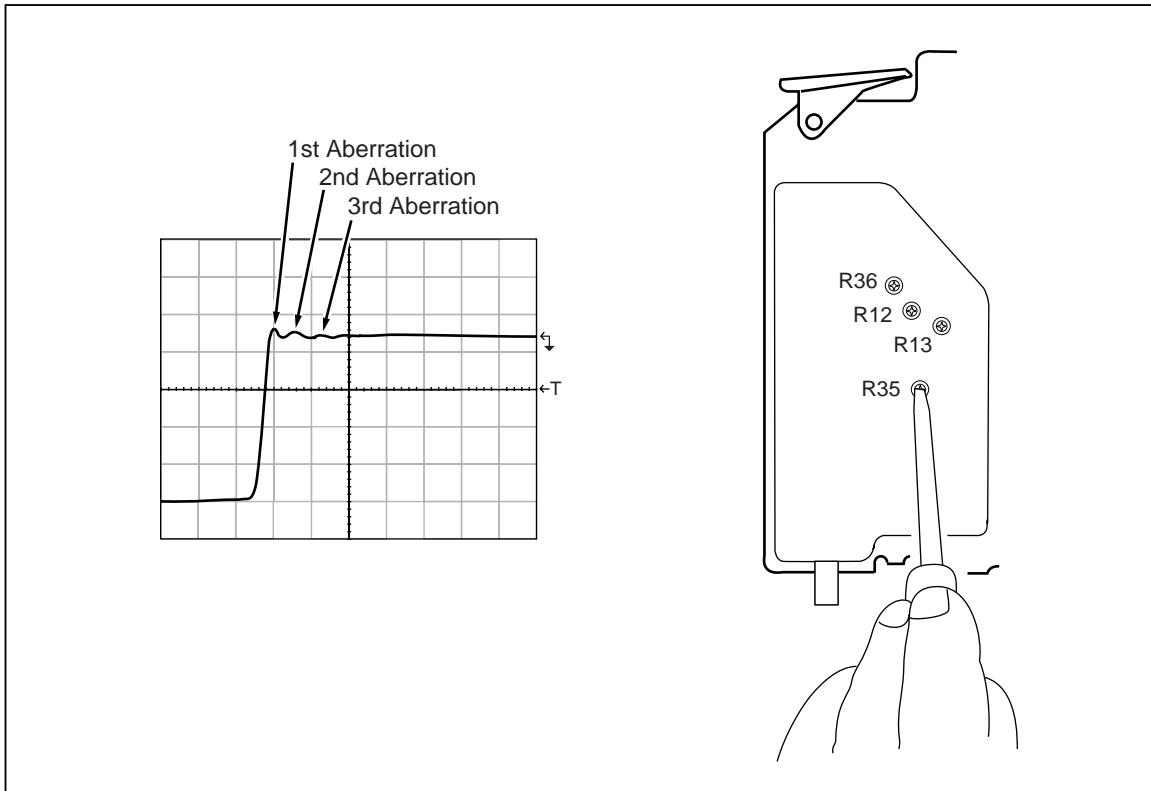


Figure 6-17. Adjusting Edge Aberrations

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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

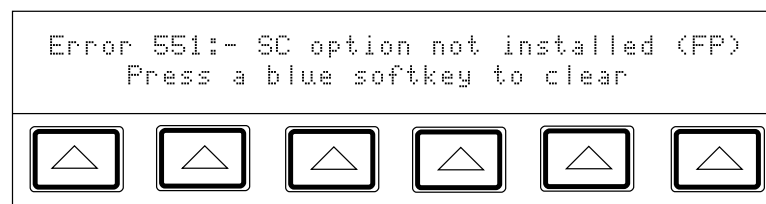
The calibration and verification procedures provide traceable results for all of the SC300 functions as long as they are performed using the recommended equipment. All of the required equipment along with the minimum specifications, are provided in Table 6-41 under “Equipment Required for Calibration 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, tcal ± 5 $^{\circ}$ 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, tcal ± 5 $^{\circ}$ C	$\pm (25$ ppm of setting + 15 mHz)			
Typical Aberration within 20 μ s from leading edge	< (2% of output + 100 μ V)			
<p>[1] The square wave signal into 1 MΩ 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.</p> <p>[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 μV). 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.</p> <p>[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.</p>				

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	< 400 ps	
Leading Edge Aberrations	within 10 ns	< (3% 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 50 Ω	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 [3]	±(25 + t*1000) ppm [1]	±(25 + t* 15,000) ppm [1]	± 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 [2]
Sequence (cardinal points)	5-2-1 from 5 s to 2 ns (e.g., 500 ms, 200 ms, 100 ms)			
Adjustment Range	At least ± 10% around each cardinal points.			
Resolution	4 digits			
[1] t is the time in seconds. Examples: At 5 s the uncertainty is 5,025 ppm; At 50 μs the uncertainty is 25.75 ppm. [2] The 2 ns time marker is typically > 0.5 V p-p. [3] Away from the cardinal points, add ± 50 ppm to uncertainty.				

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.

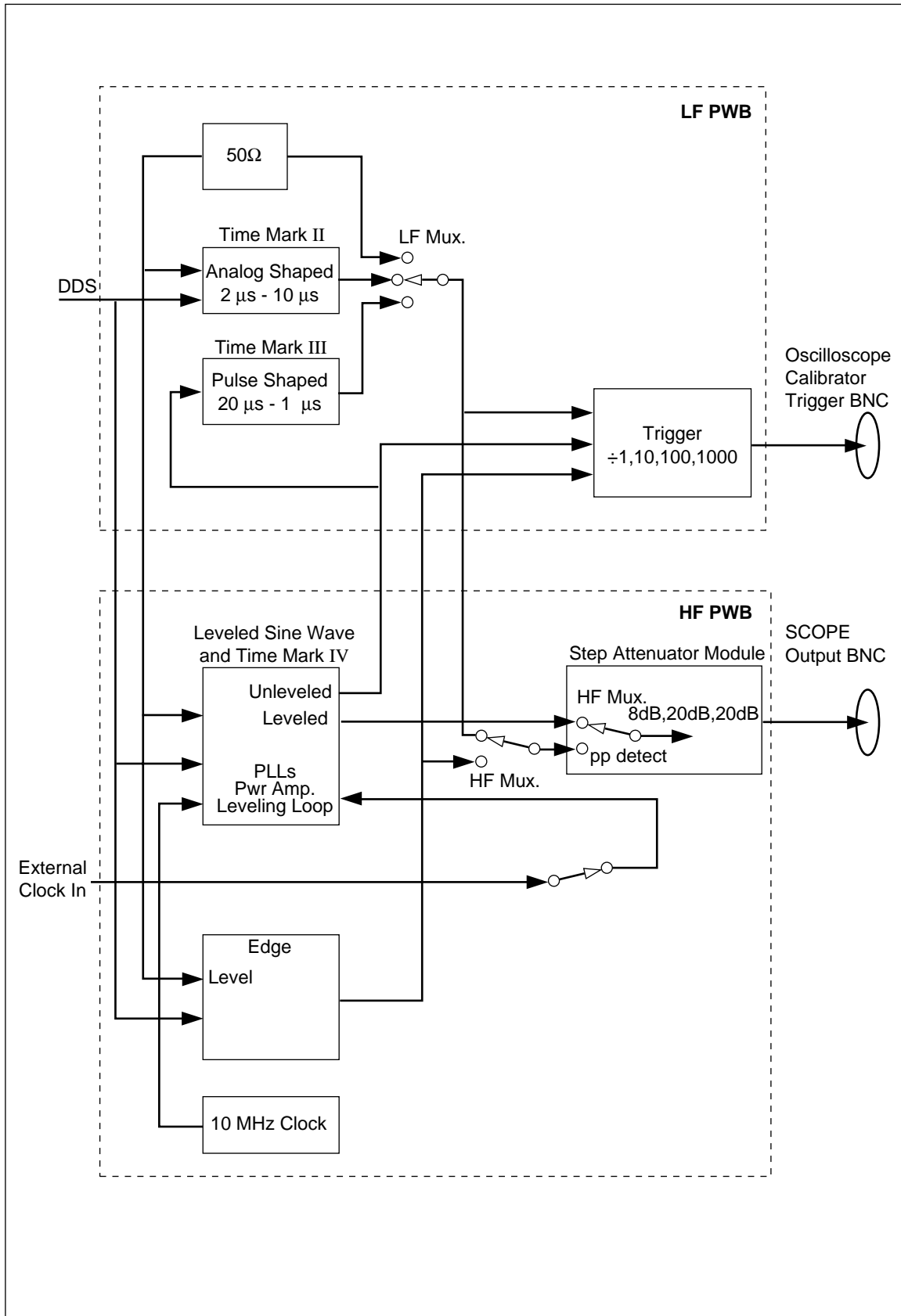


Figure 6-18. SC300 Block Diagram

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6-99. Equipment Required for Calibration and Verification

Table 6-47 lists the equipment, recommended models, and minimum specifications required for each calibration and verification procedure.

Table 6-47. 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 E4418A	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 ± 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 6-48 and Figure 6-19.

Table 6-48. 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.

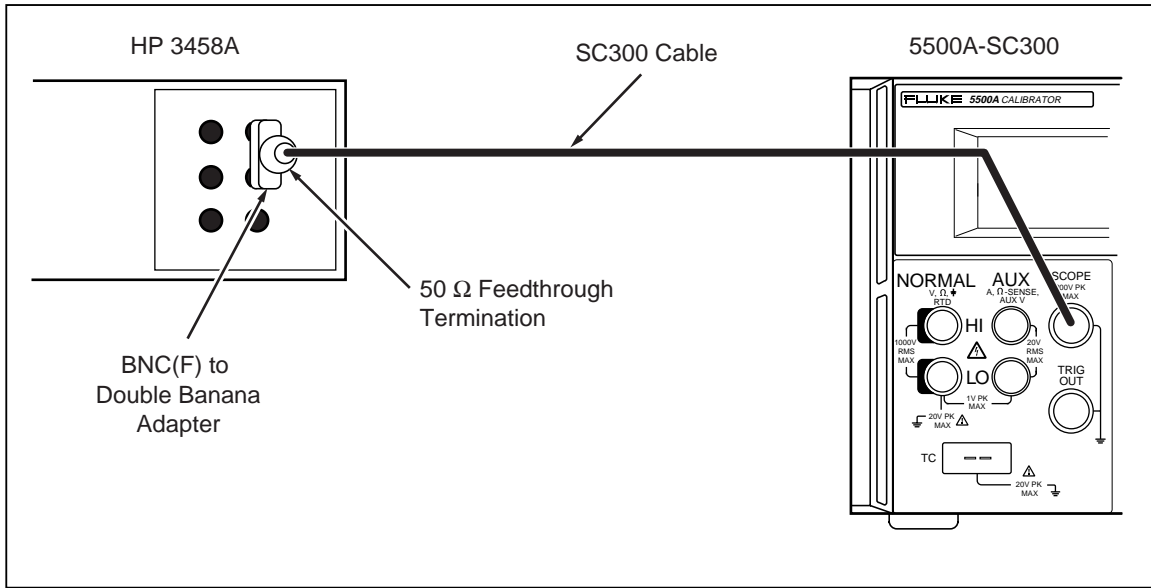


Figure 6-19. Equipment Setup for SC300 Square Wave Measurements.

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 $0.0 \text{ V DC} \pm 100 \mu\text{V}$.
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 $(0.5 * (50 + R_{load})/R_{load})$, where R_{load} = 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.

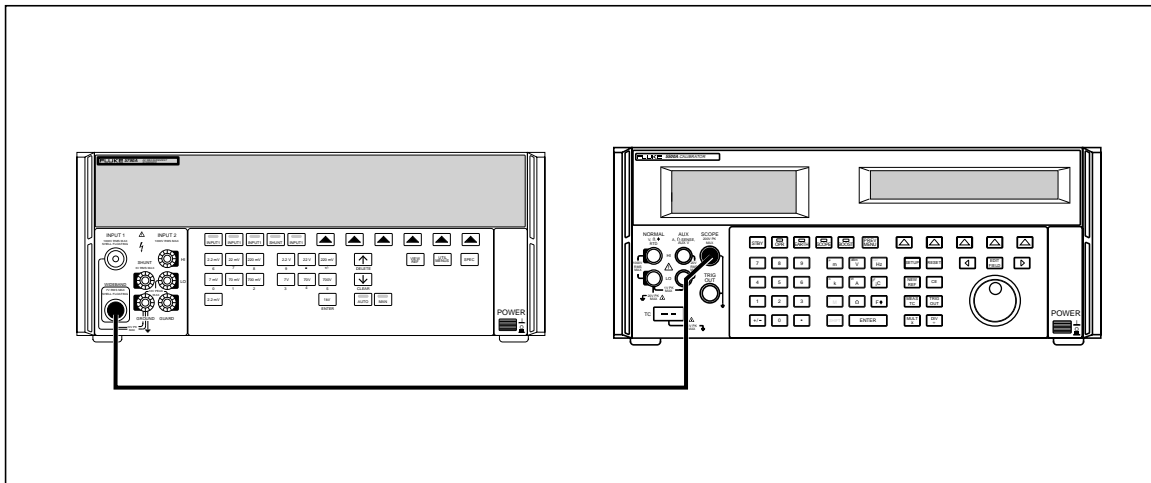
Press the **OPTIONS** and **NEXT SECTION** blue softkeys until the display reads “Set up to measure leveled sine amplitude”. Then follow these steps to calibrate Leveled Sine Wave amplitude:

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 $(0.5 * (50 + R_{load}) / R_{load})$, 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 6-20. 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” later 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 6-49. 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 6-49.
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 MΩ).

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 6-50. 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 6-50.

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 6-49. 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 6-50. 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 6-48. 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 6-48.

Table 6-51. AC Voltage Verification at 1 M 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	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 6-48. 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 6-52. 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 6-52. The peak-to-peak value is the difference between the topline and baseline measurements. Multiply the readings by $(0.5 * (50 + Rload) / Rload)$, where Rload = the actual feedthrough termination resistance, to correct for the resistance error. Compare the result to the tolerance column.

Table 6-52. 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

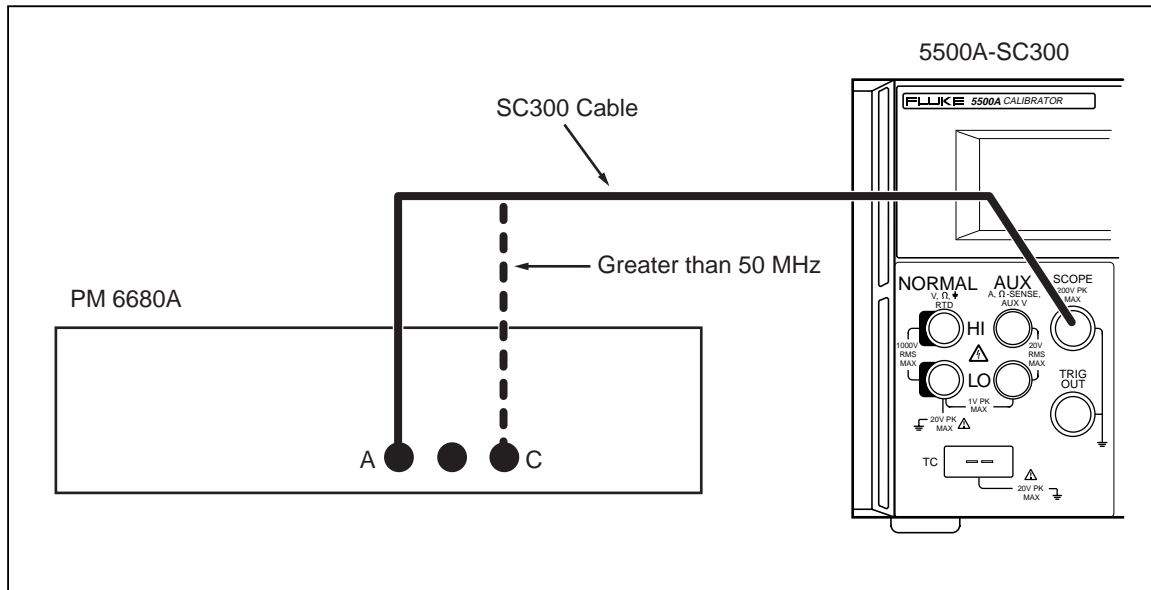


Figure 6-21. Frequency Verification Setup

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 6-53.
4. Allow the PM 6680 reading to stabilize, then record the PM 6680 reading for each frequency listed in Table 6-53. Compare to the tolerance column of Table 6-53.

Table 6-53. AC Voltage Frequency Verification

Calibrator Mainframe Frequency (output @ 2.1 V p-p)	PM 6680 Reading (Frequency)	Tolerance
10 Hz		0.01525 Hz
100 Hz		0.0175 Hz
1 kHz		0.04 Hz
10 kHz		0.265 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 6-54.
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 6-54.

Table 6-54. 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 6-55.
4. Allow the PM 6680 reading to stabilize, then record the PM 6680 reading for each frequency listed in Table 6-55. Compare to the tolerance column of Table 6-55.

Table 6-55. 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. Set the scope trigger amplitude to "divide by 10".

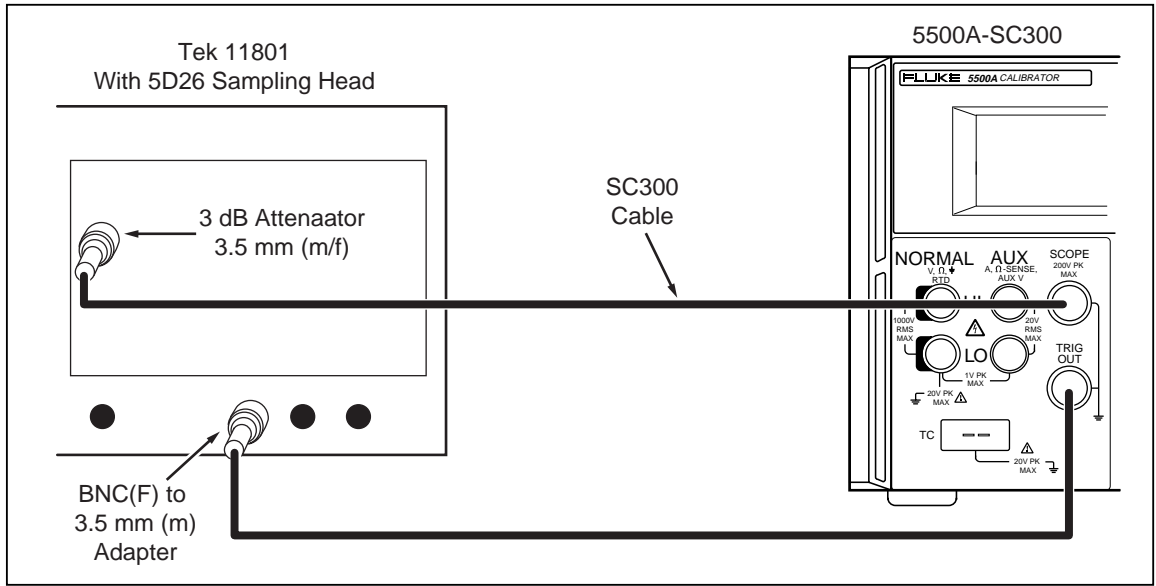


Figure 6-22. Edge Rise Time Verification Setup

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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 6-56. 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 6-56. 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 6-56.

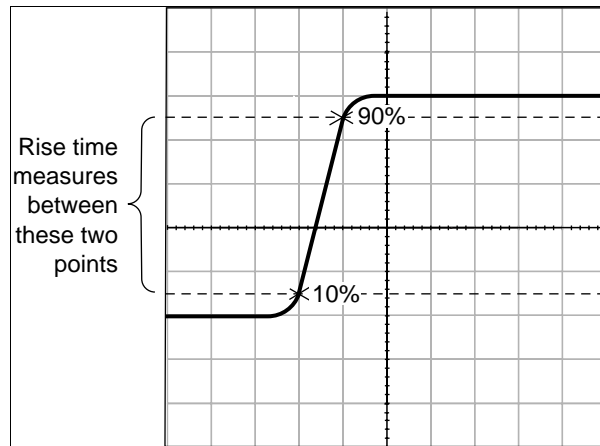


Figure 6-23. Edge Rise Time

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Table 6-56. Edge Rise Time Verification

Calibrator Mainframe Output		DSO Vertical Axis (mV/div)	A 11801 Reading	B Corrected Reading	Tolerance
Voltage	Frequency				
250 mV	1 MHz	20.0			< 400 ps
500 mV	1 MHz	50.0			< 400 ps
1 V	1 MHz	100.0			< 400 ps
2.5 V	1 MHz	200.0			< 400 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
- Use the same trigger setup found in the “Edge Rise Time Verification” section.

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 6-57.

Table 6-57. 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 Reference 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 6-58.
4. Allow the 5790A reading to stabilize, then record the 5790A's rms reading for each voltage listed in Table 6-58.
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 6-58. Leveled 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. 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 SC300

Refer to Figure 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 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 6-59. 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 6-59. 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 6-59.

Table 6-59. 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.

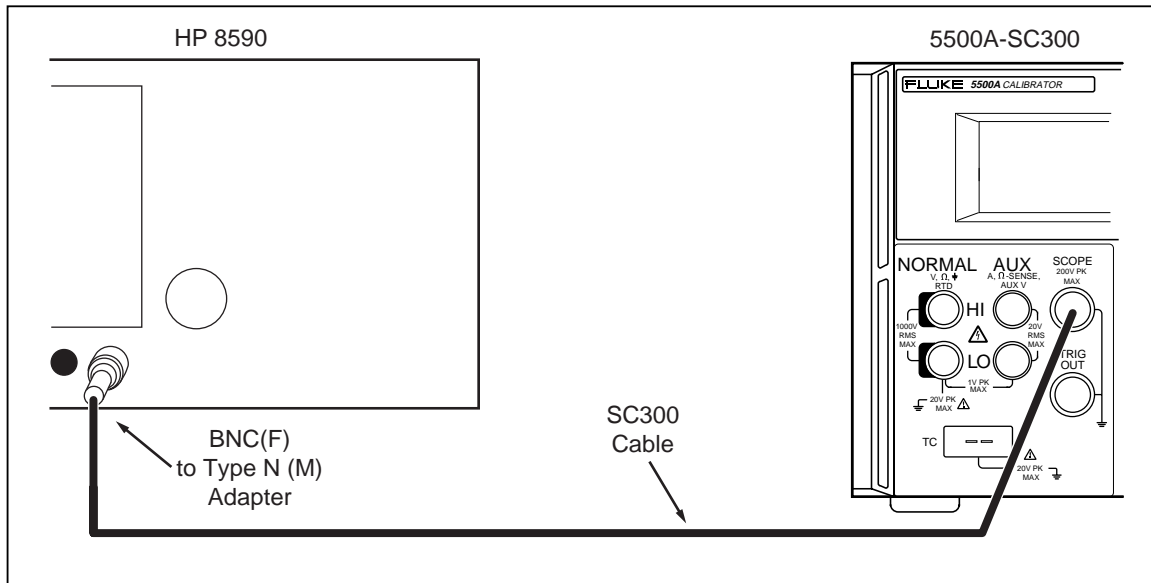


Figure 6-24. Leveled Sine Wave Harmonics Verification Setup

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 6-60. 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 6-60. 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 6-60.

Table 6-60. 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.

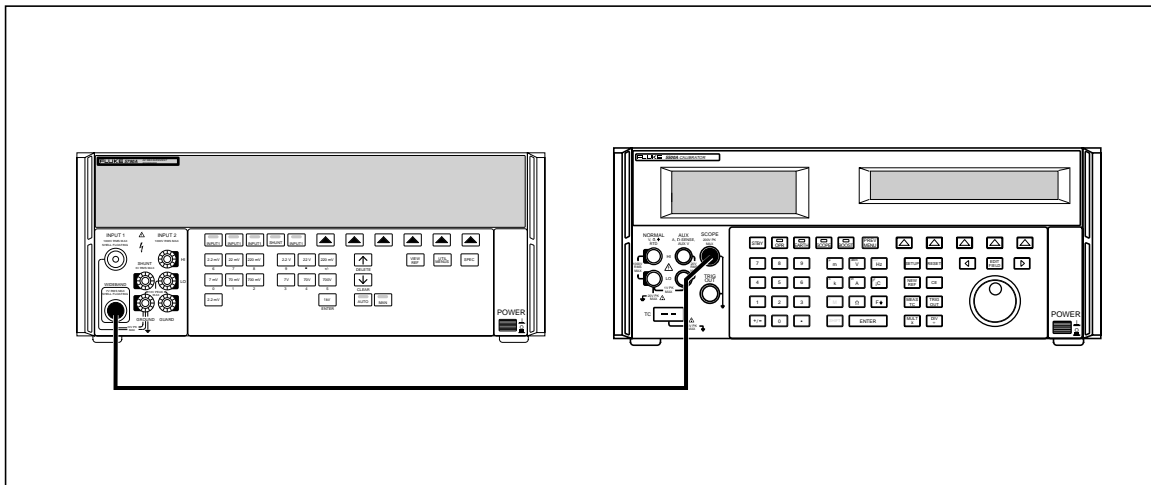


Figure 6-25. Connecting the Calibrator Mainframe to the 5790A AC Measurement Standard

6-129. Equipment Setup for High Frequency Flatness

All high frequency flatness procedures use the following equipment:

- Hewlett-Packard E4418A Power Meter
- Hewlett-Packard 8482A and 8481D Power Sensors
- BNC(f) to Type N(f) adapter
- BNC cable supplied with the Calibrator Mainframe

Note

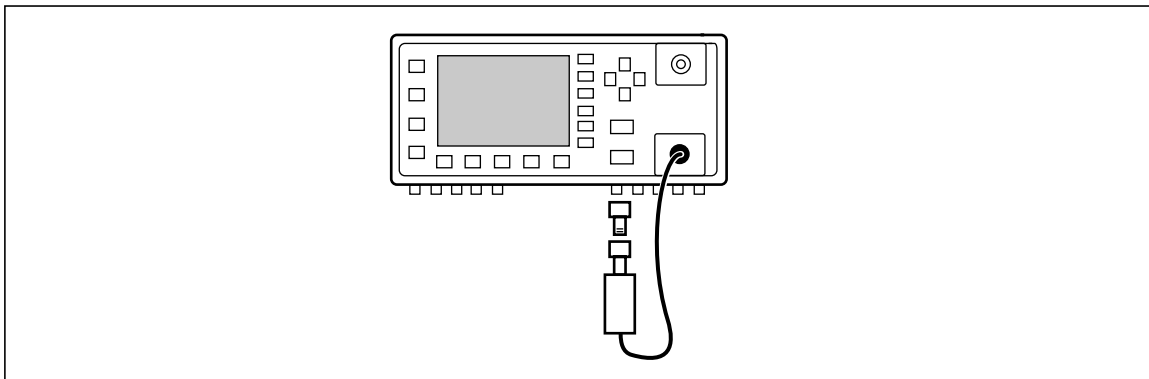
When high frequencies at voltages below 63 mV p-p are verified, use the 8481D Power Sensor. Otherwise, use the 8482A Power Sensor.

Connect the HP E4418A 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.

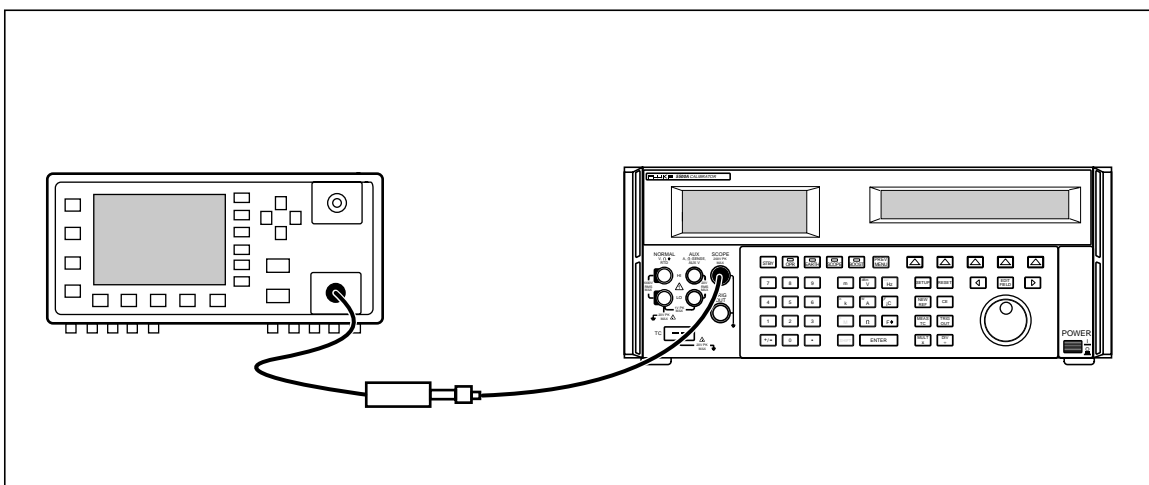
The Hewlett-Packard E4418A Power Meter must be configured by setting the parameters listed below. Zero and self-calibrate the power meter with the power sensor being used. Refer to the Hewlett-Packard E4418A operators manual for details.

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



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Figure 6-26. Connecting the HP E4418A 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 6-61.

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 6-61.
3. Enter 50 kHz into the Calibrator Mainframe. Allow the 5790A reading to stabilize, then enter the 5790A reading in Column B of Table 6-61.
4. Enter the next frequency listed in Table 6-61. 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 6-61.
6. Repeat steps 4 and 5 for all of frequencies listed in Table 6-61. 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 6-61 by performing the calculations for column C. Compare Column C to the specifications listed in the final column.

Table 6-61. 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 6-62. 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 6-62.

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 6-62.
4. Enter the next frequency listed in Table 6-62. 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 6-62.
6. Repeat steps 4 and 5 for all of frequencies listed in Table 6-62. 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 6-62 by performing the calculations for each column. Compare Column E to the specifications listed in the final column.

Table 6-62. High Frequency Flatness Verification at 5.5 V

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	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-E as follows:</p> <p>A Enter the E4418A present frequency Reading (W).</p> <p>B Enter the E4418A 10 MHz Reading (W).</p> <p>C Apply power sensor correction factor for present frequency (W): $CF * (\text{Column A entry})$.</p> <p>D Apply power sensor correction factor for 10 MHz (W): $CF * (\text{Column B entry})$.</p> <p>E Compute and enter Error relative to 10 MHz (%): $100 * (\text{sqrt}(\text{Column C entry}) - \text{sqrt}(\text{Column D entry})) / \text{sqrt}(\text{Column D entry})$.</p>						

Table 6-63. High Frequency Flatness Verification at 7.5 mV

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	Calibrator Mainframe Flatness Spec. (%)
20						± 1.50 +100 μV
50						± 1.50 +100 μV
100						± 1.50 +100 μV
125						± 2.00 + 100 μV
160						± 2.00 + 100 μV
200						± 2.00 + 100 μV
220						± 2.00 + 100 μV
235						± 2.00 + 100 μV
250						± 2.00 + 100 μV
300						± 2.00 + 100 μV

Complete Columns A-E as follows:

- A Enter the E4418A present frequency Reading (W).
- B Enter the E4418A 10 MHz Reading (W).
- C Apply power sensor correction factor for present frequency (W): CF * (Column A entry).
- D Apply power sensor correction factor for 10 MHz (W): CF * (Column B entry).
- E Compute and enter Error relative to 10 MHz (%): $100 * (\text{sqrt}(\text{Column C entry}) - \text{sqrt}(\text{Column D entry})) / \text{sqrt}(\text{Column D entry})$.

Table 6-64. High Frequency Flatness Verification at 25 mV

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	Calibrator Mainframe Flatness Spec. (%)
20						± 1.50 +100 μV
50						± 1.50 +100 μV
100						± 1.50 +100 μV
125						± 2.00 + 100 μV
160						± 2.00 + 100 μV
200						± 2.00 + 100 μV
220						± 2.00 + 100 μV
235						± 2.00 + 100 μV
250						± 2.00 + 100 μV
300						± 2.00 + 100 μV

Complete Columns A-E as follows:

- A Enter the E4418A present frequency Reading (W).
- B Enter the E4418A 10 MHz Reading (W).
- C Apply power sensor correction factor for present frequency (W): CF * (Column A entry).
- D Apply power sensor correction factor for 10 MHz (W): CF * (Column B entry).
- E Compute and enter Error relative to 10 MHz (%): $100 * (\text{sqrt}(\text{Column C entry}) - \text{sqrt}(\text{Column D entry})) / \text{sqrt}(\text{Column D entry})$.

Table 6-65. High Frequency Flatness Verification at 70 mV

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	Calibrator Mainframe Flatness Spec. (%)
20						± 1.50 +100 μV
50						± 1.50 +100 μV
100						± 1.50 +100 μV
125						± 2.00 + 100 μV
160						± 2.00 + 100 μV
200						± 2.00 + 100 μV
220						± 2.00 + 100 μV
235						± 2.00 + 100 μV
250						± 2.00 + 100 μV
300						± 2.00 + 100 μV
<p>Complete Columns A-E as follows:</p> <ul style="list-style-type: none"> A Enter the E4418A present frequency Reading (W). B Enter the E4418A 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 (%): $100 * (\text{sqrt}(\text{Column C entry}) - \text{sqrt}(\text{Column D entry})) / \text{sqrt}(\text{Column D entry})$. 						

Table 6-66. High Frequency Flatness Verification at 250 mV

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	Calibrator Mainframe Flatness Spec. (%)
20						± 1.50 +100 μV
50						± 1.50 +100 μV
100						± 1.50 +100 μV
125						± 2.00 + 100 μV
160						± 2.00 + 100 μV
200						± 2.00 + 100 μV
220						± 2.00 + 100 μV
235						± 2.00 + 100 μV
250						± 2.00 + 100 μV
300						± 2.00 + 100 μV
<p>Complete Columns A-E as follows:</p> <ul style="list-style-type: none"> A Enter the E4418A present frequency Reading (W). B Enter the E4418A 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 (%): $100 * (\text{sqrt}(\text{Column C entry}) - \text{sqrt}(\text{Column D entry})) / \text{sqrt}(\text{Column D entry})$. 						

Table 6-67. High Frequency Flatness Verification at 800 mV

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	Calibrator Mainframe Flatness Spec. (%)
20						$\pm 1.50 +100 \mu\text{V}$
50						$\pm 1.50 +100 \mu\text{V}$
100						$\pm 1.50 +100 \mu\text{V}$
125						$\pm 2.00 + 100 \mu\text{V}$
160						$\pm 2.00 + 100 \mu\text{V}$
200						$\pm 2.00 + 100 \mu\text{V}$
220						$\pm 2.00 + 100 \mu\text{V}$
235						$\pm 2.00 + 100 \mu\text{V}$
250						$\pm 2.00 + 100 \mu\text{V}$
300						$\pm 2.00 + 100 \mu\text{V}$
<p>Complete Columns A-E as follows:</p> <p>A Enter the E4418A present frequency Reading (W).</p> <p>B Enter the E4418A 10 MHz Reading (W).</p> <p>C Apply power sensor correction factor for present frequency (W): $\text{CF} * (\text{Column A entry})$.</p> <p>D Apply power sensor correction factor for 10 MHz (W): $\text{CF} * (\text{Column B entry})$.</p> <p>E Compute and enter Error relative to 10 MHz (%): $100 * (\text{sqrt}(\text{Column C entry}) - \text{sqrt}(\text{Column D entry})) / \text{sqrt}(\text{Column D entry})$.</p>						

Table 6-68. High Frequency Flatness Verification at 3.4 V

Calibrator Mainframe Freq. (MHz)	A	B 10 MHz	C	D	E	Calibrator Mainframe Flatness Spec. (%)
20						$\pm 1.50 +100 \mu\text{V}$
50						$\pm 1.50 +100 \mu\text{V}$
100						$\pm 1.50 +100 \mu\text{V}$
125						$\pm 2.00 + 100 \mu\text{V}$
160						$\pm 2.00 + 100 \mu\text{V}$
200						$\pm 2.00 + 100 \mu\text{V}$
220						$\pm 2.00 + 100 \mu\text{V}$
235						$\pm 2.00 + 100 \mu\text{V}$
250						$\pm 2.00 + 100 \mu\text{V}$
300						$\pm 2.00 + 100 \mu\text{V}$
<p>Complete Columns A-E as follows:</p> <p>A Enter the E4418A present frequency Reading (W).</p> <p>B Enter the E4418A 10 MHz Reading (W).</p> <p>C Apply power sensor correction factor for present frequency (W): $\text{CF} * (\text{Column A entry})$.</p> <p>D Apply power sensor correction factor for 10 MHz (W): $\text{CF} * (\text{Column B entry})$.</p> <p>E Compute and enter Error relative to 10 MHz (%): $100 * (\text{sqrt}(\text{Column C entry}) - \text{sqrt}(\text{Column D entry})) / \text{sqrt}(\text{Column D entry})$.</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 6-69.

1. Program the Calibrator Mainframe to the output as listed in Table 6-69.
2. Using the BNC cable, connect the SCOPE connector on the Calibrator Mainframe to the PM 6680 at the channel indicated in Table 6-69. 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 6-69. Time Marker Verification

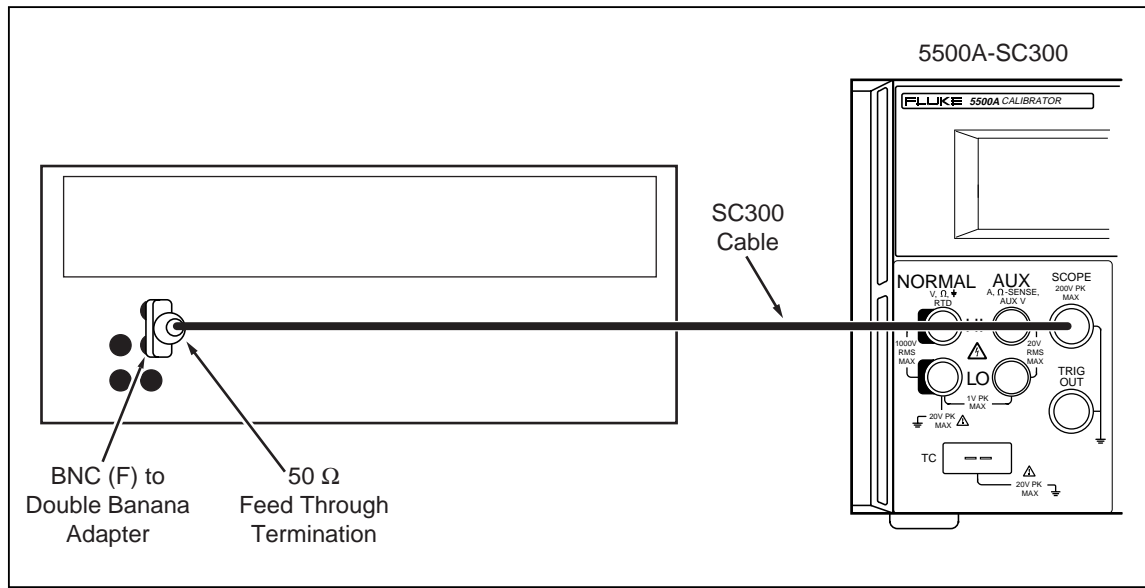
Calibrator Mainframe Period	PM 6680 Settings		PM 6680 Reading (Frequency)	¹ PM 6680 Reading (Period)	Tolerance
	Channel	Filter			
4.979 s	A	On			24.91E-3 s
2.002 s	A	On			4.06E-3 s
50.0 ms	A	Off			3.75E-6 s
20.0 ms	A	Off			900E-09 s
10.0.ms	A	Off			350E-09 s
50.0 μs	A	Off			1.29E-9 s
20.0 μs	A	Off			506E-12 s
10.0 μs	A	Off			251.5E-12 s
1.0 μs	A	Off			25.0E-12 s
50.0 ns	A	Off			1.25E-12 s
20.0 ns	A	Off			500E-15 s
10.0 ns	A	Off			250E-15 s
5.00 ns	A	Off			125E-15 s
2.00 ns	C	Off			50E-15 s

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.



om065f.eps

Figure 6-28. Wave Generator Verification Setup

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 6-70.
5. Allow the 5790A reading to stabilize, then record the 5790A rms reading for each wave type and voltage in Table 6-70.
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 6-71.
5. Allow the 5790A reading to stabilize, then record the 5790A rms reading for each wave type and voltage in Table 6-71.
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 6-70. 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	5.0 mV		2.0000		250.00 μV
square	20.0 mV		2.0000		700.00 μV
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 μV
sine	20.0 mV		2.8284		700.00 μV
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 μV
triangle	20.0 mV		3.4641		700.00 μV
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 6-71. 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

Note

Before beginning SC300 hardware adjustments, it must be determined which revision of the option is installed in the instrument. To do this, remove the top cover of the calibrator and look at the circuit board tab protruding through the guard cover that is closest to the right front corner of the calibrator. If this tab is marked A4, proceed to the “SC300 Hardware Adjustments for the A4 Board” section of this manual.

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 needs 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.

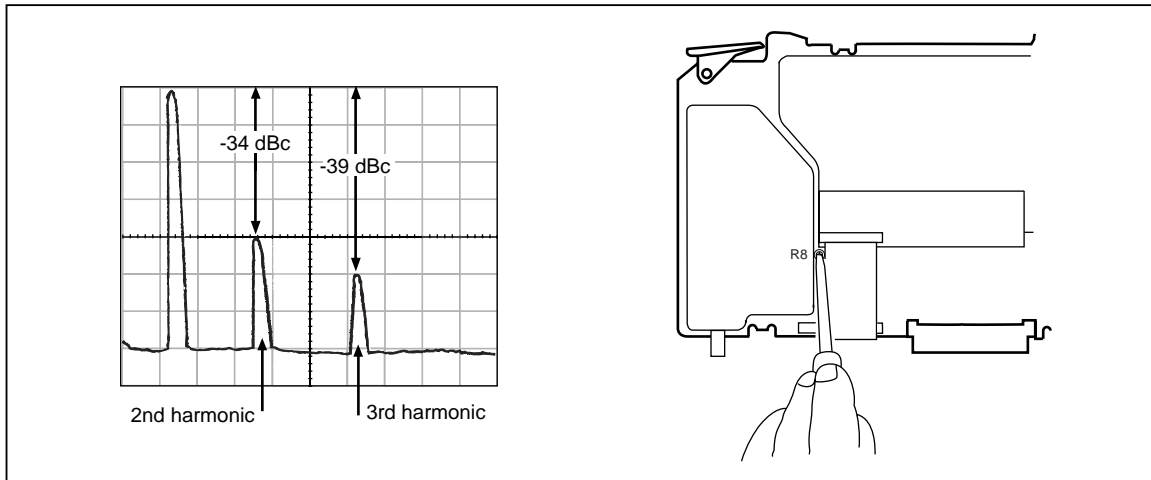


Figure 6-29. Adjusting the Leveled Sine Wave Harmonics

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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.

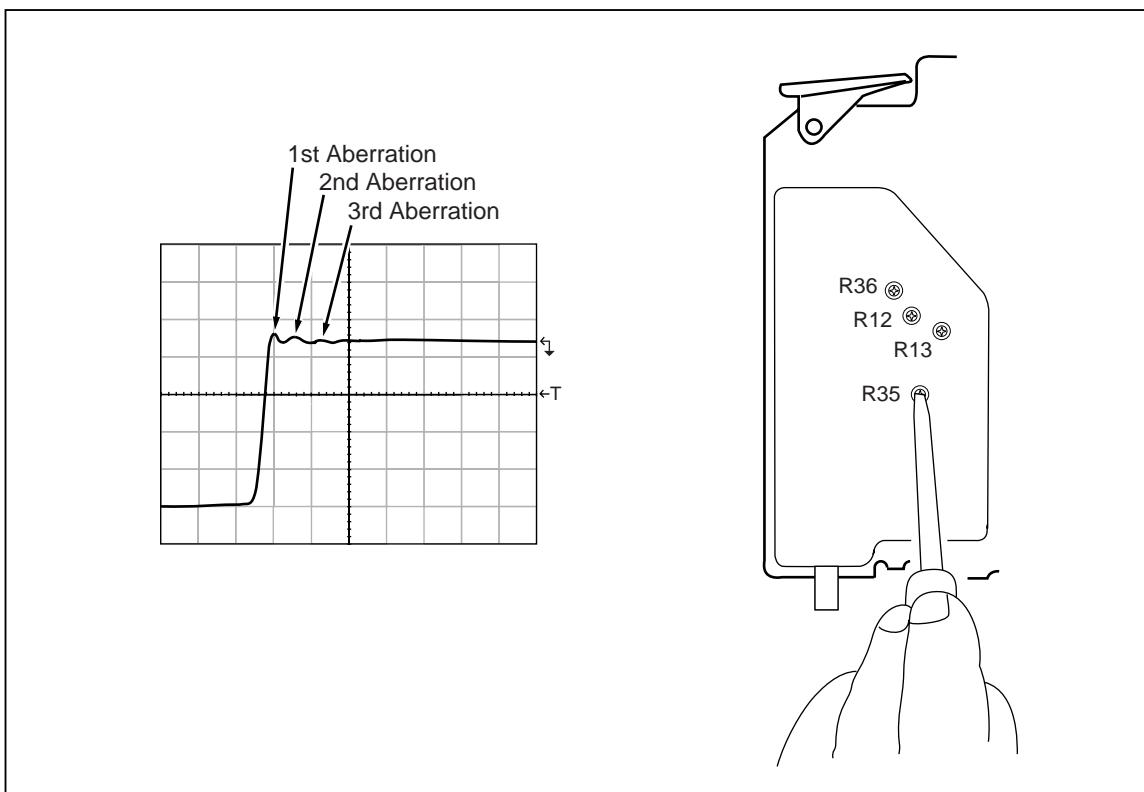


Figure 6-30. Adjusting Edge Aberrations

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6-144. SC300 Hardware Adjustments for the A4 Board

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.

6-145. 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 11801B with SD-22)
- Delay Cable, 60 ns
- Spectrum Analyzer (Hewlett Packard 8590A)

6-146. 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.

6-147. 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 5.5V p-p @ 110 MHz. Press **OPR** to activate the output.

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.

6-148. 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 5.5V @ 110 MHz.
2. Set the Spectrum Analyzer to the parameters listed below.

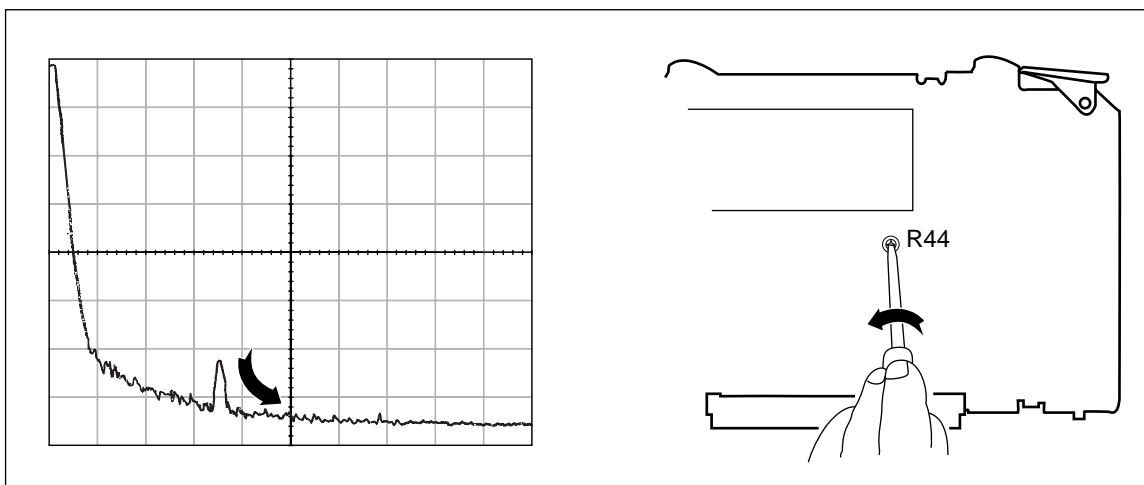
Spectrum Analyzer Setup

Start Frequency	110 MHz
Stop Frequency	113 MHz
Resolution Bandwidth	30 kHz
Video Bandwidth	3 kHz
Reference Level	20 dBm

The Spectrum Analyzer will display a spur in the waveform approximately 1 MHz away from the carrier frequency. Refer to Figure 6-31 to identify the spur.

3. You need to adjust the wave until the spur disappears. To do this, *slowly* rotate R44 (shown in the diagram) counterclockwise until the spur just disappears. As you adjust it, the spur will move down the waveform, towards the right. As soon as the spur is gone, stop rotating R44. If you rotate it too far, the spur will reappear.

Once you have turned R44 to the point at which the spur just disappears, the signal is balanced between the VCOs and you have completed the adjustment.



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Figure 6-31. Adjusting the Leveled Sine Wave Balance

6-149. 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 6-32.
3. To adjust the harmonics, adjust R8, as shown in Figure 6-32 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.

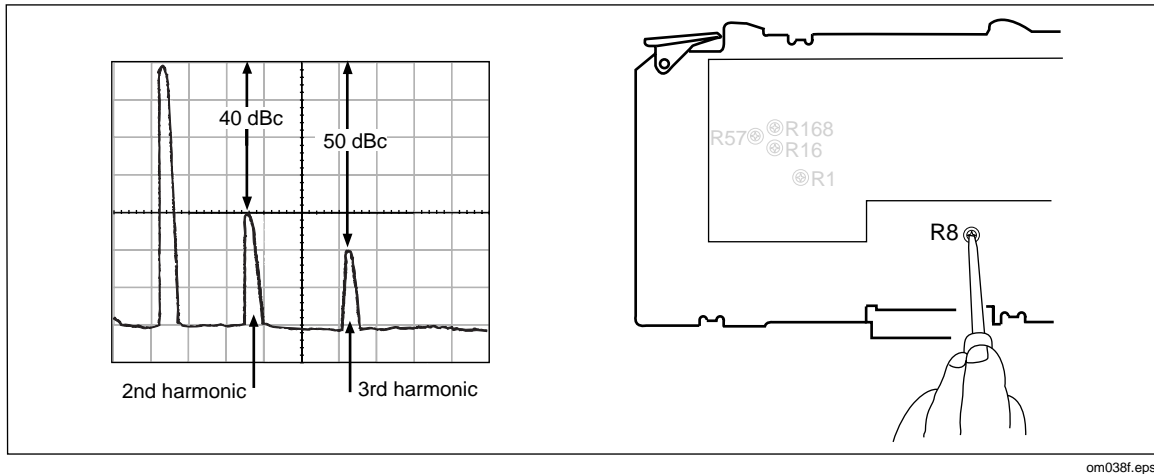


Figure 6-32. Adjusting the Leveled Sine Wave Harmonics

6-150. Adjusting the Aberrations for the Edge Function

Adjustments need to be made after repair to the edge function to adjust the edge aberrations. There are two SC300 boards currently available, and each requires separate aberration adjustment procedures; thus certain procedure headings include specific part numbers. The two boards are listed below. Check the part number of your board before you begin aberration adjustments. If you are not certain which board you have, contact your Fluke Service Center.

- SC300 Board 5500A-4004-1 (Fluke PN 600749)
- SC300 Board 5500A-4004 (Fluke PN 937383)

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 SC300.

6-151. Equipment Setup

Program the Calibrator Mainframe to output 1V p-p @ 100 kHz. Set the Trigger to /1. Using the 60 ns Delay Cable, connect the SCOPE output of the Calibrator Mainframe to the SD-22 sampling head on the oscilloscope. Connect the trigger output to the 11801B's trigger input. Then set the sampling heads to the settings listed below, to establish a reference signal.

In addition to the settings shown below, adjust the scan control for a well-triggered display. (You may need to adjust the signal averaging on the 11801B.)

11801B Setup

Voltage/division	10 mV/div
dc offset	Centered
Dot Response	Centered
Smooth	On
Time Base Position	5 μ s
Time/division	0.5 μ s
Trigger Level	Center, negative slope
Trigger Input	x10
External Trigger	1 M Ω
Sequential	On
Scan Repetitive	On

6-152. Adjusting the Edge Aberrations for Board 5500A-4004-1

Follow this procedure only if you have Board 5500A-4004-1 (Fluke PN 600749).

1. Adjust the dc offset on the 11801B so the last 500 ns of the peak of the square wave is on the center line.
2. Change the time/div on the 11801B to 20 ns/div.
3. Slowly adjust pot R168 and observe its effect on the waveform. the left half of the wave peak will move up and down as you turn R168. Adjust R168 until the center of the wave peak is half of a division above the center line, as shown in Figure 6-33.
4. Change the time/div on the 11801B to 5 ns/div.
5. Slowly adjust R57. It will affect the first 50 ns of the wave form. Adjust R57 so the rising edge falls back and crosses the horizontal center line one division before the vertical center. Refer to Figure 6-34. The base of the aberration should be 10 ns apart.
6. Change the time/div on the 11801B to 2 ns/div.
7. Adjust R16 until the rising edge ledge reaches the center line. Refer to Figure 6-35.
8. Return to 5 ns/div and verify that the pattern shown in Figure 6-34 still exists. Repeat the adjustment in step 5 if necessary.
9. At this point in the adjustment, each graticule line on the oscilloscope represents a 1% aberration. Typically this board shows aberrations of 0.5% within the first 10 ns, and aberrations of 0.25% during the following 10-30 ns.

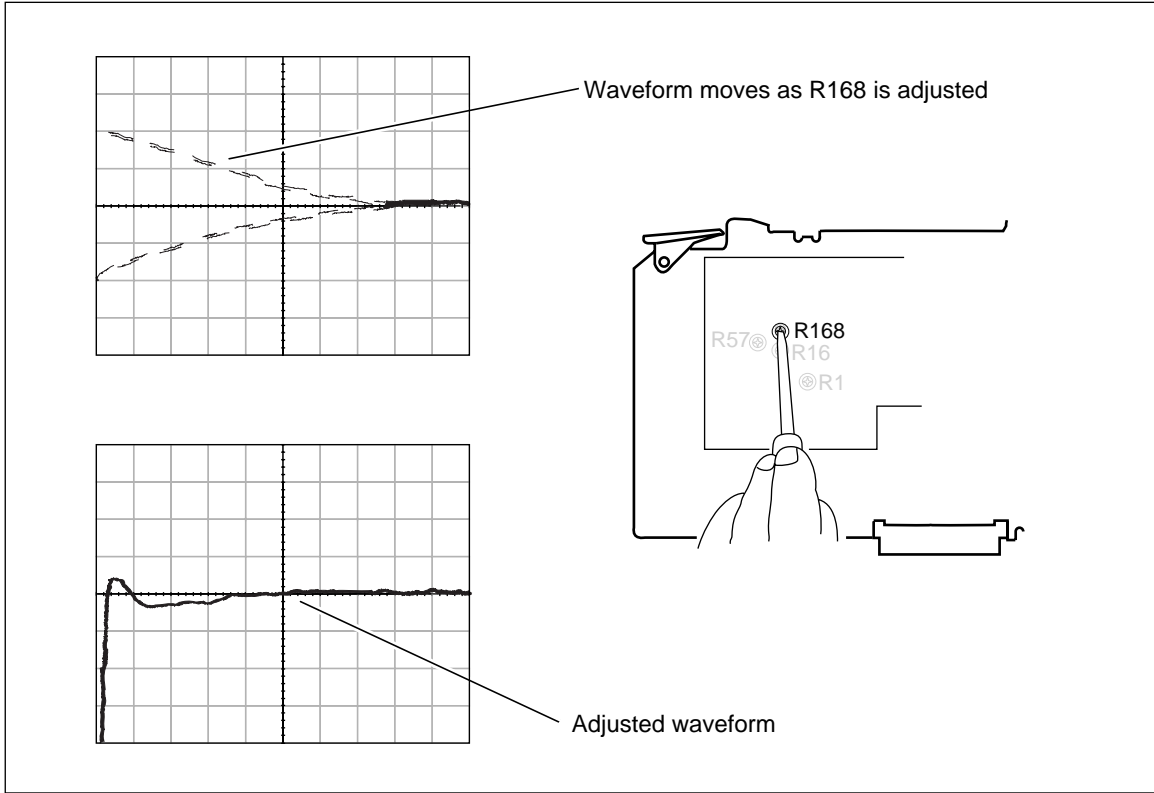


Figure 6-33. Adjusting the Wave Peak Center with R168

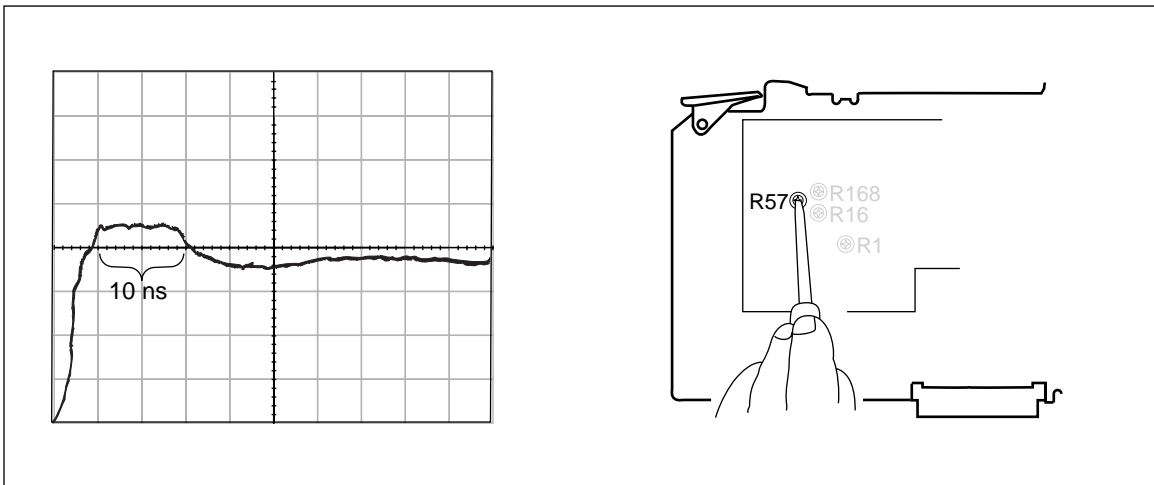
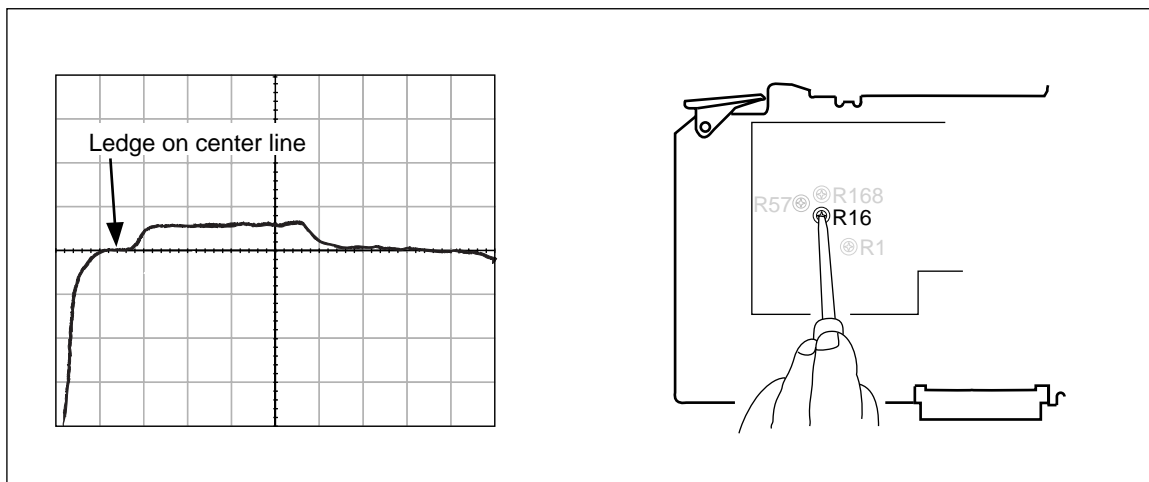


Figure 6-34. Adjusting Base of Peak with R57



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Figure 6-35. Adjusting the Ledge with R16

Note

Aberration adjustments are interactive with rise time adjustments. When you have completed this aberration adjustment, verify the edge rise time to ensure that it remains within tolerance. If it does not, repeat the aberration and rise time adjustments until you achieve the best compromise, within the listed tolerance levels.

6-153. Adjusting the Edge Aberrations for Board 5500A-4004

Follow this procedure only if you have Board 5500A-4004 (Fluke PN 937383).

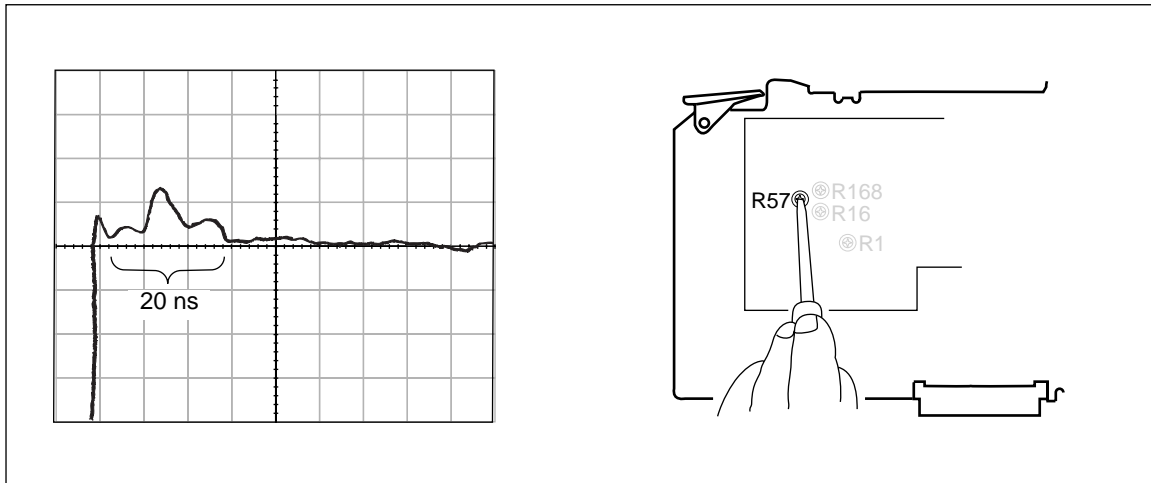
1. Adjust the dc offset on the 11801B so the peak of the square wave is on the center line.
2. Change the time/div on the 11801B to 5 ns/div.
3. Adjust R16 so that the wave crosses the horizontal center line one division before the vertical center.
4. Slowly adjust pot R57 and observe its effect on the first 15 ns of the waveform.
5. Adjust R57 so the rising edge falls back and crosses the horizontal center line one division before the vertical center. The edge should cross the center line at two points, where it rises and falls, and these points should be 20 ns apart. Refer to Figure 6-36.
6. Change the time/div on the 11801B to 2 ns/div.
7. Now adjust pot R1, and observe the ledge that occurs within the first 2 ns of the rising edge. Adjust R1 so this ledge is as flat as possible. Refer to Figure 6-37.
8. Now adjust R57 until this first ledge is on the horizontal center line. When you make this adjustment, the ledge will lose some of its flatness.
9. Return to R1 and flatten the ledge as much as possible. Then return to R57 and try to position the ledge on the center line while keeping it as flat as possible. You want to achieve the best combination of flatness and position.

As you make these adjustments, make sure the peak remains between 4 ns and 6 ns. It is possible to achieve a very flat ledge close to the horizontal center, but if the peak is too high or too low, then the aberrations will not be properly adjusted.

Typically this board shows aberrations of 1%.

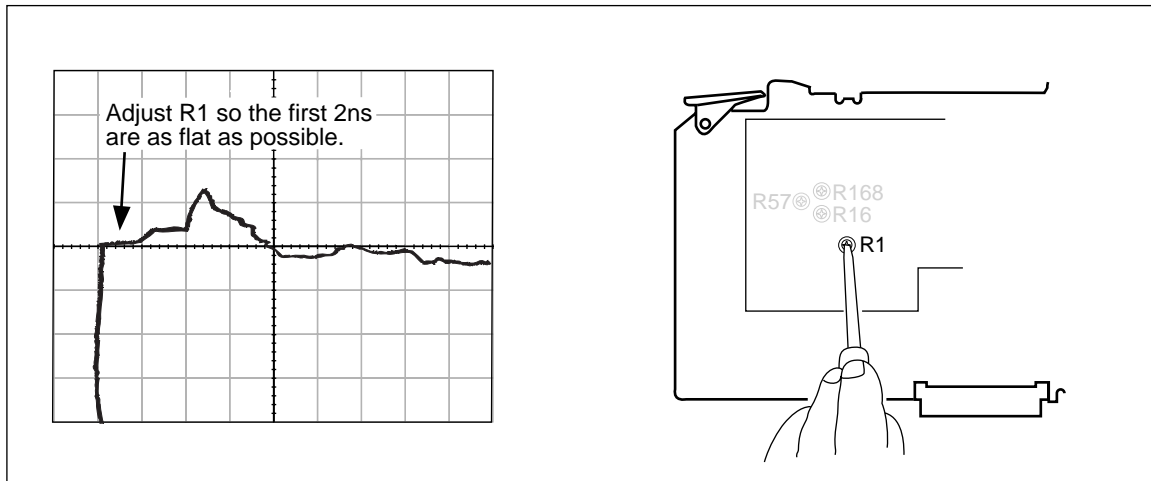
Note

Aberration adjustments are interactive with rise time adjustments. When you have completed this aberration adjustment, verify the edge rise time to ensure that it remains within tolerance. If it does not, repeat the aberration and rise time adjustments until you achieve the best compromise, within the listed tolerance levels.



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Figure 6-36. Adjusting the Peak Base with R57



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Figure 6-37. Adjust the Ledge Flatness with R1

6-154. Adjusting the Rise Time for the Edge Function

This procedure adjusts the edge rise time, and must be performed after repair. Both boards use the same procedure to adjust the rise time.

6-155. Equipment Setup

Before you start this procedure, program the Calibrator Mainframe to output 250 mV p-p @ 100 kHz. Program the digital storage oscilloscope to the parameters listed below.

Digital Storage Oscilloscope Setup

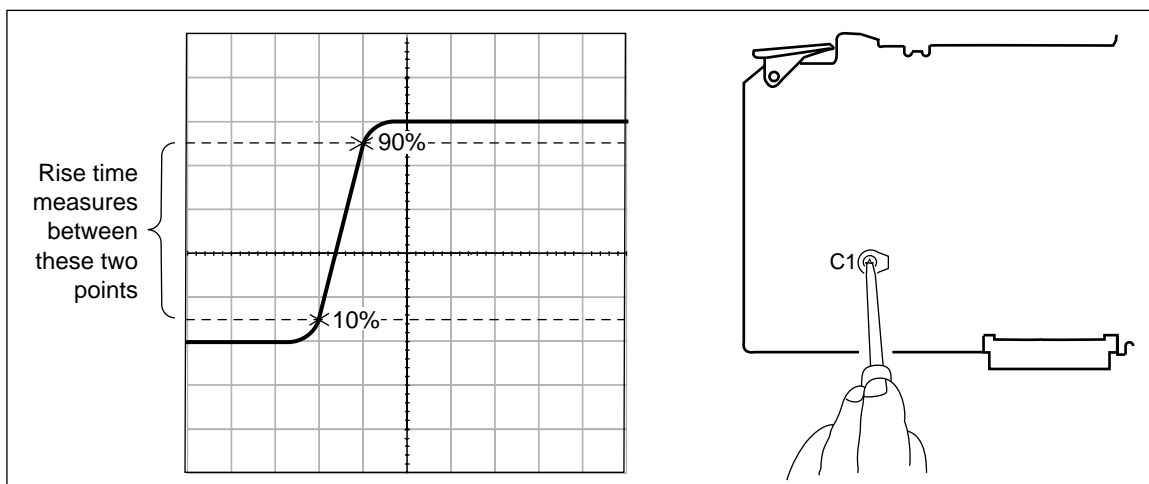
Vertical Axis: 50 mV/div

Horizontal Axis: 1 ns/div

Function: Rise Time

6-156. Adjusting the Edge Rise Time

Only one adjustment needs to be made to the edge rise time. You want a rise time of $950 \text{ ps} \pm 25 \text{ ps}$. To achieve this rise time, adjust C1 until this rise time on the oscilloscope is within this range as shown in Figure 6-38.



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Figure 6-38. Adjusting the Edge Rise Time with C1

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