5502A

Multi-Product Calibrator

Service Manual

September 2014

LIMITED WARRANTY AND LIMITATION OF LIABILITY

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

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

To obtain warranty service, contact your nearest Fluke authorized service center to obtain return authorization information, then send the product to that service center, with a description of the difficulty, postage and insurance prepaid (FOB Destination). Fluke assumes no risk for damage in transit. Following warranty repair, the product will be returned to Buyer, transportation prepaid (FOB Destination). If Fluke determines that failure was caused by neglect, misuse, contamination, alteration, accident, or abnormal condition of operation or handling, including overvoltage failures caused by use outside the product’s specified rating, or normal wear and tear of mechanical components, Fluke will provide an estimate of repair costs and obtain authorization before commencing the work. Following repair, the product will be returned to the Buyer transportation prepaid and the Buyer will be billed for the repair and return transportation charges (FOB Shipping Point).

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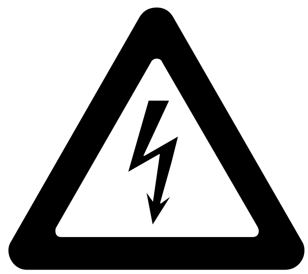
OPERATOR SAFETY SUMMARY

WARNING



HIGH VOLTAGE

is used in the operation of this equipment

LETHAL VOLTAGE

may be present on the terminals, observe all safety precautions!

To prevent electrical shock hazard, the operator should not electrically contact the output HI or sense HI terminals or circuits connected to these terminals. During operation, lethal voltages of up to 1020 V ac or dc may be present on these terminals.

When the nature of the operation permits, keep one hand away from equipment to reduce the hazard of current flowing through vital organs of the body.

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Introduction

⚠⚠Warning

To prevent possible electrical shock, fire, or personal injury, read all safety information before you use the Product.

The 5502A Calibrator (the Product or the Calibrator), shown in Figure 1-1 is a fully programmable precision source for:

- 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 29 μA to 20.5 A, with variable frequency limits.
- DC current from 0 to ±20.5 A.
- Resistance values from a short circuit to 1100 MΩ.
- Capacitance values from 220 pF to 110 mF.
- Simulated output for eight types of Resistance Temperature Detectors (RTDs).
- Simulated output for eleven types of thermocouples.

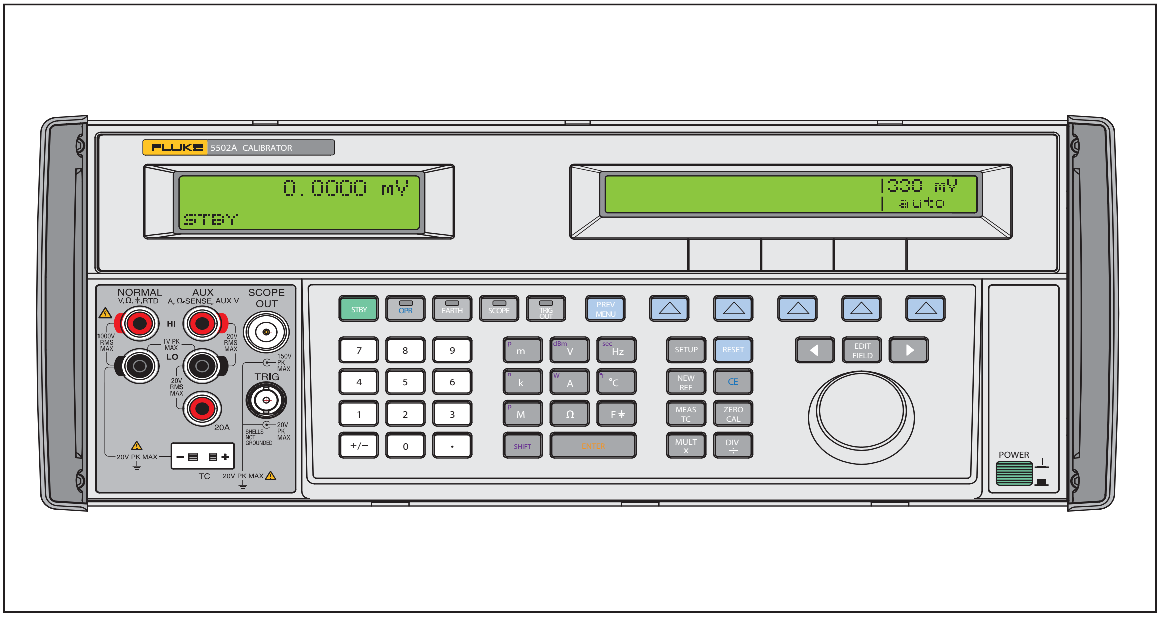

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Figure 1-1. 5502A Multi-Product Calibrator

Features of the Calibrator include:

- Calculates meter errors automatically, with user selectable reference values.
- MULT X and DIV ÷ keys that change the output value to pre-determined cardinal values for various functions.
- Programmable entry limits that prevent operator entries that are more than preset output limits.
- Output of voltage and current at the same time, to a maximum equivalent of 20.9 kW.
- Pressure measurement when used with Fluke 700 Series pressure modules.
- 10 MHz reference input and output. Use this to input a high-accuracy 10 MHz reference to transfer the frequency accuracy to the 5502A, or have one or more Calibrators that are synchronized to a master 5502A.
- Output of two voltages at the same time.
- 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, that complies with ANSI/IEEE Standards 488.1-1987 and 488.2-1987.
- EIA Standard RS-232 serial data interface to print or transfer internally stored calibration constants, and for remote control of the 5502A.
- Pass-through RS-232 serial data interface to communicate with the Unit Under Test (UUT).

Safety Information

A **Warning** identifies conditions and procedures that are dangerous to the user. A **Caution** identifies conditions and procedures that can cause damage to the Product or the equipment under test.

Symbols used in this manual and on the Product are explained in Table 1-1.

Table 1-1. Symbols

Symbol	Description	Symbol	Description
CAT I	IEC Measurement Category I – CAT I is for measurements not directly connected to mains. Maximum transient Overvoltage is as specified by terminal markings.	CSA C US	Conforms to relevant North American Safety Standards.
CE	Conforms to European Union directives.		Do not dispose of this product as unsorted municipal waste. Go to the Fluke Calibration website for recycling information.
⚠	Risk of Danger. Important information. See manual.	⚠	Hazardous voltage
⏚	Earth ground	N10140	Conforms to relevant Australian EMC requirements.

⚠⚠Warning

To prevent possible electrical shock, fire, or personal injury:

- **Use the Product only as specified, or the protection supplied by the Product can be compromised.**
- **Carefully read all instructions.**
- **Do not use the Product around explosive gas, vapor, or in damp or wet environments.**
- **Use this Product indoors only.**
- **Do not touch voltages > 30 V ac rms, 42 V ac peak, or 60 V dc.**
- **Do not use the Product if it operates incorrectly.**
- **Do not use and disable the Product if it is damaged.**
- **Use only cables with correct voltage ratings.**
- **Use only the mains power cord and connector approved for the voltage and plug configuration in your country and rated for the Product.**
- **Make sure the ground conductor in the mains power cord is connected to a protective earth ground. Disruption of the protective earth could put voltage on the chassis that could cause death.**

- **Replace the mains power cord if the insulation is damaged or if the insulation shows signs of wear.**
- **Do not connect directly to mains.**
- **Do not use an extension cord or adapter plug.**
- **For safe operation and maintenance of the Product, make sure that the space around the Product meets minimum requirements.**

This Calibrator complies with:

- ANSI/ISA-61010-1 (82.02.01)
- CAN/CSA C22.2 No. 61010-1-04
- ANSI/UL 61010-1:2004
- EN 61010-1:2001
- ANSI/IEEE Standards 488.1-1987 and 488.2-1987.

Overload Protection

The Calibrator supplies reverse-power protection, fast output disconnection, and/or fuse protection on the output terminals for all functions.

Reverse-power protection prevents damage to the calibrator from occasional, accidental, normal-mode, and common-mode overloads to a maximum of ±300 V peak. It is not intended as protection against frequent (systematic and repeated) abuse. Such abuse will cause the Calibrator to fail.

For volts, ohms, capacitance, and thermocouple functions, there is fast output disconnection protection. This protection senses applied voltages higher than 20 volts on the output terminals. It quickly disconnects the internal circuits from the output terminals and resets the calibrator when such overloads occur.

For current and aux voltage functions, user replaceable fuses supply protection from overloads applied to the Current/Aux Voltage output terminals. The fuses are accessed by an access door on the bottom of the calibrator. You must use replacement fuses of the same capacity and type specified in this manual, or the protection supplied by the Calibrator will be compromised.

Operation Overview

The Calibrator can be operated at the front panel in the local mode, or remotely through the RS-232 or IEEE-488 ports. For remote operations, there are a number of software options available to integrate 5502A operation into a wide variety of calibration requirements.

Local Operation

Typical local operations include front panel connections to the Unit Under Test (UUT), and then manual keystroke entries at the front panel to set the output mode of the Calibrator. You can review Calibrator specifications at the push of two buttons. The backlit liquid crystal display is easy to see from many different angles and light conditions. The large, easy-to-read keys are color-coded and supply tactile feedback.

Remote Operation (RS-232)

There are two rear-panel serial data RS-232 ports: SERIAL 1 FROM HOST, and SERIAL 2 TO UUT (see Figure 1-2). Each port is dedicated to serial data communications to operate and control the 5502A when you do calibration procedures. For complete information on remote operations, see Chapter 5 of the *5502A Operators Manual*.

The SERIAL 1 FROM HOST serial data port connects a host terminal or personal computer to the Calibrator. You can send remote commands to the Calibrator from a terminal (or a PC running a terminal program), a BASIC program you write, or an optional Windows-based software such as 5500/CAL or MET/CAL. The 5500/CAL Software includes more than 200 example procedures that include a wide range of test tools the Product can calibrate. (See Chapter 6 of the *5502A Operators Manual* for a discussion of the RS-232 commands.)

The SERIAL 2 TO UUT serial data port connects a UUT to a PC or terminal through the Product (see Figure 1-2). This "pass-through" configuration removes the requirement for two COM ports at the PC or terminal. A set of four commands control the operation of the SERIAL 2 TO UUT serial port. See Chapter 6 of the *5502A Operators Manual* for a discussion of the UUT_* commands. The SERIAL 2 TO UUT port is also used to connect to the Fluke 700 Series Pressure Modules.

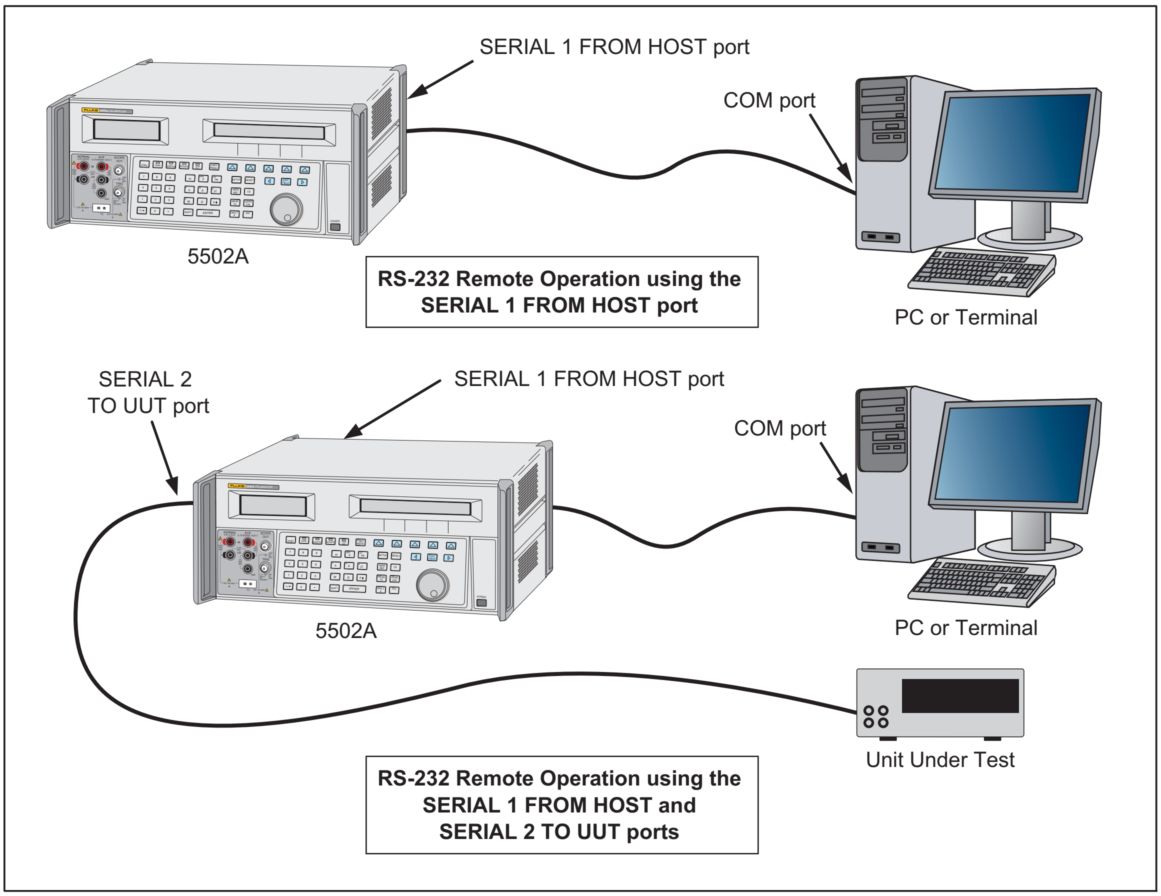

Figure 1-2. RS-232 Remote Connection

Remote Operation (IEEE-488)

The rear panel IEEE-488 port is a fully programmable parallel interface bus that operates to IEEE-488.1 and IEEE-488.2 (supplement) standards. When controlled remotely by an instrument controller, the Calibrator operates exclusively as a "talker/listener." You can write your own programs with commands from the IEEE-488 command set or run the optional Windows-based

MET/CAL software. (See Chapter 6 of the *5502A Operators Manual* for a discussion of the commands available for IEEE-488 operation.)

Service Information

If you have a problem with the Calibrator in the 1-year warranty period, send it to a Fluke Service Center for warranty repair. For out of warranty repair, get in touch with a Fluke Service Center for a cost estimate.

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

How to Contact Fluke Calibration

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

- Technical Support USA: 1-877-355-3225
- Calibration/Repair USA: 1-877-355-3225
- Canada: 1-800-36-FLUKE (1-800-363-5853)
- Europe: +31-40-2675-200
- Japan: +81-3-6714-3114
- Singapore: +65-6799-5566
- China: +86-400-810-3435
- Brazil: +55-11-3759-7600
- Anywhere in the world: +1-425-446-6110

To see product information and download the latest manual supplements, visit Fluke Calibration's website at www.flukecal.com.

To register your product, visit http://flukecal.com/register-product.

General Specifications

The following tables list the 5502A specifications. All specifications are valid after allowing a warm-up period of 30 minutes, or twice the time the 5502A has been turned off. (For example, if the 5502A 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 tcal ±5 °C (tcal is the ambient temperature when the 5502A was calibrated), the temperature coefficient as stated in the General Specifications must be applied.

The specifications also assume the Calibrator is zeroed every seven days or whenever the ambient temperature changes more than 5 °C. The tightest ohms specifications are maintained with a zero cal every 12 hours within ±1 °C of use.

Also see additional specifications later in this chapter for information on extended specifications for ac voltage and current.

Warmup Time .... Twice the time since last warmed up, to a maximum of 30 minutes.

Settling Time .... Less than 5 seconds for all functions and ranges except as noted.

Standard Interfaces .... IEEE-488 (GPIB), RS-232

Temperature

Operating .... 0 °C to 50 °C

Calibration (tcal)... 15 °C to 35 °C

Storage .... -20 °C to +70 °C; The DC current ranges 0 to 1.09999 A and 1.1 A to 2.99999 A are sensitive to storage temperatures above 50 °C. If the 5502A is stored above 50 °C for greater than 30 minutes, these ranges must be re-calibrated. Otherwise, the 90 day and 1 year uncertainties of these ranges double.

Temperature Coefficient...................................... Temperature coefficient for temperatures outside of tcal ±5 °C is 10 % of the stated specification per °C.

Relative Humidity	
Operating	<80 % to 30 °C, <70 % to 40 °C, <40 % to 50 °C
Storage	<95 %, non-condensing. After long periods of storage at high humidity, a drying-out period (with power on) of at least one week may be required.
Altitude	
Operating	3,050 m (10,000 ft) maximum at ≤120 V line voltage operation 2,000 m (6,500 ft) maximum at >120 V line voltage operation
Non-operating	12,200 m (40,000 ft) maximum
Safety	IEC 61010-1: Overvoltage CAT II, Pollution Degree 2
Output Terminal Electrical Overload Protection	Provides reverse-power protection, immediate output disconnection, and/or fuse protection on the output terminals for all functions. This protection is for applied external voltages up to ±300 V peak.
Analog Low Isolation	20 V normal operation, 400 V peak transient
Electromagnetic Environment	IEC 61326-1: Controlled
Electromagnetic Compatibility	If used in areas with electromagnetic fields of 1 V/m to 3 V/m from 0.08 GHz to 1 GHz, 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) to the binding posts. Good static awareness practices should be followed when handling this and other pieces of electronic equipment. Additionally, this instrument may be susceptible to electrical fast transients on the mains terminals. If any disturbances in operation are observed, it is recommended that the rear-panel chassis ground terminal be connected to a known good earth ground with a low-inductance ground strap. Note that a mains power outlet, while providing a suitable ground for protection against electric shock hazard, may not provide an adequate ground to properly drain away conducted rf disturbances and may, in fact, be the source of the disturbance. This instrument was certified for EMC performance with data I/O cables not in excess of 3 m.
Line Power	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. For optimal performance at full dual outputs (e.g. 1000 V, 20 A) choose a line voltage setting that is ±7.5 % from nominal.
Power Consumption	600 VA
Dimensions (HxWxL)	17.8 cm x 43.2 cm x 47.3 cm (7 in x 17 in x 18.6 in) Standard rack width and rack increment, plus 1.5 cm (0.6 in) for feet on bottom of unit.
Weight (without options)	22 kg (49 lb)
Absolute Uncertainty Definition	The 5502A 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 5502A for the temperature range indicated.
Specification Confidence Level	99 %

Detailed Specifications

DC Voltage

Range	Absolute Uncertainty, tcal ± 5 °C ±(% of output + µV)		Stability	Resolution (µV)	Max Burden [1]
	90 Day	1 Year	24 hours, ± 1 °C ±(ppm of output + µV)		
0 to 329.9999 mV	0.005 + 3	0.006 + 3	5 + 1	0.1	65 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 3.29999 V	0.03 + 350	0.04 + 350	30 + 100	10	5 mA
3.3 to 7 V	0.03 + 350	0.04 + 350	30 + 100	100	5 mA
TC Simulate and Measure in Linear 10 µV/°C and 1 mV/°C modes [3]					
0 to 329.9999 mV	0.005 + 3	0.006 + 3	5 + 1	0.1	10 Ω

[1] Remote sensing is not provided. Output resistance is < 5 mΩ for outputs ≥ 0.33 V. The AUX output has an output resistance of <1 Ω. TC simulation has an output impedance of 10 Ω ± 1 Ω.
[2] Two channels of dc voltage output are provided.
[3] TC simulating and measuring are not specified for operation in electromagnetic fields above 0.4 V/m.

Range	Noise	
	Bandwidth 0.1 Hz to 10 Hz p-p ±(ppm of output + floor in µV)	Bandwidth 10 Hz to 10 kHz rms
0 to 329.9999 mV	0 + 1	6 µV
0 to 3.299999 V	0 + 10	60 µV
0 to 32.99999 V	0 + 100	600 µV
30 to 329.9999 V	10 + 1000	20 mV
100 to 1020.000 V	10 + 5000	20 mV
Auxiliary Output (dual output mode only) [1]		
0 to 329.999 mV	0 + 5 µV	20 µV
0.33 to 3.29999 V	0 + 20 µV	200 µV
3.3 to 7 V	0 + 100 µV	1000 µV

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

DC Current

Range	Absolute Uncertainty, tcal ±5 °C ±(% of output +μA)		Resolution	Max Compliance Voltage V	Max Inductive Load mH
	90 Day	1 Year			
0 to 329.999 μA	0.012 + 0.02	0.015 + 0.02	1 nA	10	400
0 to 3.29999 mA	0.010 + 0.05	0.013 + 0.05	0.01 μA	10	
0 to 32.9999 mA	0.008 + 0.25	0.010 + 0.25	0.1 μA	7	
0 to 329.999 mA	0.008 + 3.3	0.010 + 2.5	1 μA	7	
0 to 1.09999 A	0.023 + 44	0.038 + 44	10 μA	6	
1.1 to 2.99999 A	0.030 + 44	0.038 + 44	10 μA	6	
0 to 10.9999 A (20 A Range)	0.038 + 500	0.060 + 500	100 μA	4	
11 to 20.5 A [1]	0.080 + 750 [2]	0.10 + 750 [2]	100 μA	4	

[1] Duty Cycle: Currents <11 A may be provided continuously. For currents >11 A, see Figure 1. The current may be provided Formula 60-T-I minutes any 60 minute period where T is the temperature in °C (room temperature is about 23 °C) and I is the output current in amperes. For example, 17 A, at 23 °C could be provided for 60-23-17 = 20 minutes each hour. When the 5502A is outputting currents between 5 and 11 amps for long periods, the internal self-heating reduces the duty cycle. Under those conditions, the allowable "on" time indicated by the formula and Figure 1 is achieved only after the 5502A is outputting currents <5 A for the "off" period first.

[2] Floor specification is 1500 μA within 30 seconds of selecting operate. For operating times >30 seconds, the floor specification is 750 μA.

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

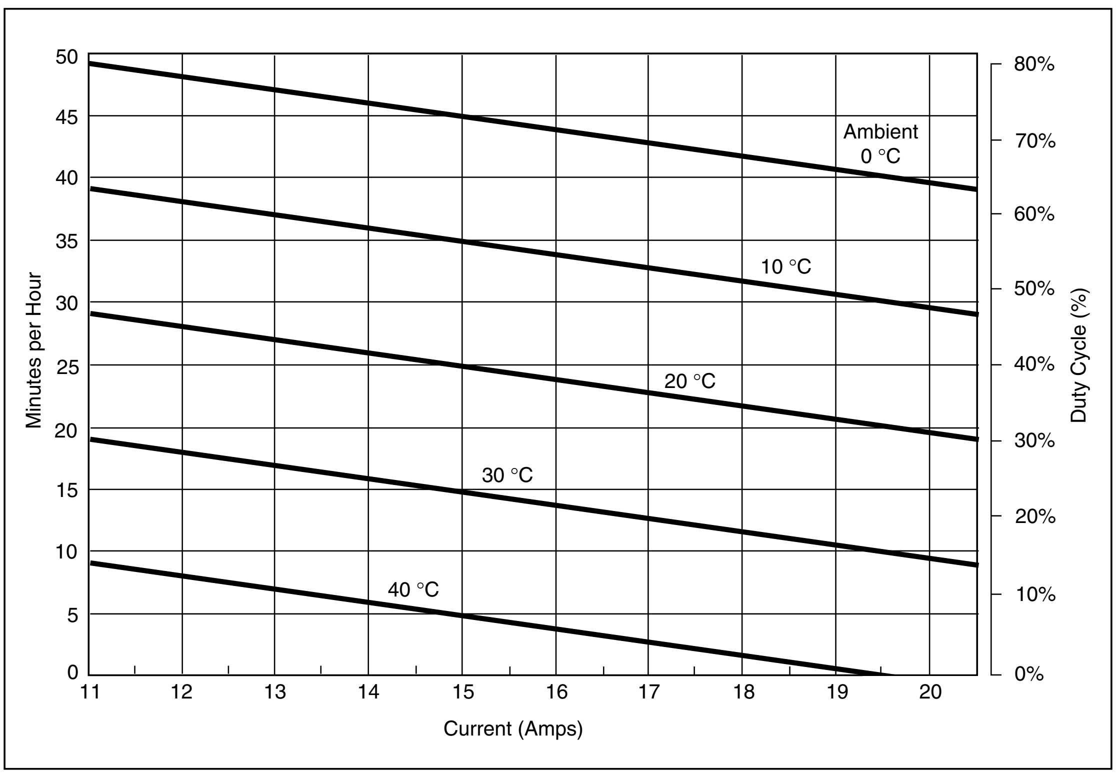

Figure 1. Allowable Duration of Current >11 A

Resistance

Range [1]	Absolute Uncertainty, tcal ±5 °C ±(% of output + floor) [2]				Resolution (Ω)	Allowable Current [3] (A)
	% of output		Floor (Ω) Time and temp since ohms zero cal			
	90 Day	1 Year	12 hrs ±1 °C	7 days ±5 °C		
0 to 10.999 Ω	0.009	0.012	0.001	0. 01	0.001	1 mA to 125 mA
11 to 32.999 Ω	0.009	0.012	0.0015	0.015	0.001	1 mA to 125 mA
33 to 109.999 Ω	0.007	0.009	0.0014	0.015	0.001	1 mA to 70 mA
110 to 329.999 Ω	0.007	0.009	0.002	0.02	0.001	1 mA to 40 mA
330 to 1.09999 kΩ	0.007	0.009	0.002	0.02	0.01	1 mA to 18 mA
1.1 to 3.29999 kΩ	0.007	0.009	0.02	0.2	0.01	100 µA to 5 mA
3.3 to 10.9999 kΩ	0.007	0.009	0.02	0.1	0.1	100 µA to 1.8 mA
11 to 32.9999 kΩ	0.007	0.009	0.2	1	0.1	10 µA to .5 mA
33 to 109.999 kΩ	0.008	0.011	0.2	1	1	10 µA to 0.18 mA
110 to 329.999 kΩ	0.009	0.012	2	10	1	1 µA to 50 µA
330 kΩ to 1.09999 MΩ	0.011	0.015	2	10	10	1 µA to 18 µA
1.1 to 3.29999 MΩ	0.011	0.015	30	150	10	250 nA to 5 µA
3.3 to 10.9999 MΩ	0.045	0.06	50	250	100	250 nA to 1.8 µA
11 to 32.9999 MΩ	0.075	0.1	2500	2500	100	25 nA to 500 nA
33 to 109.999 MΩ	0.4	0.5	3000	3000	1000	25 nA to 180 nA
110 to 329.999 MΩ	0.4	0.5	100000	100000	1000	2.5 nA to 50 nA
330 to 1100.00 MΩ	1.2	1.5	500000	500000	10000	1 nA to 13 nA

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

[2] Applies for 4-WIRE compensation only. For 2-WIRE and 2-WIRE COMP, add 5 µV per amp of stimulus current to the floor specification. For example, in 2-WIRE mode, at 1 kΩ the floor specification within 12 hours of an ohms zero cal for a measurement current of 1 mA is: 0.002 Ω + 5 µV / 1 mA = (0.002 + 0.005) Ω = 0.007 Ω.

[3] 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 50 µA stimulus measuring 100 Ω has a floor specification of: 0.0014 Ω x 1 mA/50 µA = 0.028 Ω, assuming an ohms zero calibration within 12 hours.

AC Voltage (Sine Wave)

Range	Frequency	Absolute Uncertainty, tcal ±5 °C ± (% of output + μV)		Resolution	Max Burden	Max Distortion and Noise 10 Hz to 5 MHz Bandwidth ±(% of output + floor)
		90 Day	1 Year			
1.0 to 32.999 mV	10 Hz to 45 Hz	0.120 + 20	0.150 + 20	1 μV	65 Ω	0.15 + 90 μV
	45 Hz to 10 kHz	0.080 + 20	0.100 + 20			0.035 + 90 μV
	10 kHz to 20 kHz	0.120 + 20	0.150 + 20			0.06 + 90 μV
	20 kHz to 50 kHz	0.160 + 20	0.200 + 20			0.15 + 90 μV
	50 kHz to 100 kHz	0.300 + 33	0.350 + 33			0.25 + 90 μV
	100 kHz to 500 kHz	0.750 + 60	1.000 + 60			0.3 + 90 μV [1]
33 mV to 329.999 mV	10 Hz to 45 Hz	0.042 + 20	0.050 + 20	1 μV	65 Ω	0.15 + 90 μV
	45 Hz to 10 kHz	0.029 + 20	0.030 + 20			0.035 + 90 μV
	10 kHz to 20 kHz	0.066 + 20	0.070 + 20			0.06 + 90 μV
	20 kHz to 50 kHz	0.086 + 40	0.100 + 40			0.15 + 90 μV
	50 kHz to 100 kHz	0.173 + 170	0.230 + 170			0.2 + 90 μV
	100 kHz to 500 kHz	0.400 + 330	0.500 + 330			0.2 + 90 μV [1]
0.33 V to 3.29999 V	10 Hz to 45 Hz	0.042 + 60	0.050 + 60	10 μV	10 mA	0.15 + 200 μV
	45 Hz to 10 kHz	0.028 + 60	0.030 + 60			0.035 + 200 μV
	10 kHz to 20 kHz	0.059 + 60	0.070 + 60			0.06 + 200 μV
	20 kHz to 50 kHz	0.083 + 60	0.100 + 60			0.15 + 200 μV
	50 kHz to 100 kHz	0.181 + 200	0.230 + 200			0.2 + 200 μV
	100 kHz to 500 kHz	0.417 + 900	0.500 + 900			0.2 + 200 μV [1]
3.3 V to 32.9999 V	10 Hz to 45 Hz	0.042 + 800	0.050 + 800	100 μV	10 mA	0.15 + 2 mV
	45 Hz to 10 kHz	0.025 + 600	0.030 + 600			0.035 + 2 mV
	10 kHz to 20 kHz	0.064 + 600	0.070 + 600			0.08 + 2 mV
	20 kHz to 50 kHz	0.086 + 600	0.100 + 600			0.2 + 2 mV
	50 kHz to 100 kHz	0.192 + 2000	0.230 + 2000			0.5 + 2 mV
33 V to 329.999 V	45 Hz to 1 kHz	0.039 + 3000	0.050 + 3000	1 mV	5 mA, except 20 mA for 45 Hz to 65 Hz	0.15 + 10 mV
	1 kHz to 10 kHz	0.064 + 9000	0.080 + 9000			0.05 +10 mV
	10 kHz to 20 kHz	0.079 + 9000	0.090 + 9000			0.6 + 10 mV
	20 kHz to 50 kHz	0.096 + 9000	0.120 + 9000			0.8 + 10 mV
	50 kHz to 100 kHz	0.192 + 80000	0.240 + 80000			1 + 10 mV
330 V to 1020 V	45 Hz to 1 kHz	0.042 + 20000	0.050 + 20000	10 mV	2 mA, except 6 mA for 45 to 65 Hz	0.15 + 30 mV
	1 kHz to 5 kHz	0.064 + 20000	0.080 + 20000			0.07 + 30 mV
	5 kHz to 10 kHz	0.075 + 20000	0.090 + 20000			0.07 + 30 mV

[1] Max Distortion for 100 kHz to 200 kHz. For 200 kHz to 500 kHz, the maximum distortion is 0.9 % of output + floor as shown.

Note

Remote sensing is not provided. Output resistance is <5 mΩ for outputs ≥0.33 V. The AUX output resistance is <1 Ω. The maximum load capacitance is 500 pF, subject to the maximum burden current limits.

AC Voltage (Sine Wave) (cont.)

AUX (Auxiliary Output) [dual output mode only]						
Range	**Frequency** [1]	**Absolute Uncertainty, tcal ±5 °C ±(% of output + µV)**		**Resolution**	**Max Burden**	**Max Distortion and Noise 10 Hz to 5 MHz Bandwidth ±(% of output + floor)**
		90 Day	**1 Year**			
1.0 to 329.999 mV	10 to 20 Hz	0.15 + 370	0.20 + 370	1 µV	5 mA	0.20 + 200 µV
	20 to 45 Hz	0.08 + 370	0.10 + 370			0.06 + 200 µV
	45 to 1 kHz	0.08 + 370	0.10 + 370			0.08 + 200 µV
	1 to 5 kHz	0.15 + 450	0.20 + 450			0.30 + 200 µV
	5 to 10 kHz	0.30 + 450	0.40 + 450			0.60 + 200 µV
	10 to 30 kHz	4.00 + 900	5.00 + 900			1.00 + 200 µV
0.33 to 3.29999 V	10 to 20 Hz	0.15 + 450	0.20 + 450	10 µV	5 mA	0.20 + 200 µV
	20 to 45 Hz	0.08 + 450	0.10 + 450			0.06 + 200 µV
	45 to 1 kHz	0.07 + 450	0.09 + 450			0.08 + 200 µV
	1 to 5 kHz	0.15 + 1400	0.20 + 1400			0.30 + 200 µV
	5 to 10 kHz	0.30 + 1400	0.40 + 1400			0.60 + 200 µV
	10 to 30 kHz	4.00 + 2800	5.00 + 2800			1.00 + 200 µV
3.3 to 5 V	10 to 20 Hz	0.15 + 450	0.20 + 450	100 µV	5 mA	0.20 + 200 µV
	20 to 45 Hz	0.08 + 450	0.10 + 450			0.06 + 200 µV
	45 to 1 kHz	0.07 + 450	0.09 + 450			0.08 + 200 µV
	1 to 5 kHz	0.15 + 1400	0.20 + 1400			0.30 + 200 µV
	5 to 10 kHz	0.30 + 1400	0.40 + 1400			0.60 + 200 µV

[1] There are two channels of voltage output. The maximum frequency of the dual output is 30 kHz.

Note

Remote sensing is not provided. Output resistance is <5 mΩ for outputs ≥0.33 V. The AUX output resistance is <1 Ω. The maximum load capacitance is 500 pF, subject to the maximum burden current limits.

AC Current (Sine Wave)

Range	Frequency	Absolute Uncertainty, tcal ±5 °C ± (% of output + µA) 90 Day	Absolute Uncertainty, tcal ±5 °C ± (% of output + µA) 1 Year	Compliance adder ±(µA/V)	Max Distortion and Noise 10 Hz to 100 kHz BW ±(% of output + floor)	Max Inductive Load µH
LCOMP Off						
29 to 329.99 µA	10 to 20 Hz	0.16 + 0.1	0.2 + 0.1	0.05	0.15 + 0.5 µA	200
	20 to 45 Hz	0.12 + 0.1	0.15 + 0.1	0.05	0.10 + 0.5 µA	
	45 Hz to 1 kHz	0.1 + 0.1	0.125 + 0.1	0.05	0.05 + 0.5 µA	
	1 to 5 kHz	0.25 + 0.15	0.3 + 0.15	1.5	0.50 + 0.5 µA	
	5 to 10 kHz	0.6 + 0.2	0.8 + 0.2	1.5	1.00 + 0.5 µA	
	10 to 30 kHz	1.2 + 0.4	1.6 + 0.4	10	1.20 + 0.5 µA	
0.33 to 3.29999 mA	10 to 20 Hz	0.16 + 0.15	0.2 + 0.15	0.05	0.15 + 1.5 µA	200
	20 to 45 Hz	0.1 + 0.15	0.125 + 0.15	0.05	0.06 + 1.5 µA	
	45 Hz to 1 kHz	0.08 + 0.15	0.1 + 0.15	0.05	0.02 + 1.5 µA	
	1 to 5 kHz	0.16 + 0.2	0.2 + 0.2	1.5	0.50 + 1.5 µA	
	5 to 10 kHz	0.4 + 0.3	0.5 + 0.3	1.5	1.00 + 1.5 µA	
	10 to 30 kHz	0.8 + 0.6	1.0 + 0.6	10	1.20 + 0.5 µA	
3.3 to 32.9999 mA	10 to 20 Hz	0.15 + 2	0.18 + 2	0.05	0.15 + 5 µA	50
	20 to 45 Hz	0.075 + 2	0.09 + 2	0.05	0.05 + 5 µA	
	45 Hz to 1 kHz	0.035 + 2	0.04 + 2	0.05	0.07 + 5 µA	
	1 to 5 kHz	0.065 + 2	0.08 + 2	1.5	0.30 + 5 µA	
	5 to 10 kHz	0.16 + 3	0.2 + 3	1.5	0.70 + 5 µA	
	10 to 30 kHz	0.32 + 4	0.4 + 4	10	1.00 + 0.5 µA	
33 to 329.999 mA	10 to 20 Hz	0.15 + 20	0.18 + 20	0.05	0.15 + 50 µA	50
	20 to 45 Hz	0.075 + 20	0.09 + 20	0.05	0.05 + 50 µA	
	45 Hz to 1 kHz	0.035 + 20	0.04 + 20	0.05	0.02 + 50 µA	
	1 to 5 kHz	0.08 + 50	0.10 + 50	1.5	0.03 + 50 µA	
	5 to 10 kHz	0.16 + 100	0.2 + 100	1.5	0.10 + 50 µA	
	10 to 30 kHz	0.32 + 200	0.4 + 200	10	0.60 + 50 µA	
0.33 to 1.09999 A	10 to 45 Hz	0.15 + 100	0.18 + 100		0.20 + 500 µA	2.5
	45 Hz to 1 kHz	0.036 + 100	0.05 + 100		0.07 + 500 µA	
	1 to 5 kHz	0.5 + 1000	0.6 + 1000	[2]	1.00 + 500 µA	
	5 to 10 kHz	2.0 + 5000	2.5 + 5000	[3]	2.00 + 500 µA	
1.1 to 2.99999 A	10 to 45 Hz	0.15 + 100	0.18 + 100		0.20 + 500 µA	2.5
	45 Hz to 1 kHz	0.05 + 100	0.06 + 100		0.07 + 500 µA	
	1 to 5 kHz	0.5 + 1000	0.6 + 1000	[2]	1.00 + 500 µA	
	5 to 10 kHz	2.0 + 5000	2.5 + 5000	[3]	2.00 + 500 µA	
3 to 10.9999 A	45 to 100 Hz	0.05 + 2000	0.06 + 2000		0.2 + 3 mA	1
	100 Hz to 1 kHz	0.08 + 2000	0.10 + 2000		0.1 + 3 mA	
	1 kHz to 5 kHz	2.5 + 2000	3.0 + 2000		0.8 + 3 mA	
11 to 20.5 A [1]	45 to 100 Hz	0.1 + 5000	0.12 + 5000		0.2 + 3 mA	1
	100 Hz to 1 kHz	0.13 + 5000	0.15 + 5000		0.1 + 3 mA	
	1 to 5 kHz	2.5 + 5000	3.0 + 5000		0.8 + 3 mA	

[1] Duty Cycle: Currents <11 A may be provided continuously. For currents >11 A, see Figure 1. The current may be provided 60-T-I minutes any 60 minute period where T is the temperature in °C (room temperature is about 23 °C) and I is the output current in amps. For example, 17 A, at 23 °C could be provided for 60-17-23 = 20 minutes each hour. When the 5502A is outputting currents between 5 and 11 amps for long periods, the internal self-heating reduces the duty cycle. Under those conditions, the allowable "on" time indicated by the formula and Figure 1 is achieved only after the 5502A is outputting currents <5 A for the "off" period first.

[2] For compliance voltages greater than 1 V, add 1 mA/V to the floor specification from 1 to 5 kHz.

[3] For compliance voltages greater than 1 V, add 5 mA/V to the floor specification from 5 to 10 kHz.

AC Current (Sine Wave) (cont.)

Range	Frequency	Absolute Uncertainty, tcal ±5 °C ±(% of output + µA)		Max Distortion and Noise 10 Hz to 100 kHz BW ±(% of output + floor)	Max Inductive Load
		90 Day	1 Year		
LCOMP On					
29 to 329.99 µA	10 to 100 Hz	0.20 + 0.2	0.25 + 0.2	0.1 + 1.0 µA	400 µH
	100 Hz to 1 kHz	0.50 + 0.5	0.60 + 0.5	0.05 + 1.0 µA	
330 µA to 3.29999 mA	10 to 100 Hz	0.20 + 0.3	0.25 + 0.3	0.15 + 1.5 µA	
	100 Hz to 1 kHz	0.50 + 0.8	0.60 + 0.8	0.06 + 1.5 µA	
3.3 to 32.9999 mA	10 to 100 Hz	0.07 + 4	0.08 + 4	0.15 + 5 µA	
	100 Hz to 1 kHz	0.18 + 10	0.20 + 10	0.05 + 5 µA	
33 to 329.999 mA	10 to 100 Hz	0.07 + 40	0.08 + 40	0.15 + 50 µA	
	100 Hz to 1 kHz	0.18 + 100	0.20 + 100	0.05 + 50 µA	
330 mA to 2.99999 A	10 to 100 Hz	0.10 + 200	0.12 + 200	0.2 + 500 µA	
	100 to 440 Hz	0.25 + 1000	0.30 + 1000	0.25 + 500 µA	
3.3 A to 20.5 A [1]	45 to 100 Hz	0.10 + 2000 [2]	0.12 + 2000 [2]	0.1 + 0 µA	400 µH [4]
	100 to 440 Hz	0.80 + 5000 [3]	1.00 + 5000 [3]	0.5 + 0 µA	

[1] Duty Cycle: Currents <11 A may be provided continuously. For currents >11 A, see Figure 1. The current may be provided 60-T-I minutes any 60 minute period where T is the temperature in °C (room temperature is about 23 °C) and I is the output current in amps. For example, 17 A, at 23 °C could be provided for 60-17-23 = 20 minutes each hour. When the 5502A is outputting currents between 5 and 11 amps for long periods, the internal self-heating reduces the duty cycle. Under those conditions, the allowable "on" time indicated by the formula and Figure 1 is achieved only after the 5502A is outputting currents <5 A for the "off" period first.

[2] For currents >11 A, Floor specification is 4000 µA within 30 seconds of selecting operate. For operating times >30 seconds, the floor specification is 2000 µA.

[3] For currents >11 A, Floor specification is 10000 µA within 30 seconds of selecting operate. For operating times >30 seconds, the floor specification is 5000 µA.

[4] Subject to compliance voltages limits.

Range	Resolution µA	Max Compliance Voltage V rms [1]
29 to 329.99 µA	0.01	7
0.33 to 3.29999 mA	0.01	7
3.3 to 32.9999 mA	0.1	5
33 to 329.999 mA	1	5
0.33 to 2.99999 A	10	4
3 to 20.5 A	100	3

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

Capacitance

Range	Absolute Uncertainty, tcal ±5 °C ±(% of output + floor) [1] [2] [3]		Resolution	Allowed Frequency or Charge-Discharge Rate		
	90 Day	1 Year		Min and Max to Meet Specification	Typical Max for <0.5 % Error	Typical Max for <1 % Error
220.0 to 399.9 pF	0.38 + 0.01 nF	0.5 + 0.01 nF	0.1 pF	10 Hz to 10 kHz	20 kHz	40 kHz
0.4 to 1.0999 nF	0.38 + 0.01 nF	0.5 + 0.01 nF	0.1 pF	10 Hz to 10 kHz	30 kHz	50 kHz
1.1 to 3.2999 nF	0.38 + 0.01 nF	0.5 + 0.01 nF	0.1 pF	10 Hz to 3 kHz	30 kHz	50 kHz
3.3 to 10.999 nF	0.19 + 0.01 nF	0.25 + 0.01 nF	1 pF	10 Hz to 1 kHz	20 kHz	25 kHz
11 to 32.999 nF	0.19 + 0.1 nF	0.25 + 0.1 nF	1 pF	10 Hz to 1 kHz	8 kHz	10 kHz
33 to 109.99 nF	0.19 + 0.1 nF	0.25 + 0.1 nF	10 pF	10 Hz to 1 kHz	4 kHz	6 kHz
110 to 329.99 nF	0.19 + 0.3 nF	0.25 + 0.3 nF	10 pF	10 Hz to 1 kHz	2.5 kHz	3.5 kHz
0.33 to 1.0999 μF	0.19 + 1 nF	0.25 + 1 nF	100 pF	10 to 600 Hz	1.5 kHz	2 kHz
1.1 to 3.2999 μF	0.19 + 3 nF	0.25 + 3 nF	100 pF	10 to 300 Hz	800 Hz	1 kHz
3.3 to 10.999 μF	0.19 + 10 nF	0.25 + 10 nF	1 nF	10 to 150 Hz	450 Hz	650 Hz
11 to 32.999 μF	0.30 + 30 nF	0.40 + 30 nF	1 nF	10 to 120 Hz	250 Hz	350 Hz
33 to 109.99 μF	0.34 + 100 nF	0.45 + 100 nF	10 nF	10 to 80 Hz	150 Hz	200 Hz
110 to 329.99 μF	0.34 + 300 nF	0.45 + 300 nF	10 nF	0 to 50 Hz	80 Hz	120 Hz
0.33 to 1.0999 mF	0.34 + 1 μF	0.45 + 1 μF	100 nF	0 to 20 Hz	45 Hz	65 Hz
1.1 to 3.2999 mF	0.34 + 3 μF	0.45 + 3 μF	100 nF	0 to 6 Hz	30 Hz	40 Hz
3.3 to 10.999 mF	0.34 + 10 μF	0.45 + 10 μF	1 μF	0 to 2 Hz	15 Hz	20 Hz
11 to 32.999 mF	0.7 + 30 μF	0.75 + 30 μF	1 μF	0 to 0.6 Hz	7.5 Hz	10 Hz
33 to 110.00 mF	1.0 + 100 μF	1.1 + 100 μF	10 μF	0 to 0.2 Hz	3 Hz	5 Hz

[1] The output is continuously variable from 220 pF to 110 mF.

[2] Specifications apply to both dc charge/discharge capacitance meters and ac RCL meters. The maximum allowable peak voltage is 3 V. The maximum allowable peak current is 150 mA, with an rms limitation of 30 mA below 1.1 μF and 100 mA for 1.1 μF and above.

[3] The maximum lead resistance for no additional error in 2-wire COMP mode is 10 Ω.

Temperature Calibration (Thermocouple)

TC Type [1]	Range °C [2]	Absolute Uncertainty Source/Measure tcal ±5 °C ± °C [3]	
		90 Day	1 Year
B	600 to 800	0.42	0.44
	800 to 1000	0.34	0.34
	1000 to 1550	0.30	0.30
	1550 to 1820	0.26	0.33
C	0 to 150	0.23	0.30
	150 to 650	0.19	0.26
	650 to 1000	0.23	0.31
	1000 to 1800	0.38	0.50
	1800 to 2316	0.63	0.84
E	-250 to -100	0.38	0.50
	-100 to -25	0.12	0.16
	-25 to 350	0.10	0.14
	350 to 650	0.12	0.16
	650 to 1000	0.16	0.21
J	-210 to -100	0.20	0.27
	-100 to -30	0.12	0.16
	-30 to 150	0.10	0.14
	150 to 760	0.13	0.17
	760 to 1200	0.18	0.23
K	-200 to -100	0.25	0.33
	-100 to -25	0.14	0.18
	-25 to 120	0.12	0.16
	120 to 1000	0.19	0.26
	1000 to 1372	0.30	0.40

TC Type [1]	Range °C [2]	Absolute Uncertainty Source/Measure tcal ±5 °C ± °C [3]	
		90 Day	1 Year
L	-200 to -100	0.37	0.37
	-100 to 800	0.26	0.26
	800 to 900	0.17	0.17
N	-200 to -100	0.30	0.40
	-100 to -25	0.17	0.22
	-25 to 120	0.15	0.19
	120 to 410	0.14	0.18
	410 to 1300	0.21	0.27
R	0 to 250	0.48	0.57
	250 to 400	0.28	0.35
	400 to 1000	0.26	0.33
	1000 to 1767	0.30	0.40
S	0 to 250	0.47	0.47
	250 to 1000	0.30	0.36
	1000 to 1400	0.28	0.37
	1400 to 1767	0.34	0.46
T	-250 to -150	0.48	0.63
	-150 to 0	0.18	0.24
	0 to 120	0.12	0.16
	120 to 400	0.10	0.14
U	-200 to 0	0.56	0.56
	0 to 600	0.27	0.27

[1] Temperature standard ITS-90 or IPTS-68 is selectable.
TC simulating and measuring are not specified for operation in electromagnetic fields above 0.4 V/m.

[2] Resolution is 0.01 °C

[3] Does not include thermocouple error

Temperature Calibration (RTD)

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

RTD Type	Range °C [1]	Absolute Uncertainty tcal ±5 °C ± °C [2]	
		90 Day	1 Year
Pt 385, 500 Ω	-200 to -80	0.03	0.04
	-80 to 0	0.04	0.05
	0 to 100	0.05	0.05
	100 to 260	0.06	0.06
	260 to 300	0.07	0.08
	300 to 400	0.07	0.08
	400 to 600	0.08	0.09
	600 to 630	0.09	0.11
Pt 385, 1000 Ω	-200 to -80	0.03	0.03
	-80 to 0	0.03	0.03
	0 to 100	0.03	0.04
	100 to 260	0.04	0.05
	260 to 300	0.05	0.06
	300 to 400	0.05	0.07
	400 to 600	0.06	0.07
	600 to 630	0.22	0.23
PtNi 385, 120 Ω (Ni120)	-80 to 0	0.06	0.08
	0 to 100	0.07	0.08
	100 to 260	0.13	0.14
Cu 427 10 Ω [3]	-100 to 260	0.3	0.3

[1] Resolution is 0.003 °C
[2] Applies for COMP OFF (to the 5502A Calibrator front panel NORMAL terminals) and 2-wire and 4-wire compensation.
[3] Based on MINCO Application Aid No. 18

Phase

1-Year Absolute Uncertainty, tcal ±5 °C, (Δ Φ °)					
Frequency (Hz)					
10 to 65 Hz	**65 to 500 Hz**	**500 Hz to 1 kHz**	**1 to 5 kHz**	**5 to 10 kHz**	**10 to 30 kHz**
0.15 °	0.9 °	2 °	6 °	10 °	15 °

Note
See Power and Dual Output Limit Specifications for applicable outputs.

Phase (Φ) Watts	Phase (Φ) VARs	PF	Power Uncertainty Adder due to Phase Error					
			10 to 65 Hz	65 to 500 Hz	500 Hz to 1 kHz	1 to 5 kHz	5 to 10 kHz	10 to 30 kHz
0 °	90 °	1.0	0.00 %	0.01 %	0.06 %	0.55 %	1.52 %	3.41 %
5 °	85 °	0.996	0.02 %	0.15 %	0.37 %	1.46 %	3.04 %	5.67 %
10 °	80 °	0.985	0.05 %	0.29 %	0.68 %	2.39 %	4.58 %	7.97 %
15 °	75 °	0.966	0.07 %	0.43 %	1.00 %	3.35 %	6.17 %	10.34 %
20 °	70 °	0.940	0.10 %	0.58 %	1.33 %	4.35 %	7.84 %	12.83 %
25 °	65 °	0.906	0.12 %	0.74 %	1.69 %	5.42 %	9.62 %	15.48 %
30 °	60 °	0.866	0.15 %	0.92 %	2.08 %	6.58 %	11.54 %	18.35 %
35 °	55 °	0.819	0.18 %	1.11 %	2.50 %	7.87 %	13.68 %	21.53 %
40 °	50 °	0.766	0.22 %	1.33 %	2.99 %	9.32 %	16.09 %	25.12 %
45 °	45 °	0.707	0.26 %	1.58 %	3.55 %	11.00 %	18.88 %	29.29 %
50 °	40 °	0.643	0.31 %	1.88 %	4.22 %	13.01 %	22.21 %	34.25 %
55 °	35 °	0.574	0.37 %	2.26 %	5.05 %	15.48 %	26.32 %	40.37 %
60 °	30 °	0.500	0.45 %	2.73 %	6.11 %	18.65 %	31.60 %	48.24 %
65 °	25 °	0.423	0.56 %	3.38 %	7.55 %	22.96 %	38.76 %	58.91 %
70 °	20 °	0.342	0.72 %	4.33 %	9.65 %	29.27 %	49.23 %	74.52 %
75 °	15 °	0.259	0.98 %	5.87 %	13.09 %	39.56 %	66.33 %	100.00 %
80 °	10 °	0.174	1.49 %	8.92 %	19.85 %	59.83 %	100.00 %	—
85 °	5 °	0.087	2.99 %	17.97 %	39.95 %	—	—	—
90 °	0 °	0.000	—	—	—	—	—	—

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

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

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

$$Adder(\%) = 100(1 - \frac{Cos(23 + .15)}{Cos(23)}) = 0.11\%$$

AC and DC Power Specifications

Power is simulated through the controlled simultaneous outputs of voltage and current from the Calibrator. While the amplitude and frequency ranges of the outputs are broad, there are certain combinations of voltage and current where the specifications are valid. In general these are for all dc voltages and currents, and AC voltages of 30 mV to 1020 V, ac currents from 33 mA to 20.5 A, for frequencies from 10 Hz to 30 kHz. Operation outside of these areas, within the overall calibrator capabilities, is possible, but it is not specified. The table and figure below illustrate the specified areas where power and dual output are possible.

Specification Limits for Power and Dual Output Operation

Frequency	Voltages (NORMAL)	Currents	Voltages (AUX)	Power Factor (PF)
dc	0 to ±1020 V	0 to ±20.5 A	0 to ±7 V	—
10 to 45 Hz	33 mV to 32.9999 V	3.3 mA to 2.99999 A	10 mV to 5 V	0 to 1
45 to 65 Hz	33 mV to 1020 V	3.3 mA to 20.5 A	10 mV to 5 V	0 to 1
65 to 500 Hz	330 mV to 1020 V	33 mA to 2.99999 A	100 mV to 5 V	0 to 1
65 to 500 Hz	3.3 to 1020 V	33 mA to 20.5 A	100 mV to 5 V	0 to 1
500 Hz to 1 kHz	330 mV to 1020 V	33 mA to 20.5 A	100 mV to 5 V	0 to 1
1 to 5 kHz	3.3 to 500 V	33 mA to 2.99999 A	100 mV to 5 V	0 to 1
5 to 10 kHz	3.3 to 250 V	33 to 329.99 mA	1 to 5 V	0 to 1
10 to 30 kHz	3.3 V to 250 V	33 mA to 329.99 mA	1 V to 3.29999 V	0 to 1

Notes

The range of voltages and currents shown in “DC Voltage Specifications,” “DC Current Specifications,” “AC Voltage (Sine Wave) Specifications,” and “AC Current (Sine Wave) Specifications” are available in the power and dual output modes (except minimum current for ac power is 0.33 mA). Only those limits shown in this table and illustrated in the following figure are specified.

See “Calculate Power Uncertainty” to determine the uncertainty at these points.

The phase adjustment range for dual ac outputs is 0 ° to ±179.99 °. The phase resolution for dual ac outputs is 0.01 °.

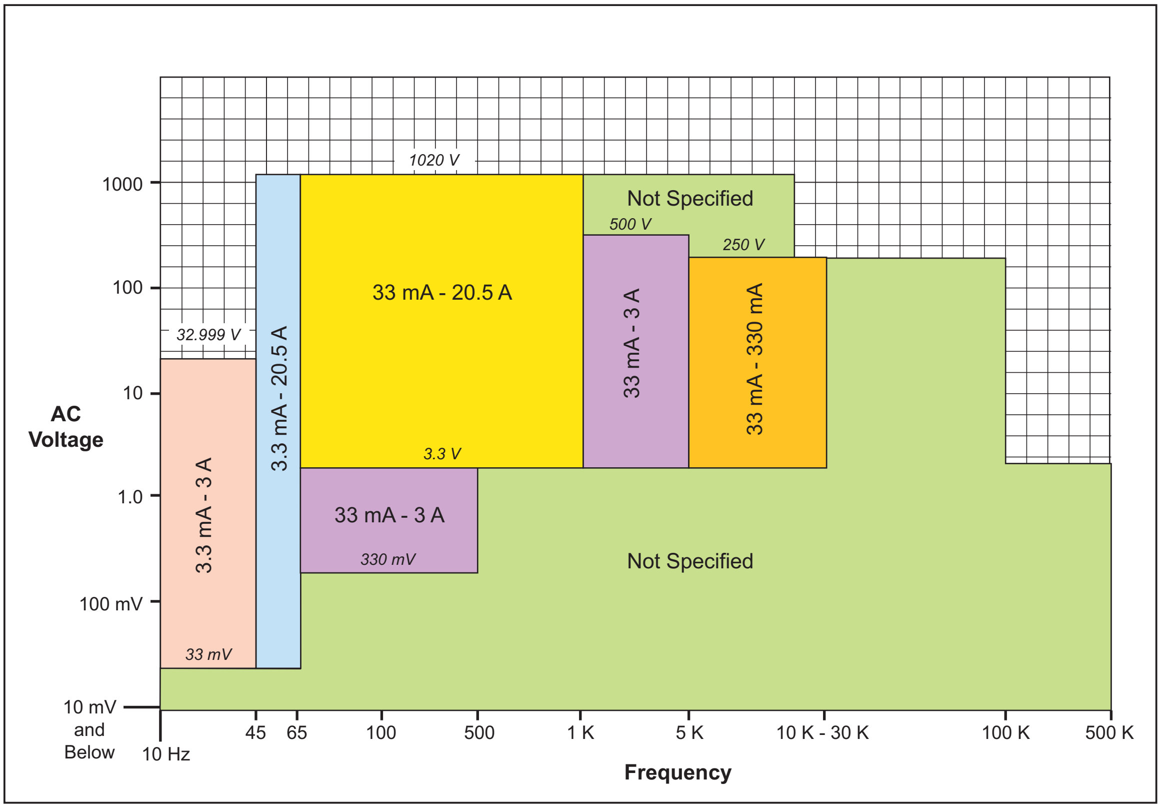

Figure 2. Permissible Combinations of AC Voltage and AC Current for Power and Dual Output

Calculate the Uncertainty Specifications of Power and Dual Output Settings

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, if AC power, the phase parameters:

Watts uncertainty $$U_{\mathrm{power}} = \sqrt{U^2_{\mathrm{Voltage}} + U^2_{\mathrm{Current}} + U^2_{\mathrm{Phase}}}$$

VARs uncertainty $$U_{\mathrm{VARs}} = \sqrt{U^2_{\mathrm{Voltage}} + U^2_{\mathrm{Current}} + U^2_{\mathrm{Phase}}}$$

Dual Output uncertainty $$U_{\mathrm{Dual}} = \sqrt{U^2_{\mathrm{Voltage}} + U^2_{\mathrm{AuxVoltage}} + U^2_{\mathrm{Phase}}}$$

Because there are an infinite number of combinations, you must calculate the actual ac power uncertainty for your selected parameters. The results of this method of calculation are shown in the subsequent example. These examples are at various selected calibrator settings (with 1-year specifications):

Examples of Specified Power Uncertainties at Various Output Settings:

Selected Output Settings						Absolute Uncertainty as specified for tcal ±5 °C, ±(% of output setting)			Power Absolute Uncerainty ±(% of Watts)[1]
Voltage Setting (Volts)	Current Setting (Amps)	Frequency Hz	Phase Setting (units of PF)	Phase Setting (Degrees)	Selected Power (Watts)	$U_{Voltage}$	$U_{Current}$	U_{Phase}	U_{Power}
+10.000	+0.500.000	DC			5	0.00550 %	0.04680 %		0.047 %
15.000	+2.0000	DC			30	0.00533 %	0.03220 %		0.033 %
100.000	+20.000	DC			2000	0.00600 %	0.10375 %		0.104 %
1000.00	20.000	DC			20000	0.00565 %	0.10375 %		0.104 %
120.000	1.00000	60	1	0.0	120	0.05250 %	0.06000 %	0.000 %	0.080 %
120.000	1.00000	60	0.766	40.0	91.92	0.05250 %	0.06000 %	0.220 %	0.234 %
240.000	1.00000	50	1	0.0	240	0.05125 %	0.06000 %	0.000 %	0.079 %
240.000	1.00000	50	0.766	40.0	183.84	0.05125 %	0.06000 %	0.220 %	0.234 %
1000.00	20	55	1	0.0	20000	0.05200 %	0.14500 %	0.000 %	0.154 %
1000.00	20	55	0.766	40.0	15320	0.05200 %	0.14500 %	0.220 %	0.269 %
1000.00	20	55	-0.906	-25.0	18120	0.05200 %	0.14500 %	0.122 %	0.196 %
100	0.30	30000	1	0.0	30.0	0.12900 %	0.4667 %	3.407 %	3.442 %
100	0.30	30000	0.766	40.0	22.98	0.12900 %	0.4667 %	25.128 %	25.133 %

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

Calculate 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 phase parameters:

Watts uncertainty $$U_{\text{Power}} = \sqrt{U^2_{\text{Voltage}} + U^2_{\text{Current}} + U^2_{\text{Phase}}}$$

VARs uncertainty $$U_{\text{VARs}} = \sqrt{U^2_{\text{Voltage}} + U^2_{\text{Current}} + U^2_{\text{Phase}}}$$

Because there are an infinite number of combinations, you must calculate the actual ac power uncertainty for your selected parameters. The method of calculation is best shown in the subsequent examples (with 1-year specifications):

<u>**Example 1**</u> Output: 100 V, 1 A, 60 Hz, Power Factor = 1.0 (Φ=0).

Voltage Uncertainty Uncertainty for 100 V at 60 Hz is 0.050 % + 3 mV, totaling: 100 V x .0.0005 = 50 mV added to 3 mV = 53 mV. Expressed in percent: 53 mV/100 V x 100 = <u>0.053 %</u> (see “AC Voltage (Sine Wave) Specifications”).

Current Uncertainty Uncertainty for 1 A at 60 Hz is 0.05 % +100 µA, totaling: 1 A x 0.0005 = 500 µA added to 100 µA = 0.6 mA. Expressed in percent: 0. 6 mA/1 A x 100 = <u>0.06 %</u> (see “AC Current (Sine Waves) Specifications”).

Phase Uncertainty (Watts) Adder for PF = 1 (Φ=0) at 60 Hz is <u>0 %</u> (see “Phase Specifications”).

Total Power Uncertainty = $U_{\text{power}} = \sqrt{0.053^2 + 0.06^2 + 0^2} = 0.080\%$

<u>**Example 2**</u> Output: 100 V, 1 A, 400 Hz, Power Factor = 0.5 (Φ=60)

Voltage Uncertainty Uncertainty for 100 V at 400 Hz is 0.050% + 3 mV, totaling: 100 V x .0.0005 = 50 mV added to 3 mV = 53 mV. Expressed in percent: 53 mV/100 V x 100 = <u>0.053 %</u> (see “AC Voltage (Sine Wave) Specifications”).

Current Uncertainty Uncertainty for 1 A at 400 Hz is 0.05 % +100 µA, totaling: 1 A x 0.0005 = 500 µA added to 100 µA = 0.6 mA. Expressed in percent: 0. 6 mA/1 A x 100 = <u>0.06 %</u> (see “AC Current (Sine Waves) Specifications”).

Phase Uncertainty (Watts) Adder for PF = 0.5 (Φ=60) at 400 Hz is <u>2.73 %</u> (see “Phase Specifications”).

Total Power Uncertainty = $U_{\text{power}} = \sqrt{0.053^2 + 0.06^2 + 2.73^2} = 2.73\%$

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:

<u>**Example 3**</u> Output: 100 V, 1 A, 60 Hz, Power Factor = 0.174 (Φ=80)

Voltage Uncertainty Uncertainty for 100 V at 60 Hz is 0.050% + 3 mV, totaling: 100 V x .0.0005 = 50 mV added to 3 mV = 53 mV. Expressed in percent: 53 mV/100 V x 100 = <u>0.053 %</u> (see “AC Voltage (Sine Wave) Specifications”).

Current Uncertainty Uncertainty for 1 A at 60 Hz is 0.05 % +100 µA, totaling: 1 A x 0.0005 = 500 µA added to 100 µA = 0.6 mA. Expressed in percent: 0. 6 mA/1 A x 100 = <u>0.06 %</u> (see “AC Current (Sine Waves) Specifications”).

Phase Uncertainty (VARs) Adder for Φ=80 at 60 Hz is 0.05 % (see “Phase Specifications”).

Total VARS Uncertainty = $U_{VARs} = \sqrt{0.053^2 + 0.06^2 + 0.05^2} = 0.094\,\%$

Additional Specifications

The subsequent paragraphs provide additional specifications for the 5502A 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 5502A 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.

Frequency

Frequency Range	Resolution	1-Year Absolute Uncertainty, tcal ±5 °C ±(ppm + mHz)	Jitter
0.01 to 119.99 Hz	0.01 Hz	25 + 1	2 µs
120.0 to 1199.9 Hz	0.1 Hz	25 + 1	2 µs
1.2 to 11.999 kHz	1 Hz	25 + 1	2 µs
12 to 119.99 kHz	10 Hz	25 + 15	140 ns
120.0 to 1199.9 kHz	100 Hz	25 + 15	140 ns
1.2 to 2.000 MHz	1 kHz	25 + 15	140 ns

Harmonics (2nd to 50th)

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 2.99999 A	10 mV to 5 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 20.5 A	10 mV to 5 V	
65 to 500 Hz	33 mV to 1020 V	33 mA to 20.5 A	100 mV to 5 V	
500 Hz to 5 kHz	330 mV to 1020 V	33 mA to 20.5 A	100 mV to 5 V	
5 to 10 kHz	3.3 to 1020 V	33 to 329.9999 mA	100 mV to 5 V	
10 to 30 kHz	3.3 to 1020 V	33 to 329.9999 mA	100 mV to 3.29999 V	

[1] The maximum frequency of the harmonic output is 30 kHz (10 kHz for 3.3 to 5 V on the Aux terminals). For example, if the fundamental output is 5 kHz, the maximum selection is the 6th harmonic (30 kHz). All harmonic frequencies (2nd to 50th) are available for fundamental outputs between 10 Hz and 600 Hz (200 Hz for 3.3 to 5 V on the Aux terminals).

Phase Uncertainty.. 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 ° (from “Phase Specifications”). Another example, the phase uncertainty of a 50 Hz fundamental output and a 400 Hz harmonic output is 1 degree.

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 (Sine Wave) 90 Day Specifications” the single output specification for 100 V, 100 Hz, is 0.039 % + 3 mV. For the dual output in this example, the specification is 0.039 % + 6 mV as the 0.039 % is the same, and the floor is twice the value (2 x 3 mV).

AUX (50th Harmonic) Output:

100 mV, 5 kHz .... From “AC Voltage (Sine Wave) 90 Day Specifications” the auxiliary output specification for 100 mV, 5 kHz, is 0.15 % + 450 µV. For the dual output in this example, the specification is 0.15 % + 900 µV as the 0.15 % is the same, and the floor is twice the value (2 x 450 µV).

AC Voltage (Sine Wave) Extended Bandwidth

Range	Frequency	1-Year Absolute Uncertainty tcal ±5 °C	Max Voltage Resolution
Normal Channel (Single Output Mode)			
1.0 to 33 mV	0.01 to 9.99 Hz	±(5.0 % of output +0.5 % of range)	Two digits, e.g., 25 mV
34 to 330 mV			Three digits
0.4 to 33 V			Two digits
0.3 to 3.3 V	500.1 kHz to 1 MHz	-10 dB at 1 MHz, typical	Two digits
	1.001 to 2 MHz	-31 dB at 2 MHz, typical	
Auxiliary Output (Dual Output Mode)			
10 to 330 mV	0.01 to 9.99 Hz	±(5.0 % of output +0.5 % of range)	Three digits
0.4 to 5 V			Two digits

AC Voltage (Non-Sine Wave)

Triangle Wave & Truncated Sine Range, p-p [1]	Frequency	1-Year Absolute Uncertainty, tcal ±5 °C, ±(% of output + % of range) [2]	Max Voltage Resolution
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
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 20 kHz	0.5 + 0.25	
	20 to 100 kHz [3]	5.0 + 0.5	
93 to 929.999 mV	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 20 kHz	0.5 + 0.25	
	20 to 100 kHz [3]	5.0 + 0.5	
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 20 kHz	0.5 + 0.25	
	20 to 100 kHz [3]	5.0 + 0.5	
9.3 to 93 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 20 kHz	0.5 + 0.25	
	20 to 100 kHz [3]	5.0 + 0.5	
Auxiliary Output (Dual Output Mode)			
29 to 929.999 mV	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	
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	
9.3 to 14.0000 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 triangle wave, multiply the p-p value by 0.2886751. To convert p-p to rms for truncated sine wave, 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.

AC Voltage (Non-Sine Wave) (cont.)

Square Wave Range (p-p) [1]	Frequency	1-Year Absolute Uncertainty, tcal ±5 °C, ±(% of output + % of range) [2]	Max Voltage Resolution
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
	10 to 45 Hz	0.25 + 0.5	Six digits on each range
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 20 kHz	0.5 + 0.25	
	20 to 100 kHz	5.0 + 0.5	
66 to 659.999 mV	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 20 kHz	0.5 + 0.25	
	20 to 100 kHz	5.0 + 0.5	
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 20 kHz	0.5 + 0.25	
	20 to 100 kHz	5.0 + 0.5	
6.6 to 66.0000 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 20 kHz	0.5 + 0.25	
	20 to 100 kHz	5.0 + 0.5	
Auxiliary Output (Dual Output Mode)			
29 to 659.999 mV	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 [3]	5.0 + 0.5	
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 [3]	5.0 + 0.5	
6.6 to 14.0000 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 [3]	5.0 + 0.5	

[1] To convert p-p to rms for square wave, multiply the p-p value by 0.5.
[2] Uncertainty is stated in p-p. Amplitude is verified using an rms-responding DMM.
[3] Limited to 1 kHz for Auxiliary outputs ≥6.6 V p-p.

AC Voltage, DC Offset

Range [1] (Normal Channel)	Offset Range [2]	Max Peak Signal	1-Year Absolute Uncertainty, tcal ±5 °C [3] ±(% of dc output + floor)
Sine Waves (rms)			
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 μV
0.33 to 3.29999 V	0 to 5 V	8 V	0.1 + 3300 μV
3.3 to 32.9999 V	0 to 50 V	55 V	0.1 + 33 mV
Triangle Waves and Truncated Sine Waves (p-p)			
9.3 to 92.999 mV	0 to 50 mV	80 mV	0.1 + 93 μV
93 to 929.999 mV	0 to 500 mV	800 mV	0.1 + 930 μV
0.93 to 9.29999 V	0 to 5 V	8 V	0.1 + 9300 μV
9.3 to 93.0000 V	0 to 50 V	55 V	0.1 + 93 mV
Square Waves (p-p)			
6.6 to 65.999 mV	0 to 50 mV	80 mV	0.1 + 66 μV
66 to 659.999 mV	0 to 500 mV	800 mV	0.1 + 660 μV
0.66 to 6.59999 V	0 to 5 V	8 V	0.1 + 6600 μV
6.6 to 66.0000 V	0 to 50 V	55 V	0.1 + 66 mV

[1] Offsets are not allowed on ranges above the highest range shown above.

[2] The maximum offset value is determined by the difference between the peak value of the selected voltage output and the allowable maximum peak signal. For example, a 10 V p-p square wave output has a peak value of 5 V, allowing a maximum offset up to ± 50 V to not exceed the 55 V maximum peak signal. The maximum offset values shown above are for the minimum outputs in each range.

[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.

AC Voltage, Square Wave Characteristics

Risetime @ 1 kHz Typical	Settling Time @ 1 kHz Typical	Overshoot @ 1 kHz Typical	Duty Cycle Range	Duty Cycle Uncertainty
<1 μs	<10 μs to 1 % of final value	<2 %	1 % to 99 % <3.3 V p-p. 0,01 Hz to 100 kHz	±(0.02 % of period + 100 ns), 50 % duty cycle ±(0.05 % of period + 100 ns), other duty cycles from 10 % to 90 %

AC Voltage, Triangle Wave 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

AC Current (Non-Sine Wave)

Triangle Wave & Truncated Sine Wave Range p-p	Frequency	1-Year Absolute Uncertainty tcal ±5 °C ±(% of output + % of range)	Max Current Resolution
0.047 to 0.92999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	10 + 2	
0.93 to 9.29999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	10 + 2	
9.3 to 92.9999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	10 + 2	
93 to 929.999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.5	
	1 to 10 kHz	10 + 2	
0.93 to 8.49999 A [2]	10 to 45 Hz	0.5 + 1.0	Six digits
	45 Hz to 1 kHz	0.5 + 0.5	
	1 to 10 kHz	10 + 2	
8.5 to 57 A [2]	45 to 500 Hz	0.5 + 0.5	
	500 Hz to 1 kHz	1.0 + 1.0	

[1] Frequency limited to 1 kHz with LCOMP on.
[2] Frequency limited to 440 Hz with LCOMP on.

AC Current (Non-Sine Wave) (cont.)

Square Wave Range p-p	Frequency	1-Year Absolute Uncertainty tcal ±5 °C ±(% of output + % of range)	Max Current Resolution
0.047 to 0.65999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	10 + 2	
0.66 to 6.59999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	10 + 2	
6.6 to 65.9999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.25	
	1 to 10 kHz	10 + 2	
66 to 659.999 mA [1]	10 to 45 Hz	0.25 + 0.5	Six digits
	45 Hz to 1 kHz	0.25 + 0.5	
	1 to 10 kHz	10 + 2	
0.66 to 5.99999 A [2]	10 to 45 Hz	0.5 + 1.0	
	45 Hz to 1 kHz	0.5 + 0.5	
	1 to 10 kHz	10 + 2	
6 to 41 A [2]	45 to 500 Hz	0.5 + 0.5	
	500 Hz to 1 kHz	1.0 + 1.0	

[1] Frequency limited to 1 kHz with LCOMP on.
[2] Frequency limited to 440 Hz with LCOMP on.

AC Current, Square Wave Characteristics (typical)

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

AC Current, Triangle Wave 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

Introduction

This chapter gives a description of the analog and digital sections of the Calibrator at a block diagram level. Figure 2-1 shows the configuration of assemblies in the Calibrator.

The Calibrator outputs:

- 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 29 μA to 20.5 A, with variable frequency limits.
- DC current from 0 to ±20.5 A.
- Resistance values from a short circuit to 1100 MΩ.
- Capacitance values from 220 pF to 110 mF.
- Simulated output for eight types of Resistance Temperature Detectors (RTDs).
- Simulated output for eleven types of thermocouples.

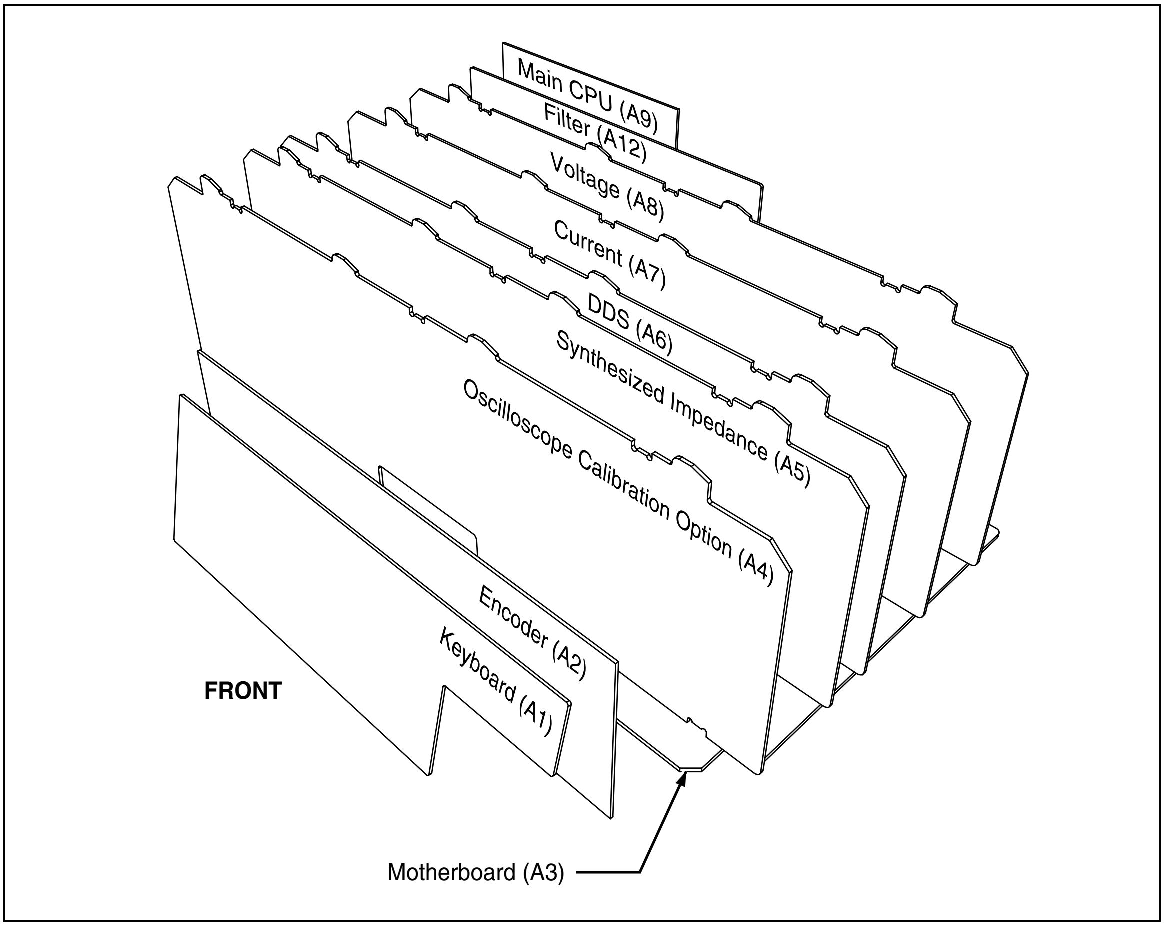

Figure 2-1. 5502A Internal Layout

Encoder PCA (A2)

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

Synthesized Impedance PCA (A5)

The Synthesized Impedance PCA (A5) supplies 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.

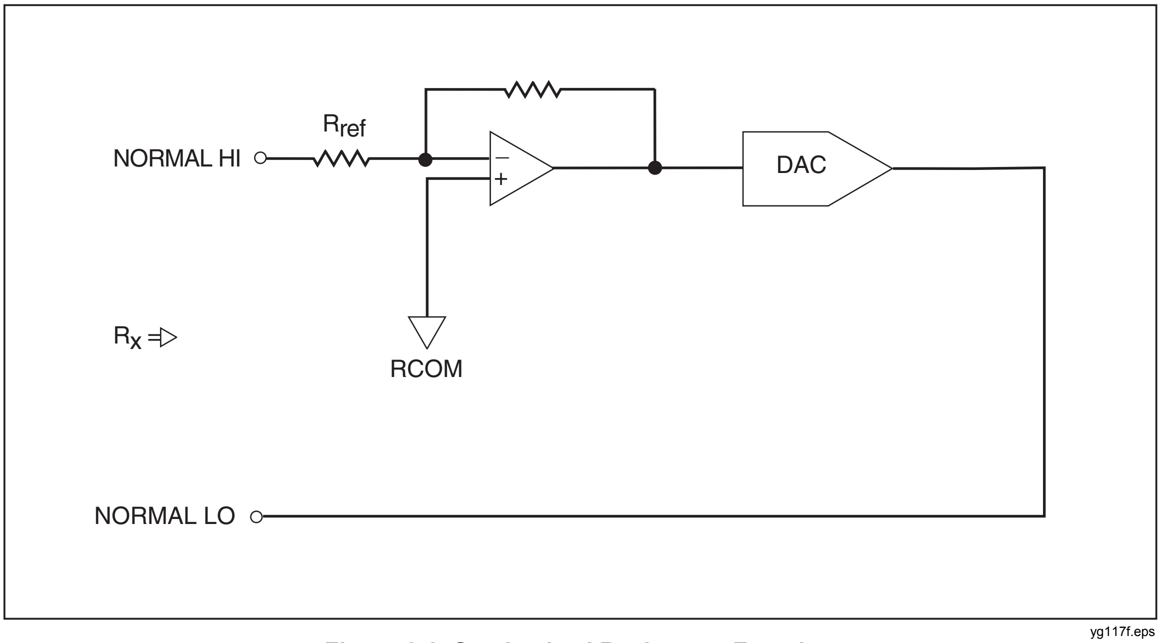

Figure 2-2. Synthesized Resistance Function

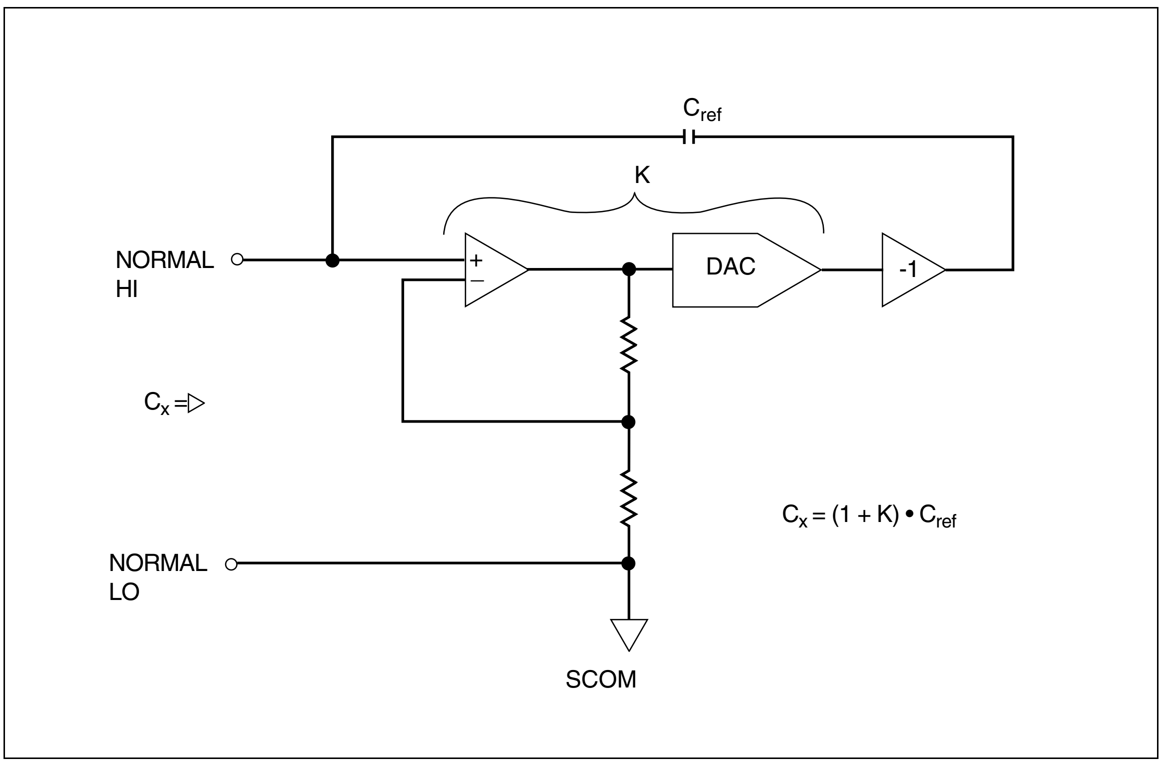

Figure 2-3. Synthesized Capacitance Function

DDS PCA (A6)

The DDS (Direct Digital Synthesis) PCA (A6) has these functional blocks:

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

These functional blocks, when used with the Voltage (A8) and/or Current (A7) assemblies, supply:

- Single or dual channel ac and dc volts, amps, and watts
- Offsettable and nonsinusoidal waveforms
- Duty cycle
- Thermocouple measurement and sourcing
- Internal calibration and diagnostics
- Digital control of 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) supplies finely stepped digital sine, triangular, and other waveforms.

Current PCA (A7)

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

The Current PCA connects to the DDS PCA (A6). The Filter PCA (A12) supplies the high current power supplies.

The Current PCA (A7) has these functional blocks:

- A supply that floats.
- Several stages of transconductance amplifier.
- Shunts that sense current and shunt amplifier. (These are the elements that set accuracy.)
- AUX voltage function.

Power for the Current PCA is filtered by the Filter PCA (A12). Its common is isolated from SCOM by a shunt resistor.

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

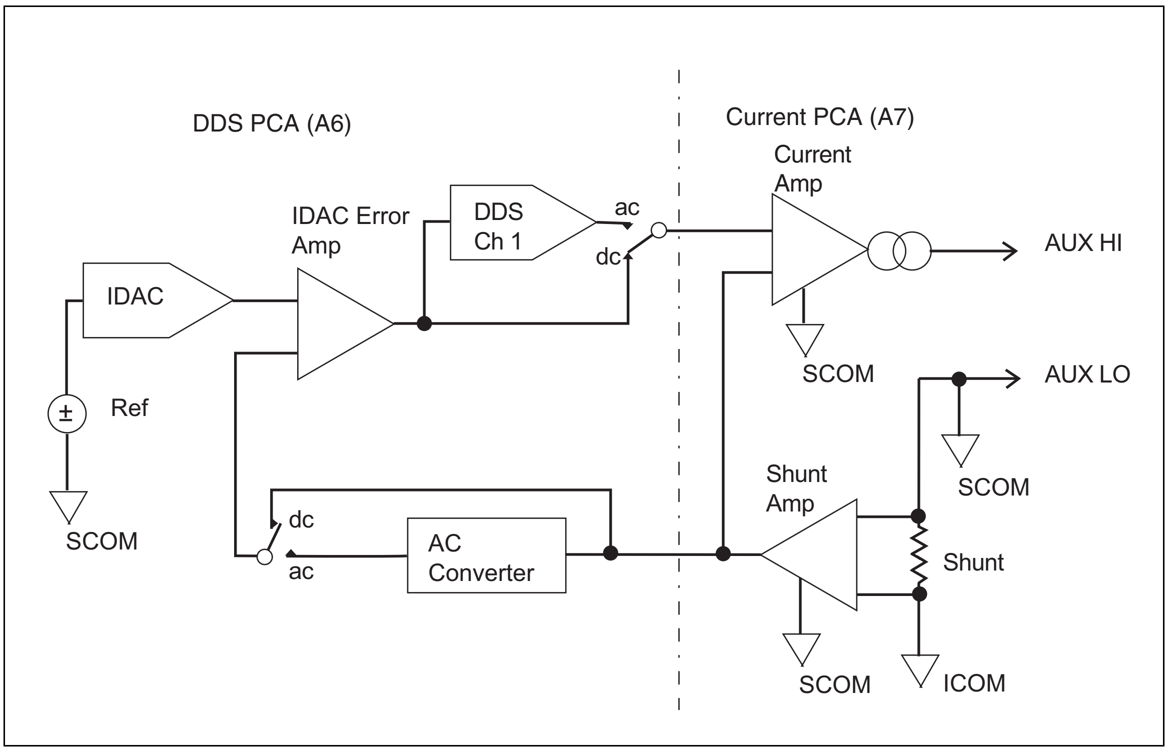

Figure 2-4. Current Function (AUX Out Ranges)

Voltage PCA (A8)

The Voltage PCA (A8) supplies dc and ac voltage outputs in the range 3.3 V and above. It also supplies all the inguard supplies referenced to SCOM. See the “Power Supplies” section.

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 PCA. Note that the voltage amplifier for outputs ≥3.3 V resides on the Voltage PCA, but the amplifier for voltage outputs <3.3 V is on the DDS PCA.

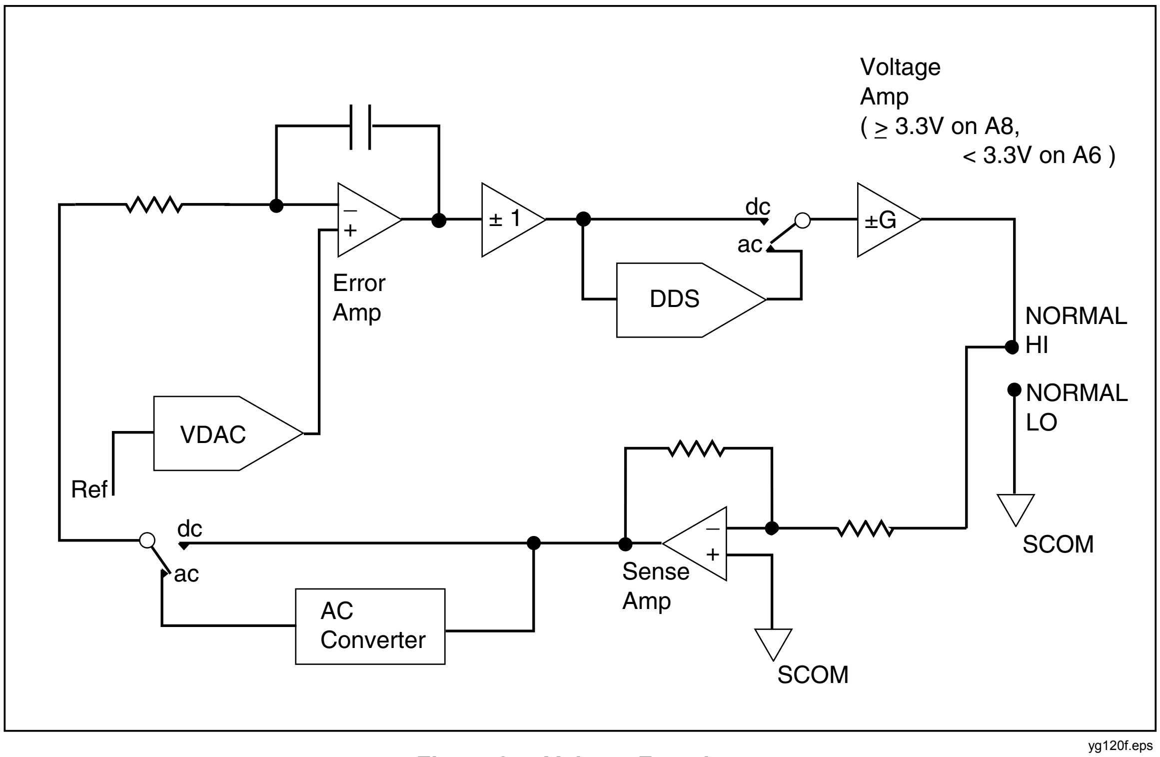

Figure 2-5. Voltage Function

Main CPU PCA (A9)

The Main CPU PCA (A9) attached to the rear-panel assembly communicates with:

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

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

Each analog assembly has the same bus structure:

- One or more Chip Select lines
- Common data bus that connects to the motherboard, latched in by latches
- A fault line that sets all modules to a safe condition if a malfunction is found

The routing of signals to the front panel jacks are controlled by output relays on the motherboard.

Power Supplies

AC line voltage is applied through a line filter to a power module in the rear panel. The module switches to accomodate four line voltages. The outputs of the power module are attached 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 attached 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 attached to earth ground.

Outguard Supplies

The motherboard supplies 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 in front of the fan lets you to connect to the raw and regulated supplies. The outguard supplies are used only by the CPU PCA (A9) and Encoder PCA (A2).

Inguard Supplies

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

Filter capacitors for the high-current supply for the Current PCA (A7) are put on the Filter PCA (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 approximately 6.3 V. Test points for these supplies are put in a row across the top of the Voltage PCA. The 65 V supplies are rectified and filtered on the motherboard but regulated on the Voltage PCA (A8).

Chapter 3
Calibration and Verification

Introduction

Calibrate the Calibrator at the end of a 90 day or 1 year calibration interval. If you recalibrate on a 90 day interval, use the 90 day specifications, which gives higher performance. Use the verification procedure or a section of the procedure when it becomes necessary to make sure that the Calibrator does operate to its specifications.

Fluke recommends that you send the Calibrator to Fluke Calibration for calibration and verification. The Fluke Calibration Service Center uses a software-controlled verification procedure and supplies a test report that includes traceability to national standards. If you plan to calibrate or do a verification of the Calibrator at your site, use this chapter as a guide. The procedures in this chapter are manual versions of the software-controlled procedure used at the Fluke Calibration Service Center.

Equipment Necessary for Calibration and Verification

Table 3-1 is a list of necessary equipment to calibrate and do a verification of the performance of the Calibrator. If a specified instrument is not available, you can use an equivalent instrument that has the same or better performance.

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

Qty	Manufacturer	Model	Equipment	Purpose
1	Fluke	5500A/LEADS	Test lead set	All functions
1	Fluke	8508A	Reference Multimeter	DC voltage, dc current, resistance, thermocouple measurement and sourcing
1	Fluke	752A	Reference Divider 100:1, 10:1	DC voltage
1	Keithley	155	Null Detector	DC voltage (calibrate Fluke 752A for dc voltage)
1	Fluke	742A-1k	Resistance Standard, 1 kΩ	DC current
1	Fluke	742A-100	Resistance Standard, 100 Ω	DC current
1	Fluke	742A-10	Resistance Standard, 10 Ω	DC current
1	Fluke	742A-1	Resistance Standard, 1 Ω	DC current
1	Guildline	9230	0.1 Ω shunt	DC current, verification procedure only
1	Guildline	9230	0.01 Ω shunt	DC current
1	Fluke	742A-1M	Resistance Standard, 1 MΩ	Resistance
1	Fluke	742A-10 M	Resistance Standard, 10 MΩ	Resistance
1	Guildline	9334/100 M	Resistance Standard, 100 MΩ	Resistance
1	Guildline	9334/1G	Resistance Standard, 1GΩ	Resistance
1	Fluke	PN 900394	Type N to dual banana adapter	AC voltage
1	Fluke	5790A	AC Measurement Standard	AC voltage, ac current
1	Fluke	A40	10 mA, 20 mA, 200 mA, 2 A current shunts	AC current

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

Qty	Manufacturer	Model	Equipment	Purpose
1	Fluke	A40A	20 A current shunt	AC current
1	Fluke	792A-7004	A40 Current Shunt Adapter	AC current
1	various	metal film resistors	1 kΩ, 200 Ω	AC current
1	Fluke	PM 9540/BAN	Cable Set	Capacitance
1	Fluke	6304	LCR Meter	Capacitance
1	Fluke	5700A	Calibrator	Precision current source for ac/dc current transfers, and to use in conjunction with an Fluke 8508A DMM for thermocouple measurement function
1	ASTM	56 C	Mercury thermometer	Thermocouple measurement
1	various	various	Dewar flask and cap, mineral oil lag bath	Thermocouple measurement
1	North Atlantic Or Clarke-Hess	2000 6000	Precision Phase Meter [1]	Phase
1	Fluke	PN 690567	Fluke resistor network used as a shunt, 0.01 Ω, 0.09 Ω, 0.9 Ω values needed	Phase
1	Hewlett-Packard	3458A	Digital Multimeter	Capacitance
1	Fluke	6680B	Frequency Counter	Frequency

[1] If desired, the test uncertainty ratio (TUR) can be improved by characterizing the phase meter with a primary phase standard like the Clarke-Hess 5500 before use.

Calibration

The standard Calibrator has no internal hardware adjustments. Oscilloscope options have hardware adjustments. See Chapter 6. The Control Display steps you through the calibration procedure. Calibration occurs in these steps:

1. The Calibrator sources output values and you measure the outputs with a traceable measurement instrument of higher accuracy. The Calibrator automatically sets the outputs and instructs you to make external connections to applicable measurement instruments.
2. At each measure and enter step, you can push the OPTIONS, and BACK UP STEP softkeys to redo a step, or SKIP STEP to skip over a step.
3. You can type in the measured results through the front panel keyboard or remotely with an external terminal or computer.

Note

Intermixed with the "output and measure" procedures are internal 5520A calibration procedures where operator input is not necessary.

4. The Calibrator calculates a software correction factor and puts it in volatile memory.
5. When the calibration procedure is complete, you are instructed to put all the correction factors in nonvolatile memory or discard them and start again.

For most calibration procedures, the frequency and phase steps are not necessary. All the calibration steps are available from the front panel interface and the remote interface (IEEE-488 or serial). Frequency and phase calibration are recommended after instrument repair, and are available only through the remote interface (IEEE-488 or serial). See the "Calibration Remote Commands" section to learn more about calibration through the remote interface.

Start Calibration

From the front panel, push the SETUP key, followed by the **CAL** softkey twice, and then the **5502A CAL** softkey. The CALIBRATION SWITCH on the rear panel can be in the ENABLE or NORMAL position when you begin calibration. It must be set to ENABLE to store the correction factors into nonvolatile memory.

You start a calibration procedure when you push the **5502A CAL** softkey. From this point:

1. The Calibrator automatically sets the outputs and prompts you to make external connections to applicable measurement instruments.
2. The Calibrator then goes into Operate mode, or instructs you to put it into Operate mode.
3. You are then instructed to type in the value read on the measurement instrument.

Note

At each measure and enter step, to do a step again, push the ***OPTIONS****, and* ***BACK UP STEP*** *softkey, or skip a step with the* ***SKIP STEP*** *softkey.*

DC Volts Calibration (NORMAL Output)

Table 3-2 is a list of equipment necessary to calibrate the dc volts function. (The equipment is also shown in the consolidated table, Table 3-1).

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

Qty	Manufacturer	Model	Equipment
1	Fluke	5500A/LEADS	Test lead set
1	Fluke	8508A	Reference Multimeter
1	Fluke	752A	Reference Divider
1	Keithley	155	Null Detector

To calibrate the dc voltage function:

1. On the Fluke 8508A put a 4-wire short (Fluke PN 2540973) across the HI and LO input and sense terminals.
2. Push DCV, then INPUT, and then ZERO FUNC. Allow the zero function to finish.
3. Make sure that the UUT (Unit Under Test) is in Standby.
4. Start the Calibrator calibration as instructed in the “Start Calibration” section.
5. Do an internal DC Zeros Calibration as instructed.
6. Connect the test equipment as shown in Figure 3-1.
7. Measure and type in the values into the UUT for steps 1 through 6 in Table 3-3 as instructed. You will disconnect and reconnect the reference multimeter as instructed in these steps.
8. Make sure that the UUT is in Standby.
9. Connect the reference multimeter and Reference Divider to the UUT as shown in Figure 3-1.
10. For voltages 30 V dc and above, see the subsequent section.

Table 3-3. Calibration Steps for DC Volts

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

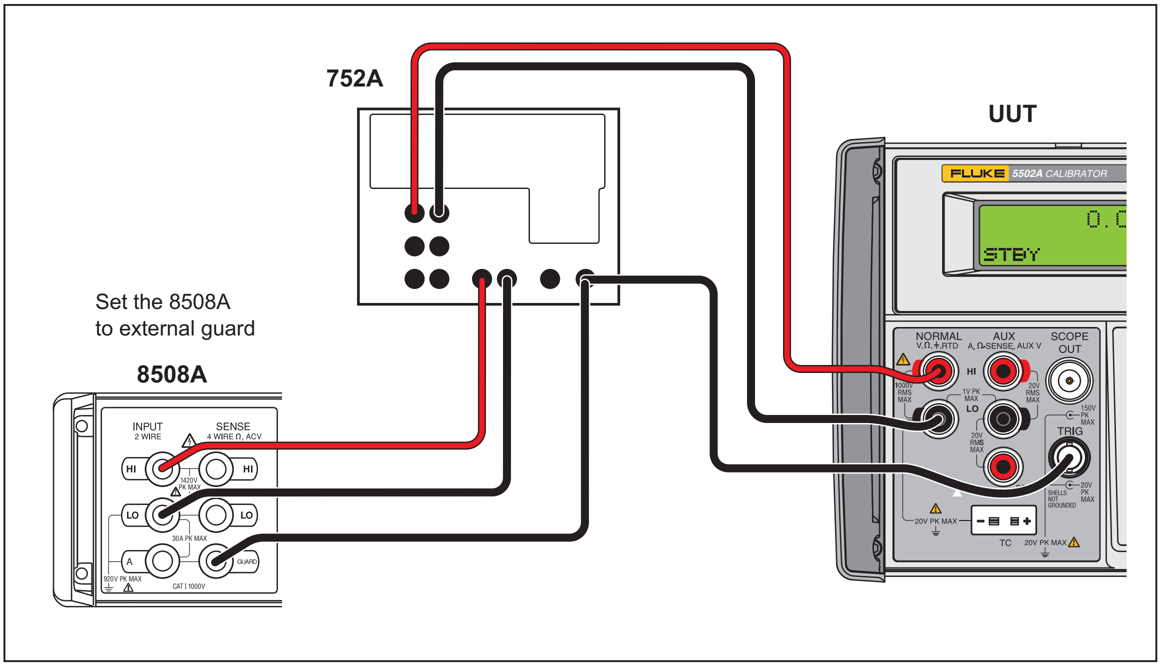

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Figure 3-1. DC Volts Calibration Connections up to 30 V

DC Volts Calibration (30 V dc and Above)

To calibrate the dc voltage function (30 Vdc and above):

1. Before you use the 752A, do the self-calibration on the 752A with the null detector and a 20 V source. See the 752A documentation.
2. Connect the Calibrator (unit under test), 752A, and 8508A as in Figure 3-2. Make sure that the ground to guard strap on the 752A is not connected.
3. The 8508A must be used on the 10 Vdc range for all measurements. The 752A mode switch must be set to 10:1 for the 30 V measurement, and to 100:1 for all voltages more than 30 V.
4. Measure and type in the values into the UUT for steps 7 through 9 in Table 3-3 (30 V and above) as prompted.
5. Make sure that the UUT is in Standby and disconnect the test equipment.

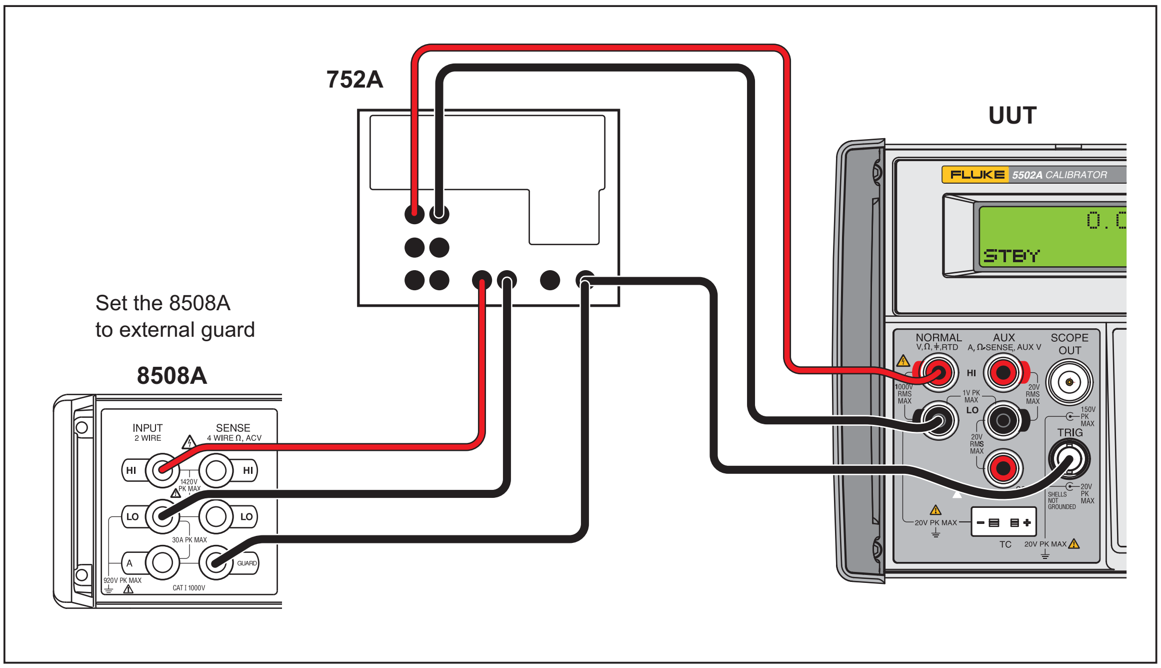

Figure 3-2. DC Volts 30 V and Above Calibration Connections

AC Volts Calibration (NORMAL Output)

Table 3-4 is a list of equipment necessary to calibrate the ac volts function. (The equipment is also shown in the consolidated table, Table 3-1.)

Table 3-4. Test Equipment Necessary for AC Volts Calibration

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

To calibrate the ac voltage function:

1. Measure the Calibrator output with Input 1 of a Fluke 5790A AC Measurement Standard. Use a Type N to dual banana adapter as Figure 3-3 shows.
2. Set the 5502A and 5790A to use an external guard connection.
3. Connect the guard to the output low connection at the normal output low terminal of the 5502A.
4. Type in the measured values into the Calibrator for each step in Table 3-5 as instructed.

Table 3-5. AC Volts Calibration Steps

Steps	5502A Output (NORMAL)	
	Amplitude	**Frequency**
1	3.29990 V	100.00 Hz
2	0.33000 V	100.00 Hz
3	3.00000 V	500.0 kHz
4	3.0 V	9.99 Hz
5	30.000 mV	100.00 Hz
6	300.000 mV	100.00 Hz
7	300.000 mV	500.0 kHz
8	30.0000 V	100.00 Hz
9	300.000 V	70.00 kHz
10	1000.00 V	100.00 Hz
11	1000.00 V	7.000 kHz

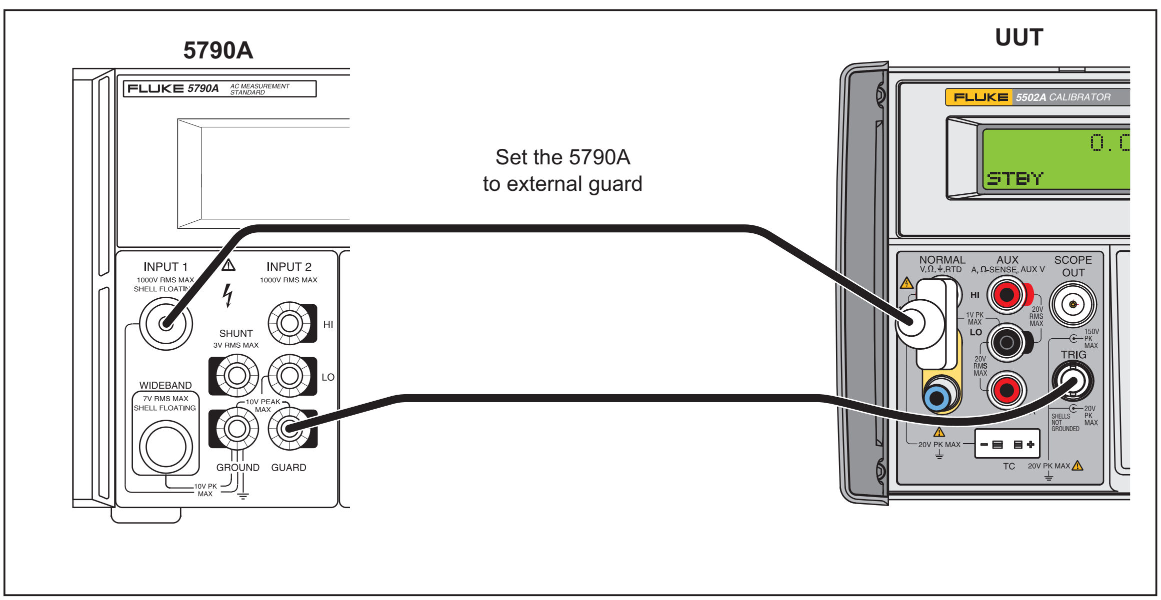

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Figure 3-3. AC Volts Calibration Connections

Thermocouple Function Calibration

Table 3-6 is a list of equipment necessary to calibrate the thermocouple measure and source functions. (The equipment is also shown in the consolidated table, Table 3-1.)

Table 3-6. Test Equipment Necessary for Thermocouple Function Calibration

Qty	Manufacturer	Model	Equipment
1	Fluke	5520A/LEADS	Test lead set (includes Type-J thermocouple, wire, and mini plug)
4 feet	various	various	24-gauge solid copper telephone wire
1	ASTM	56C	Mercury thermometer
1	various	various	Dewar flask and cap, mineral oil lag bath
1	Fluke	8508A	Reference Multimeter

To calibrate the thermocouple function:

1. Make sure that the UUT is in standby.
2. With no connections to the UUT terminals, push the **GO ON** softkey as instructed to start TC calibration. Let the internal calibration steps complete.
3. Connect the 8508A to the TC terminals with solid copper telephone wire and a copper (uncompensated) TC miniplug as shown in Figure 3-4. Attach the wires directly to the Reference Multimeter binding posts. Set the Reference Multimeter to read dc millivolts.
4. Type the measured value into the UUT for step 1 in Table 3-7 as instructed.
5. Disconnect the test equipment.
6. Connect a Type-J thermocouple to the TC terminals on the UUT. Put the thermocouple and a precision mercury thermometer fully in to a mineral oil lag bath that is ± 2 °C of ambient temperature. The test setup is shown in Figure 3-5.
7. Let the temperature measurement become stable for a minimum of 3 minute, then read the temperature on the mercury thermometer and type it into the UUT.

Table 3-7. Thermocouple Measurement Calibration Steps

Step	5502A Output (AUX HI, LO)
1	300 mV dc (NORMAL)
2	Enter temperature read from mercury thermometer as prompted

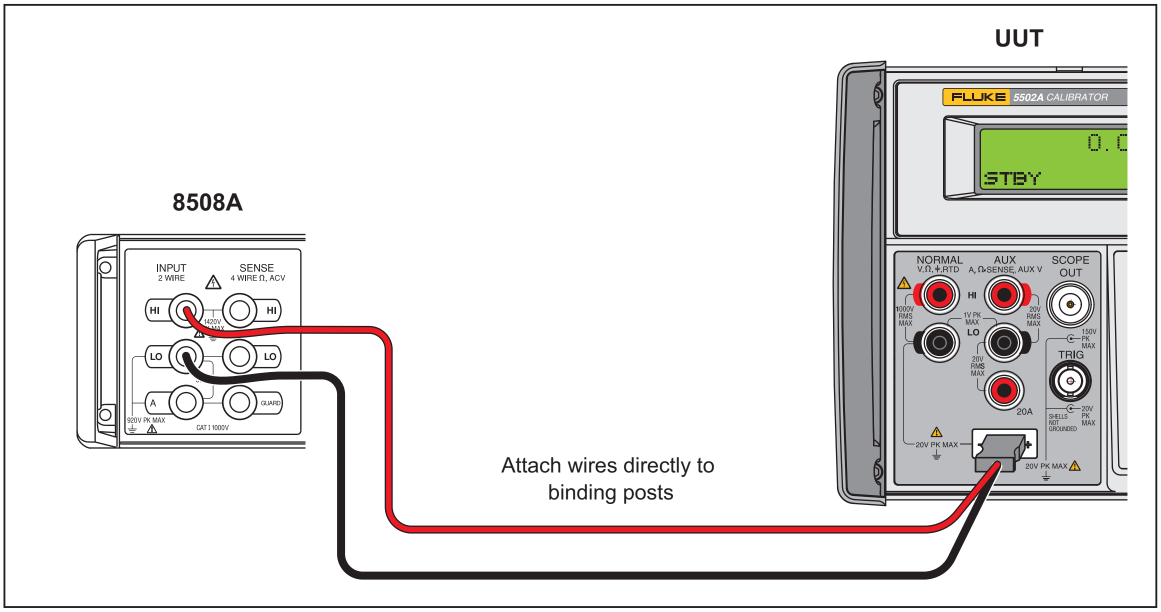

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Figure 3-4. Thermocouple Source Calibration Connections

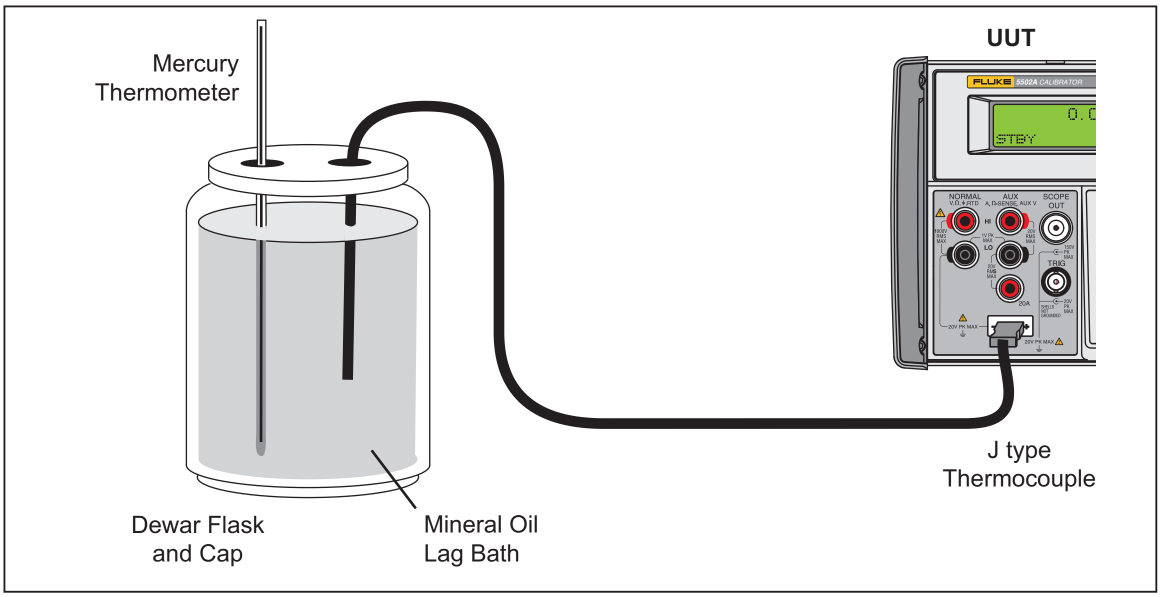

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Figure 3-5. Thermocouple Measure Calibration Connections

DC Current Calibration

Table 3-8 is a list of equipment necessary to calibrate the dc current function. (The equipment is also listed in Table 3-1.)

You must use the calibrated dc current function of the Calibrator later to prepare for ac calibration. Because of this, you must save the dc current constants after dc current calibration and exit calibration, then resume calibration. This dc current calibration procedure shows how to save, exit, and resume calibration.

Table 3-8. Test Equipment Necessary for DC Current Calibration

Qty	Manufacturer	Model	Equipment
1	Fluke	5500A/LEADS	Test lead set
1	Fluke	8508A	Reference Multimeter
1	Fluke	742A-1k	Resistance Standard, 1 kΩ
1	Fluke	742A-100	Resistance Standard, 100 Ω
1	Fluke	742A-10	Resistance Standard, 10 Ω
1	Fluke	742A-1	Resistance Standard, 1 Ω
1	Guildline	9230	0.01 Ω shunt

To calibrate the dc current function:

1. On the Fluke 8508A put a 4-wire short (Fluke PN 2540973) across the HI and LO input and sense terminals.
2. Push DCV, then INPUT, and then ZERO FUNC. Allow the zero function to finish.
3. Make sure that the UUT is in standby.
4. Set the 8508A to measure dc voltage.
5. Connect the 8508A and 742A-1k Resistance Standard to the UUT as shown in Figure 3-6.
6. On the first dc current calibration point in Table 3-9, let the output become stable, record the 8508A voltage measurement, and compute the UUT current output with the certified resistance value of the 742A.
7. Type in the calculated value into the UUT.
8. Continue to the subsequent calibration point, make sure that the UUT is in standby, and disconnect the 742A.
9. Do steps 3 through 6 again with the resistance standard or current shunt specified for each calibration point in Table 3-9.
10. Exit calibration and save the calibration constants that were changed so far with the front panel menus or the CAL_STORE remote command.

Table 3-9. DC Current Calibration Steps

Step	5502A Output (AUX HI, LO)	Shunt to Use
1	300.000 µA	Fluke 742A-1k 1 kΩ Resistance Standard
2	3.00000 mA	Fluke 742A-100 100 Ω Resistance Standard
3	30.000 mA	Fluke 742A-10 10 Ω Resistance Standard
4	300.000 mA	Fluke 742A-1 1 Ω Resistance Standard
5	2.00000 A	Guildline 9230 0.01 Ω shunt
	20A, LO	
6	10.0000 A	Guildline 9230 0.01 Ω shunt

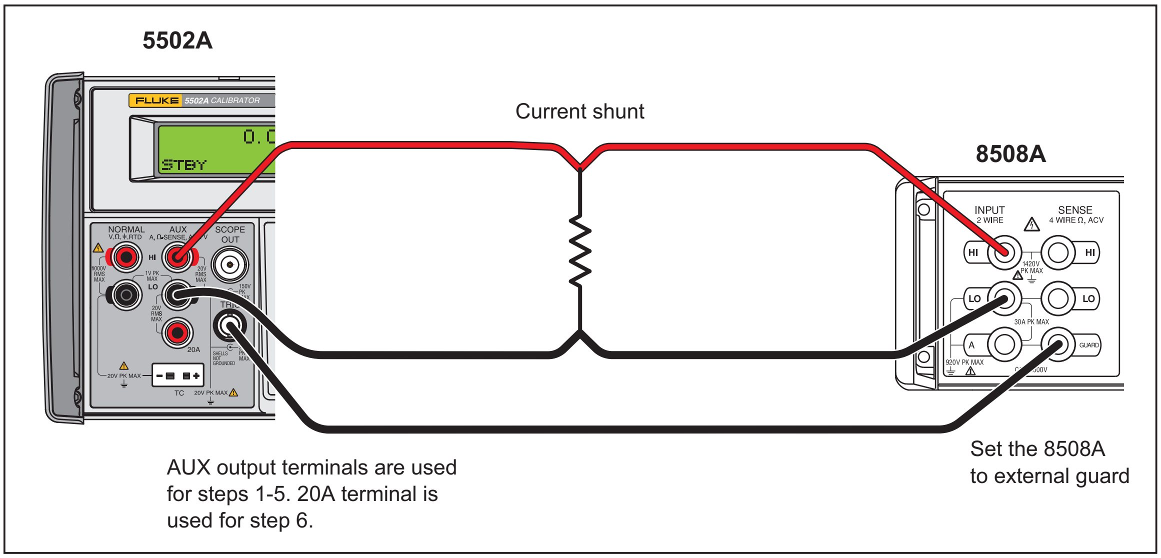

Figure 3-6. DC Current Calibration Connections

AC Current Calibration

Note

DC current must be calibrated before you do the ac current calibration.

The ac current calibration uses a number of current shunts that must be dc characterized before they can be used. You can do the dc characterization with the Calibrator, but you must do the complete Calibrator dc current calibration first. In the dc characterization procedure, data is collected for each of the ac current levels that is necessary for the ac current calibration procedure. For example, if a shunt is used for 0.33 mA ac and 3.3 mA ac calibrations, you must get data at .33 mA dc and 3.3 mA dc.

Follow these steps to characterize the shunt:

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

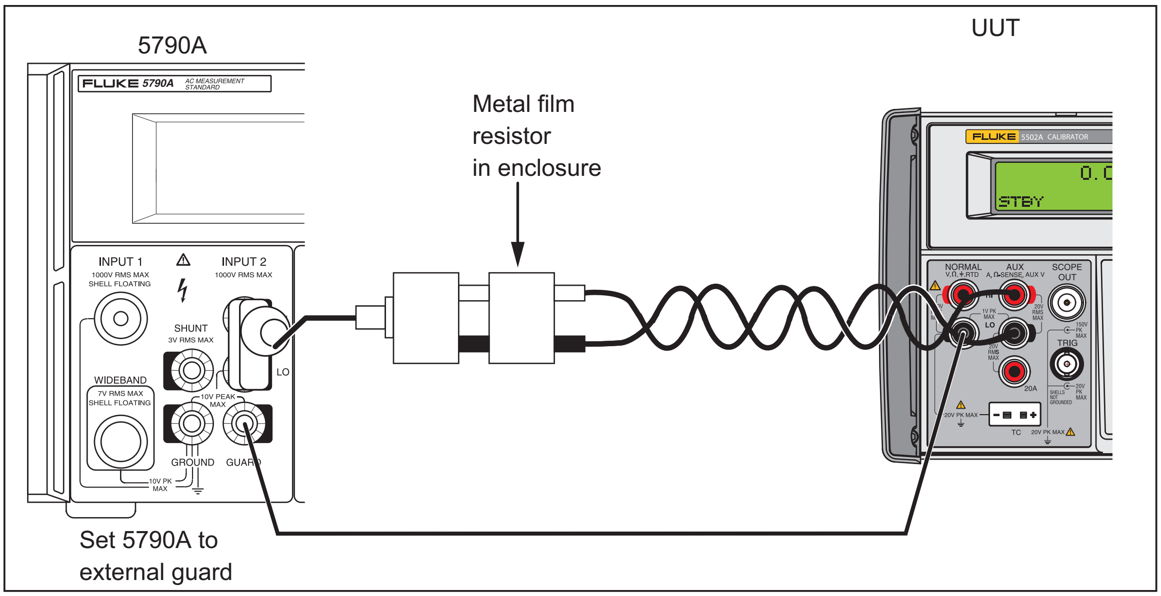

Figure 3-7. AC Current Calibration with Fluke A40 Shunt Connections

For each amplitude shown in Table 3-11, apply the equivalent +(positive) and –(negative) dc current from the Calibrator.

Calculate the actual dc characterization value with this formula:

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

The time between the dc characterization of a current shunt and its use in the calibration procedure must be kept to a minimum. To decrease this time, each shunt is characterized immediately before you use it. As the ac current calibration procedure is done, it must be temporarily aborted each time a new shunt value is necessary. After the shunt is characterized, the calibration procedure is continued at the point immediately before.

An example of this procedure:

1. Do the dc current calibration procedure.
2. In Table 3-11, select the first current shunt (A40-10 mA)
3. Do a dc characterization of the shunt at the amplitude specified in the table (as demonstrated above).
4. Do the ac current calibration procedure again and push the SKIP STEP softkey to go to the step(s) where shunt characterization is necessary.
5. Set the Calibrator to OPERATE and measure the ac voltage across the shunt.
6. Use the data collected in the dc characterization with the ac correction factors supplied for the shunt by the manufacturer to calculate the ac current. Type this value into the calibrator.
7. Continue this procedure until you do all the steps in Table 3-11.

Some of the important remote commands used in this procedure are:

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

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

Table 3-10 is a list of equipment necessary to calibrate the ac current function. (The equipment is also shown in the Table 3-1.) Refer to Figure 3-8 for the equipment connections.

Table 3-10. Test Equipment Necessary for AC Current Calibration

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

Table 3-11. AC Current Calibration Steps

Steps	5502A Output (AUX HI, LO)		
	Amplitude	Frequency	Shunt to Use
1	3.29990 mA	100.00 Hz	Fluke A40 10 mA
2	0.33000 mA	100.00 Hz	Fluke A40 10 mA
3	3.00000 mA	10.00 kHz	Fluke A40 10 mA
4	3.00000 mA	30.000 kHz	Fluke A40 10 mA
5	0.30000 mA	100.00 Hz	Fluke A40 10 mA
6	0.30000 mA	10.00 kHz	Fluke A40 10 mA
7	0.30000 mA	30.00 kHz	Fluke A40 10 mA
8	30.0000 mA	100.00 Hz	Fluke A40 200 mA
9	30.0000 mA	10.00 kHz	Fluke A40 200 mA
10	30.0000 mA	30.00 kHz	Fluke A40 200 mA
11	300.000 mA	100.00 Hz	Fluke A40 2 A
12	300.000 mA	10.00 kHz	Fluke A40 2 A
13	300.000 mA	30.00 kHz	Fluke A40 2 A
14	2.00000 A	100.00 Hz	Fluke A40 2 A
15	2.00000 A	1000.0 Hz	Fluke A40 2 A
16	2.00000 A	5000.0 Hz	Fluke A40 2 A
17	2.00000 A	60.00 Hz	Fluke A40 2 A
18	2.00000 A	100.00 Hz	Fluke A40 2 A
19	2.00000 A	440.00 Hz	Fluke A40 2 A
AUX 20A, LO			
20	10.0000 A	100.00 Hz	Fluke A40A 20 A
21	10.0000 A	500.00 Hz	Fluke A40A 20 A
22	10.0000 A	1000.00 Hz	Fluke A40A 20 A
23	10.0000 A	60.00 Hz	Fluke A40A 20 A
24	10.0000 A	100.00 Hz	Fluke A40A 20 A
25	10.0000 A	440.00 Hz	Fluke A40A 20 A

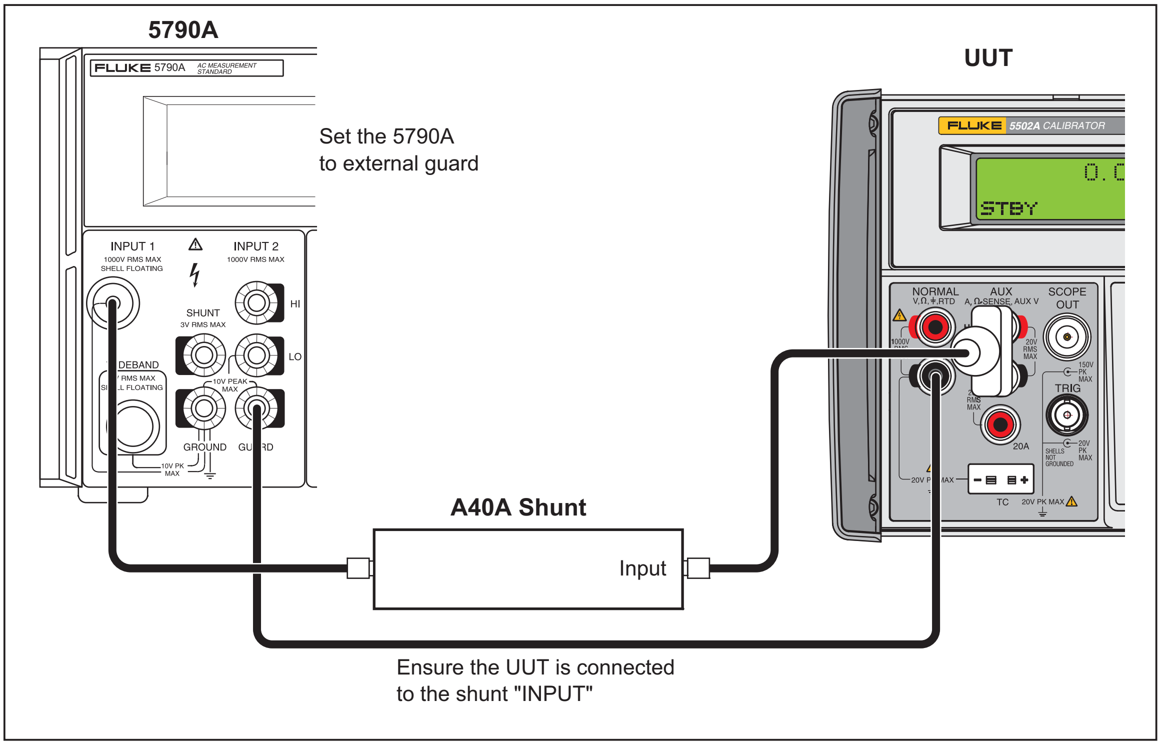

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Figure 3-8. AC Current Calibration with Fluke A40A Shunt Connection

```
Fluke Calibration - Worldwide Support Center MET/CAL Procedure
=============================================================================
INSTRUMENT:             Sub Fluke 5502A ACI ADJ
DATE:                   22-Sep-98
AUTHOR:                 Gary Bennett, Metrology Specialist
REVISION:               0.6
ADJUSTMENT THRESHOLD:   70%
NUMBER OF TESTS:        1
NUMBER OF LINES:        487
CONFIGURATION:          Fluke 5790A
=============================================================================
 STEP    FSC    RANGE NOMINAL        TOLERANCE     MOD1        MOD2  3   4 CON
# 10 Sep 98 changed Cal_Info? commands to Out? and checked for 10A -
# needs cal_next to get past display; check for 0 out when ACI is done.
#
  1.001  ASK-   R   Q N                    U         C            F        W

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

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

  1.021  ACMS                                                    G

  1.022  5790         A                                          SH    N  2W
```

Figure 3-9. Sample MET/CAL Program

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


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


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

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


# Calculate difference between the average value of both polarities of DC
# Current and the applied AC Current.
  1.056  MATH        M[21] = 0.0032999 - (.0032999 * (1 - (MEM / M[17])))
```

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

```
# Determine measurement frequency to retrieve correct AC-DC difference value.
  1.057  IEEE        OUT?[I$][GTL]
  1.058  MATH        M[2] = FLD(MEM2,5,",")
# Retrieve AC-DC difference from data file named "A40-10mA"
  1.059  DOS         get_acdc A40-10mA
  1.060  JMPT        1.064
  1.061  OPBR        An error occurred during get_acdc
  1.061  OPBR        Press YES to try again or NO to terminate.
  1.062  JMPT        1.059
  1.063  JMP         1.231

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

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

DC Volts Calibration (AUX Output)

To calibrate the auxiliary dc voltage function, use the same procedure used for the normal dc voltage output, but connect to the AUX HI and LO terminals on the UUT. Table 3-12 is a list of the calibration steps for AUX dc volts.

Table 3-12. AUX DC Volts Calibration Steps

Step	5502A Output (AUX)
1	300.000 mV
2	3.00000 V
3	7.00000 V

AC Volts Calibration (AUX Output)

To calibrate the auxiliary ac voltage function, use the same procedure used for the normal ac voltage output, but connect to the AUX HI and LO terminals on the UUT. Table 3-13 is a list of the calibration steps for AUX dc volts.

Table 3-13. AUX Output AC Volts Calibration Steps

Step	5502A Output (AUX)	
	Amplitude	Frequency
1	300.000 mV	100 Hz
2	300.000 mV	5 kHz
3	3.00000 V	100 Hz
4	3.00000 V	5 kHz
5	5.0000 V	100 Hz
6	5.0000 V	5 kHz
7	3.0 V	9.99 Hz

Resistance Calibration

Table 3-14 is a list of equipment necessary to calibrate the resistance function. (The equipment is also shown in the consolidated table, Table 3-1.)

Table 3-14. Test Equipment Necessary for Resistance Calibration

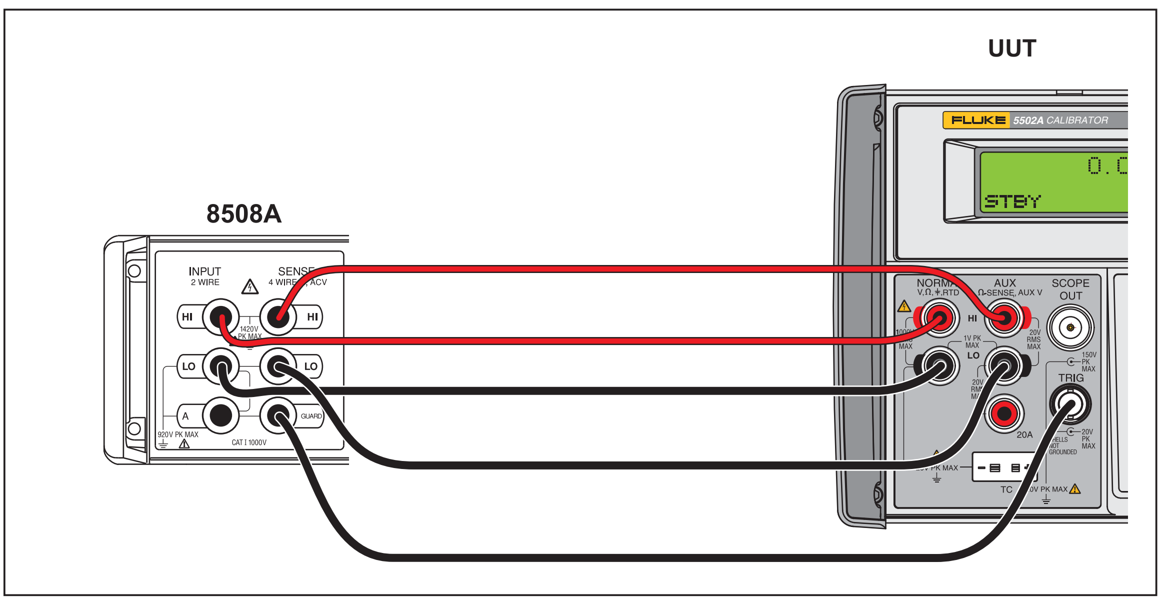
Qty	Manufacturer	Model	Equipment
1	Fluke	5500A/LEADS	Test lead set
1	Fluke	8508A	Reference Multimeter

To calibrate the resistance function:

1. On the Fluke 8508A put a 4-wire short (Fluke PN 2540973) across the HI and LO input and sense terminals.
2. Push Ohms, then INPUT, and then ZERO FUNC. Allow the zero function to finish.
3. Make sure that the UUT (Unit Under Test) is in Standby.
4. Follow the instructions on the Control Display to connect the 8508A to the UUT for 4 wire ohms measurement as shown in Figure 3-10.
5. Push the **GO ON** softkey and let the internal calibration steps complete.
6. Measure and type the values into the UUT for calibration steps 1 through 8 in Table 3-15 as instructed.
7. Connect the UUT to the 8508A in a 2-wire ohms configuration as shown in Figure 3-11.
8. On the 8508A, set the function to OHMS. In the Ohms Config menu, turn on **LoI** and turn off **Fast** and **4wΩ**. Set the applicable resistance range for each step in Table 3-15.
9. Measure and type the values into the UUT for calibration steps 9 through 16 in Table 3-15 as instructed.
10. Make sure that the UUT is in standby and disconnect the equipment.

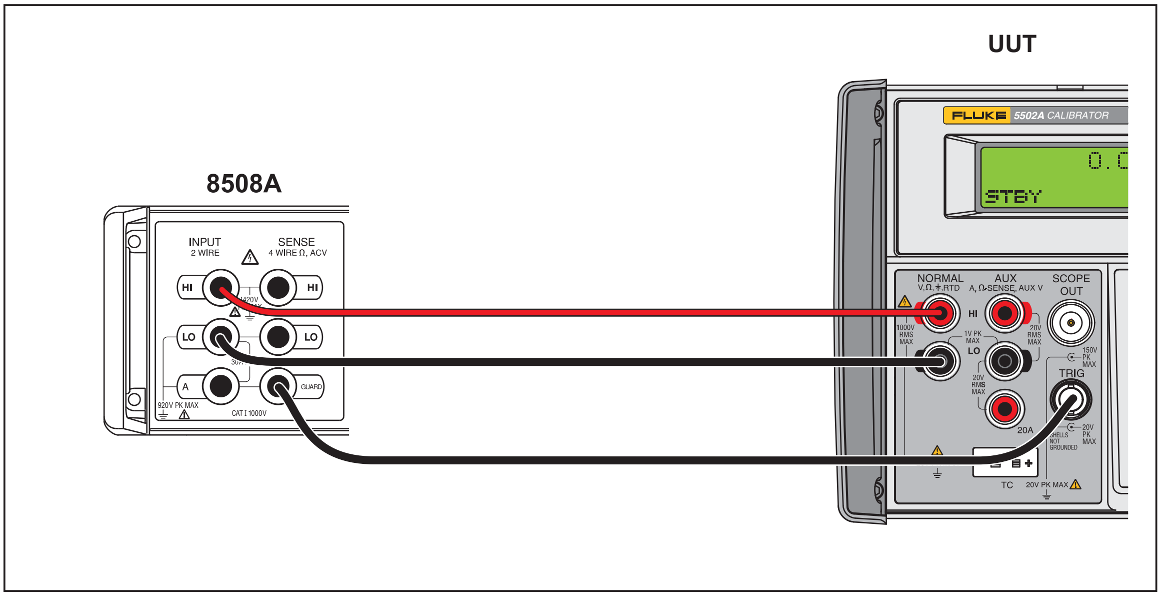
Table 3-15. Resistance Calibration Steps

Step	5502A Output (4-Wire Ohms, NORMAL and AUX)
1	1.0000 Ω
2	11.0000 Ω
3	110.0000 Ω
4	0.350000 kΩ
5	1.100000 kΩ
6	3.50000 kΩ
7	11.00000 kΩ
8	35.0000 kΩ
2-Wire Ohms, NORMAL	
9	110.0000 kΩ
10	0.350000 MΩ
11	1.100000 MΩ
12	3.50000 MΩ
13	11.00000 MΩ
14	35.0000 MΩ
15	110.000 MΩ
16	400.00 MΩ



hvw119.eps

Figure 3-10. 4-Wire Resistance Connection



hvw121.eps

Figure 3-11. 2-Wire Resistance Connection

Capacitance Calibration

Table 3-16 is a list of equipment necessary to calibrate the capacitance function. (The equipment is also shown Table 3-1.)

Table 3-16. Test Equipment Necessary for Capacitance Calibration

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

To calibrate the capacitance function:

1. Connect the UUT to the LCR meter with the Fluke PM 9540/BAN cables as shown in Figure 3-12. These special cables remove the necessity for a four-wire connection.

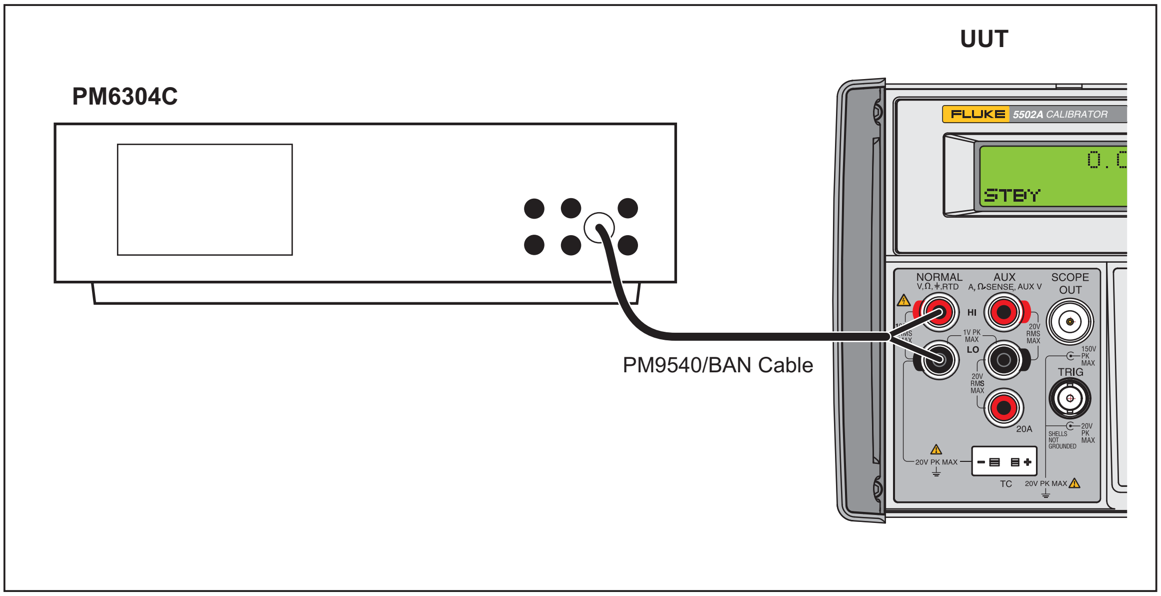
Note

Make sure there are no other connections to the Calibrator, especially the SCOPE BNC. More ground connections to the Calibrator can cause erroneous capacitance outputs.

2. Set the frequency on the LCR meter as shown in Table 3-17.
3. Measure and type the values into the UUT for the calibration steps in Table 3-17 as instructed. The right column in the table shows the best stimulus frequency for each calibration point.
4. Make sure that the UUT is in Standby and disconnect the LCR meter.

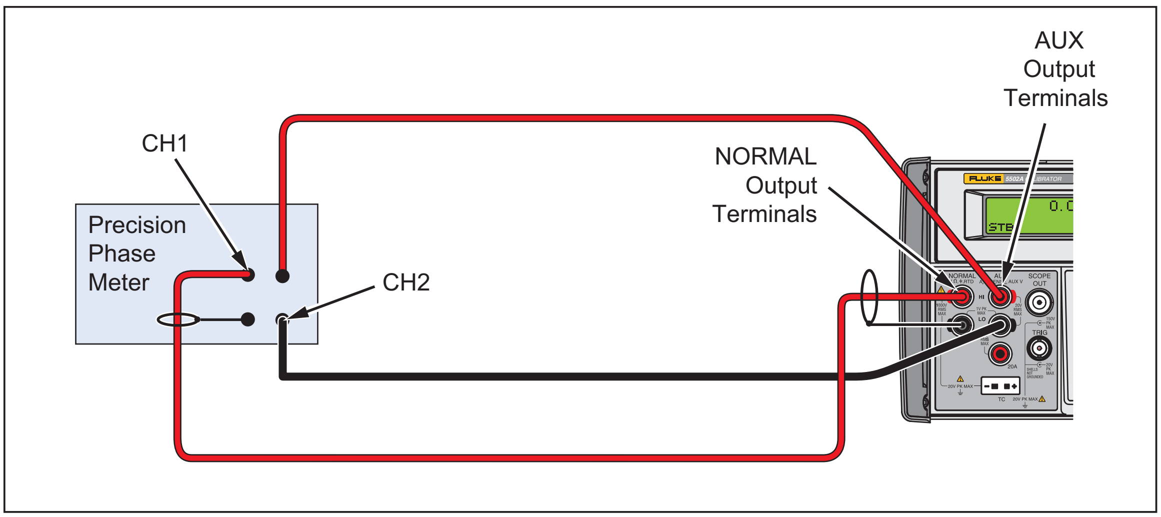
Table 3-17. Capacitance Calibration Steps

Step	5502A Output (NORMAL)	
	Calibrator Output	Best Stimulus Frequency
1	200 pF	1 kHz
2	0.5000 nF	1 kHz
3	1.1000 nF	1 kHz
4	3.5000 nF	1 kHz
5	11.0000 nF	1 kHz
6	35.000 nF	1 kHz
7	110.000 nF	1 kHz
8	0.35000 μF	100 Hz
9	1.10000 μF	100 Hz
10	3.3000 μF	100 Hz
11	11.0000 μF	100 Hz
12	33.000 μF	100 Hz



hvw123.eps

Figure 3-12. Capacitance Calibration Connection



hvw102.eps

Figure 3-13. Normal Volts and AUX Volts Phase Verification Connection

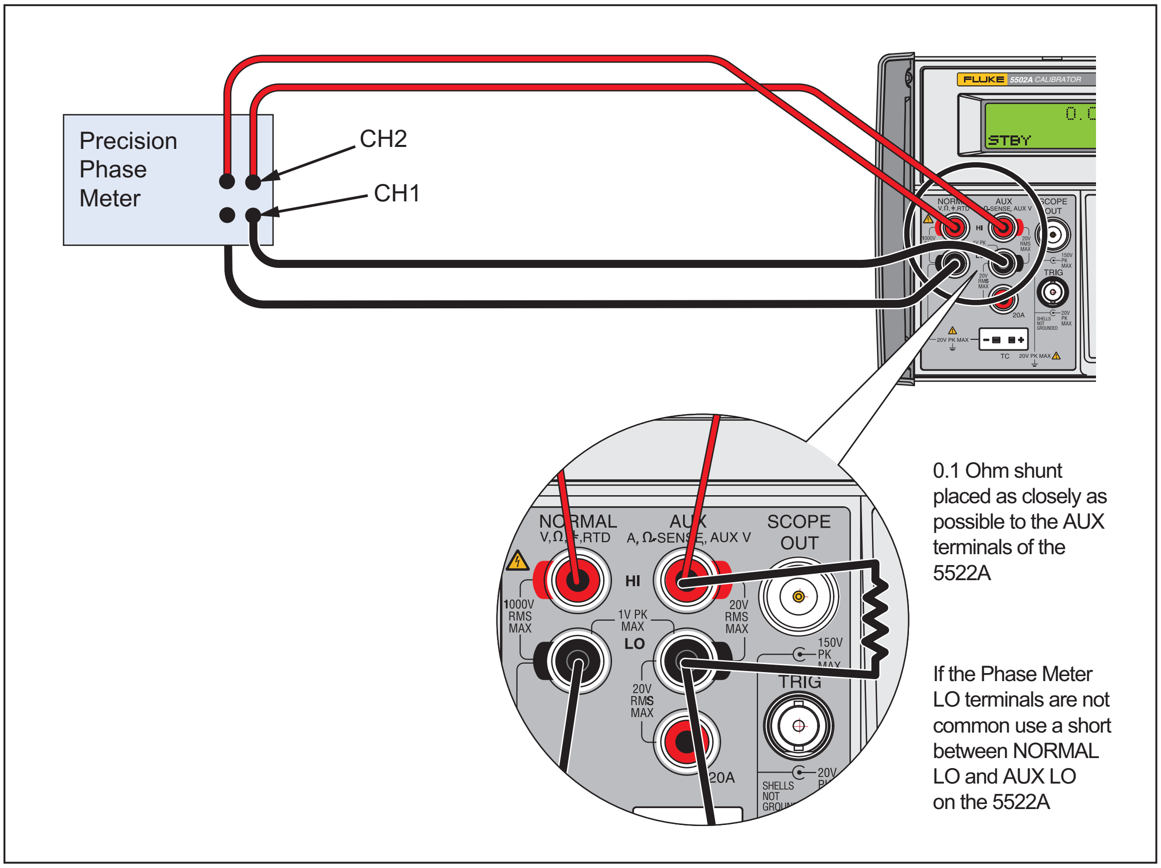


Figure 3-14. Volts and Current Phase Verification Connection

Calibration Remote Commands

Calibration of the calibrator with remote commands is simple. To access the standard calibration steps, send the command:

```
CAL_START MAIN
```

To jump to specified calibration steps, you can append a modifier to this command. Table 3-18 is a list of calibration entry points.

Table 3-18. Calibration Entry Points 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
AC Volts	AV

To go directly to ac volts calibration, send:

```
CAL_START MAIN,AV
```

To go directly to resistance calibration, send:

```
CAL_START MAIN,R
```

These calibration commands can be used through the IEEE-488 or serial interface. To use the serial interface without a calibration program:

1. Connect the applicable COM port from a PC to the Serial 1 connector of the Calibrator, with a Fluke PM8914 cable.
2. In Microsoft Windows, open the Terminal program. Set the communications parameters to the values of the Calibrator.
3. Push ENTER. Type the calibration command, for example, `CAL_START MAIN`.

What follows is a list of remote calibration commands for the Calibrator. The common commands in this list do not show the * character that must be the first character of the command. These remote commands duplicate what can be initiated through the front panel of the Calibrator when it is set to local mode.

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

☒ IEEE-488 ☒RS-232 ☒Sequential ☐Overlapped ☐Coupled

Sequential Commands Commands executed immediately as they are found in the data stream are called sequential commands. A command that is not overlapped or coupled is sequential.

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

Coupled Commands Some commands are coupled commands because they "couple" in a compound command sequence. You must be careful to make sure that one command does not disable the second command and thereby cause a fault.

CAL_ABORT

Description: Instructs the Calibrator to abort the calibration procedure after the present step

Example: CAL_ABORT

CAL_BACKUP

Description: Skip to the subsequent entry point in calibration procedure.

CAL_DATE?

Description: Sends a calibration date related to the stored calibration constants.

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

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

Response: The date

CAL_DAYS?

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

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

Response: 1. (Integer) Days

2. (Integer) Hours

CAL_FACT

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

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

Example: CAL_FACT ABORT (this is the default)

CAL_FACT?

Description: Get the procedure "fault action" flag.

Response: (Character) CONT or ABORT

Example: ABORT

CAL_FAULT?

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

Response: 1. error number (use EXPLAIN? command to interpret)

2. Name of step where error occurred

CAL_INFO?

Description: Sends message or instructions related to the present step.

Response: (String) the message string

CAL_NEXT

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

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

Example: CAL_NEXT

CAL_NEXT 2.999987

CAL_REF?

Description: Sends nominal value possible for reference entry.

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

CAL_SKIP

Description: Skip to the subsequent entry point in calibration procedure.

CAL_SECT

Description: Skip to the subsequent section of calibration procedure.

CAL_START

Description: Start a calibration procedure.

Parameter: 1. Procedure name:

MAIN is the procedure for the 5520A minus a scope cal option

ZERO is the internal procedure to correct zero offsets

OHMSZERO is the internal procedure to touch up resistance offsets

SCOPE is the procedure for the 5520A-SC300 scope cal option

SC600 is the procedure for the 5520A-SC600 scope cal option

DIAG is the diagnostic pseudo-cal procedure

NOT aborts a procedure after the step underway

2. (Optional) name of the step at which to start.

If this parameter is not supplied, calibration starts at the start.

Example: CAL_START MAIN

CAL_START MAIN,DVG3_3

CAL_STATE?

Description: Sends state of calibration.

Response: RUN - In a calibration step

REF - Stopped for a CAL_NEXT with reference (measurement) value

INS - Instruction available, stopped for a CAL_NEXT

NOT - Not in a calibration procedure (or at end of one)

CAL_STEP?

Description: Sends name of step currently running.

Response: (Char) the step name

Example: IDAC_RATIO (running IDAC ratio calibration)

NOT (not running a calibration procedure now)

CAL_STORE

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

CAL_STORE?

Description: Sends if a cal store is necessary or not.

Response: 1 is yes, 0 if no

CAL_SW?

Description: Sends how the calibration switch is set.

Response: (Integer) 1 for enable, 0 for normal

Example: 1

EOFSTR

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

The maximum length is two characters. The EOF character is kept in nonvolatile memory.

Parameter: The EOF string (two characters maximum)

EOFSTR?

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

Parameter: None

Response: (String) The End-Of-File character string

PR_RPT

Description: Prints a self-calibration report out of one of the serial ports

Parameter: 1. Type of report to print: STORED, ACTIVE, or CONSTS

2. Format of report: PRINT (designed to be read)

SPREAD (designed to be loaded into a spreadsheet)

3. Calibration interval to be used for instrument specifications in the report: I90D (90 day specifications) or I1Y (1 year specifications)

4. Serial port out which to print report: HOST or UUT

Example: PR_RPT STORED,PRINT,I90D,HOST

RPT?

Description: Sends a self-calibration report.

Parameter: 1. Type of report to send: STORED, ACTIVE, or CONSTS

2. Format of report: PRINT (designed to be read)

SPREAD (designed to be loaded into a spreadsheet)

3. Calibration interval to be used for instrument specifications in the report:
I90D (90 day specifications) or I1Y (1 year specifications)

Example: RPT? STORED,PRINT,I90D

RPT_PLEN

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

Parameter: Page length

RPT_PLEN?

Description: Sends the page length used for calibration reports.

Parameter: None

Response: (Integer) Page length

RPT_STR

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

Parameter: String of a maximum of 40 characters

RPT_STR?

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

Parameter: None

Response: (String) A maximum of 40 characters

STOP_PR

Description: Stops a calibration report print job if one was queued to print.

Parameter: None

UNCERT?

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

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

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

Response: 1. (Float) 90 day specified uncertainty of primary output.

2. (Float) 1 year specified uncertainty of primary output.

3. (Character) unit of primary output uncertainty.

4. (Float) 90 day specified uncertainty of secondary output.

5. (Float) 1 year specified uncertainty of secondary output.

6. (Character) unit of secondary output uncertainty.

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

How to Make a Calibration Report

Three different calibration reports are available from the Calibrator, each one formatted to print, or in comma-separated variable format for importation into a spreadsheet. Use the **REPORT SETUP** softkey below **UTILITY FUNCTS / CAL** to select lines per page, calibration interval, type of report, format, and which serial port to use. The specification shown in these reports is contingent on the interval set in the **REPORT SETUP** menu.

The three report types are:

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

Performance Verifcation Tests

To make sure that the Product is in specification, use Tables 3-19 through 3-31. The tables are for approved metrology personnel who have access to a standards laboratory that has the correct equipment to test calibration equipment of this level of accuracy. The tables show the recommended test points and the permitted maximum and lower limits for each point. The limits were calculated by adding or subtracting the 90-day specification from the output value. There is no built-in factor for measurement uncertainty.

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

Range	Output	Lower Limit	Upper Limit
329.9999 mV	0.0000 mV	-0.0030 mV	0.0030 mV
329.9999 mV	329.0000 mV	328.9805 mV	329.0194 mV
329.9999 mV	-329.0000 mV	-329.0194 mV	-328.9805 mV
3.299999 V	0.000000 V	-0.000005 V	0.000005 V
3.299999 V	1.000000 V	0.9999855 V	1.000045 V
3.299999 V	-1.000000 V	-1.000045 V	-0.999955 V
3.299999 V	3.290000 V	3.2899863 V	3.290136 V
3.299999 V	-3.290000 V	-3.290136 V	-3.2898638 V
32.99999 V	0.00000 V	-0.00005 V	0.00005 V
32.99999 V	10.00000 V	9.99955 V	10.00045 V
32.99999 V	-10.00000 V	-10.00045 V	-9.99955 V
32.99999 V	32.90000 V	32.89863 V	-32.90136 V
32.99999 V	-32.90000 V	32.90136 V	-32.89863 V
329.9999 V	50.0000 V	49.9972 V	50.0027 V
329.9999 V	329.0000 V	328.9846 V	329.0153 V
329.9999 V	-50.0000 V	-50.0027 V	-49.9972 V
329.9999 V	-329.0000 V	-329.0153 V	-328.9846 V
1000.000 V	334.000 V	333.983 V	334.016 V
1000.000 V	900.000 V	899.958 V	900.042 V

1000.000 V	1020.000 V	1019.952 V	1020.047 V
1000.000 V	-334.000 V	-334.016V	-333.983 V
1000.000 V	-900.000 V	-900.042 V	-899.958 V
1000.000 V	-1020.000 V	-1020.047 V	-1019.952 V

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

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

Table 3-21. Verification Tests for DC Current (AUX)

Range	Output	Lower Limit	Upper Limit
329.999 µA	0.000 µA	-0.020 µA	0.020 µA
329.999 µA	190.000 µA	189.957 µA	190.043 µA
329.999 µA	-190.000 µA	-190.043 µA	-189.957 µA
329.999 µA	329.000 µA	328.941 µA	329.059 µA
329.999 µA	-329.000 µA	-329.059 µA	-328.941 µA
3.29999 mA	0.00000 mA	-0.00005 mA	0.00005 mA
3.29999 mA	1.90000 mA	1.89976 mA	1.90024 mA
3.29999 mA	-1.90000 mA	-1.90020 mA	-1.89980 mA
3.29999 mA	3.29000 mA	3.28969 mA	3.29031 mA
3.29999 mA	-3.29000 mA	-3.29031 mA	-3.28969 mA
32.9999 mA	0.0000 mA	-0.00025 mA	0.00025 mA
32.9999 mA	19.0000 mA	18.9982 mA	19.0018 mA
32.9999 mA	-19.0000 mA	-19.0018 mA	-18.9982 mA
32.9999 mA	32.9000 mA	32.8971 mA	32.9029 mA
32.9999 mA	-32.9000 mA	-32.9029 mA	-32.8971 mA
329.999 mA	0.000 mA	-0.0033 mA	0.0033 mA
329.999 mA	190.000 mA	189.982 mA	190.018 mA
329.999 mA	-190.000 mA	-190.018 mA	-189.982 mA
329.999 mA	329.000 mA	328.971 mA	329.029 mA
329.999 mA	-329.000 mA	-329.029 mA	-328.971 mA
2.99999 A	0.00000 A	-0.00004 A	0.00004 A

Table 3-21. Verification Tests for DC Current (AUX) (cont.)

Range	Output	Lower Limit	Upper Limit
2.99999 A	1.09000 A	1.08979 A	1.09021 A
2.99999 A	-1.09000 A	-1.09021 A	-1.08962 A
2.99999 A	2.99000 A	2.98906 A	2.99094 A
2.99999 A	-2.99000 A	-2.99094 A	-2.98906 A
20.5000 A	0.0000 A	-0.0005 A	0.0005 A
20.5000 A	11.0000 A	10.9953 A	11.0046 A
20.5000 A	-11.0000 A	-11.0046 A	10.9953 A
20.5000 A	20.0000 A	19.9833 A	20.0168 A
20.5000 A	-20.0000 A	-20.0168 A	-19.9833 A

Table 3-22. Verification Tests for Resistance

Range	Output	Lower Limit	Upper Limit
10.999 Ω	0.000 Ω	-0.0010 Ω	0.0010 Ω
10.999 Ω	2.000 Ω	1.9989 Ω	2.0011 Ω
10.999 Ω	10.900 Ω	10.8980 Ω	10.9019 Ω
32.999 Ω	11.900 Ω	11.8974 Ω	11.9025 Ω
32.999 Ω	19.000 Ω	18.9967 Ω	19.0032 Ω
32.999 Ω	30.000 Ω	29.9958 Ω	30.0042 Ω
109.999 Ω	33.000 Ω	32.9962 Ω	33.0037 Ω
109.999 Ω	109.000 Ω	108.9909 Ω	109.0090 Ω
329.999 Ω	119.000 Ω	118.9896 Ω	119.0103 Ω
329.999 Ω	190.000 Ω	189.9847 Ω	190.0153 Ω
329.999 Ω	300.000 Ω	299.9770 Ω	300.0230 Ω
1.09999 kΩ	0.33000 kΩ	0.329749 kΩ	0.330251 kΩ
1.09999 kΩ	1.09000 kΩ	1.089921 kΩ	1.090078 kΩ
3.29999 kΩ	1.19000 kΩ	1.189896 kΩ	1.190103 kΩ
3.29999 kΩ	1.9000 kΩ	1.899847 kΩ	1.900153 kΩ
3.29999 kΩ	3.00000 kΩ	2.999770 kΩ	3.000230 kΩ
10.9999 kΩ	3.3000 kΩ	3.29974 kΩ	3.30025 kΩ
10.9999 kΩ	10.9000 kΩ	10.89921 kΩ	10.90078 kΩ
32.9999 kΩ	11.9000 kΩ	11.89896 kΩ	11.90103 kΩ
32.9999 kΩ	19.0000 kΩ	18.99847 kΩ	19.00153 kΩ
32.9999 kΩ	30.0000 kΩ	29.99977 kΩ	30.00230 kΩ

Table 3-22. Verification Tests for Resistance (cont.)

Range	Output	Lower Limit	Upper Limit
109.999 kΩ	33.000 kΩ	32.9971 kΩ	33.0028 kΩ
109.999 kΩ	109.000 kΩ	108.9910 kΩ	109.0089 kΩ
329.999 kΩ	119.000 kΩ	118.9872 kΩ	119.0127 kΩ
329.999 kΩ	190.000 kΩ	189.9809 kΩ	190.0191 kΩ
329.999 kΩ	300.000 kΩ	299.9710 kΩ	300.0290 kΩ
1.09999 MΩ	0.33000 MΩ	0.329961 MΩ	0.330038 MΩ
1.09999 MΩ	1.09000 MΩ	1.089878 MΩ	1.090121 MΩ
3.29999 MΩ	1.19000 MΩ	1.189839 MΩ	1.190160 MΩ
3.29999 MΩ	1.90000 MΩ	1.899761 MΩ	1.900239 MΩ
3.29999 MΩ	3.00000 MΩ	2.999640 MΩ	3.000360 MΩ
10.9999 MΩ	3.3000 MΩ	3.29846 MΩ	3.30153 MΩ
10.9999 MΩ	10.9000 MΩ	10.89504 MΩ	10.90495 MΩ
32.9999 MΩ	11.9000 MΩ	11.88857 MΩ	11.91142 MΩ
32.9999 MΩ	19.0000 MΩ	18.98325 MΩ	19.01675 MΩ
32.9999 MΩ	30.0000 MΩ	29.99750 MΩ	30.02500 MΩ
109.999 MΩ	33.000 MΩ	32.8650 MΩ	33.1350 MΩ
109.999 MΩ	109.000 MΩ	108.5610 MΩ	109.4390 MΩ
329.999 MΩ	119.000 MΩ	118.4240 MΩ	119.5760 MΩ
329.999 MΩ	290.000 MΩ	288.7400 MΩ	291.2600 MΩ
1100.00 MΩ	400.00 MΩ	394.700 MΩ	405.300 MΩ
1100.00 MΩ	640.00 MΩ	631.820 MΩ	648.180 MΩ
1100.00 MΩ	1090.00 MΩ	1076.420 MΩ	1103.580 MΩ

Table 3-23. Verification Tests for AC Voltage (Normal)

Range	Output	Frequency	Lower Limit	Upper Limit
32.999 mV	3.000 mV	45 Hz	2.977 mV	3.022 mV
32.999 mV	3.000 mV	10 kHz	2.977 mV	3.022 mV
32.999 mV	30.000 mV	9.5 Hz	28.350 mV	31.650 mV,
32.999 mV	30.000 mV	10 Hz	29.944 mV	30.056 mV
32.999 mV	30.000 mV	45 Hz	29.956 mV	30.044 mV
32.999 mV	30.000 mV	1 kHz	29.956 mV	30.044 mV
32.999 mV	30.000 mV	10 kHz	29.956 mV	30.044 mV
32.999 mV	30.000 mV	20 kHz	29.944 mV	30.056 mV

Table 3-23. Verification Tests for AC Voltage (Normal) (cont.)

Range	Output	Frequency	Lower Limit	Upper Limit
32.999 mV	30.000 mV	50 kHz	29.932 mV	30.068 mV
32.999 mV	30.000 mV	100 kHz	29.877 mV	30.123 mV
32.999 mV	30.000 mV	450 kHz	29.715 mV	30.285 mV
329.999 mV	33.000 mV	45 Hz	32,970 mV	33.029 mV
329.999 mV	33.000 mV	10 kHz	32.970 mV	33.029 mV
329.999 mV	300.000 mV	9.5 Hz	283.350 mV	316.650 mV
329.999 mV	300.000 mV	10 Hz	299.917 mV	300.083 mV
329.999 mV	300.000 mV	45 Hz	299.893 mV	300.107 mV
329.999 mV	300.000 mV	1 kHz	299.983 mV	300.107 mV
329.999 mV	300.000 mV	10 kHz	299.983 mV	300.107 mV
329.999 mV	300.000 mV	20 kHz	299.782 mV	300.218 mV
329.999 mV	300.000 mV	50 kHz	299.702 mV	300.298 mV
329.999 mV	300.000 mV	100 kHz	299.311 mV	300.689 mV
329.999 mV	300.000 mV	500 kHz	298.470 mV	301.530 mV
3.29999 V	0.33000 V	45 Hz	0.32984 V	0.33015 V
3.29999 V	0.33000 V	10 kHz	0.32984 V	0.33015V
3.29999 V	3.00000 V	9.5 Hz	2.83500 V	3.16500 V
3.29999 V	3.00000 V	10 Hz	2.99868 V	3.00132 V
3.29999 V	3.00000 V	45 Hz	2.99910 V	3.00090 V
3.29999 V	3.00000 V	1 kHz	2.99910V	3.00090 V
3.29999 V	3.00000 V	10 kHz	2.99910 V	3.00090 V
3.29999 V	3.00000 V	20 kHz	2.99817 V	3.00183 V
3.29999 V	3.00000 V	50 kHz	2.99745 V	3.00255 V
3.29999 V	3.00000 V	100 kHz	2.99437 V	3.00563V
3.29999 V	3.00000 V	450 kHz	2.98659 V	3.01340 V
3.29999 V	3.29000 V	1 MHz	2.250 V [1]	
32.9999 V	3.3000 V	45 Hz	3.2985 V	3.3014 V
32.9999 V	3.3000 V	10 kHz	3.2985 V	3.3014 V
32.9999 V	30.0000 V	9.5 Hz	28.3500 V	31.6500 V
32.9999 V	30.0000 V	10 Hz	29.9866 V	30.0134V
32.9999 V	30.0000 V	45 Hz	29.9919 V	30.0081 V
32.9999 V	30.0000 V	1 kHz	29.9919 V	30.0081 V
32.9999 V	30.0000 V	10 kHz	29.9919 V	30.0081 V

Table 3-23. Verification Tests for AC Voltage (Normal) (cont.)

Range	Output	Frequency	Lower Limit	Upper Limit
32.9999 V	30.0000 V	20 kHz	29.9802 V	30.0198 V
32.9999 V	30.0000 V	50 kHz	29.9736 V	30.0264 V
32.9999 V	30.0000 V	90 kHz	29.9404 V	30.0596 V
329.999 V	33.000 V	45 Hz	32.984 V	33.015 V
329.999 V	33.000 V	10 kHz	32.969 V	33.030V
329.999 V	300.000 V	45 Hz	299.880 V	300.120 V
329.999 V	300.000 V	1 kHz	299.880 V	300.120 V
329.999 V	300.000 V	10 kHz	299.799 V	300.201 V
329.999 V	300.000 V	18 kHz	299.754 V	300.246 V
329.999 V	300.000 V	50 kHz	299.703 V	300.297 V
329.999 V	200.000 V	100 kHz	199.536 V	200.464 V
1020.00 V	330.00 V	45 Hz	329.84 V	330.15 V
1020.00 V	330.00 V	10 kHz	329.73 V	330.26 V
1020.00 V	1000.00V	45 Hz	999.56 V	1000.44 V
1020.00 V	1000.00 V	1 kHz	999.56 V	1000.44 V
1020.00 V	1000.00 V	5 kHz	999.349 V	1000.66 V
1020.00 V	1000.00 V	8 kHz	999.23 V	1000.77 V
1020.00 V	1020.00 V	1 kHz	1019.55 V	1020.44 V
1020.00 V	1020.00 V	8 kHz	1019.21 V	1020.78 V

[1] Typical specification is -24 dB at 2 MHz

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

Range	Output, AUX [1]	Frequency	Lower Limit	Upper Limit
329.999 mV	10.000 mV	45 Hz	9.622 mV	10.378 mV
329.999 mV	10.000 mV	1 kHz	9.622 mV	10.378 mV
329.999 mV	10.000 mV	5 kHz	9.535 mV	10.465 mV
329.999 mV	10.000 mV	10 kHz	9.520 mV	10.480 mV
329.999 mV	10.000 mV	30 kHz	8.700 mV	11.300 mV
329.999 mV	300.000 mV	9.5 Hz	283.500 mV	316.500 mV
329.999 mV	300.000 mV	10 Hz	299.180 mV	300.820 mV
329.999 mV	300.000 mV	45 Hz	299.390 mV	300.610 mV
329.999 mV	300.000 mV	1 kHz	299.390 mV	300.610 mV
329.999 mV	300.000 mV	5 kHz	299.100 mV	300.900 mV
329.999 mV	300.000 mV	10 kHz	298.650 mV	301.350 mV

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

Range	Output, AUX [1]	Frequency	Lower Limit	Upper Limit
329.999 mV	300.000 mV	30 kHz	287.100 mV	312.900 mV
3.29999 V	3.00000 V	9.5 Hz	2.835 V	3.165V
3.29999 V	3.00000 V	10 Hz	2.99505 V	3.00495 V
3.29999 V	3.00000 V	45 Hz	2.99745 V	3.00255 V
3.29999 V	3.00000 V	1 kHz	2.99745 V	3.00255 V
3.29999 V	3.00000 V	5 kHz	2.99410 V	3.00590 V
3.29999 V	3.00000 V	10 kHz	2.98960 V	3.01040 V
3.29999 V	3.00000 V	30 kHz	2,87720 V	3.12280 V
5.00000 V	5.00000 V	9.5 Hz	4.72500 V	5.27500 V
5.00000 V	5.00000 V	10 Hz	4.99205 V	5.00795 V
5.00000 V	5.00000 V	45 Hz	4.99605 V	5.00395 V
5.00000 V	5.00000 V	1 kHz	4.99605 V	5.00395 V
5.00000 V	5.00000 V	5 kHz	4.99110 V	5.00890 V
5.00000 V	5.00000 V	10 kHz	4.98360 V	5.01640 V

[1] Set the NORMAL output to 300 mV.

Table 3-25. Verification Tests for AC Current

Range	Output	Frequency	Lower Limit	Upper Limit
329.99 µA	33.00 µA	1 kHz	32.87 µA	33.13 µA
329.99 µA	33.00 µA	10 kHz	32.60 µA	33.40 µA
329.99 µA	33.00 µA	30 kHz	32.20 µA	33.80 µA
329.99 µA	190.00 µA	45 Hz	189.71 µA	190.29 µA
329.99 µA	190.00 µA	1 kHz	189.71 µA	190.29 µA
329.99 µA	190.00 µA	10 kHz	188.66 µA	191.34 µA
329.99 µA	190.00 µA	30 kHz	187.32 µA	192.68 µA
329.99 µA	329.00 µA	10 Hz	328.37 µA	329.63 µA
329.99 µA	329.00 µA	45 Hz	328.57 µA	329.43 µA
329.99 µA	329.00 µA	1 kHz	328.57 µA	329.43 µA
329.99 µA	329.00 µA	5 kHz	328.03 µA	329.97 µA
329.99 µA	329.00 µA	10 kHz	326.83 µA	331.17 µA
329.99 µA	329.00 µA	30 kHz	324.65 µA	333.35 µA
3.2999 mA	0.3300 mA	1 kHz	0.3296 mA	0.3304 mA
3.2999 mA	0.3300 mA	5 kHz	0.3293 mA	0.3307 mA
3.2999 mA	0.3300 mA	30 kHz	0.3268 mA	0.3332 mA

Table 3-25. Verification Tests for AC Current (cont.)

Range	Output	Frequency	Lower Limit	Upper Limit
3.2999 mA	1.9000 mA	1 kHz	1.8983 mA	1.9017 mA
3.2999 mA	1.9000 mA	10 kHz	1.8921 mA	1.9079 mA
3.2999 mA	1.9000 mA	30 kHz	1.8842 mA	1.9158 mA
3.2999 mA	3.2900 mA	10 Hz	3.2846 mA	3.2954 mA
3.2999 mA	3.2900 mA	45 Hz	3.2872 mA	3.2928 mA
3.2999 mA	3.2900 mA	1 kHz	3.2872 mA	3.2928 mA
3.2999 mA	3.2900 mA	5 kHz	3.2845 mA	3.2955 mA
3.2999 mA	3.2900 mA	10 kHz	3.2765 mA	3.3035 mA
3.2999 mA	3.2900 mA	30 kHz	3.2631 mA	3.3169 mA
32.999 mA	3.3000 mA	1 kHz	3.297 mA	3.303 mA
32.999 mA	3.3000 mA	5 kHz	3.296 mA	3.304 mA
32.999 mA	3.3000 mA	30 kHz	3.285 mA	3.315 mA
32.999 mA	19.0000 mA	1 kHz	18.991 mA	19.009 mA
32.999 mA	19.0000 mA	10 kHz	18.967 mA	19.033 mA
32.999 mA	19.0000 mA	30 kHz	18.935 mA	19.065 mA
32.999 mA	32.9000 mA	10 Hz	32.849 mA	32.951 mA
32.999 mA	32.9000 mA	1 kHz	32.886 mA	32.914 mA
32.999 mA	32.9000 mA	5 kHz	32.877 mA	32.923 mA
32.999 mA	32.9000 mA	10 kHz	32.844 mA	32.956 mA
32.999 mA	32.9000 mA	30 kHz	32.791 mA	33.009 mA
329.99 mA	33.0000 mA	1 kHz	32.97 mA	33.03 mA
329.99 mA	33.0000 mA	5 kHz	32.92 mA	33.08 mA
329.99 mA	33.0000 mA	30 kHz	32.69 mA	33.31 mA
329.99 mA	190.0000 mA	1 kHz	189.91 mA	190.09 mA
329.99 mA	190.0000 mA	10 kHz	189.60 mA	190.40 mA
329.99 mA	190.0000 mA	30 kHz	189.19 mA	190.81 mA
329.99 mA	329.0000 mA	10 Hz	328.49 mA	329.51 mA
329.99 mA	329.0000 mA	45 Hz	328.86 mA	329.14 mA
329.99 mA	329.0000 mA	1 kHz	328.86 mA	329.14 mA
329.99 mA	329.0000 mA	5 kHz	328.69 mA	329.31 mA
329.99 mA	329.0000 mA	10 kHz	328.37 mA	329.63 mA
329.99 mA	329.0000 mA	30 kHz	327.75 mA	330.25 mA
2.99999 A	0.33000 A	1 kHz	0.32978 A	0.33022 A

Table 3-25. Verification Tests for AC Current (cont.)

Range	Output	Frequency	Lower Limit	Upper Limit
2.99999 A	0.33000 A	5 kHz	0.32735 A	0.33265 A
2.99999 A	0.33000 A	10 kHz	0.31840 A	0.34160 A
2.99999 A	1.09000 A	10 Hz	1.08827 A	1.09174 A
2.99999 A	1.09000 A	45 Hz	1.08951 A	1.09049 A
2.99999 A	1.09000 A	1 kHz	1.08951 A	1.09049 A
2.99999 A	1.09000 A	5 kHz	1.08355 A	1.09645 A
2.99999 A	1.09000 A	10 kHz	1.06320 A	1.11680A
2.99999 A	2.99000 A	10 Hz	2.98542 A	2.99459 A
2.99999 A	2.99000 A	45 Hz	2.98840 A	2.99160 A
2.99999 A	2.99000 A	1 kHz	2.98840 A	2.99160 A
2.99999 A	2.99000 A	5 kHz	2.97405 A	3.00595 A
2.99999 A	2.99000 A	10 kHz	2.92520 A	3.05480 A
20.5000 A	3.3000 A	500 Hz	3.2954 A	3.3046 A
20.5000 A	3.3000 A	1 kHz	3.2954 A	3.3046 A
20.5000 A	3.3000 A	5 kHz	3.2155 A	3.3845 A
20.5000 A	11.0000 A	45 Hz	10.9840A	11.0160 A
20.5000 A	11.0000 A	65 Hz	10.9840 A	11.0160A
20.5000 A	11.0000 A	500 Hz	10.9807 A	11.0193 A
20.5000 A	11.0000 A	1 kHz	10.9807 A	11.0193 A
20.5000 A	11.0000 A	5 kHz	10.7200 A	11.2800A
20.5000 A	20.0000 A	45 Hz	19.9750 A	20.0250 A
20.5000 A	20.0000 A	65 Hz	19.9750 A	20.0250 A
20.5000 A	20.0000 A	500 Hz	19.9690 A	20.0310 A
20.5000 A	20.0000 A	1 kHz	19.9690 A	20.0310 A
20.5000 A	20.0000 A	5 kHz	19.4950 A	20.5050 A

Table 3-26. Verification Tests for Capacitance

Range	Output	Test Frequency or Current	Lower Limit	Upper Limit
0.3999 nF	0.2200 nF	5 kHz	0.2192 nF	0.2308 nF
0.3999 nF	0.3500 nF	1 kHz	0.3387 nF	0.3613 nF
1.0999 nF	0.4800 nF	1 kHz	0.4682 nF	0.4918 nF
1.0999 nF	0.6000 nF	1 kHz	0.5877 nF	0.6123 nF
1.0999 nF	1.0000 nF	1 kHz	0.9862 nF	1.0138 nF

Table 3-26. Verification Tests for Capacitance (cont.)

Range	Output	Test Frequency or Current	Lower Limit	Upper Limit
3.299 nF	2.0000 nF	1 kHz	1.9824 nF	2.0176 nF
10.999 nF	7.0000 nF	1 kHz	6.9767 nF	7.0233 nF
10.999 nF	10.9000 nF	1 kHz	10.8693 nF	10.9307 nF
32.999 nF	20.000 nF	1 kHz	19.8620 nF	20.1380 nF
109.99 nF	70.00 nF	1 kHz	69.767 nF	70.233 nF
109.99 nF	109.00 nF	1 kHz	108.693 nF	109.307 nF
329.99 nF	200.00 nF	1 kHz	199.320 nF	200.680 nF
329.99 nF	300.00 nF	1 kHz	299.130 nF	300.870 nF
1.0999 µF	0.7000 µF	100 Hz	0.69767 µF	0.70233 µF
1.0999 µF	1.0900 µF	100 Hz	1.05929 µF.	1.12071 µF
3.2999 µF	2.0000 µF	100 Hz	1.99320 µF	2.00680 µF
3.2999 µF	3.0000 µF	100 Hz	2.99130 µF	3.00870 µF
10.999 µF	7.000 µF	100 Hz	6.9767 µF	7.0233 µF
10.999 µF	10.900 µF	100 Hz	10.8693 µF	10.9307 µF
32.999 µF	20.000 µF	100 Hz	19.9100 µF	20.0900 µF
32.999 µF	30.000 µF	100 Hz	29.8800 µF	30.1200 µF
109.99 µF	70.00 µF	50 Hz	69.662 µF	70.338 µF
109.99 µF	109.00 µF	50 Hz	108.529 µF	109.471 µF
329.99 µF	200.00 µF	54 µA dc	199.020 µF	200.980 µF
329.99 µF	300.00 µF	80 µA dc	298.680 µF	301.320 µF
1.0999 mF	0.3300 mF	90 µA dc	0.32788 mF	0.33212 mF
1.0999 mF	0.7000 mF	180 µA dc	0.69662 mF	0.70338 mF
1.0999 mF	1.0900 mF	270 µA dc	1.08529 mF	1.09471 mF
3.299 mF	1.100 mF	270 µA dc	1.0933 mF	1.1067 mF
3.299 mF	2.000 mF	540 µA dc	1.9902 mF	2.0098 mF
3.299 mF	3.000 mF	800 µA dc	2.9868 mF	3.0132 mF
10.999 mF	3.300 mF	900 µA dc	3.2788 mF	3.3212 mF
10.999 mF	10.900 mF	2.7 mA dc	10.8529 mF	10.9471 mF
32.999 mF	20.000 mF	5.4 mA dc	19.8300 mF	20.1700 mF
32.999 mF	30.000 mF	8.0 mA dc	29.7600 mF	30.2400 mF
110.00 mF	33.00 mF	9.0 mA dc	32.570 mF	33.430 mF
110.00 mF	110.00 mF	27.0 mA dc	108.800 mF	111.200 mF

Table 3-27. Verification Tests for Thermocouple Simulation

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

Table 3-28. Verification Tests for Thermocouple Measurement

TC Type	Input, mV	Lower Limit, °C	Upper Limit, °C
10 µV/°C	0.00 °C (0,0000 mV)	-0.30	-0.30
	10000.00 °C (100.0000 mV)	9999.30	10000.70
	-10000.00 °C (-100.0000 mV)	-10000.70	-9999.30
	30000.00 °C (300.0000 mV)	29998.50	30001.50
	-30000.00 °C (-300.0000 mV)	-30001.50	-29998.50

Table 3-29. Verification Tests for Phase Accuracy, V and V

Range, Normal Output, V	Output, Normal V	Frequency	Range, AUX Output	Output, AUX	Phase °	Lower Limit°	Upper Limit °
3.29999	3.00000	65 Hz	3.29999 V	3.00000 V	0	-0.150	0.150
		400 Hz				-0.900	0.900
		1 kHz				-2.000	2.000
		5 kHz				-6.000	6.000
		10 kHz				-10.000	10.000
		30 kHz				-15.000	15.000
		65 Hz			60	59.850	60.150
		400 Hz				59.100	60.900
		1 kHz				58.000	62.000
		5 kHz				54.000	66.000
		10 kHz				50.000	70.000
		30 kHz				45.000	75.000
		65 Hz			90	89.850	90.150
		400 Hz				89.100	90.900
		1 kHz				88.000	92.000
		5 kHz				84.000	96.000
		10 kHz				80.000	100.000
		30 kHz				75.000	105.000
32.9999	30.0000	65 Hz				89.85	90.15
329.999	50.000	65 Hz				89.85	90.15

Table 3-30. Verification Tests for Phase Accuracy, V and I

Range, Normal Output, V	Output, Normal V	Frequency	Range, AUX Output	Output, AUX	Phase °	Lower Limit °	Upper Limit °
329.999 mV	30.000 mV	65 Hz	329.99 mA	300.00 mA	0	-0.15	0.15
		1 kHz	329.99 mA	300.00 mA		-2.00	2.00
		30 kHz	329.99 mA	300.00 mA		-15.00	15.00
	200.000 mV	65 Hz	2099999 A	2.00000 A		-0.15	0.15
	50.000 mV	65 Hz	20.5000 A	5.0000 A		-0.15	0.15
		400 Hz	20.5000 A	5.0000 A		-0.90	0.90
	30.000 mV	65 Hz	329.99 mA	300.00 mA	60	59.85	60.15
	200.000 mV	65 Hz	2.99999 A	2.00000 A		59.85	60.15
		65 Hz	20.5000 A	20.0000 A		59.85	60.15
		400 Hz	20.5000 A	20.0000 A		59.10	60.90
32.999 mV	3.3000 V	65 Hz	329.99 mA	300.00 mA	0	-0.15	0.15
		65 Hz	2.99999 A	2.00000 A		-0.15	0.15
		65 Hz	20.5000 A	5.0000 A		-0.15	0.15
		400 Hz	20.5000 A	5.0000 A		-0.90	0.90
		65 Hz	329.99 mA	300.00 mA	90	89.85	90.15
		65 Hz	2.99999 A	2.00000 A		89.85	90.15
		65 Hz	20.5000 A	20.0000 A		89.85	90.15
		400 Hz	20.5000 A	20.0000 A		89.10	90.90
329.999 V	33.000 V	65 Hz	329.99 mA	300.00 mA	0	-0.15	0.15
		65 Hz	2.99999 A	2.00000 A		-0.15	0.15
		65 Hz	20.5000 A	5.0000 A		-0.15	0.15
		400 Hz	20.5000 A	5.0000 A		-0.90	0.90
		65 Hz	329.99 mA	300.00 mA	90	89.85	90.15
		65 Hz	2.99999 A	2.00000 A		89.85	90.15
		65 Hz	20.5000 A	20.0000 A		89.85	90.15
		400 Hz	20.5000 A	20.0000 A		89.10	90.90

Table 3-31. Verification Tests for Frequency

Range, Normal Output, V	Output, Normal, V	Frequency	Lower Limit [1]	Upper Limit [1]
3.29999	3.00000	119.00 Hz	118.99602 Hz	119.00398 Hz
		120.0 Hz	119.99600 Hz	120.00400 Hz
		1000.0 Hz	999.974000 Hz	1000.026000 Hz
		100.00 kHz	99.99750000 Hz	100.00250000 Hz

[1] Frequency accuracy is specified for 1 year.

Chapter 4
Maintenance

Introduction

The Calibrator is a high performance instrument and it is not recommended that the user repair the boards to the component level. It is easy to introduce a subtle long-term stability problem when you touch the boards. Access procedures are supplied for those who must replace a defective module.

Basic Maintenance

This section tells you how to do the usual maintenance and calibration tasks necessary to keep the 5502A Calibrator in service.

⚠⚠ Warning

To prevent possible electrical shock, fire, or personal injury:

- **Turn off the Product and remove the mains power cord. Stop for 2 minutes to let the internal circuits discharge before you open the fuse door or remove Product covers.**
- **Replace a blown fuse with exact replacement only for continued protection against arc flash.**
- **Disconnect the mains power cord before you remove the Product covers.**
- **Use only specified replacement parts.**
- **Use only specified replacement fuses.**
- **Have an approved technician repair the Product.**

Replace the Mains Fuse

Access the mains power fuse from the rear panel. The fuse rating information above the ac power input module shows the correct replacement fuse for each line voltage setting. Table 4-1 shows the fuse part numbers for each line voltage setting.

To verify or replace the fuse, refer to Figure 4-1 and do the subsequent steps:

1. Disconnect mains power.

⚠⚠ Warning

To prevent possible electrical shock, fire, or personal injury, turn off the Product and remove the mains power cord. Stop for 2 minutes to let the internal circuits discharge before you open the fuse door or remove Product covers.

2. The mains power fuse and mains voltage switch are in a compartment on the right end of the ac input module. To open the compartment and remove the fuse, put the blade of a standard screwdriver to the left of the tab at the left side of the compartment cover.
3. Pull the tab out of the slot and the compartment cover will come part way out.
4. Remove the compartment cover.
5. The fuse comes out with the compartment cover and can be easily replaced.

To install the fuse, push the compartment cover back into the compartment until the tab locks with the ac input module.

Table 4-1. Replacement Line Fuses

Part Number	Fuse Description	Line Voltage Setting
⚠ 109215	5A/250 V Time Delay	100 V or 120 V
⚠ 851931	2.5A/250 V Time Delay	220 V or 240 V
⚠To ensure safety, use exact replacement only.		

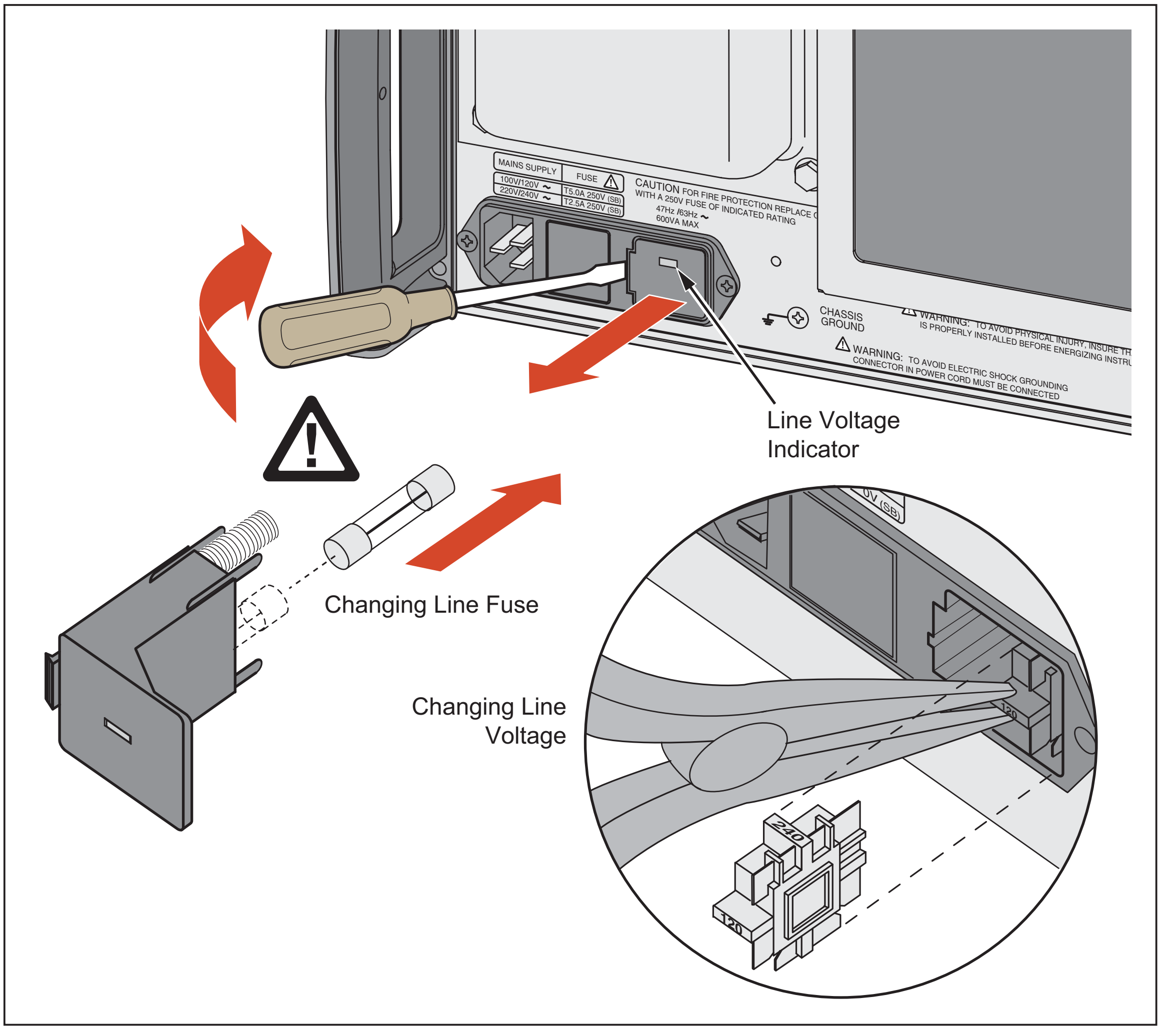


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Figure 4-1. Accessing the Fuse

Replace the Current Fuses

⚠⚠ Warning

To prevent possible electrical shock, fire, or personal injury:

- **Disconnect the mains power cord before you remove the bottom fuse cover.**
- **Use only specified replacement fuses.**

Access the current fuses from the bottom of the Calibrator. These fuses are the 3A and 20A outputs protection from over-current. Table 4-2 shows the fuse part numbers for the two current fuses. To replace a current fuse:

1. Turn the Calibrator over on its top.
2. Remove the two screws with a Phillips head screwdriver as shown in Figure 4-2.

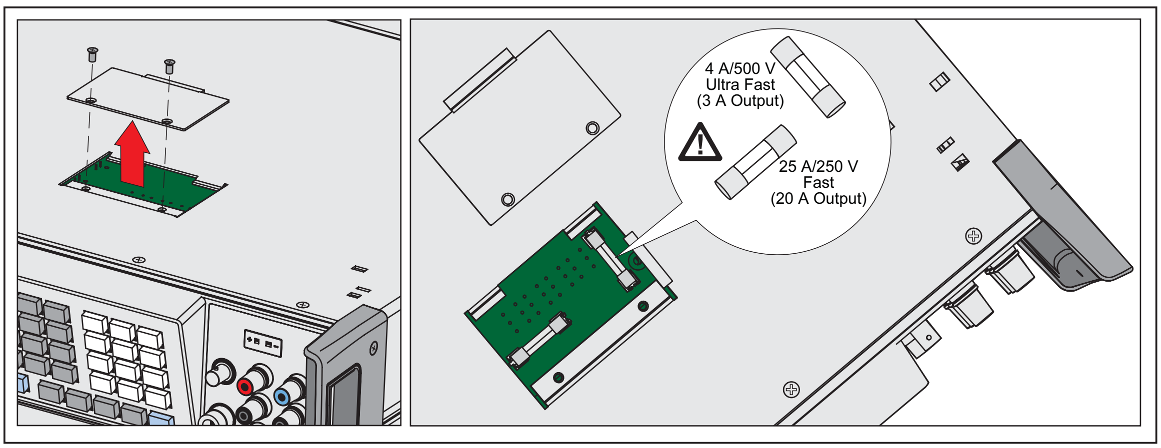

Figure 4-2. Current Fuse Replacement

3. Lift off the fuse door.
4. Remove the fuse and replace it with a new fuse of the same rating.

Table 4-2. Replacement Current Fuses

Part Number	Fuse Description
3674001	4A/500 V Ultra Fast
3470596	25A/250 V Fast
⚠To ensure safety, use exact replacement only.	

5. Replace the fuse door over the fuse compartment.
6. Install the two screws to hold the fuse door in position.

Clean the Air Filter

The air filter must be removed and cleaned every 30 days or more frequently if the calibrator is operated in a dusty environment. The air filter is accessed from the rear panel of the calibrator.

To clean the air filter, refer to Figure 4-3 and continue as follows:

1. Turn off the power, let the fan stop, and disconnect the ac mains cord.
2. Remove the filter element.
3. Hold the top and bottom of the air filter frame.
4. Squeeze the edges of the frame to the middle to disengage the filter tabs from the slots in the calibrator.
5. Pull the filter frame straight out from the calibrator.
6. Clean the filter element.
7. Clean the filter element in soapy water.
8. Flush the filter element.
9. Shake out the unwanted water, and then let the filter element to dry before you install it.
10. Install the filter element. Do the filter removal steps in reverse.

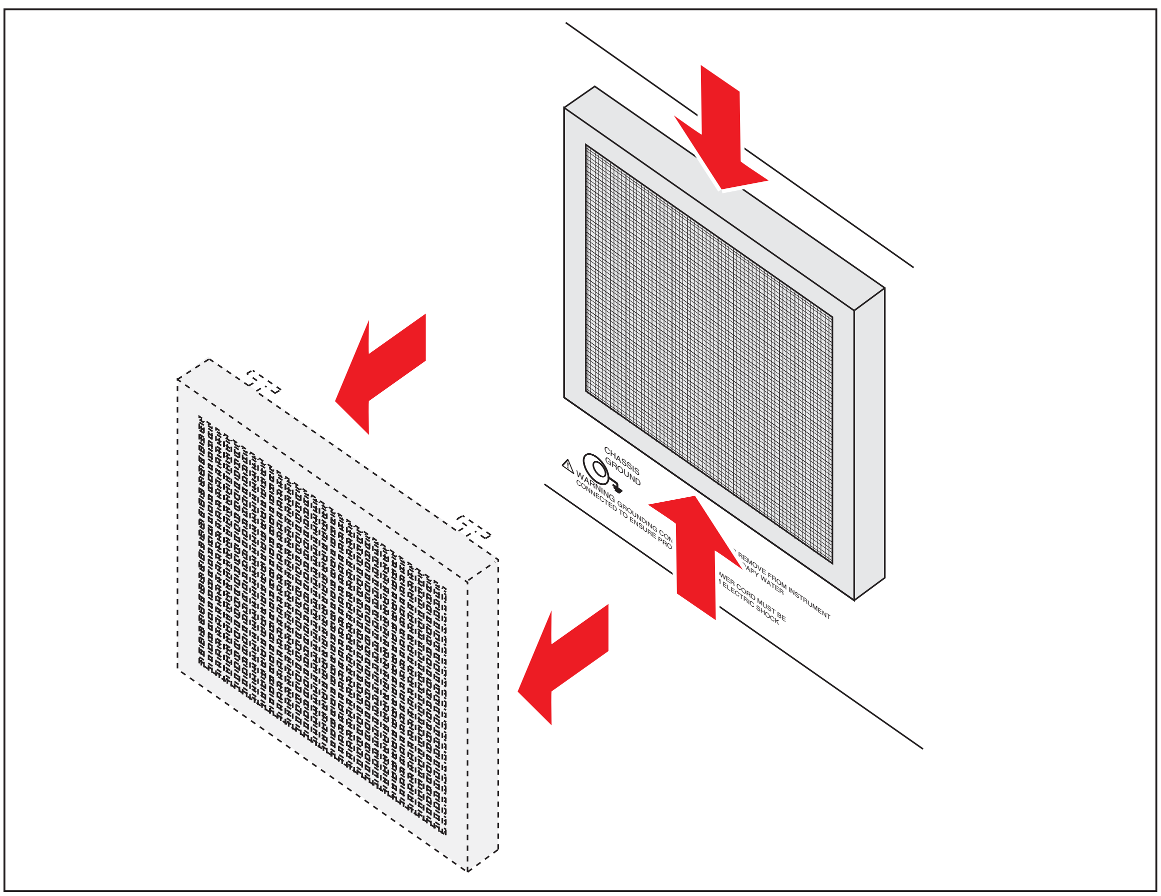

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Figure 4-3. Access the Air Filter

Clean the Calibrator

Clean the case, front panel keys, and display with a soft cloth dampened with water or a non-abrasive weak cleaning solution that will not harm plastics.

⚠ Caution

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. They can damage the plastic materials used in the calibrator.

PCA Access Procedure

Use the procedures in this section to remove:

- Analog modules
- Main Central Processing Unit (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

Remove Analog Modules

To remove the Voltage (A8), Current (A7), DDS (A6), or Synthesized Impedance (A5) modules:

1. Remove eight Phillips screws from the top cover.
2. Remove the top cover.
3. Remove eight Phillips screws form the guard box cover. The locations of the analog modules are printed on the guard box cover.
4. Lift off the guard box cover with the finger pull on the rear edge of the cover.
5. Release the board edge locks on the analog module to be removed.
6. Lift the board out of its socket in the Motherboard. Put 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 install the shield, first align one set of tabs then push the other side into position.

Main CPU (A9)

You can remove the Main CPU (A9) with the rear panel and Filter PCA (A12) installed. To remove the Main CPU PCA:

1. Remove the 3/16 inch jack screws from the SERIAL 1, SERIAL 2, and BOOST AMPLIFIER connectors.
2. Remove the ¼ inch jack screws from the IEEE-488 connector.
3. Remove 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 (A90).

Rear-Panel Assemblies

To remove the transformer and the ac line input filter:

Note

Figure 4-4 shows an exploded view of the rear-panel assemblies.

1. Remove six Allen screws from the rear handles and then remove the handles.
2. Remove eight Phillips screws from the bottom cover.
3. Remove the bottom cover.
4. Remove the three Phillips screws that you access through holes in the bottom flange.
5. Remove the power switch pushrod.
6. Remove the rear panel. If the Main CPU (A9) is removed, then there are three large cables, plus one for fan power. If the Main CPU is installed, there is one more cable.

Filter PCA (A12)

To remove the Filter PCA (A12):

1. Remove the top cover and guard-box cover. See the instructions in the “Remove Analog Modules” section.
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.

Encoder (A2) PCA and Display Assembly

To remove the Encoder PCA (A2) PCA and Display assembly:

Note

Figure 4-5 shows an exploded view of the front-panel assemblies.

1. Remove top and bottom covers.
2. With the bottom side up, disconnect all the cables that go to the front panel. One of these cables is attached by a cable tie that must be cut, then replaced with a new one when you assemble the Calibrator.
3. Remove six Allen screws from the two front handles. Then remove the handles.

4. Remove the front panel. The Encoder PCA (A2) and display pcas are now accessible.

Keyboard (A1) and Access the Output Block

To remove the keyboard and access the output block:

1. Do all four steps in the “Encoder and Display” section.
2. Unlatch the plastic catches that fasten the front panel together.
3. Remove four Phillips screws that are around the output block.
4. Remove the output cables.
5. Pull apart the two main parts of the front panel.

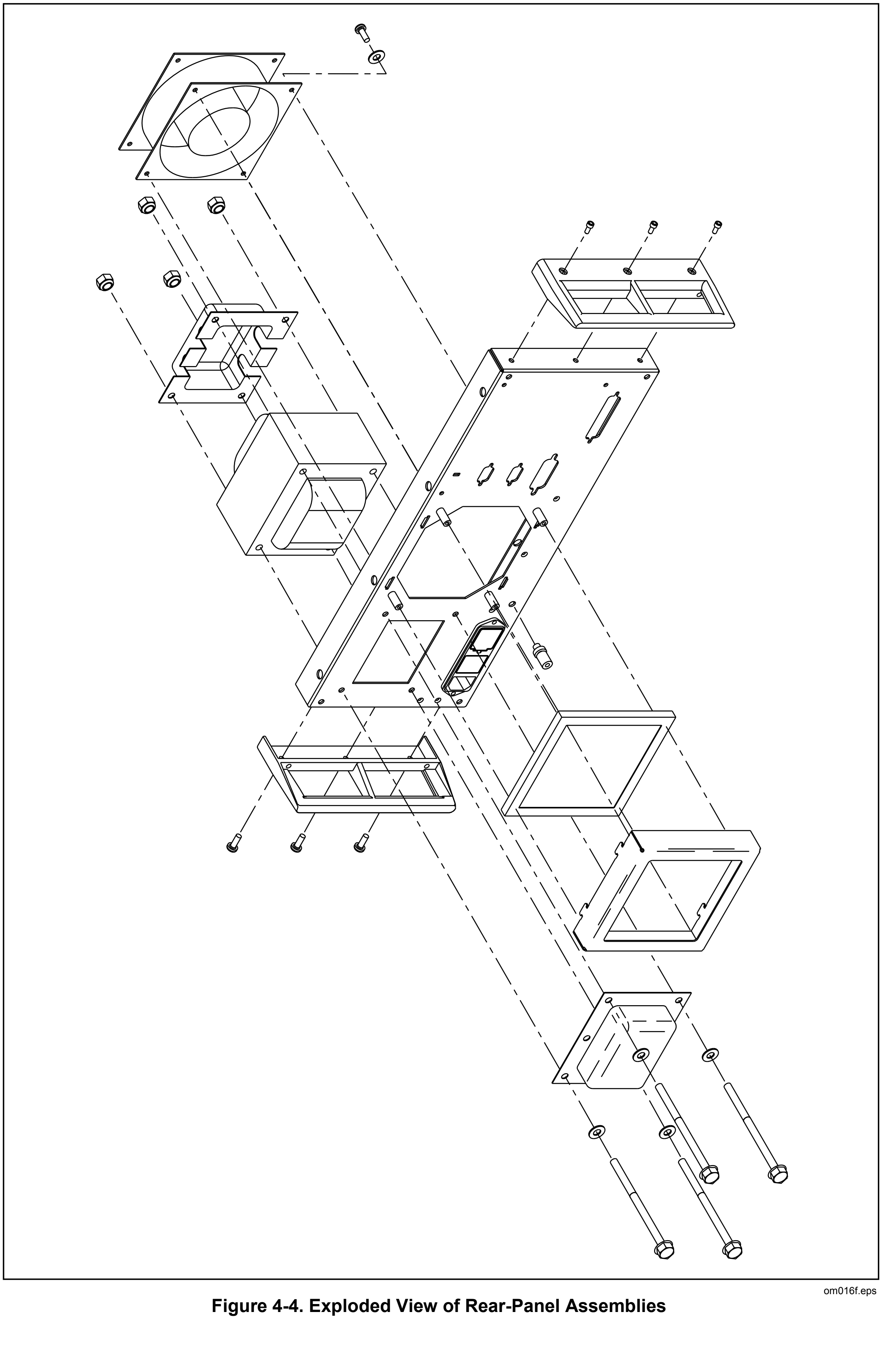

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Figure 4-4. Exploded View of Rear-Panel Assemblies

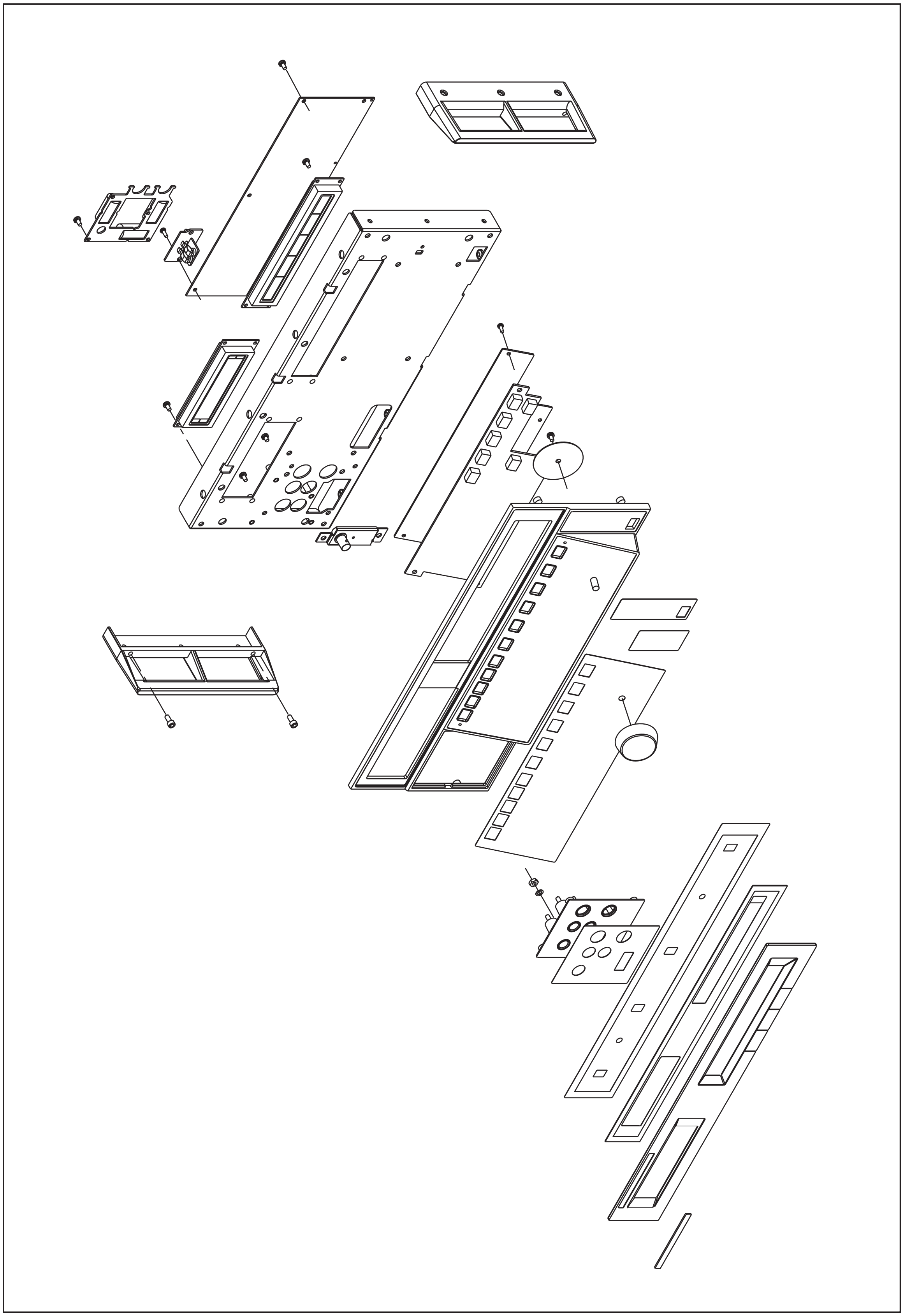

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Figure 4-5. Exploded View of Front-Panel Assemblies

Diagnostic Tests

The Calibrator software has extensive self-test procedures. If self-test finds a malfunction, then use diagnostic tests to start fault isolation.

Note

Only do self-tests after the Calibrator has completed its warm-up.

To access the diagnostic menus:

1. Push SETUP.
2. Push the **UTILITY FUNCTNS** softkey.
3. Push the **SELF TEST** softkey.

The menu shows:

- **DIAG** – Starts internal diagnostics
- **FRONT PANEL** – Lets you start the test for front panel knob, keys, bell, and displays.
- **SERIAL IF TEST** – Does a loopback test between the two serial ports. For this test, you must attach a straight-through serial cable between the two serial ports. Pins 2, 3, and 5 must be connected for this test.
- **DIGITAL TEST** – Does a test on the RAM and the bus on the Main CPU (A9).

How to Do Diagnostic Tests

To do diagnostic tests:

1. Push SETUP.
2. Push the **UTILITY FUNCTNS** softkey.
3. Push the **SELF TEST** softkey. The menu shows **OPTIONS** and **GO ON**.
4. Push the **GO ON** softkey to start diagnostics.

The Calibrator instructs you to remove all cables from the front-panel outputs. Install a low-ohm copper short circuit across the **20A** and **AUX LO** terminals.

After you push the **GO ON** softkey, an automatic sequence of tests start. Diagnostics has a set of steps that are almost the same as the zero calibration and reports errors.

How to Test the Front Panel

To test the front panel:

1. Push SETUP.
2. Push the **UTILITY FUNCTNS** softkey.
3. Push the **SELF TEST** softkey.
4. Push the **DIAG** softkey.

The menu shows:

KNOB TEST – Does a test on the knob encoder that shows a cursor that moves when you turn the knob.

KEY TEST – A test that shows the name of the key in the display when you push a key. Push PREV MENU to exit the test.

BELL TEST – Lets you operate the beeper for different periods of time.

DISPLAY – Turns on segments of the two displays. Push RESET to exit the test. With Main software version 3.6, you can also push PREV MENU, STBY, or OPR to exit the test.

Note

*When you do a test on the output display (**DISPLAY MEAS**), you can select one of three test patterns: **ALLON**, **ALLOFF**, and **CURSOR TEST**.*

Complete List of Error Messages

Table 4-3 is a list of Calibrator error messages.

Table 4-3. Error Message Format

Error Number	(Message Class :	Description)	Text Characters
0 to 65536	**QYE** Query Error, caused by a full input buffer, unterminated action or interrupted action	**F** Error is shown on the front panel as it occurs.	Up to 36 text characters
	DDE Device-Specific Error, caused by some condition in the 5520A, for example, overrange	**R** Error is queued to the remote interface as it occurs	
	EXE Execution Error, caused by an element external to, or inconsistent with, the 5502A	**S** Error causes instrument to go to Standby	
	CME Command Error, caused by incorrect command syntax, unrecognized header, or parameter of the incorrect type	**D** Error causes instrument to go to the power up state	
		(none) Error is sent to to the initiator only (i.e., local initiator or remote initiator)	

0	(QYE:)	No Error
1	(DDE:FR)	Error queue overflow
100	(DDE:FR D)	Inguard not responding (send)
101	(DDE:FR D)	Inguard not responding (recv)
102	(DDE:FR D)	Lost sync with inguard
103	(DDE:FR)	Invalid guard xing command
104	(DDE:FR D)	Hardware relay trip occurred
105	(DDE:FR D)	Inguard got impatient
106	(DDE:FR D)	A/D fell asleep
107	(DDE:FR D)	Inguard watchdog timeout
108	(DDE:FR)	Inguard is obsolete
109	(DDE:FR D)	Inguard parity error

110	(DDE:FR D)	Inguard overrun error
111	(DDE:FR D)	Inguard framing error
112	(DDE:FR D)	Inguard fault error
113	(DDE:FR D)	Inguard fault input error
114	(DDE:FR D)	Inguard fault detect error
115	(DDE:FR D)	Inguard read/write error
300	(DDE:)	Invalid procedure number
301	(DDE:)	No such step in procedure
302	(DDE:)	Can't change that while busy
303	(DDE:)	Can't begin/resume cal there
304	(DDE:)	Wrong unit for reference
305	(DDE:)	Entered value out of bounds
306	(DDE:)	Not waiting for a reference
307	(DDE:)	Continue command ignored
308	(DDE:FR)	Cal constant outside limits
309	(DDE:FR)	Cal try to null failed
310	(DDE:FR D)	Sequence failed during cal
311	(DDE:FR D)	A/D measurement failed
312	(DDE:FR)	Invalid cal step parameter
313	(DDE:)	Cal switch must be ENABLED
314	(DDE:FR)	Divide by zero encountered
315	(DDE:FR)	Must be in OPER at this step
316	(DDE:FR)	Open thermocouple for RJ cal
317	(DDE:FR)	Bad reference Z or entry
318	(DDE:FR)	Cal takes DAC over top limit
319	(DDE: R)	Zero cal needed every 7 days
320	(DDE: R)	Ohms zero needed every 12 hours
398	(QYE:F)	Unusual cal fault %d
399	(QYE:F)	Fault during %s
400	(DDE:FR D)	Encoder not responding VERS
401	(DDE:FR D)	Encoder not responding COMM
402	(DDE:FR D)	Encoder not responding STAT
403	(DDE:FR)	Encoder self-test failed
405	(DDE:FR)	Message over display R side
406	(DDE:FR)	Unmappable character #%d
407	(DDE:FR)	Encoder did not reset
408	(DDE:FR)	Encoder got invalid command
409	(DDE:FR D)	Encoder unexpectedly reset
500	(DDE:)	Internal state error
501	(DDE:)	Invalid keyword or choice
502	(DDE:)	Harmonic must be 1 - 50
503	(DDE:)	Frequency must be >= 0
504	(DDE:)	AC magnitude must be > 0
505	(DDE:)	Impedance must be >= 0
506	(DDE:)	Function not available
507	(DDE:)	Value not available
508	(DDE:)	Cannot enter watts by itself
509	(DDE:)	Output exceeds user limits
510	(DDE:)	Duty cycle must be 1.0-99.0
511	(DDE:)	Power factor must be 0.0-1.0
512	(DDE:)	Can't select that field now
513	(DDE:)	Edit digit out of range

514	(DDE:)	Can't switch edit field now
515	(DDE:)	Not editing output now
516	(DDE:)	dBm only for single sine ACV
517	(DDE:)	Freq too high for non-sine
518	(DDE:)	Value outside locked range
519	(DDE:)	Must specify an output unit
520	(DDE:)	Can't do two freqs at once
521	(DDE:)	Can't source 3 values at once
522	(DDE:)	Temp must be degrees C or F
523	(DDE:)	Can't do that now
526	(DDE:)	Limit too small or large
527	(DDE:)	No changes except RESET now
528	(DDE:)	Offset out of range
529	(DDE:)	Cannot edit to or from 0 Hz
530	(DDE:)	Bad state image - not loaded
531	(DDE:)	TC offset limited to +/-500 C
532	(DDE:)	Can't go to STBY in Meas TC
533	(DDE:)	Can't set an offset now
534	(DDE:)	Can't lock this range
535	(DDE:)	Can't set phase or PF now
536	(DDE:)	Can't set wave now
537	(DDE:)	Can't set harmonic now
538	(DDE:)	Can't change duty cycle now
539	(DDE:)	Can't change compensation now
540	(DDE:FR)	Current OUTPUT moved to 5725A
541	(DDE:)	TC ref must be valid TC temp
542	(DDE:)	Can't turn EARTH on now
543	(DDE: D)	STA couldn't update OTD
544	(DDE:)	Can't enter W with non-sine
545	(DDE:)	Can't edit now
546	(DDE:)	Can't set trigger to that now
547	(DDE:)	Can't set output imp. now
548	(DDE:FR)	Compensation is now OFF
549	(DDE:)	Period must be >= 0
550	(DDE:)	A report is already printing
551	(DDE:)	ScopeCal option not installed
552	(DDE:)	Not a ScopeCal function
553	(DDE:)	Can't set marker shape now
554	(DDE:)	Can't set video parameter now
555	(DDE:)	Marker location out of range
556	(DDE:)	Pulse width must be 1 - 255
557	(DDE:)	Can't set range directly now
558	(DDE:)	Not a range for this function
559	(DDE:)	Can't set TD pulse now
560	(DDE:)	ZERO_MEAS only for C or PRES meas
561	(DDE:FR)	That requires a -SC option
562	(DDE:FR)	That requires a -SC600 option
563	(DDE:)	Time limit must be 1s-60s
564	(DDE:)	Can't set ref. phase now
565	(DDE:)	ZERO_MEAS reading not valid
566	(DDE:)	Can't set dampen now
567	(DDE:)	Can't turn EXGRD on now

600	(DDE:FR D)	Outguard watchdog timeout
601	(DDE:FR)	Power-up RAM test failed
602	(DDE:FR)	Power-up GPIB test failed
700	(DDE: R)	Saving to NV memory failed
701	(DDE: R)	NV memory invalid
702	(DDE: R)	NV invalid so default loaded
703	(DDE: R)	NV obsolete so default loaded
800	(DDE:FR)	Serial parity error %s
801	(DDE:FR)	Serial framing error %s
802	(DDE:FR)	Serial overrun error %s
803	(DDE:FR)	Serial characters dropped %s
900	(DDE:FR)	Report timeout - aborted
1000	(DDE:FR)	Sequence failed during diag
1200	(DDE:FR)	Sequence name too long
1201	(DDE:FR)	Sequence RAM table full
1202	(DDE:FR)	Sequence name table full
1300	(CME: R)	Bad syntax
1301	(CME: R)	Unknown command
1302	(CME: R)	Bad parameter count
1303	(CME: R)	Bad keyword
1304	(CME: R)	Bad parameter type
1305	(CME: R)	Bad parameter unit
1306	(EXE: R)	Bad parameter value
1307	(QYE: R)	488.2 I/O deadlock
1308	(QYE: R)	488.2 interrupted query
1309	(QYE: R)	488.2 unterminated command
1310	(QYE: R)	488.2 query after indefinite response
1311	(DDE: R)	Invalid from GPIB interface
1312	(DDE: R)	Invalid from serial interface
1313	(DDE: R)	Service only
1314	(EXE: R)	Parameter too long
1315	(CME: R)	Invalid device trigger
1316	(EXE: R)	Device trigger recursion
1317	(CME: R)	Serial buffer full
1318	(EXE: R)	Bad number
1319	(EXE: R)	Service command failed
1320	(CME: R)	Bad binary number
1321	(CME: R)	Bad binary block
1322	(CME: R)	Bad character
1323	(CME: R)	Bad decimal number
1324	(CME: R)	Exponent magnitude too large
1325	(CME: R)	Bad hexadecimal block
1326	(CME: R)	Bad hexadecimal number
1328	(CME: R)	Bad octal number
1329	(CME: R)	Too many characters
1330	(CME: R)	Bad string
1331	(DDE: R)	OPER not allowed while error pending
1332	(CME:FR)	Can't change UUT settings now
1500	(DDE:FRS)	Compliance voltage exceeded
1501	(DDE:FRS)	Shunt amp over or underload
1502	(DDE:FRS)	Current Amp Thermal Limit Exceeded
1503	(DDE:FRS)	Output current lim exceeded

1504	(DDE:FRS)	Input V or A limit exceeded
1505	(DDE:FRS)	VDAC counts out of range
1506	(DDE:FRS)	IDAC counts out of range
1507	(DDE:FRS)	AC scale dac counts out of range
1508	(DDE:FRS)	DC scale dac counts out of range
1509	(DDE:FRS)	Frequency dac counts out of range
1510	(DDE:FRS)	IDAC counts (DC OFFSET) out of range
1511	(DDE:FRS)	ZDAC counts out of range
1512	(DDE:FRS)	Can't read External Clock register
1513	(DDE:FRS)	External Clock too Fast
1514	(DDE:FRS)	External Clock too Slow
1515	(DDE:FR D)	Can't load waveform for scope mode
1600	(DDE:FR D)	OPM transition error
1601	(DDE:FR D)	TC measurement fault
1602	(DDE:FR D)	Z measurement fault
65535	(DDE:FR)	Unknown error %d

Chapter 5
List of Replaceable Parts

Introduction

This chapter contains an illustrated list of replaceable parts for the Calibrator. Parts are shown by assembly, alphabetized by reference designator. Each assembly is accompanied by an illustration that shows the location of each part and its reference designator.

The parts lists contain:

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

⚠Caution

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

How to Obtain Parts

Electronic components may be ordered directly from the Fluke Corporation and its authorized representatives with the Fluke part number. Parts price information is available from the Fluke Corporation or its representatives. Refer to Tables 5-1 through 5-5.

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

- Technical Support USA: 1-877-355-3225
- Calibration/Repair USA: 1-877-355-3225
- Canada: 1-800-36-FLUKE (1-800-363-5853)
- Europe: +31-40-2675-200
- Japan: +81-3-6714-3114
- Singapore: +65-6799-5566
- China: +86-400-810-3435
- Brazil: +55-11-3759-7600

- Anywhere in the world: +1-425-446-6110

To see product information or download manuals and the latest manual supplements, visit Fluke Calibration's website at www.flukecal.com.

- To register your product, visit http://flukecal.com/register-product.

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

To make sure you get prompt delivery of the correct part, include in your order:

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

Table 5-1. Front-Panel Assembly

Reference Designator	Description	Fluke Part Number	Quantity
A1	KEYBOARD PCA	761049	1
A2	ENCODER PCA	627232	1
A10	TC BUTTON PCA	4104614	1
A11	TC CONNECTION PCA	625951	1
H15-H18	SCREW,8-32,.375,LO CAP,SCKT,STAINLESS STEEL,BLK OXIDE,LOCK	295105	4
H19-H27	SCREW,5-20,.312,WASHER HEAD, PHILLIPS, STEEL,ZINC-CHROMATE,HI-LO THD FORM	494641	9
H71-H76	SCREW,PH,P,LOCK,SS,6-32,.500	320051	6
H38-H41	WASHER, LOW THERMAL #8	859939	3
H42-H45	NUT, LOW THERMAL, 8-32	850334	4
H1-H14	SCREW,6-32,.250,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK	152140	20
H29, H60-H61	BINDING POST-RED	886832	3
H46-H49	SCREW,6-32,.625,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK	152181	4
J1	CONNECTOR,ADAPTER,C0AXIAL,N(F),SMA(F),BULKHEAD MOUNT,BULK	1279066	1
J2	CONNECTOR, CONN,COAX,BNC(F),CABLE	412858	1
MP1	FRONT PANEL, MODIFIED	1593149	1
MP3-MP4	HANDLE, 4U	3468705	2
MP66	BEZEL, FRONT PANEL	3843715	1
MP2	FRONT PANEL	3834632	1
MP6	OUTPUT BLOCK	4125101	1
MP13	LCD MODULE,5500A,16X2 CHARACTER, STN, GRAY,TRANSFLECTIVE,YEL-GRN	929179	1
MP14	LCD MODULE,5500A,40X2 CHARACTER,STN, GRAY,TRANSFLECTIVE,YEL-GRN	929182	1
MP67	GASKET TAPE,FOAM,VINYL,.500,.062	282152	1
H59	BINDING POST-BLUE	886366	1
H58	BINDING POST-BLACK	886379	1
S1	KEYPAD, ELASTOMERIC	4161742	1
MP8	DECAL, OUTPUT BLOCK	4125112	1
MP9	LENS, BEZEL	945246	1
MP18	DECAL, POWER ON/OFF	886312	1
MP20	DECAL, KEYPAD	886304	1
MP21	ENCODER WHEEL	764548	1
MP22	KNOB, ENCODER, GREY	868794	1
MP42-MP43	CORE,FERRITE,FLAT CABLE,2.0W,235 OHMS	643814	2

Table 5-1. Front-Panel Assembly (cont.)

Reference Designator	Description	Fluke Part Number	Quantity
MP40-MP41	CLIP,FLAT CABLE FERRITE CORE	643822	2
MP32-MP33	GASKET, FRONT PANEL	627072	2
MP34	GASKET, CONDUCTIVE	627064	1
MP55	GROMMET,EXTRUDED,POLYETHYLENE,.085	854351	1
MP11	ADHESIVE, BEZEL	945258	1
MP36	GROMMET,SLOT,RUBBER,.406,.062	501593	1
MP38-MP39	FOAM PAD,URETHANE,.312 W,.625 L,.375 THK,ADHESIVE	107687	2
W2	CABLE, OUTPUT TO MOTHER BOARD	3841106	1
MP47	CABLE ACCESS,TIE,11.00L,.19W,3.00 DIA	501734	1
MP35	CABLE TIE ANCHOR,ADHSV,.160TIE	407908	1
TIE	CABLE ACCESSORY ,CABLE ACCESS,TIE, 4.00L, .10W,.75 DIA	172080	3
MP12	DECAL, MODEL	4130421	1

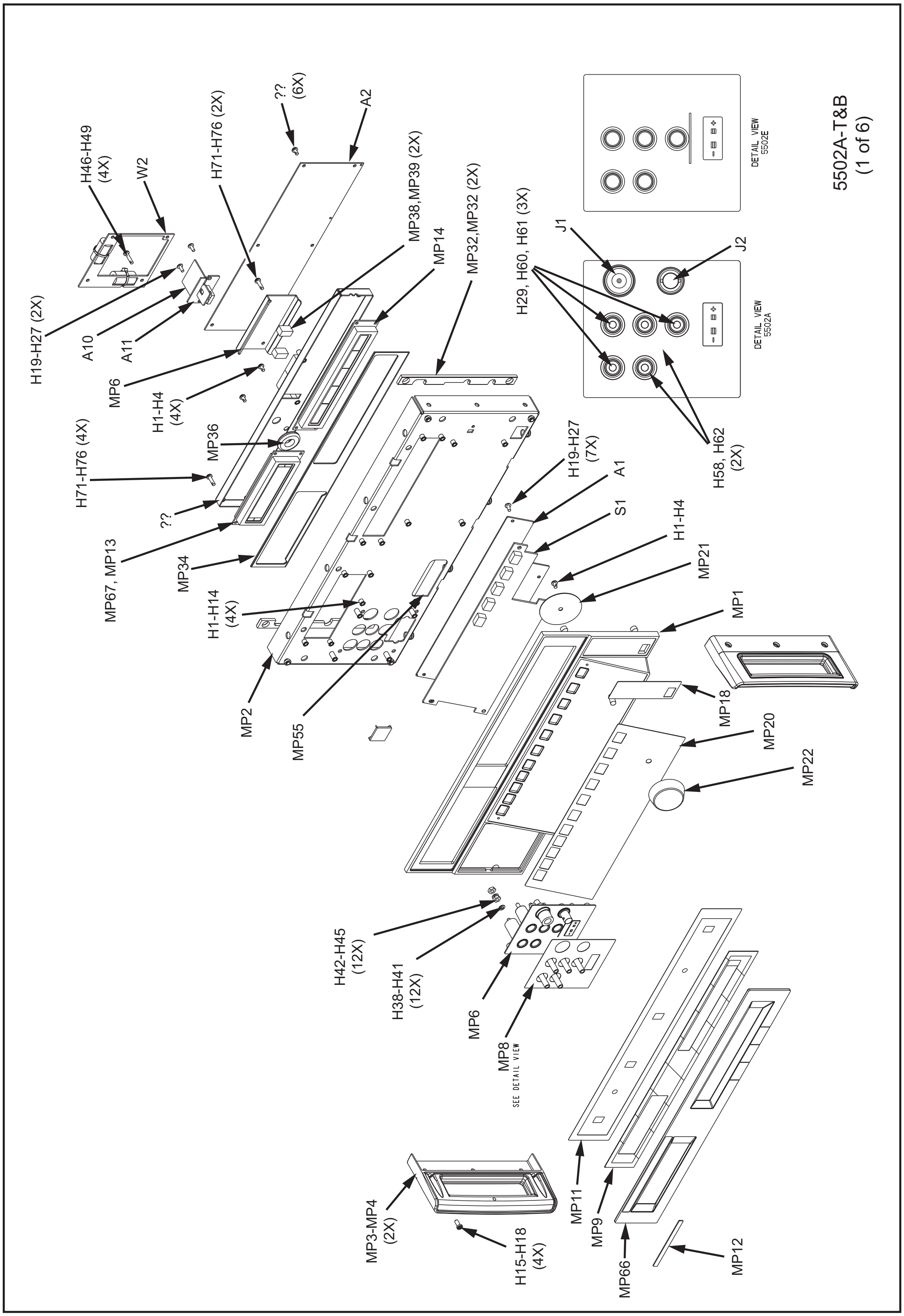

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Figure 5-1. Front-Panel Assembly

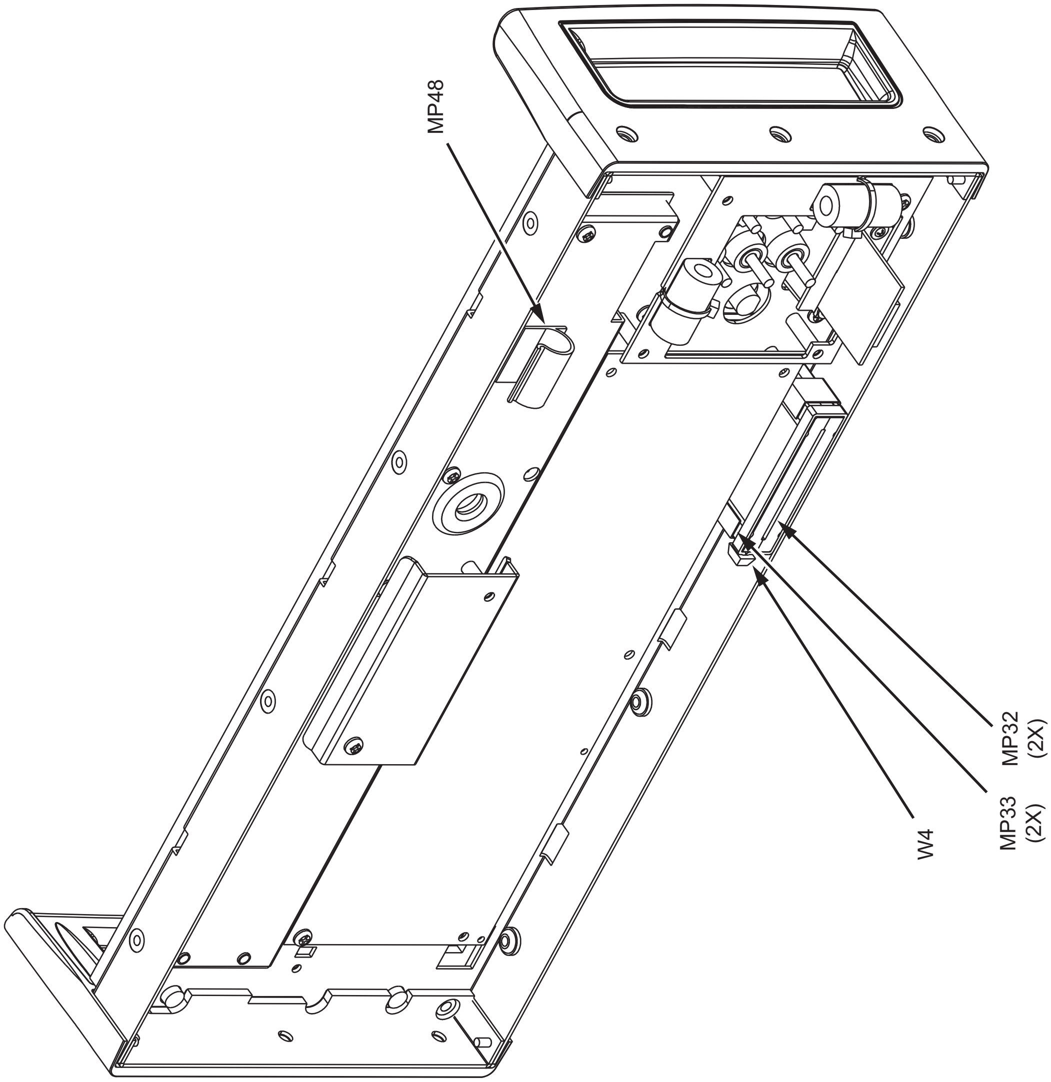

Figure 5-1. Front-Panel Assembly (cont.)

Table 5-2. Rear-Panel Assembly

Reference Designator	Description	Fluke Part Number	Quantity
A9	OUT-GUARD,CPU, PCA SERVICE, 5502A	4238703	1
MP8	AIR FILTER	945287	1
H155	WASHER,FLAT,.219 ID,.506 OD,.061 THK,STEEL, ZINC-CHROMATE	2565513	2
H22-H25	SCREW, MODIFIED	660933	4
H90 H93	CONN ACC,COAX,BNC,NUT	622719	2
H9-H12	SCREW,8-32,.375,LO CAP,SCKT,STAINLESS STEEL,BLK OXIDE,LOCK	295105	4
MP4-MP5	HANDLE, 4U	3468705	2
H91 H94	CONN ACC,COAX,BNC,LOCKWASHER	622743	2
H3-H5	SCREW,6-32,.250,PAN, PHILLIPS, STEEL, ZINC-CLEAR,LOCK	152140	3
H6-H8	WASHER,FLAT,STL,.160,.281,.010	111005	3
H63-H66	WASHER,FLAT,STL,.170,.375,.031	110288	4
H18-H21	SCREW,CAP,SCKT,STL,LOCK,6-32,.750	944772	4
W20	FAN ASSEMBLY	843029	1
H26-H29	NUT,HEX,ELASTIC STOP,STL,10-32,.375	944350	4
MP1	REAR PANEL	3834626	1
MP2	TRANSFORMER COVER, PAINTED	647138	1
MP6	HOUSING, AIR FILTER	937107	1
T1	TRANSFORMER,POWER,100-240V,50/60HZ, 7:1:2:1:8:2:1:2,5520A-6501,284W,EI175	625720	1
MP10	SHIM,TRANSFORMER	625985	1
H2	NUT,HEX,BR,1/4-28	110619	1
H92	WASHER,LOCK,INTRNL,STL,.267ID	110817	1
KIT	SHEET METAL KIT - 5522A	3834644	1
F1	FUSE,.25X1.25,5A,250V,SLOW	109215	1
F1	FUSE,.25X1.25,2.5A,250V,SLOW	851931	1
FL1	FILTER,LINE,250VAC,4A,W/ENTRY MODULE	944269	1
FL10	FILTER,LINE,PART,FUSE DRWR W/SHRT BAR	944277	1
FL9	FILTER,LINE,PART,VOLTAGE SELECTOR	944272	1
H40-H41	SCREW,FHU,P,SS,6-32,.312	867234	2
E2	BINDING POST, STUD, PLATED	102707	1
E1	BINDING HEAD, PLATED	102889	1
MP19	LABEL,CALIB, CERTIFICATION SEAL	802306	1
H59-H60	CONNECTOR ACCESSORY,D-SUB JACK SCREW,4-40,.250 L,W/FLAT WASHER	1777348	2
H49-H50	WASHER,FLAT,STL,.191,.289,.010	111047	2
H16-H17	CONNECTOR ACCESSORY,MICRO-RIBBON,SCREW LOCK,M3.5,6-32,STEEL, ZINC-BLACK OR -CLEAR	854737	2
	LABEL,SERVICE ONLY LABEL- 5080A	3779509	1
H928	WASHER,FLAT,SS,.174,.375,.030	176743	5
MP67	WIRE, 6 INCHES GROUND	626116	1
W1001	TRANSFORMER GROUND CABLE	2095956	1
H61-H62	NUT,EXT LOCK,STL,8-32	195263	2

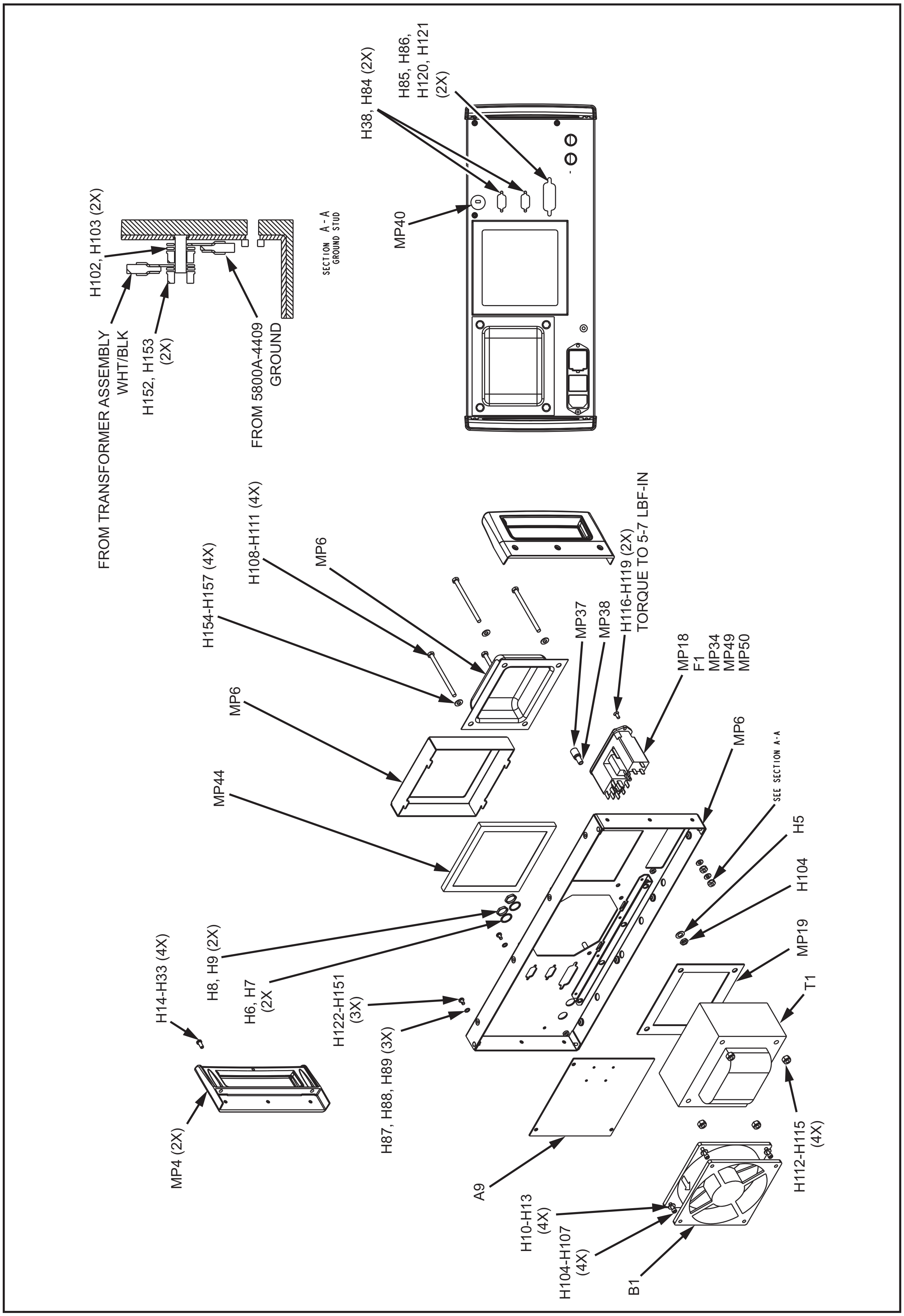

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Figure 5-2. Rear-Panel Assembly

Table 5-3. Chassis Assembly

Reference Designator	Description	Fluke Part Number	Quantity
A3	PCA, MOTHER BOARD, A3	3402295	1
A5	PCA, OHMS, A5	3440307	1
A6	PCA, DDS, A6	3440294	1
A7	PCA, CURRENT, A07	1670021	1
A8	SUB-ASSY, VOLTAGE, A08	626710	1
A12	PCA, POWER SUPPLY, A12	3440413	1
Kit	SHEET METAL KIT - 5522A	3834644	1
MP4	COVER, ANALOG, TOP	3530163	1
MP5	SHIELD, MUMETAL	1552023	1
MP6-MP7	EXTRUSION, SIDE	937271	2
MP8-MP9	INSERT, PLASTIC SIDE	937276	2
MP10	PUSH ROD	1275879	1
MP16-MP17	SHOCK ABSORBER	878983	2
MP24	5700A-2046 ,POWER BUTTON, ON/OFF	775338	1
MP25	6070A-2063 ,AIDE,PCB PULL	541730	1
MP29-MP32	GRND STRIP,CU FINGERS,.32,12.50	601770	4
MP33-MP36	GROUND STRIP,BECU FINGERS,ADHES,.32 W,12.5 L	601762	4
H921-H924	SCREW, M3X0.5,8MM,PAN,PHILLIP,STEEL,ZN-CHROMATE,ROHS COMPL.	2803610	4
MP88	TAPE ,TAPE,FOAM,POLYUR,W/LINER,.3125,.250	603134	1
MP952-MP953	RETAINER, ANALOG TOPCOVER	3472691	2
H1-H12	SCREW,8-32,.375,LO CAP,SCKT,STAINLESS STEEL,BLK OXIDE,LOCK	295105	12
H40-H41	SCREW ,SCREW,FHU,P,SS,6-32,.312	867234	2
H58-H69	SCREW,PH,P,LOCK,SS,6-32,.500	320051	12
H70-H77 H82-89	SCREW,6-32,.250,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK	152140	12
H78-H81	SCREW,6-32 X 0.25,FLAT HD UNDERCUT, PHILLIPS, HEAT TREATED,MAGNETIC SS,NYLON PATCH	320093	4
MP1998	EJECTOR, PCB CARD EJECTOR,NYLON,ACCEPTS PCB THICKNESS 1/16 IN,UP TO 3/32 IN,WHITE	494724	4

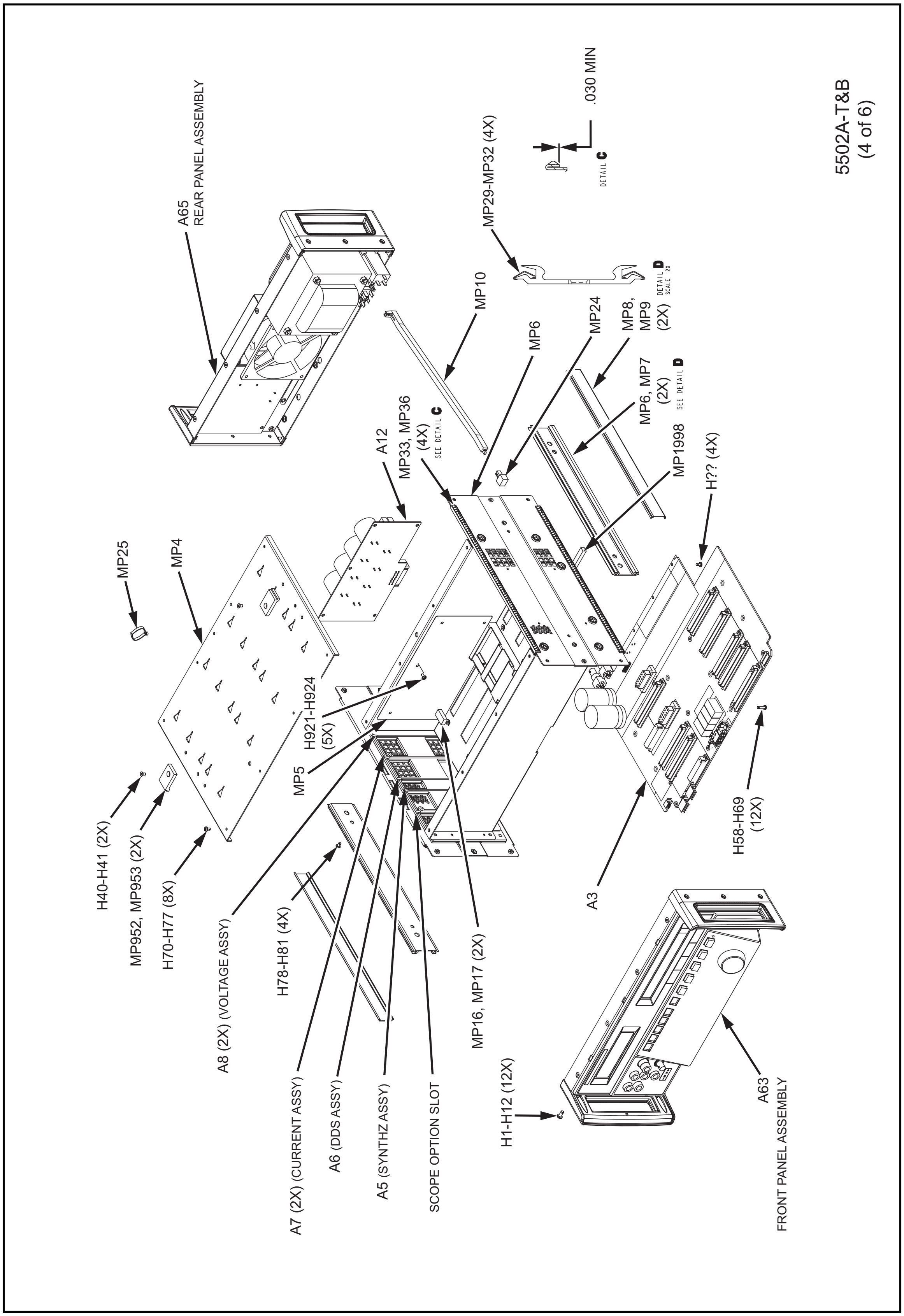

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Figure 5-3. Chassis Assembly

Table 5-4. Wiring

Reference Designator	Description	Fluke Part Number	Quantity
MP22	LABEL,MYLAR,GROUND SYMBOL	911388	1
W1	CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	3
W2	CABLE, 20AMP OUTPUT	3473928	1
W3	,WIRE, 6 INCHES GROUND	626116	1
W4	CABLE, 14 PIN SIP, OPTREX	1572102	1

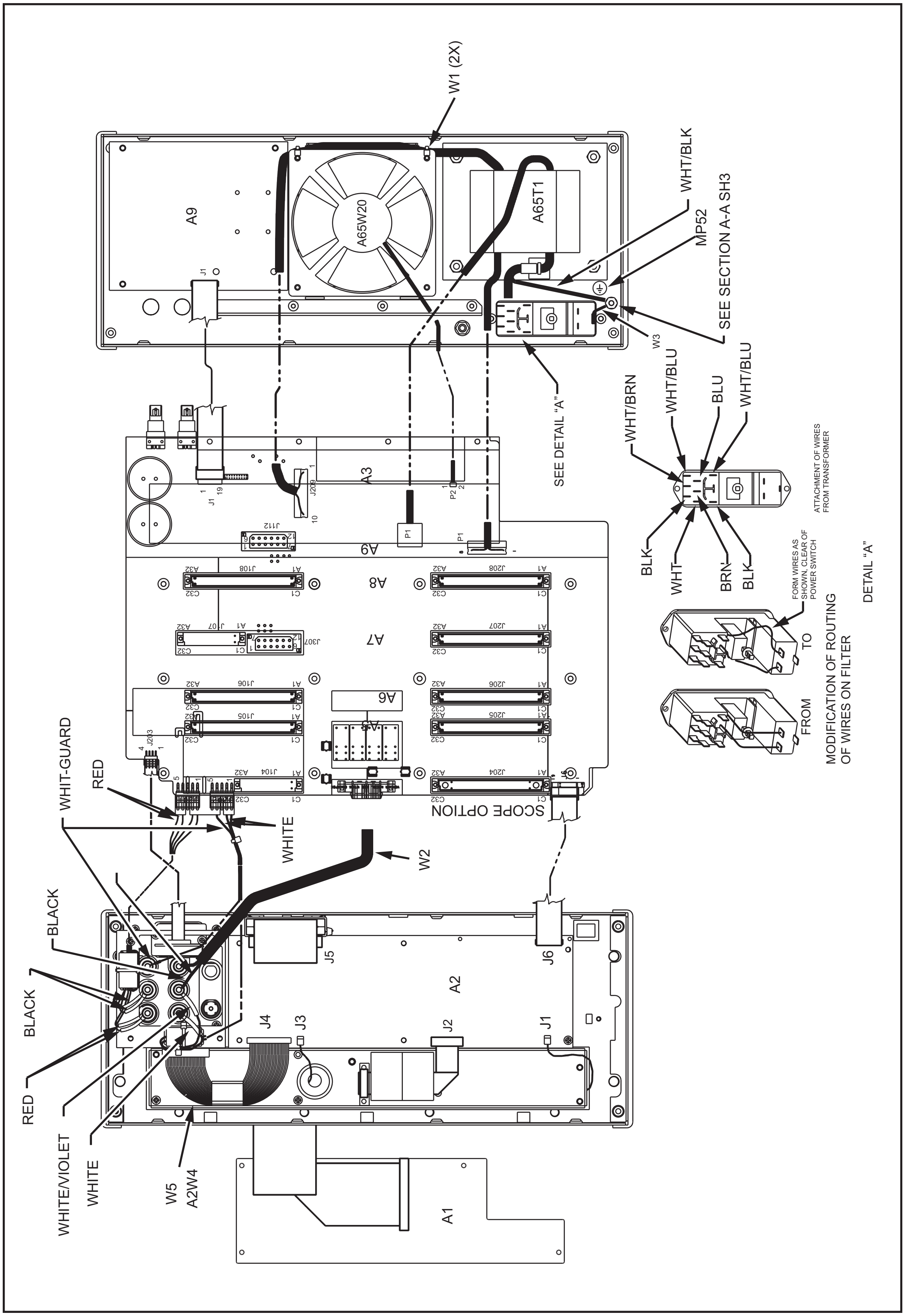

Figure 5-4. Wiring Diagram

Table 5-5. Final Assembly

Reference Designator	Description	Fluke Part Number	Quantity
H13-H28 H78-H81	SCREW,6-32 X 0.25,FLAT HD UNDERCUT,PHILLIPS,HEAT TREATED,MAGNETIC SS,NYLON PATCH	320093	22
MP2	COVER, INSTRUMENT TOP	647146	1
MP3	COVER, INSTRUMENT, BOTTOM	3528217	1
MP5	FUSE COVER	3834615	1
MP8	BOTTOM FOOT, MOLDED	868786	4
MP10	TILT STAND	2650711	2
MP7	SHIELD, ANALOG, FRONT, STANDARD – On Front Panel Assy	2058617	1
A06MP4	SHIELD, ANALOG, FRONT, On A6 PCA	937115	1
A07MP2	SHIELD, CURRENT, On A7 PCA	659935	1
MP31	CLAMP,TOROID	627080	1
MP48	SHIELD, DISPLAY – On Front Panel Assy	661717	1
A05MP3	SHIELD, SYNTHESIZED IMPEDANCE, On A5 PCA	104489	1

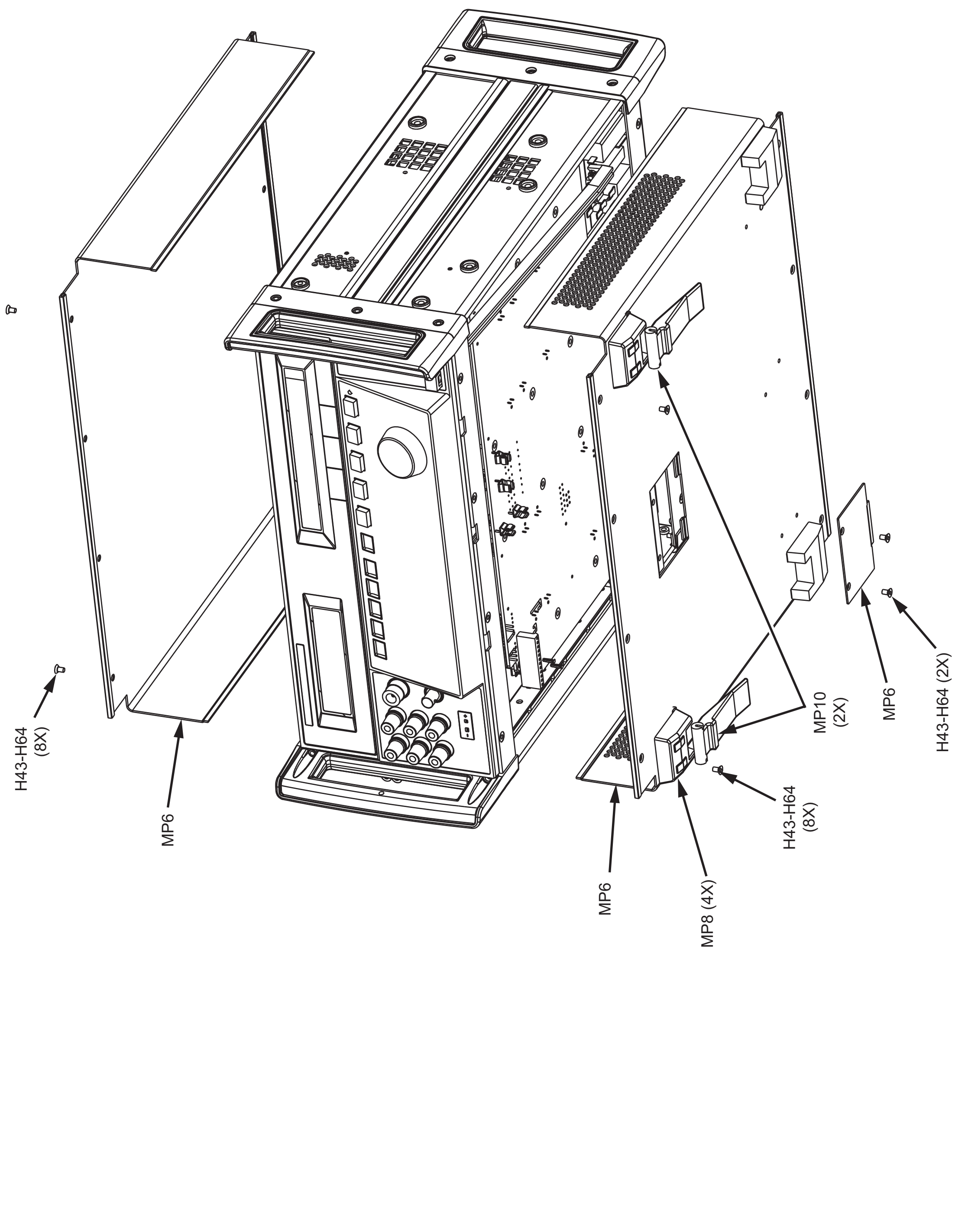

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Figure 5-5. Final Assembly

Chapter 6
SC300 Option

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

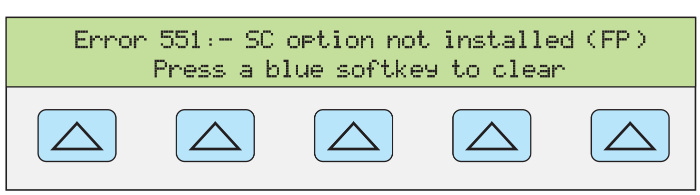
The calibration and verification procedures provide traceable results for all of the SC300 functions as long as they are performed using the recommended equipment. All of the required equipment along with the minimum specifications, are provided in Table 6-1 under "Equipment Required for Calibration 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.

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.

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.

Voltage Function Specifications

Voltage Function	DC Signal		AC Square Wave Signal	
	into 50 Ω	into 1 MΩ	into 50 Ω	into 1 MΩ
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 µV, whichever is greater ≥100 V: 5 digits			
Adjustment Range	Continuous [1]			
1-Year Absolute Uncertainty, tcal ± 5 °C	± (0.25% of output + 100 µV) [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 °C	± (25 ppm of setting + 15 mHz)			
Typical Aberration within 20 µs from leading edge	< (2% of output + 100 µV)			

[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.

[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 ± (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.

[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.

Edge Function Specifications

Edge Characteristics into 50 Ω		1-Year Absolute Uncertainty, tcal ± 5 °C
Amplitude		
Range (p-p)	4.5 mV to 2.75 V	± (2% of output + 200 μV)
Resolution	4 digits	
Adjustment Range	± 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	± (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%	

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 adjust		
1-Year Absolute Uncertainty, tcal ± 5 °C	± (2% of output + 200 µV)	± (3.5% of output + 300 µV)	± (4% of output + 300 µV)
Flatness (relative to 50 kHz)	not applicable	± (1.5% of output + 100 µV)	± (2.0% of output + 100 µV)
Short-term Stability	≤ 1% [2]		
Frequency Characteristics			
Resolution	10 Hz	10 kHz [3]	10 kHz
1-Year Absolute Uncertainty, tcal ± 5 °C	± (25 ppm + 15 mHz)	± 25 ppm [4]	± 25 ppm
Distortion Characteristics			
2nd Harmonic	≤ -33 dBc		
3rd and Higher Harmonics	≤ -38 dBc		

[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.

[2] Within one hour after reference amplitude setting, provided temperature varies no more than ± 5°C.

[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.

[4] ± (25 ppm + 15 mHz) for frequencies of 1 MHz and below.

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] tcal 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.

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.

Trigger Signal Specifications for the Time Marker Function

Time Marker Period	Division	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

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

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 6-1 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.

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.

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.

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.

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.

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.

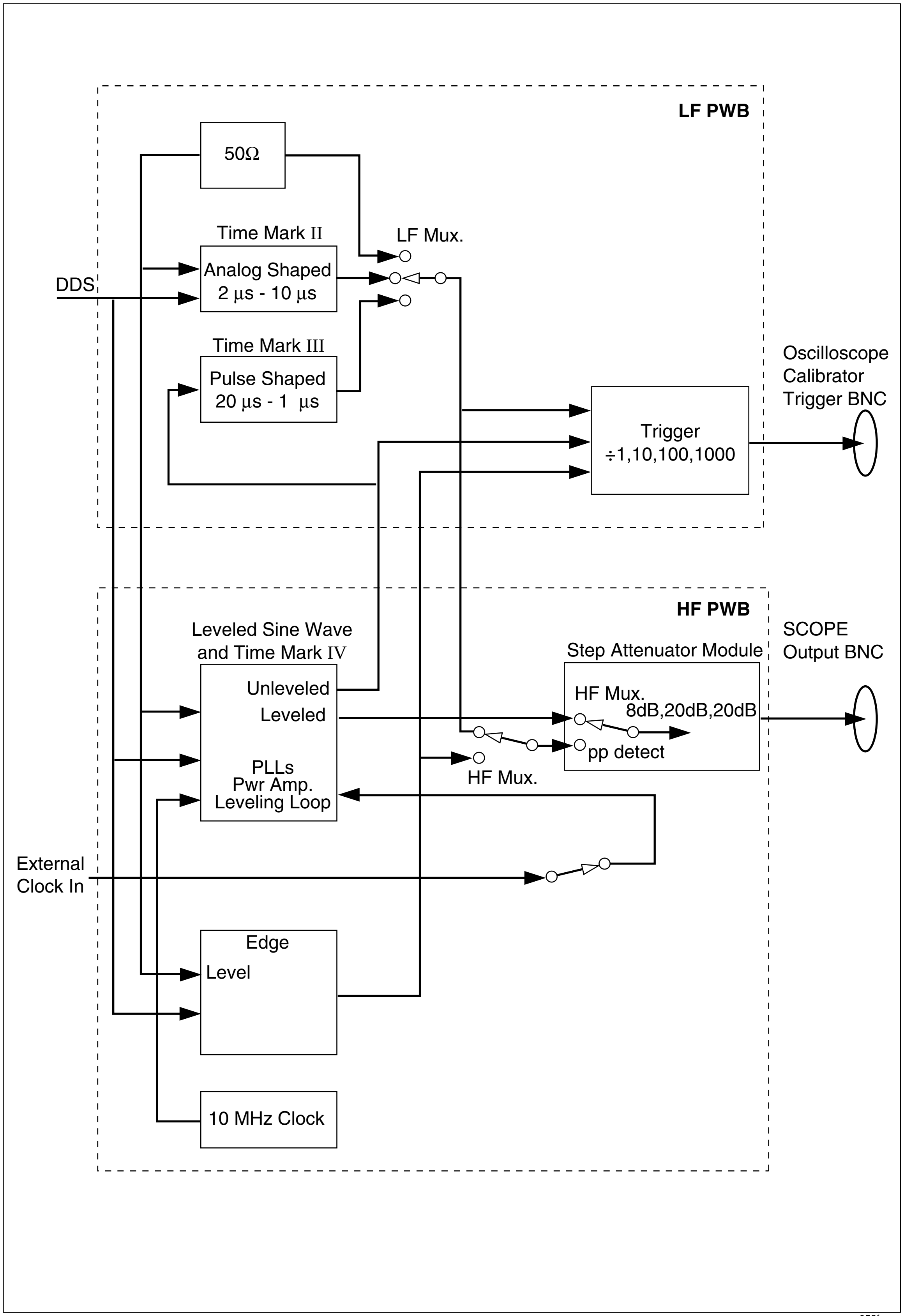

Figure 6-1. SC300 Block Diagram

Equipment Required for Calibration and Verification

Table 6-1 lists the equipment, recommended models, and minimum specifications required for each calibration and verification procedure.

6-1. 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 Ω ± 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 Ω ± 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 Ω ± 1%	
BNC Cable	(supplied with SC300)		

Table 6-1. 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 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 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 6-1. 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)		

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.

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.

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.

Setup for Square Wave Measurements

By controlling the HP 3458A's integration and sample time, it can be used to make accurate, repeat 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 6-2 and Figure 6-2.

Table 6-2. AC Square Wave Voltage and Edge Settings for the HP3458A

Voltage	HP 3458A Settings		
Input Frequency	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.

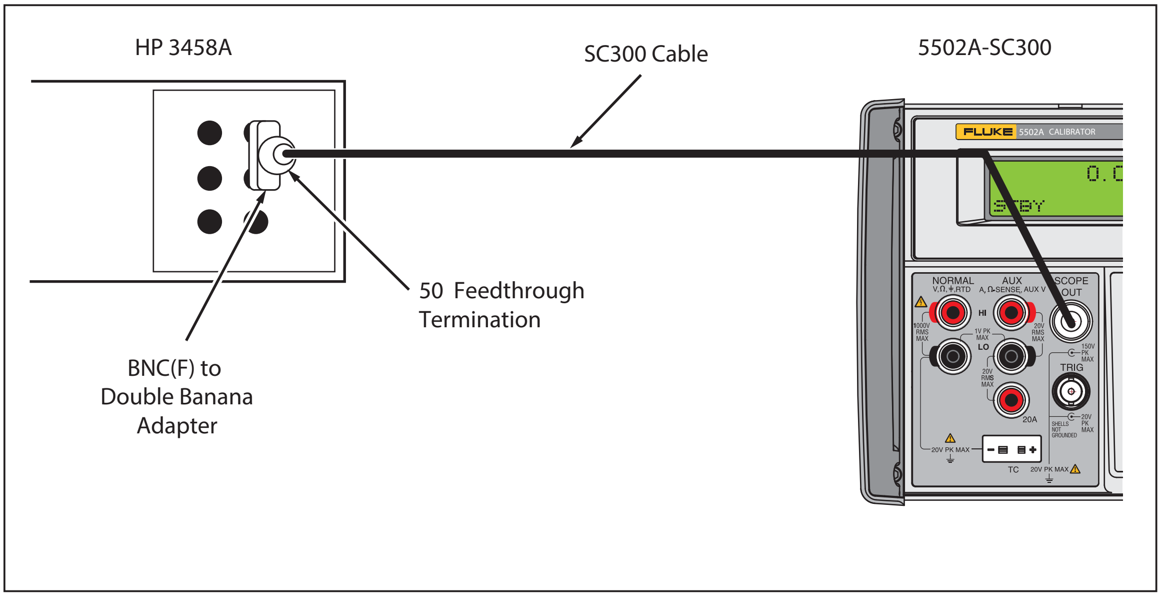

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Figure 6-2. Equipment Setup for SC300 Square Wave Measurements.

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 6-2 for the proper connections.

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 6-2 for the proper setup connections.

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

1. Connect the Calibrator Mainframe's SCOPE connector to the HP 3458A input, using the BNC cable and the BNC(f) to Double Banana adapter.
2. Set the HP 3458A to DCV, Auto Range, NPLC = 10, FIXEDZ = on.
3. Press the **GO ON** blue softkey.
4. Ensure the HP 3458A reading is 0.0 V DC ± 100 μV.
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.

AC Square Wave Voltage Calibration

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

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

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

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

Note

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

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

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 6-2 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 + Rload)/Rload), where Rload = actual feedthrough termination resistance.

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 6-3 for the proper connections.

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

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

Note

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

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

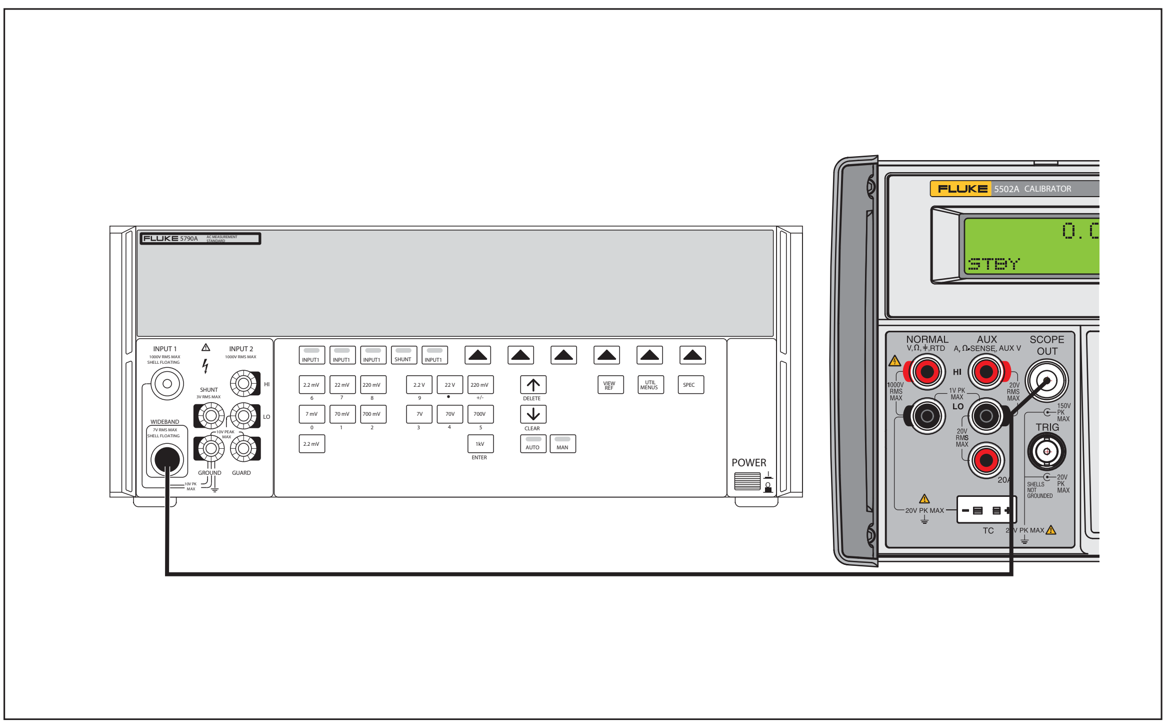

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Figure 6-3. Connecting the Calibrator Mainframe to the 5790A AC Measurement Standard

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”.

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.

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.

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.

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 6-2 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.

Verification at 1 MΩ

For the 1 MΩ 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 MΩ (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 6-3. 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 6-3.
4. Compare result to the tolerance column.

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 6-4. 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 6-4.

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 (1-year spec.) column.

Table 6-3. 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 6-4. 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

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 6-2 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.

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 Z toggles the impedance between 50 Ω and 1 MΩ.)

1. When making measurements at 1 kHz, set the HP 3458A to the values shown in Table 6-2. 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 6-2.

Table 6-5. AC Voltage Verification at 1 MΩ

Nominal Value (p-p)	Frequency	Measured Value (p-p)	Deviation (mV)	1-Year Spec. (mV)
5.0 mV	10 Hz			0.11
5.0 mV	100 Hz			0.11
5.0 mV	1 kHz			0.11
5.0 mV	5 kHz			0.11
5.0 mV	10 kHz			0.11
10.0 mV	10 kHz			0.12
20.0 mV	100 Hz			0.15
20.0 mV	1 kHz			0.15
20.0 mV	10 kHz			0.15
50.0 mV	10 kHz			0.23
89.0 mV	10 Hz			0.32
89.0 mV	10 kHz			0.32
100.0 mV	10 kHz			0.35
200.0 mV	100 Hz			0.60
200.0 mV	1 kHz			0.60
200.0 mV	10 kHz			0.60
500.0 mV	10 kHz			1.35
890.0 mV	10 Hz			2.32
890.0 mV	10 kHz			2.32
1.0 V	100 Hz			2.60
1.0 V	1 kHz			2.60
1.0 V	10 kHz			2.60
2.0 V	10 kHz			5.10
5.0 V	10 Hz			12.60
5.0 V	10 kHz			12.60
10.0 V	10 kHz			25.10
20.0 V	10 kHz			50.10
50.0 V	10 Hz			125.10
50.0 V	100 Hz			125.10
50.0 V	1 kHz			125.10
50.0 V	10 kHz			125.10
105.0 V	100 Hz			262.60
105.0 V	1 kHz			262.60

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 6-2. 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 6-6. 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 6-6. 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 6-6. 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 6-6. 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

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

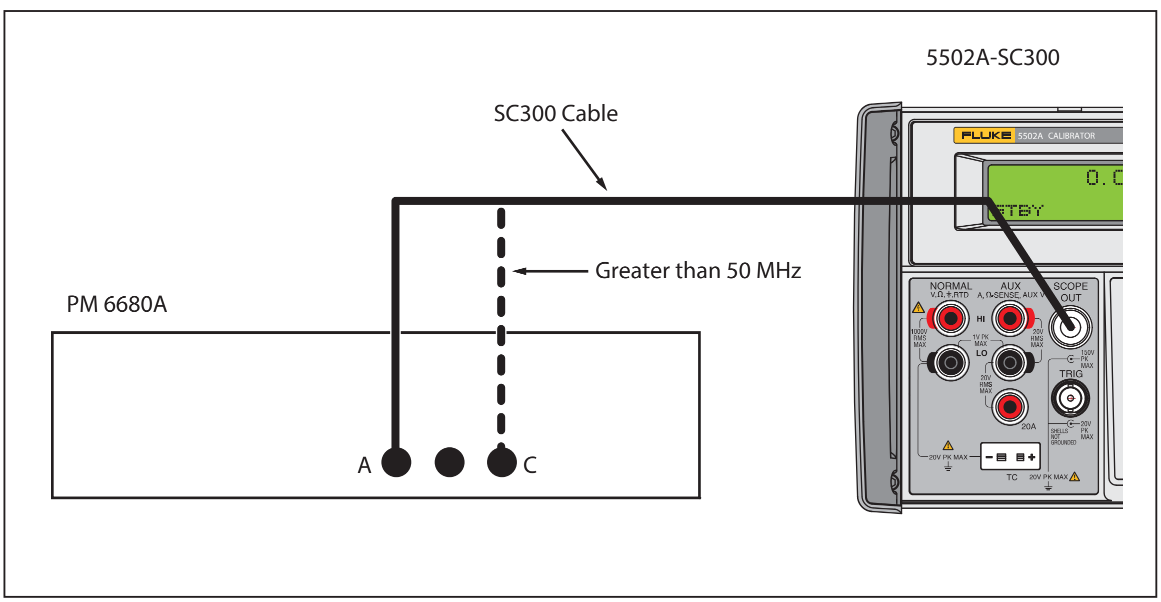

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Figure 6-4. Frequency Verification Setup

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, 1MΩ 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 6-7.
4. Allow the PM 6680 reading to stabilize, then record the PM 6680 reading for each frequency listed in Table 6-7. Compare to the tolerance column of Table 6-7.

Table 6-7. 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

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 6-8.
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 + Rload)/Rload), where Rload = actual feedthrough termination resistance. Record each reading as indicated in Table 6-8.

Table 6-8. 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

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 6-4 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 6-9.
4. Allow the PM 6680 reading to stabilize, then record the PM 6680 reading for each frequency listed in Table 6-9. Compare to the tolerance column of Table 6-9.

Table 6-9. 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

Edge Duty Cycle Verification

This procedure uses the following equipment:

- PM 6680 Frequency Counter
- BNC cable supplied with the SC300

Refer to Figure 6-4 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%.

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".

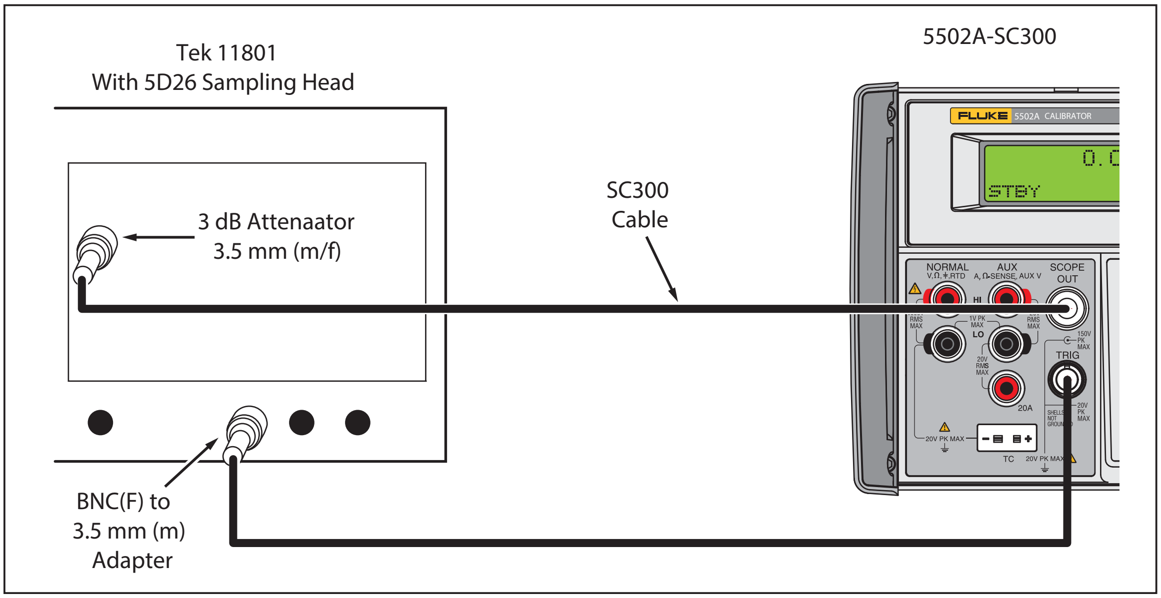

Figure 6-5. Edge Rise Time Verification Setup

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 6-10. 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 6-10. 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((Column A)^2 - (SD-22/26 rise time)^2).
4. The edge rise time measured should be less than the time indicated in Table 6-10.

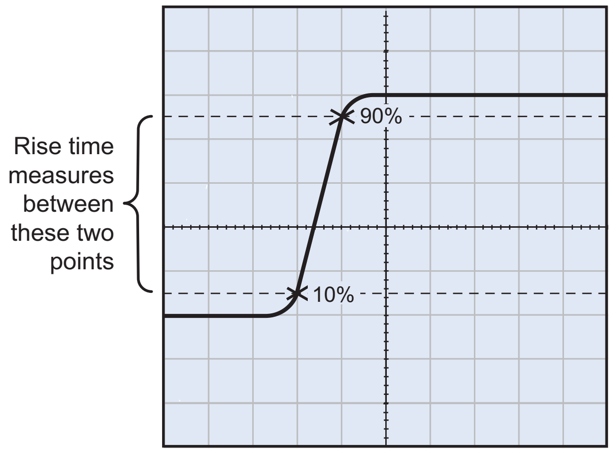

Figure 6-6. Edge Rise Time

Table 6-10. Edge Rise Time Verification

Calibrator Mainframe Output		DSO Vertical Axis	A	B	
Voltage	**Frequency**	**(mV/div)**	**11801 Reading**	**Corrected Reading**	**Tolerance**
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

Edge Aberration 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 6-11.

Table 6-11. 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%)

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 6-3 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 6-12.
4. Allow the 5790A reading to stabilize, then record the 5790A's rms reading for each voltage listed in Table 6-12.
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 6-12. 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

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 6-4 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 6-13. 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 6-13. 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 6-13.

Table 6-13. 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
300 MHz	C	Off		12500 Hz

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.

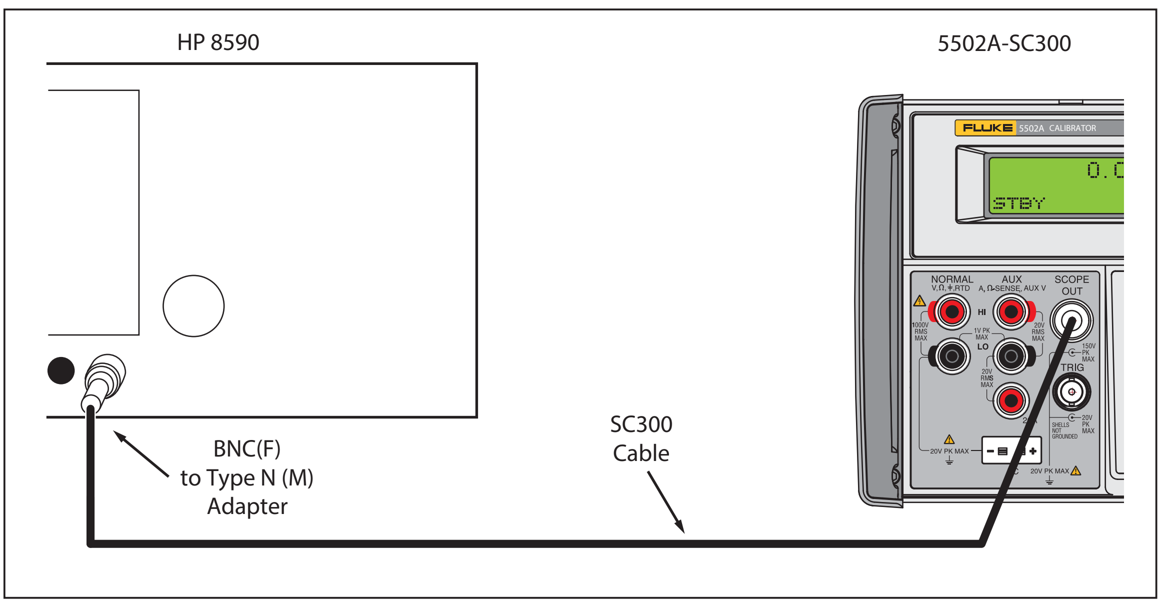

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Figure 6-7. Leveled Sine Wave Harmonics Verification Setup

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 6-14. 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 6-14. 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 6-14.

Table 6-14. 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

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.

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 6-8. Set the 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.

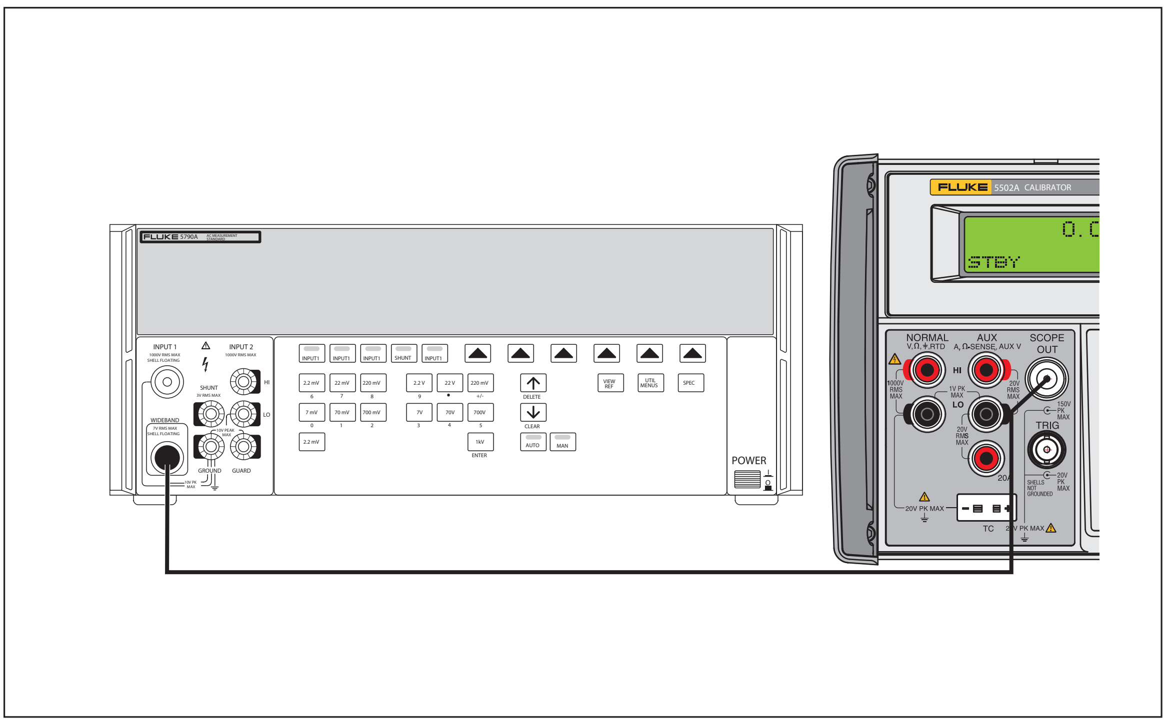

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Figure 6-8. Connecting the Calibrator Mainframe to the 5790A AC Measurement Standard

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 6-9. 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 6-10.

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 0 (default)

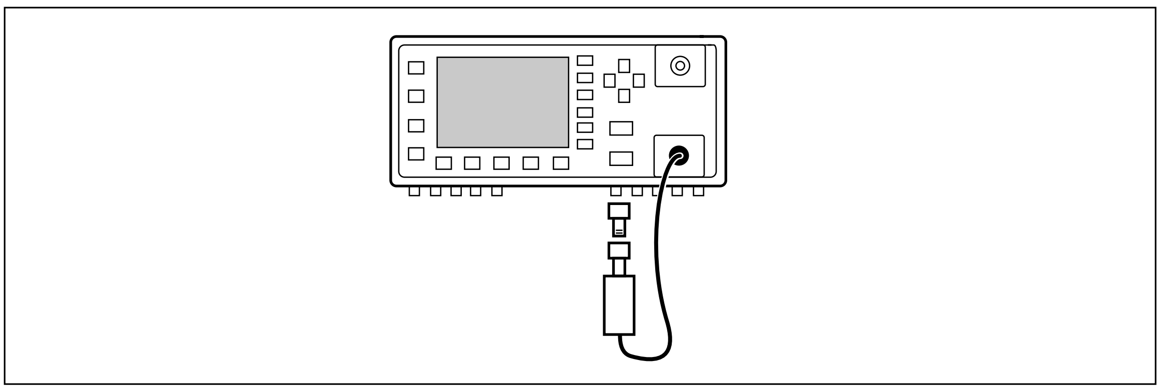

Figure 6-9. Connecting the HP E4418A Power Meter to the HP 8482A or 8481D Power Sensor

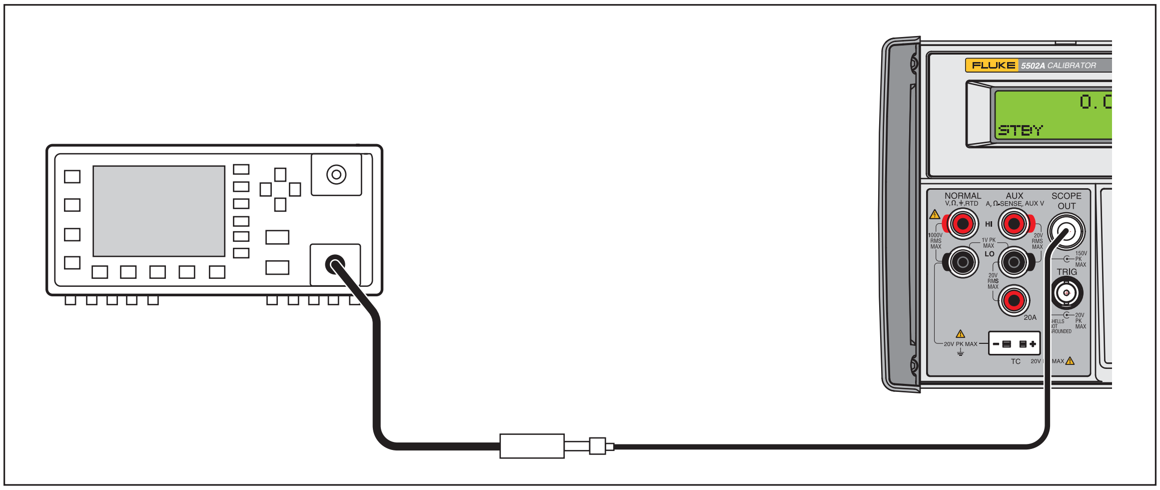

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Figure 6-10. Connecting the Calibrator Mainframe to the HP Power Meter and Power Sensor

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 6-15.

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 6-15.
3. Enter 50 kHz into the Calibrator Mainframe. Allow the 5790A reading to stabilize, then enter the 5790A reading in Column B of Table 6-15.
4. Enter the next frequency listed in Table 6-15. 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 6-15.
6. Repeat steps 4 and 5 for all of frequencies listed in Table 6-15. 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 6-15 by performing the calculations for column C. Compare Column C to the specifications listed in the final column.

Table 6-15. Low Frequency Flatness Verification at 5.5 V

Calibrator Mainframe Frequency	A	B 50 kHz	C	Calibrator Mainframe Flatness Specification (%)
500 kHz				± 1.50 + 100 µV
1 MHz				± 1.50 + 100 µV
2 MHz				± 1.50 + 100 µV
5 MHz				± 1.50 + 100 µV
10 MHz				± 1.50 + 100 µV

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 * ((Column A entry)-(Column B entry))/ (Column B entry)

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 6-16. 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 6-16.
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 6-16.
4. Enter the next frequency listed in Table 6-16. 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 6-16.
6. Repeat steps 4 and 5 for all of frequencies listed in Table 6-16. 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 6-16 by performing the calculations for each column. Compare Column E to the specifications listed in the final column.

Table 6-16. 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

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 * (sqrt(Column C entry) - sqrt(Column D entry)) / sqrt(Column D entry).

Table 6-17. 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 * (sqrt(Column C entry) - sqrt(Column D entry)) / sqrt(Column D entry).

Table 6-18. 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 * (sqrt(Column C entry) - sqrt(Column D entry)) / sqrt(Column D entry).

Table 6-19. 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

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 * (sqrt(Column C entry) - sqrt(Column D entry)) / sqrt(Column D entry).

Table 6-20. 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

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 * (sqrt(Column C entry) - sqrt(Column D entry)) / sqrt(Column D entry).

Table 6-21. High Frequency Flatness Verification at 800 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 * (sqrt(Column C entry) - sqrt(Column D entry)) / sqrt(Column D entry).

Table 6-22. High Frequency Flatness Verification at 3.4 V

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 * (sqrt(Column C entry) - sqrt(Column D entry)) / sqrt(Column D entry).

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 6-23.

1. Program the Calibrator Mainframe to the output as listed in Table 6-23.
2. Using the BNC cable, connect the SCOPE connector on the Calibrator Mainframe to the PM 6680 at the channel indicated in Table 6-23. 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 kHz = 0.999993655 ms.

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

Table 6-23. Time Marker Verification

Calibrator Mainframe Period	PM 6680Settings		PM 6680 Reading (Frequency)	$\frac{1}{\text{PM 6680 Reading}}$ (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

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 6-11 for the proper setup connections.

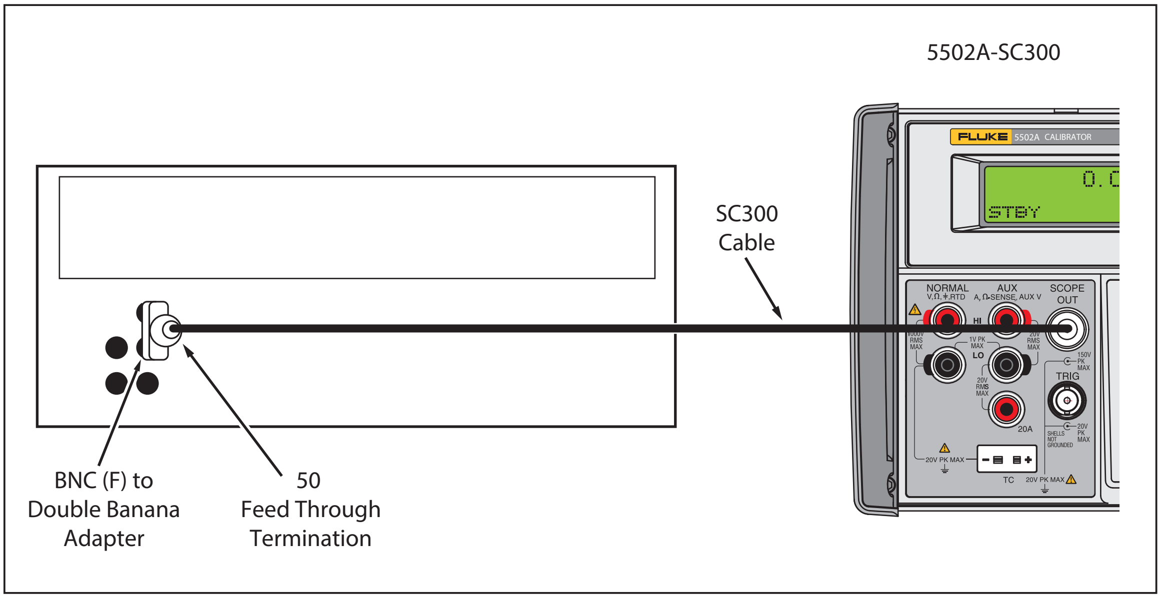

Figure 6-11. Wave Generator Verification Setup

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.

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 6-24.
5. Allow the 5790A reading to stabilize, then record the 5790A rms reading for each wave type and voltage in Table 6-24.
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.

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 6-25.
5. Allow the 5790A reading to stabilize, then record the 5790A rms reading for each wave type and voltage in Table 6-25.
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 + Rload) / Rload), where Rload = the actual feedthrough termination resistance, to correct for the resistance error. Compare result to the tolerance column.

Table 6-24. 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 6-25. 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

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.

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)

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.

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.

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 6-12.

To adjust the harmonics, adjust R8, as shown in Figure 6-12 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.

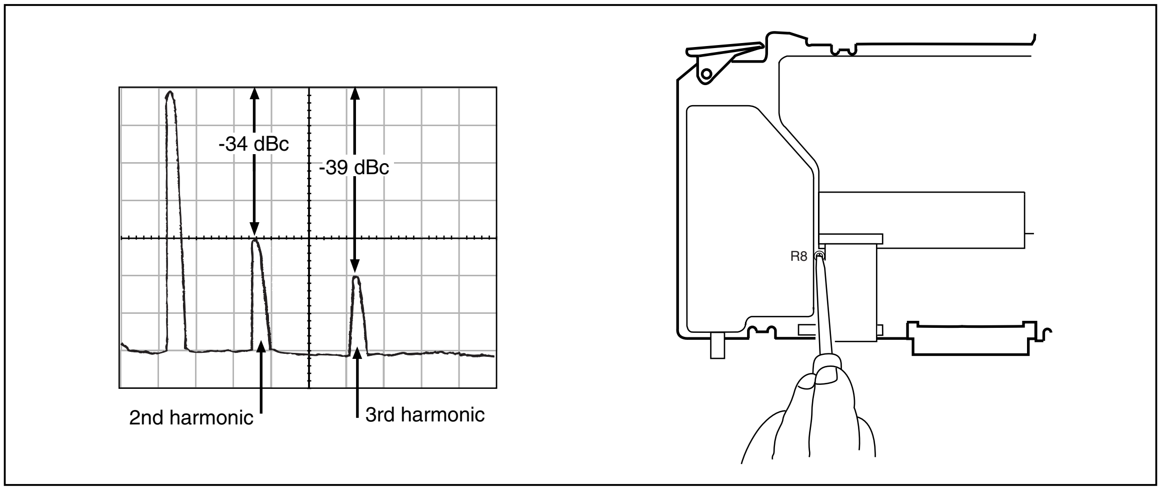

Figure 6-12. Adjusting the Leveled Sine Wave Harmonics

Adjusting the Aberrations for the Edge Function

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

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.

Adjusting the Edge Aberrations

Refer to Figure 6-13 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 ps ± 25 ps at 250 mV, 1 V, and 2.5 V outputs.

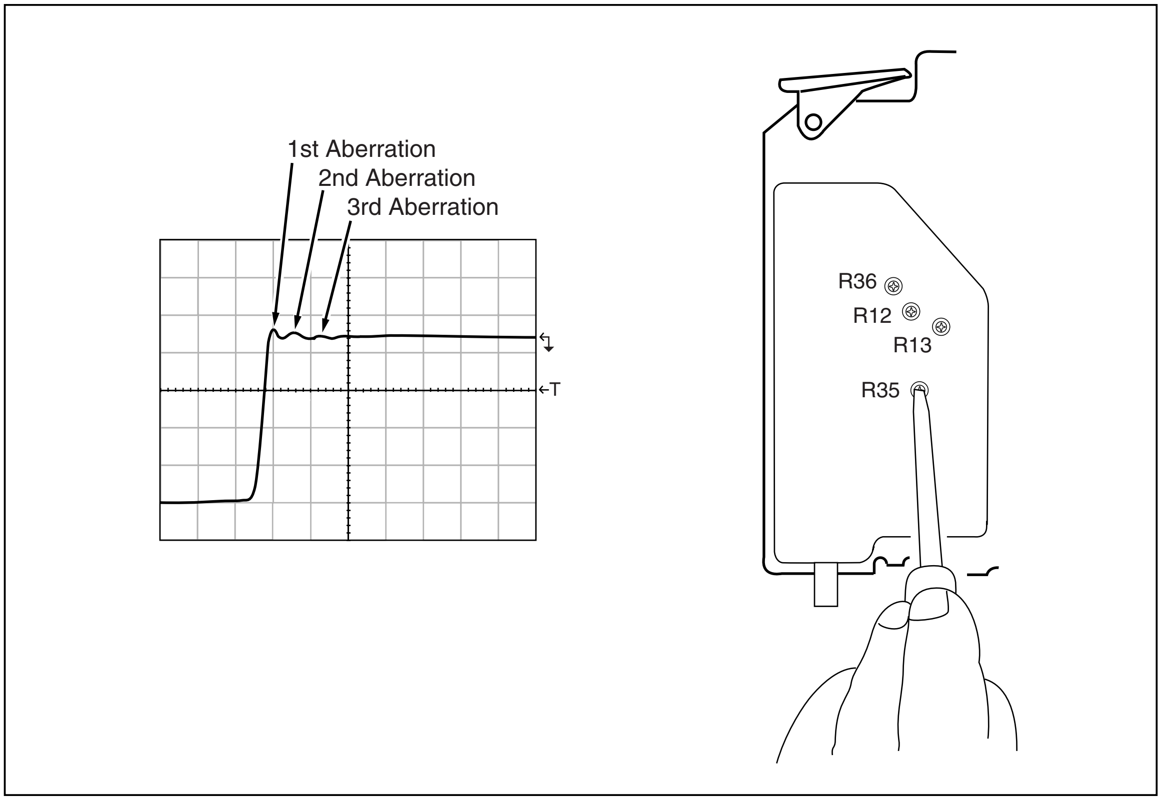

Figure 6-13. Adjusting Edge Aberrations

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.

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)

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.

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.

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 6-14 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.

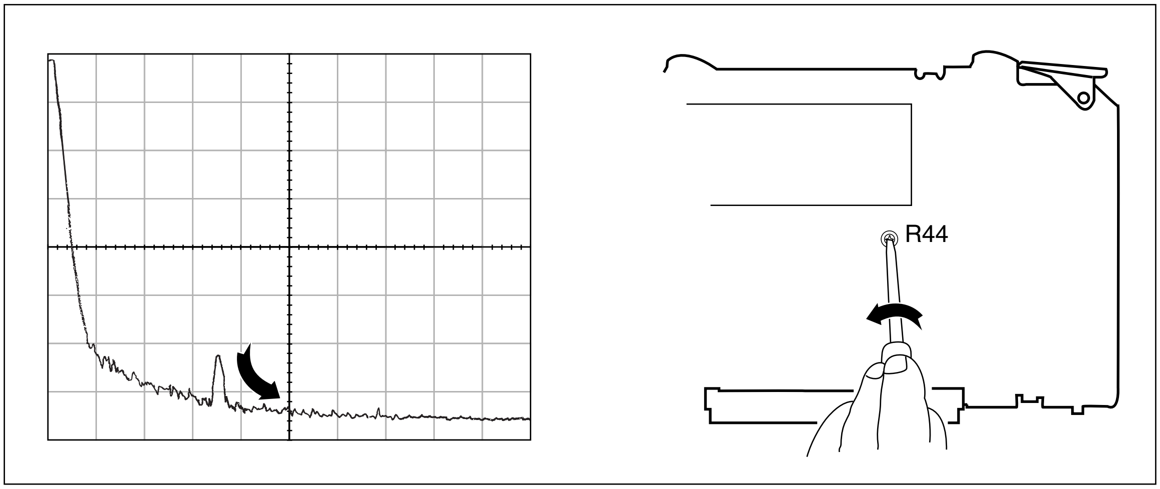

Figure 6-14. Adjusting the Leveled Sine Wave Balance

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 6-15.
3. To adjust the harmonics, adjust R8, as shown in Figure 6-15 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.

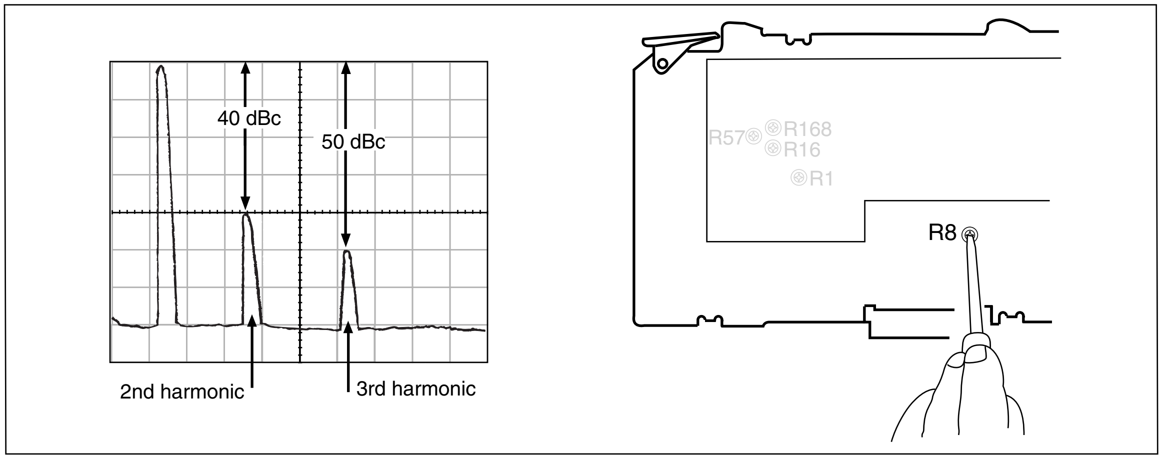

Figure 6-15. Adjusting the Leveled Sine Wave Harmonics

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.

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 µs
Time/division	0.5 µs
Trigger Level	Center, negative slope
Trigger Input	x10
External Trigger	1 MΩ
Sequential	On
Scan Repetitive	On

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 6-16.
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 6-17. 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 6-18.
8. Return to 5 ns/div and verify that the pattern shown in Figure 6-17 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.

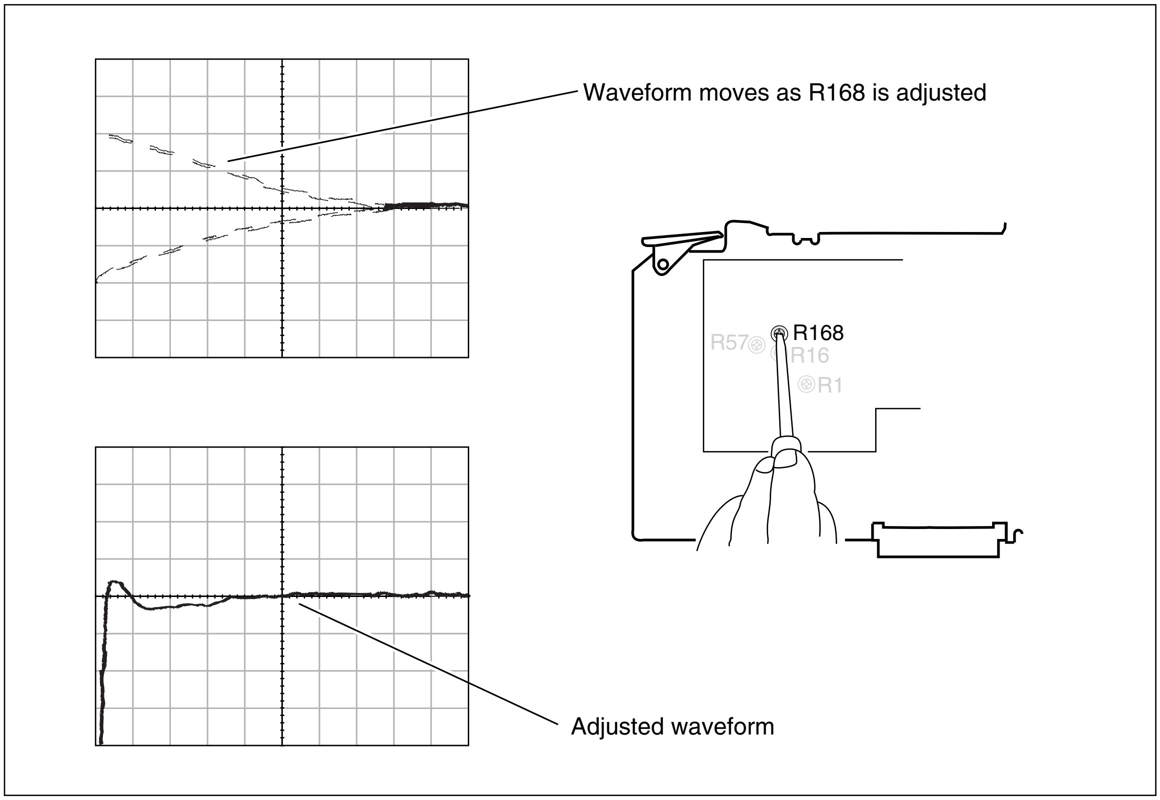

Figure 6-16. Adjusting the Wave Peak Center with R168

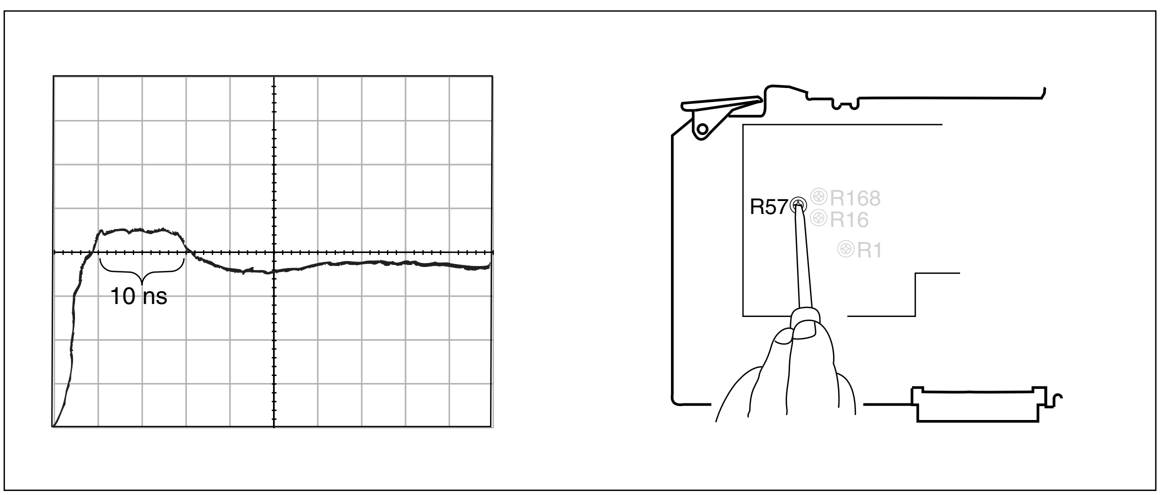

Figure 6-17. Adjusting Base of Peak with R57

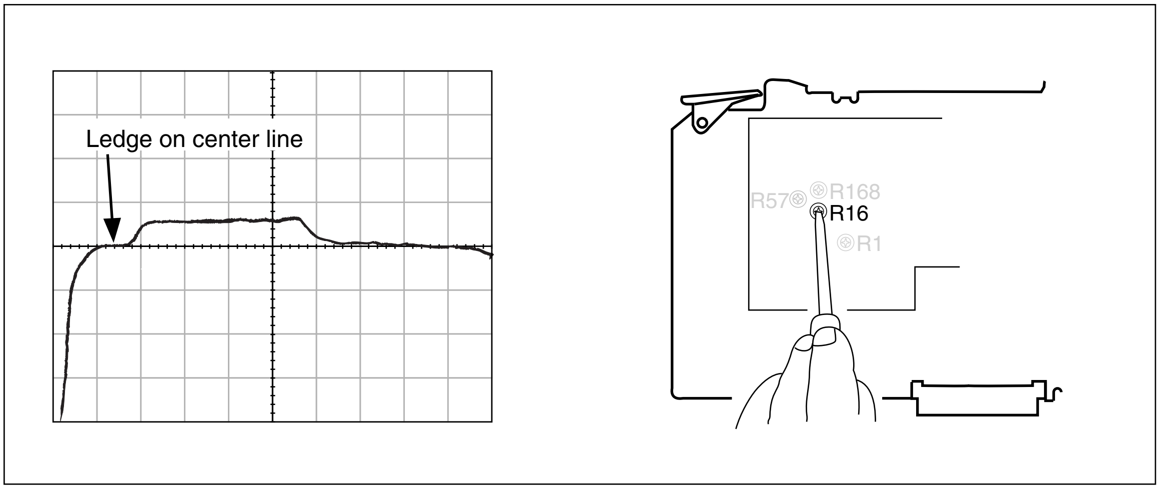

Figure 6-18. Adjusting the Ledge with R16

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.

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 6-19.
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 6-20.
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.

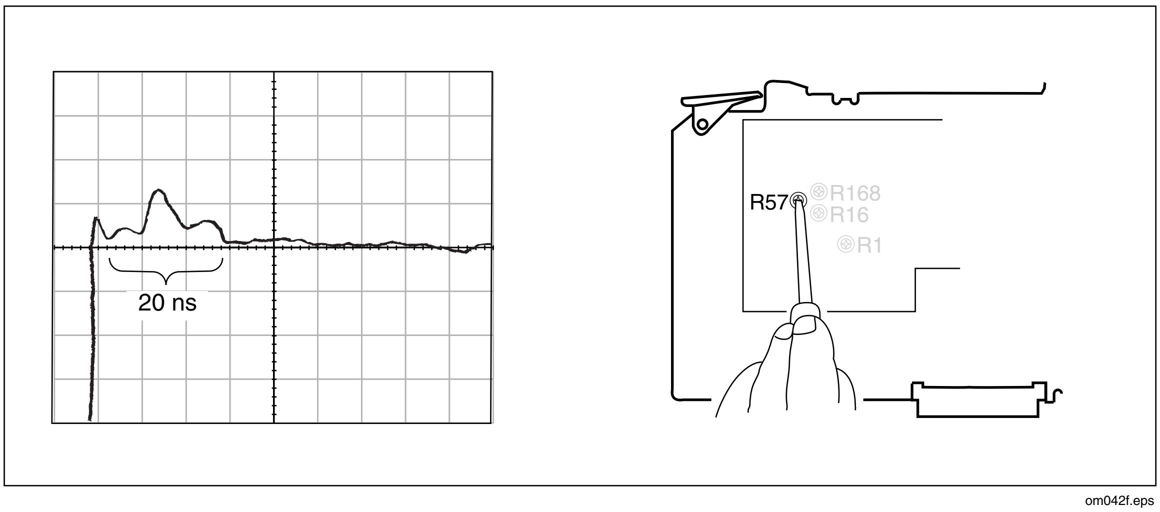

Figure 6-19. Adjusting the Peak Base with R57

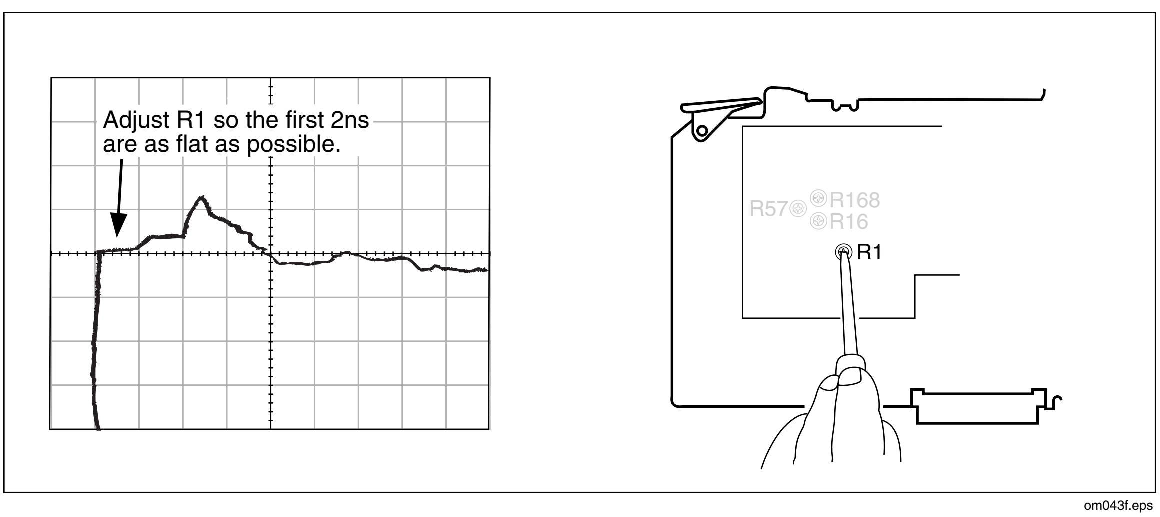

Figure 6-20. Adjust the Ledge Flatness with R1

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.

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

Adjusting the Edge Rise Time

Only one adjustment needs to be made to the edge rise time. You want a rise time of 950 ps ± 25 ps. To achieve this rise time, adjust C1 until this rise time on the oscilloscope is within this range as shown in Figure 6-21.

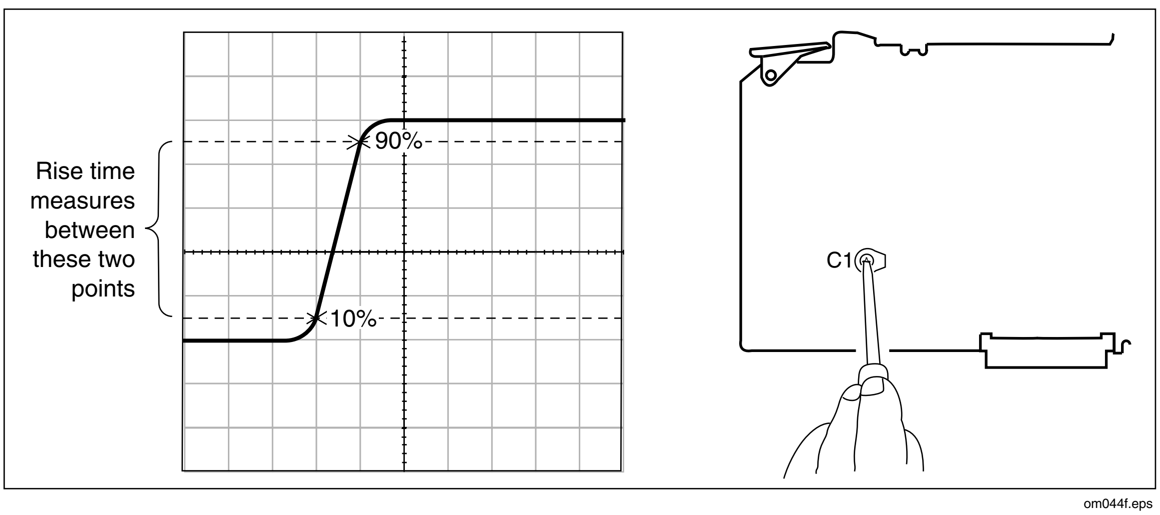

Figure 6-21. Adjusting the Edge Rise Time with C1

Chapter 7
SC600 Calibration Option

Introduction

This chapter contains information and procedures to do the servicing of the SC600 Oscilloscope Calibration Option.

The calibration and verification procedures supply traceable results for all of the SC600 functions while they are done with the recommended equipment. All of the necessary equipment, along with the minimum specifications, are shown in Table 7-1 in the “Equipment Necessary for SC600 Calibration and Verification” section.

The calibration and verification procedures in this chapter are not the ones Fluke uses at the factory. These procedures were made so you can calibrate and verify the SC600 at your own site if necessary. Look at all the procedures before you do them to make sure you have the resources to complete them. It is strongly recommended that, if possible, you send your Calibrator to Fluke for calibration and verification.

Hardware adjustments that are made after repair, at the factory, or designated Fluke service centers, are supplied in this manual.

Maintenance

There are no maintenance procedures or diagnostic remote commands for the SC600 that are available to users. If your SC600 is not installed or is not connected to power, the error message in Figure 7-1 shows in the Calibrator display when you push SCOPE.

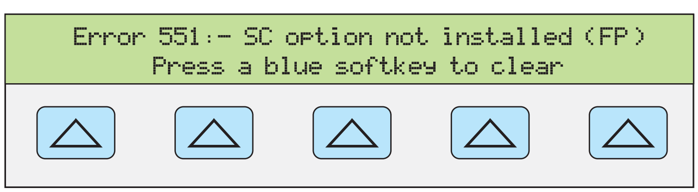

Figure 7-1. Error Message for Scope Option

If this message shows in the display, and you have the SC600 installed in the Calibrator, you must send the Calibrator to Fluke for repair. To purchase an SC600, see your Fluke sales representative.

SC600 Specifications

These specifications apply only to the SC600 Option. General specifications for the Calibrator mainframe can be found in Chapter 1. The specifications are correct for these conditions:

- The Calibrator is operated in the conditions specified in Chapter 1.
- The Calibrator has completed a warm-up period that is two times the period the Calibrator was turned off to a maximum of 30 minutes.
- The SC600 has been active more than 5 minutes.

Voltage Function Specifications

Voltage Function	DC Signal		Square Wave Signal [1]	
	50 Ω Load	1 MΩ Load	50 Ω Load	1 MΩ Load
Amplitude Characteristics				
Range	0 to ±6.599 V	0 to ±130 V	±1 mV to ±6.599 V p-p	±1 mV to ±130 V p-p
Resolution	Range 1 to 24.999 mV 25 to 109.99 mV 110 mV to 2.1999 V 2.2 to 10.999 V 11 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).

Edge Specifications

Edge Characteristics into 50 Ω Load		1-Year Absolute Uncertainty, tcal ± 5 °C
Rise Time	≤300 ps [1]	(+0 ps / -100 ps)
Amplitude Range (p-p)	4.5 mV to 2.75 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	900 Hz to 11 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 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.

Leveled Sine Wave Specifications

Leveled Sine Wave Characteristics into 50 Ω	Frequency Range			
	50 kHz (reference)	50 kHz to 100 MHz	100 to 300 MHz	300 to 600 MHz
Amplitude Characteristics (for measuring oscilloscope bandwidth)				
Range (p-p)	5 mV to 5.5 V			
Resolution	<100 mV: 3 digits ≥100 mV: 4 digits			
Adjustment Range	continuously adjustable			
1-Year Absolute Uncertainty, tcal ±5 °C	±(2 % of output + 300 μV)	±(3.5 % of output + 300 μV)	±(4 % of output + 300 μV)	±(6 % of output + 300 μV)
Flatness (relative to 50 kHz)	not applicable	±(1.5 % of output + 100 μV)	±(2 % of output + 100 μV)	±(4 % of output + 100 μV)
Short-Term Amplitude Stability	≤ 1 % [1]			
Frequency Characteristics				
Resolution	1 kHz		10 kHz	
1-Year Absolute Uncertainty, tcal ±5 °C	±2.5 ppm [2]			
Distortion Characteristics				
2nd Harmonic	≤ -33 dBc			
3rd and Higher Harmonics	≤ -38 dBc			

[1] Within 1 hour after reference amplitude setting, provided temperature varies no more than ±5 °C.

[2] With REF CLK set to ext, the frequency uncertainty of the Leveled Sine Wave is the uncertainty of the external 10 MHz clock ±0.3 Hz/gate time.

Time Marker Specifications

Time Maker into 50 Ω	5 s to 50 ms	20 ms to 100 ns	50 to 20 ns	10 ns	5 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	5-2-1 from 5 s to 2 ns (e.g., 500 ms, 200 ms, 100 ms)				
Adjustment Range	At least ±10 % around each sequence value indicated above.				
Amplitude Resolution	4 digits				

[1] t is the time in seconds.

[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.

Wave Generator Specifications

Wave Generator Characteristics	Square Wave, Sine Wave, and Triangle Wave into 50 Ω or 1 MΩ
Amplitude	
Range	into 1 MΩ: 1.8 mV to 55 V p-p into 50 Ω: 1.8 mV to 2.5 V p-p
1-Year Absolute Uncertainty, tcal ±5 °C, 10 Hz to 10 kHz	±(3 % of p-p output + 100 μV)
Sequence	1-2-5 (e.g., 10 mV, 20 mV, 50 mV)
Typical DC Offset Range	0 to ± (≥40 % of p-p amplitude) [1]
Frequency	
Range	10 Hz to 100 kHz
Resolution	4 or 5 digits depending upon frequency
1-Year Absolute Uncertainty, tcal ±5 °C	±(25 ppm + 15 mHz)

[1] The DC offset plus the wave signal must not exceed 30 V rms.

Pulse Generator Specifications

Pulse Generator Characteristics	Positive pulse into 50 Ω
Typical rise/fall times	<2 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 % of pulse width ±2 ns
Pulse Period	
Range	22 ms to 200 ns (45.5 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.

Trigger Signal Specifications (Pulse Function)

Pulse Period	Division Ratio	Amplitude into 50 Ω (p-p)	Typical Rise Time
22 ms to 200 ns	off/1/10/100	≥1 V	≤2 ns

Trigger Signal Specifications (Time Marker Function)

Time Marker Period	Division Ratio	Amplitude into 50 Ω (p-p)	Typical Rise Time
2 to 9 ns	off/100	≥1 V	≤2 ns
10 to 749 ns	off/10/100	≥1 V	≤2 ns
750 ns to 34.9 ms	off/1/10/100	≥1 V	≤2 ns
35 ms to 5 s	off/1	≥1 V	≤2 ns

Trigger Signal Specifications (Edge Function)

Edge Signal Frequency	Division Ratio	Typical Amplitude into 50 Ω (p-p)	Typical Rise Time	Typical Lead Time
900 Hz to 11 MHz	off/1	≥1 V	≤2 ns	40 ns

Trigger Signal Specifications (Square Wave Voltage Function)

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

Trigger Signal Specifications

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

Oscilloscope Input Resistance Measurement Specifications

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

Oscilloscope Input Capacitance Measurement Specifications

Scope Input selected	1 MΩ
Measurement Range	5 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.

Overload Measurement Specifications

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

Theory of Operation

This section contains a brief overview of the SC600 operation modes. This information will let you identify which of the main plug-in PCAs of the Calibrator mainframe are defective. Figure 7-2 shows a block diagram of the SC600 Option (also referred to as the A50 PCA). Functions that are not shown in the figure are sourced from the DDS Assembly (A6 PCA). See Chapter 2 for a diagram of all Calibrator mainframe PCA assemblies.

Voltage Mode

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

Edge Mode

The DDC A6 PCA is the source of the edge clock and goes to the A50 PCA. The signal is then shaped and divided to supply the fast edge and external trigger signals. The edge signal comes from the A50 PCA 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.

Leveled Sine Wave Mode

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

Time Marker Mode

There are three primary "ranges" of time marker operation: 5 s to 20 ms, 10 ms to 2 µs, and 1 µs to 2 ns.

The A6 DDS PCA is the source of the 5 s to 20 ms markers and are sent to the A50 PCA. The signal path is also divided to supply the external trigger circuitry on the A50 PCA. If turned on, the trigger is connected to the Trig Out BNC on the front panel. The marker signal that goes through the A50 PCA is connected to the attenuator assembly. The signal is then applied to the SCOPE connector on the front panel.

The 10 ms to 2 µs markers are derived from a square wave signal that comes from the A6 PCA and is applied to the A50 PCA 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 on the A50 PCA goes to the attenuator assembly and then to the SCOPE connector on the front panel.

The leveled sine wave generator on the A50 PCA is the source of the 1 µs to 2 ns markers. This signal is also divided 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 sends the signal to the marker circuits on the A50 PCA, where the signal is shaped into the other marker waveforms. The marker signals on the A50 PCA go to the attenuator assembly and then to the SCOPE connector on the front panel.

Wave Generator Mode

All signals for the wavegen function come from the A6 PCA and go to the A50 PCA. They then go to the attenuator assembly, where range attenuation occurs. Wavegen signals are then sent to the SCOPE connector on the front panel. Video and pulse generator mode signals are derived from dedicated circuitry on the A50 SC600 option PCA. If there are faults related only to these functions, then the A50 PCA is most likely defective.

Input Impedance Mode (Resistance)

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

Input Impedance Mode (Capacitance)

The A50 SC600 Scope Option PCA contains the capacitance measurement circuits, that uses signals from the leveled sine wave source. If there are faults related only to capacitance measurement, then the A50 PCA is most likely defective.

Overload Mode

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

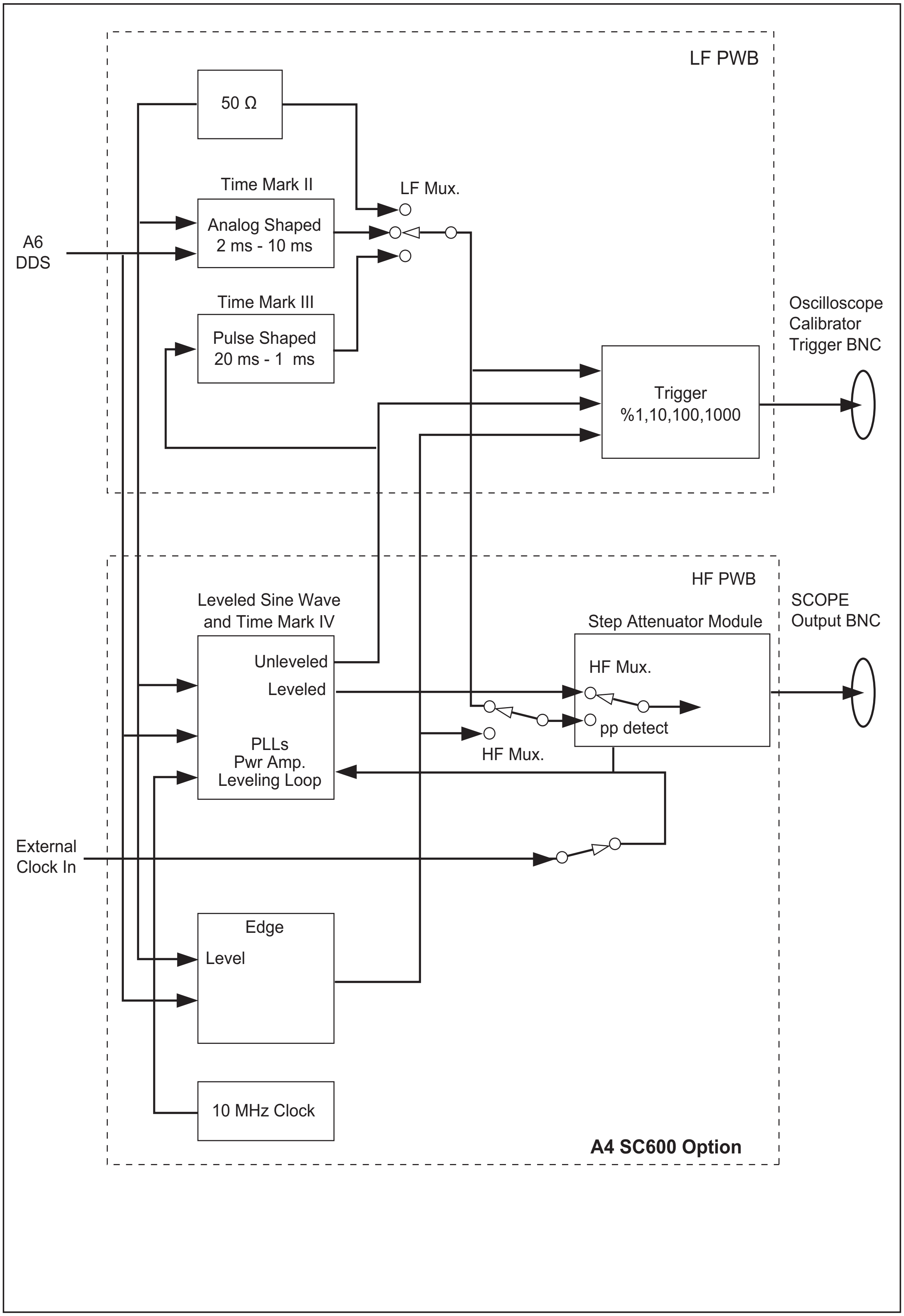

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Figure 7-2. SC600 Block Diagram

Equipment Necessary for SC600 Calibration and Verification

Table 7-1 is a list of equipment necessary for calibration and verification of the SC600 Oscilloscope Option.

Table 7-1. SC600 Calibration and Verification Equipment

Wave Generator and Edge Amplitude Calibration, AC Voltage and TD Pulser Equipment			
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		
Termination		Feedthrough 50 Ω ±1 % (used with edge amplitude Calibration and ac voltage verification)	
Output Cable	(supplied with SC600)	Type N to BNC	
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)	
Output Cable	(supplied with SC600)	Type N to BNC	
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 Ω ±1 %	
Output Cable	(supplied with SC600)	Type N to BNC	
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 Ω ±1 %	
Output Cable	(supplied with SC600)	Type N to BNC	

Table 7-1. SC600 Calibration and Verification Equipment (cont.)

Wave Generator and Edge Amplitude Calibration, AC Voltage and TD Pulser Equipment			
Instrument	**Model**	**Minimum Use Specifications**	
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)	
Output Cable	(supplied with SC600)	Type N to BNC	
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)	
Output Cable	(supplied with SC600)	Type N to BNC	
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)	
Output Cable	(supplied with SC600)	Type N to BNC	
Leveled Sine Wave Harmonics Verification			
Spectrum Analyzer	HO 8509A		
Adapter	Pomona #3288	BNC(f) to Type N(m)	
Output Cable	(supplied with SC600)	Type N to BNC	
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	
Output Cable	(supplied with SC600)	Type N to BNC	
Edge Duty Cycle			
Frequency Counter	PM 6680		
Output Cable	(supplied with SC600)	Type N to BNC	

Table 7-1. SC600 Calibration and Verification Equipment (cont.)

Wave Generator and Edge Amplitude Calibration, AC Voltage and TD Pulser Equipment			
Instrument	**Model**	**Minimum Use Specifications**	
Overload Functional Verification			
Termination		Feedthrough 50 Ω ±1 %	
Output Cable	(supplied with SC600)	Type N to BNC	
MeasZ Resistance, Capacitance Verification			
Resistors		1 MΩ 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	
Output Cable	(supplied with SC600)	Type N to BNC	
Leveled Sine Wave Flatness (High Frequency) Calibration and Verification			
Instrument	**Model**	**Minimum Use Specifications**	
Power Meter	Hewlett-Packard 437B	Range	-42 dBm to +5.6 dBm
		Frequency	10 MHz to 600 MHz
Power Sensor	Hewlett-Packard 8482A	Range	-20 dBm to +19 dBm
		Frequency	10 MHz to 600 MHz
Power Sensor	Hewlett-Packard 8481D	Range	-42 dBm to -20 dBm
		Frequency	10 MHz to 600 MHz
30 dB Reference Attenuatior	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)	
Output Cable	(supplied with SC600)	Type N to BNC	
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)	
Output Cable	(supplied with SC600)	Type N to BNC	

Table 7-1. SC600 Calibration and Verification Equipment (cont.)

Wave Generator and Edge Amplitude Calibration, AC Voltage and TD Pulser Equipment			
Instrument	**Model**	**Minimum Use Specifications**	
Wave Generator Verification			
AC Measurement Standard	Fluke 5790A with -03 option	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 Plug	
Termination		Feedthrough 50 Ω ±1 %	
Output Cable	(supplied with SC600)	Type N to BNC	

Calibration Setup

The procedures in this manual were made to let users calibrate the SC600 at their own site if it becomes necessary to do so. It is strongly recommended that, if possible, you send your Calibrator to Fluke for calibration and verification. The Calibrator Mainframe must be fully calibrated before you do calibration of the SC600.

The hardware adjustments are intended to be one-time adjustments done in the factory. Adjustment can be necessary after repair. Hardware adjustments must be done before calibration. Calibration must be done after if hardware adjustments are made. See the “Hardware Adjustments” section in this chapter.

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

The Calibrator Mainframe must complete a warm-up period and the SC600 must be turned on for a minimum of 5 minutes before you start calibration. This lets internal components become thermally stable. The Calibrator Mainframe warm-up period is a minimum of two times the period the calibrator was turned off, or a maximum of 30 minutes. Push SCOPE to turn on the SC600. The green LED on the SCOPE key is illuminated when the SC600 is turned on.

Most of the SC600 Option can be calibrated from the front panel. Push SCOPE to turn on the SC600 and wait a minimum of 5 minutes. To start the Scope Cal mode:

1. Push SETUP.
2. Push the **CAL** softkey.
3. Push the **CAL** softkey again.
4. Push the **SCOPE CAL** softkey.

Note

*If you push the **Scope Cal** softkey sooner than 5 minutes after you pushed SCOPE,, a warning message shows in the display.*

All equipment used to calibrate the SC600 must be calibrated, certified traceable if traceability is to be kept, and operated in their specified operation environment.

It is also important to make sure that the equipment has had sufficient time to warm up before you start calibration. Refer to the operation manual for each piece of equipment for more information.

Before you start calibration, look at all of the procedures to make sure you have the resources to do them.

The Calibrator starts calibration with the DC Voltage function. If it is necessary to start with a different function, push the **OPTIONS** softkey. Then push the **NEXT SECTION** softkey until you see the function name in the display.

Calibration and Verification of Square Wave Voltage Functions

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

Overview of HP3458A Operation

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

Voltage Square Wave Measurement Setup

To make accurate and repeatable measurements of the topline and baseline of a voltage square wave with a maximum frequency of 10 kHz, set the integration and sample time of the HP3458A. For this measurement, connect the external trigger of the HP3458A to the external trigger output of the SC600. Set the HP3458A to make an analog-to-digital conversion after it senses the falling edge of an external trigger.

The conversion does not occur until after the delay set by the 3458A “DELAY” command. The frequency measured by the DMM influences the actual integration time. Table 7-2 summarizes the DMM settings necessary to make topline and baseline measurements. Figure 7-3 illustrates the correct connections for this setup.

Table 7-2. Voltage HP3458A Settings

Voltage Input Frequency	HP3458A Settings		
	NPLC	DELAY (topline)	DELAY (baseline)
100 Hz	0.1	0.007 s	0.012 s
1 kHz	0.01	0.0007 s	0.0012 s
5 kHz	0.002	0.00014	0.00024
10 kHz	0.001	0.00007	0.00012

For all measurements, the HP 3458A is in DCV, manual range, with external trigger turned on. A convenient method to make these measurements from the front panel of the HP3458A is to put these parameters into some of the user-defined keys. For example, to make topline measurements at 1 kHz, you set the DMM to “NPLC .01; DELAY .0007; TRIG EXT”. To find the average of multiple measurements, you can set 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 you make measurements of a signal >1 kHz, the HP 3458A can show 0.05 % to 0.1 % peaking in the 100 mV range. For these signals, lock the HP 3458A to the 1 V range.

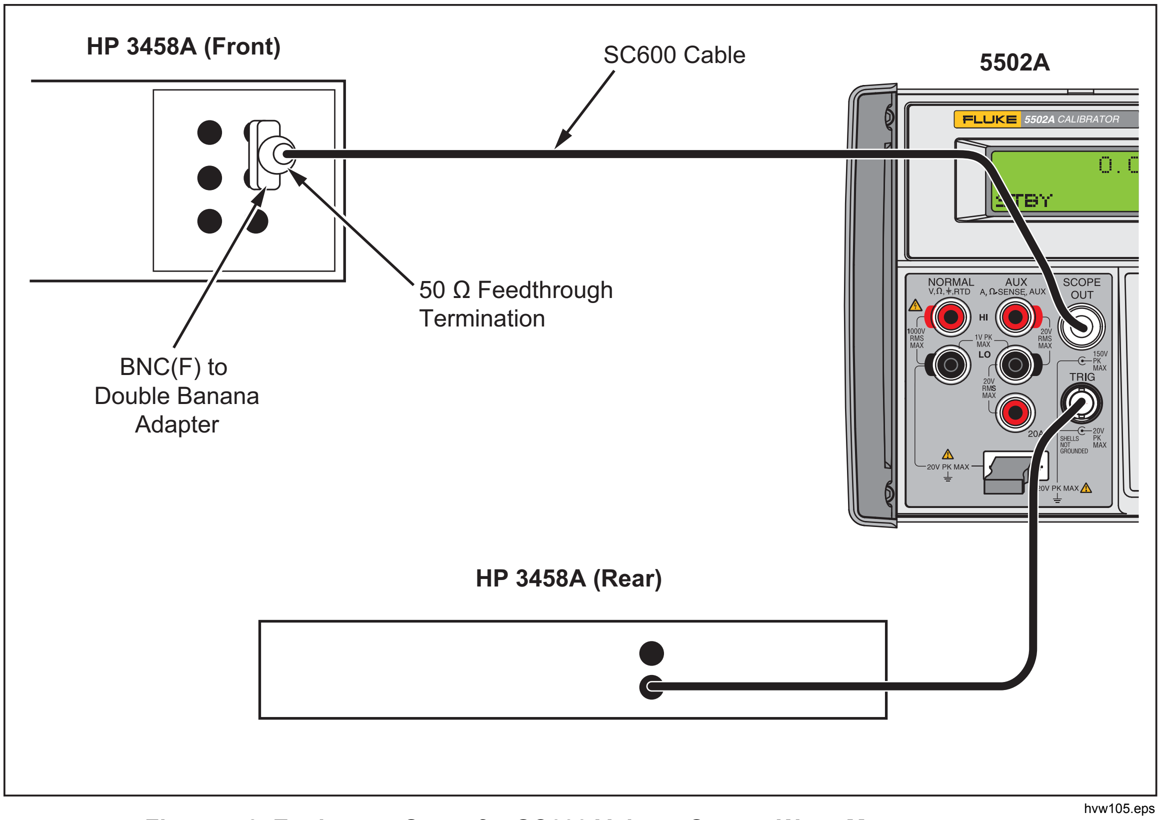

Figure 7-3. Equipment Setup for SC600 Voltage Square Wave Measurements

Edge and Wave Gen Square Wave Measurements Setup

The setup to measure the topline and baseline of Edge and Wave Generator signals is a little different from the Voltage Square Wave method given above. The HP 3458A is triggered by a change in input level rather than 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 7-3 and Figure 7-4.

Table 7-3. Edge and Wave Generator HP 3458A Settings

Voltage Input Frequency	HP3458A Settings		
	NPLC	DELAY (topline)	DELAY (baseline)
1 kHz	.01	.0002 s	.0007 s
10 kHz	.001	.00002 s	.00007 s

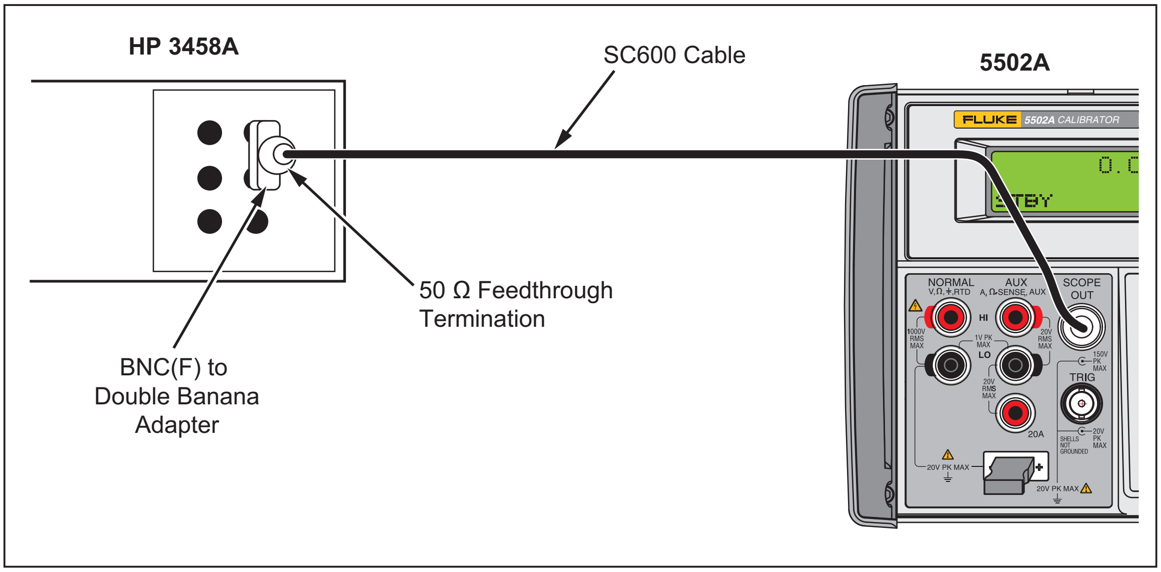

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Figure 7-4. Equipment Setup for SC600 Edge and Wave Gen Square Wave Measurements

For all measurements, the HP 3458A is in DCV, manual range, with level triggering enabled. A convenient method to make these measurements from the front panel of the HP 3458A is to put these parameters into some of the user-defined keys. For example, to make topline measurements at 1 kHz, you set the DMM to “NPLC .01; LEVEL 1; DELAY .0002; TRIG LEVEL”. To find the average of multiple measurements, you can set 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 7-4 for the correct connections

DC Voltage Calibration

This procedure uses:

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

Note

AC voltage calibration is necessary for dc voltage calibration.

See Figure 7-4 for the correct equipment connections.

Set the Calibrator Mainframe in Scope Cal mode, DC Voltage section. To calibrate DC Voltage:

1. Connect the SCOPE connector of the Calibrator to the HP 3458A input, with the output cable and the BNC(f) to Double Banana adapter.
2. Set the HP 3458A to DCV, Auto Range, NPLC = 10, FIXEDZ = on.
3. Push the **GO ON** softkey.
4. Make sure the HP 3458A measurement is 0.0 V DC ±10 µV. If not, adjust R121 on A41. R121 is a square one turn pot and has a mark on the PCA near Q29.
5. Push the **GO ON** softkey.
6. Calibration voltages 33 V and higher automatically put the Calibrator output in standby. When this occurs, push OPR on the Calibrator to output the signal.

Let the HP 3458A DC voltage measurement become stable. Type in the measurement through the Calibrator keypad and then push ENTER.

Note

The Calibrator will show a message if the typed in value is higher or lower than the limits of the value. If this occurs, examine the setup and carefully re-type in the measurement with the correct multiplier (i.e., m, µ, n, p). If the warning continues, repair may be necessary.

7. Do step 6 again until the Calibrator shows that the subsequent steps calibrate ac voltage. Push the **OPTIONS**, then **STORE CONSTS** softkeys to store the new calibration constants.

AC voltage must be calibrated: continue with the subsequent section.

AC Voltage Calibration

This procedure uses the same equipment and setup as DC Voltage calibration. Refer to Figure 7-4. DC voltages are measured and typed in to the Calibrator to calibrate the AC Voltage function.

To calibrate the Calibrator for ac voltage:

1. Push the **OPTIONS** softkey.
2. Push the **NEXT SECTION** softkey until “The next steps calibrate -SC600 ACV” shows in the display.
3. Push the **GO ON** softkey.
4. Let the HP 3485A voltage measurement become stable.
5. Type in the measurement through the keypad of the Calibrator.
6. Push ENTER.

Note

The Calibrator will show a message if the typed in value is higher or lower than the limits of the value. If this occurs, examine the setup and carefully re-type in the measurement with the correct multiplier (i.e., m, µ, n, p). If the warning continues, repair may be necessary.

7. Do step 4 again until the Calibrator shows that the subsequent steps calibrate WAVGEN. Push the **OPTIONS**, then **STORE CONSTS** softkeys to store the new calibration constants.

Wave Generator Calibration

This procedure uses:

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

To calibrate the wave generator:

1. Push the **OPTIONS** softkey.
2. Push the **NEXT SECTION** softkey until “WAVEGEN Cal:” shows in the display.
3. Connect the SCOPE connector of the Calibrator to the HP3458A input with the output cable and the BNC(f) to Double Banana adapter.

4. Set the HP 3458A to DCV, NPLC = .01, LEVEL 1, TRIG LEVEL.
5. Set the HP 3458A DELAY to .0002 for the top part of the waveform (i.e. topline) measurement, and .0007 for the lower part of the waveform (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 related baseline measurements at each step.
6. For each calibration step, get samples for 2 seconds minimum, with the HP 3458A MATH functions to retrieve the average or mean value. See the "Setup for SC600 Edge and Wave Generator Measurements" section for more information.

Edge Amplitude Calibration

This procedure uses:

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

To do Edge Amplitude Calibration:

1. Setup the equipment as shown in Figure 7-4.
2. Push the **OPTIONS** softkey.
3. Push the **NEXT SECTION** softkey until "Set up to measure fast edge amplitude" shows in the display.
4. Connect the SCOPE connector of the Calibrator to the HP 3458A input with the output cable and the BNC(f) to Double Banana adapter.
5. Set the HP 3458A to DCV, NPLC = .01, LEVEL 1, TRIG LEVEL.
6. Set the HP 3458A DELAY to .0002 for the top part of the waveform (or topline) measurement, and .0007 for the lower part of the waveform (or baseline). Manually range lock the HP 3458A to the range that gives the most resolution for the baseline measurements. Use this same range for the related baseline measurements at each step.

Note

For the edge function, the topline is near 0 V and the baseline is a negative voltage.

7. For each calibration step, get samples for 2 seconds minimum, with the HP 3458A MATH functions to retrieve the average or mean value. See the "Setup for SC600 Edge and Wave Generator Measurements" section for more information.

The "true amplitude" of the waveform is the difference between the topline and baseline measurements, after a load resistance error correction. To make this correction, multiply the measurement by (0.5 * (50 + Rload)/Rload), where Rload = actual feedthrough termination resistance.

Leveled Sine Wave Amplitude Calibration

This procedure uses:

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

To do a leveled sine wave amplitude calibration:

1. Push the **OPTIONS** softkey.
2. Push the **NEXT SECTION** softkey until "Set up to measure fast edge amplitude" shows in the display.
3. Connect the output cable to the 50 Ω feedthrough termination.
4. Connect the other end of the output cable to the SCOPE connector of the Calibrator.
5. Connect the 50 Ω feedthrough termination at the other end of the cable to input 2 of the 5790A with the BNC(f) to Double Banana adapter.
6. Set the 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.
7. Push the **GO ON** softkey on the Calibrator.
8. Push OPR to turn on the Calibrator output.
9. Let the 5790A rms measurement become stable.
10. Multiply the 5790A measurement by (0.5 * (50 + Rload)/Rload), where Rload = the actual feedthrough termination resistance, to correct for the resistance error. Type in the corrected rms measurement through the keypad of the Calibrator.
11. Push ENTER.

Note

The Calibrator will show a message if the typed in value is higher or lower than the limits of the value. If this occurs, examine the setup and carefully re-type in the measurement with the correct multiplier (i.e., m, µ, n, p). If the warning continues, repair may be necessary.

12. Do step 10 and 11 again until the Calibrator shows that the subsequent steps calibrate Leveled Sine flatness. Push the **OPTIONS**, then **STORE CONSTS** softkeys to store the new calibration constants.

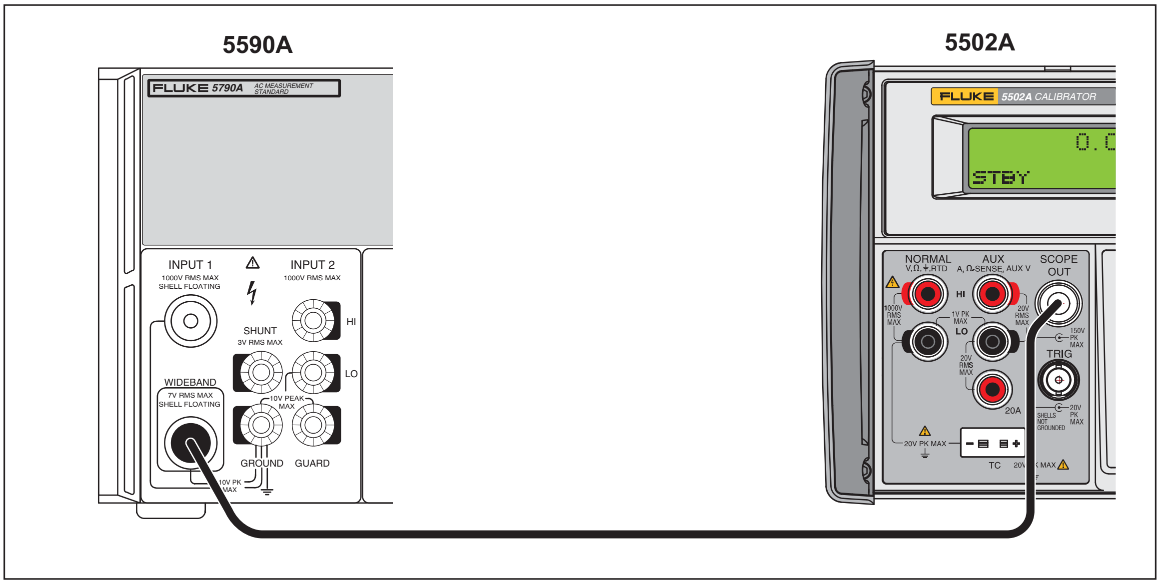

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Figure 7-5. Calibrator to 5790A AC Measurement Standard Connections

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. The low and high frequency bands are calibrated at each amplitude. Calibration starts 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.

Push the **OPTIONS** and **NEXT SECTION** softkeys until “Set up to measure leveled sine flatness” shows in the display.

Low Frequency Calibration

To do the low frequency calibration:

1. Connect the SCOPE connector of the Calibrator to the wideband input of the 5790A. See the “Equipment Setup for Low Frequency Flatness” section for more information.
2. Push the **GO ON** softkey.
3. Find the 50 kHZ reference.
   - Let the 5790A measurement become stable.
   - Push the 5790A **Set Ref** softkey.
4. Push the 5790A **Clear Ref** softkey to clear the reference if necessary.
5. Push the **GO ON** softkey.
6. Adjust the amplitude with the front panel knob of the Calibrator until the 5790A reference deviation equals the 50 kHz reference ±1000 ppm.
7. Do steps 2 through 6 again until Calibrator shows that the reference frequency is 10 MHz.

Continue with the high frequency calibration.

High Frequency Calibration

To do the high frequency calibration:

1. Connect the SCOPE connector of the Calibrator to the power meter and power sensor. See the “Equipment Setup for High Frequency Flatness” section for more information.
2. Push the **GO ON** softkey.
3. Find the 10 MHZ reference.
   - Push the power meter **SHIFT Key**, then **FREQ** key and use the arrow keys to type in the cal factor of the power sensor. Make sure the factor is correct, then push the **ENTER** key on the power meter.
   - Let the power meter measurement become stable.
   - Push the power meter **REL** key.
4. Push the **GO ON** softkey.
5. Push the power meter **SHIFT key**, then **FREQ** key, and use the arrow keys to

set the Cal Factor of the power sensor for the frequency shown in the Calibrator display. Make sure that the factor is correct, then push the power meter **ENTER** key.

6. Adjust the amplitude with the front panel knob of the Calibrator until the power sensor is equal to the 10 MHz reference ±0.1 %.
7. Do steps 1 through 5 again until the Calibrator display shows that the reference frequency is now 50 kHz or that the subsequent step is calibrate pulse width.

Do the low frequency calibration procedure for the subsequent amplitude unless the Calibrator Mainframe display shows that the subsequent steps calibrate pulse width. Push the **OPTIONS**, then **STORE CONSTS** softkeys to store the new calibration constants.

Pulse Width Calibration

This procedure uses:

- High Frequency Digital Storage Oscilloscope (DSO): 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)
- Output cable supplied with the SC600
- Second BNC cable

To do a pulse width calibration:

1. Push the **OPTIONS** softkey.
2. Push the **NEXT SECTION** softkey until “Set up to measure pulse width” shows in the display.
3. Connect the output cable to the SCOPE connector on the Calibrator. Connect the other end of the output cable to one of the BNC(f) to 3.5 mm (m) adapter and then to the sampling head of the DSO through the 3 dB attenuator.
4. Use the second BNC cable with the BNC(f) to 3.5 mm(m) adapter attached to connect the TRIG OUT of the Calibrator to the trigger input of the DSO.
5. Set the DSO to:
   - Main Time Base: 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
6. Push the **GO ON** softkey.
7. Adjust the DSO horizontal scale and main time base position until the pulse signal spans between half and full display. If no pulse is output, increase the pulse width with the front-panel knob of the Calibrator until a pulse is output.
8. If instructed to adjust the pulse width by the Calibrator display, adjust the pulse width to as near 4 ns as possible with the front-panel knob of the Calibrator.
9. Push the **GO ON** softkey.

10. Let the DSO width measurement become stable.
11. Type in the measurement through the keypad of the Calibrator.
12. Push ENTER.

Note

The Calibrator shows a message if the typed in value is higher or lower than the limits of the value. If this occurs, examine the setup and carefully re-type in the measurement with the correct multiplier (m, μ, n, p). If the warning continues, type in a value between the pulse width shown in the display and the last typed in value. Continue to do this with a value that is nearer to the pulse width in the display until the value is accepted. After you complete the pulse width calibration you must re do the calibration until all typed in values are accepted the first time without the message.

13. Do steps 7 through 12 again until the Calibrator instructs you to connect a resistor.
14. Push the **OPTIONS**, then **STORE CONSTS** softkeys to store the new calibration constants.

MeasZ Calibration

The MeasZ function is calibrated with resistors and a capacitor of known values. The actual resistance and capacitance values are typed in while they are measured by the Calibrator.

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

This procedure uses:

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

To do a MeasZ calibration:

1. Connect the equipment as shown in Figure 7-6.

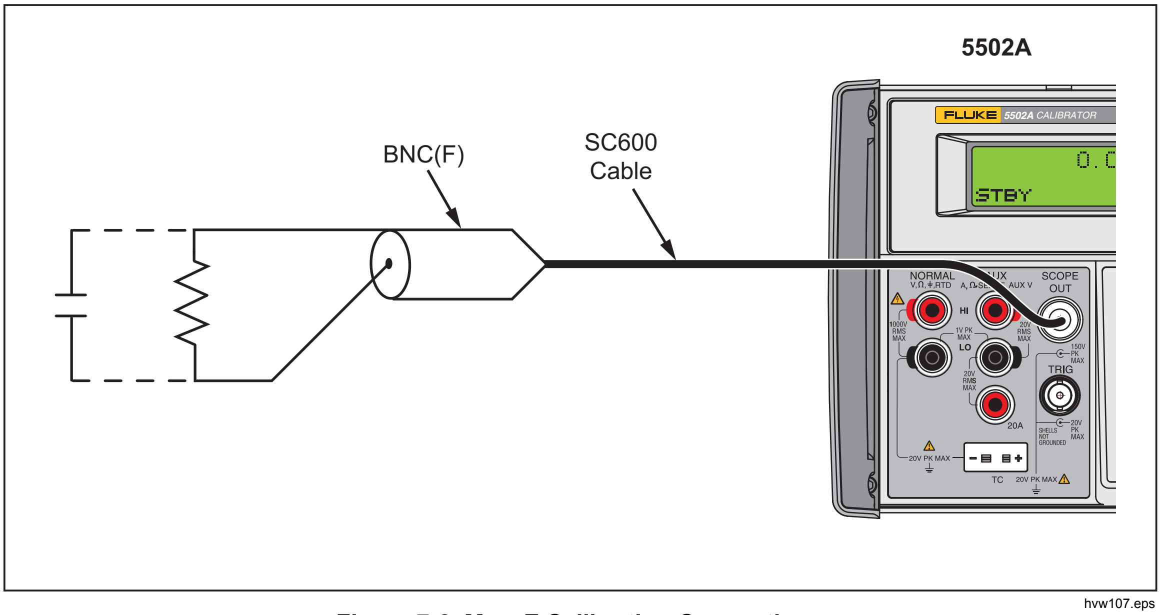

Figure 7-6. MeasZ Calibration Connections

2. Push the **OPTIONS** softkey.
3. Push the **NEXT SECTION** softkey until “connect a 50 Ω resistor” shows in the display.
4. Connect the output cable to the SCOPE connector of the Calibrator.
5. Connect the other end of the output cable to BNC(f) connector attached to the 50 Ω resistor.
6. Push the **GO ON** softkey.
7. Type in the 50 Ω resistance.

Note

The Calibrator will show a message if the typed in value is higher or lower than the limits of the value. If this occurs, examine the setup and carefully re-type in the measurement with the correct multiplier (m, μ, n, p). If the warning continues, repair may be necessary.

8. When instructed by the Calibrator, disconnect the 50 Ω resistance and connect the 1 MΩ resistance to the end of the output cable.
9. Push the **GO ON** softkey.
10. Type in the actual 1 MΩ resistance.
11. When instructed for the first reference capacitor by the Calibrator, disconnect the 1 MΩ resistance and leave nothing attached to the end of the output cable.
12. Push the **GO ON** softkey.
13. Enter 0.
14. When prompted for the second reference capacitor by the Calibrator, connect the 50 pF capacitance to the end of the output cable.

15. Push the **GO ON** blue softkey.
16. Type in the actual 50 pF capacitance.
17. When the Calibrator shows calibration is complete in the display, push the **OPTIONS**, then **STORE CONSTS** softkeys to store the new calibration constants.

Verification

Do a verification of all Oscilloscope Calibration functions a minimum of one time each year, or when the SC600 is calibrated. The verification procedures in this section supply traceable results. The factory uses different procedures and instruments of higher precision than those shown in this manual. The procedures in this manual let you verify the SC600 at your site if necessary. Fluke recommends you send the Calibrator to Fluke for calibration and verification.

All equipment used to do a verification on the SC600 must be calibrated, certified traceable if traceability is to be kept, and operated in their specified operation environment.

It is also important to make sure that the equipment has had sufficient time to warm up before you start verification. Refer to the operation manual for each piece of equipment for more information.

Before you start verification, look at all of the procedures to make sure you have the resources to do them.

Table 7-4 is a list of the SC600 functions and verification methods.

Table 7-4. Verification Methods for SC600 Functions

Function	Verification Method
DC Voltage	Procedure supplied in this manual.
AC Voltage amplitude	Procedure supplied in this manual.
AC Voltage frequency	Procedure supplied in this manual.
Edge amplitude	Procedure supplied in this manual.
Edge frequency, duty cycle, rise time	Procedure supplied in this manual.
Tunnel Diode Pulser amplitude	Procedure supplied in this manual. See the “Voltage and Edge Calibration and Verification” section for more information.
Leveled sine wave amplitude, frequency, harmonics, and flatness	Procedure supplied in this manual.
Time marker period	Procedure supplied in this manual.
Wave generator amplitude	Procedure supplied in this manual.
Pulse width, period	Procedure supplied in this manual.
MeasZ resistance, capacitance	Procedure supplied in this manual.
Overload functionality	Procedure supplied in this manual.

DC Voltage Verification

This procedure uses:

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

For dc voltage verification, see Figure 7-4 for equipment connections.

Set the Calibrator to SCOPE mode, with the Volt menu shown in the display.

Verification at 1 MΩ

To do a 1 MΩ verification:

1. Connect the SCOPE connector of the Calibrator to the HP 3458A input, with the cable and the BNC(f) to Double Banana adapter.
2. Make sure the Calibrator is set to 1 MΩ (The **Output @** softkey toggles the impedance between 50 Ω and 1 MΩ).
3. Set the HP 3458A to DCV, Auto Range, NPLC = 10, FIXEDZ = on.
4. Set the Calibrator output to the voltage in Table 7-5.
5. Push OPR on the Calibrator.
6. Let the HP 3458A measurement become stable.
7. Record the HP 3458A measurement for each voltage in Table 7-5.
8. Compare the result to the tolerance column.

Verification at 50 Ω

To do a 50 Ω verification:

1. Connect the SCOPE connector of the Calibrator to the HP 3458A input, with the cable and the 50 Ω termination connected to the BNC(f) to Double Banana adapter.
2. Make sure the Calibrator impedance is set to 50 Ω (The **Output @** softkey toggles the impedance between 50 Ω and 1 MΩ).
3. Set the HP 3458A to DCV, Auto Range, NPLC = 10, FIXEDZ = on.
4. Set the Calibrator output to the voltage in Table 7-6.
5. Push OPR on the Calibrator.
6. Let the HP 3458A measurement become stable.
7. Record the HP 3458A measurement for each voltage in Table 7-6.
8. Compare the result to the tolerance column.

Table 7-5. DC Voltage Verification at 1 MΩ

Calibrator Output	HP3458A Measurement (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

Table 7-5. DC Voltage Verification at 1 MΩ (cont.)

Calibrator Output	HP3458A Measurement (V dc)	Tolerance ±(V dc)
-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 7-6. DC Voltage Verification at 50 Ω

Calibrator Output	HP3458A Measurement (V dc)	Tolerance (V dc min.)	Tolerance (V dc max.)
0 mV		-0.040 mV	0.040 mV
2.49 mV		2.4438 mV	2.5362 mV
-2.49 mV		-2.5362 mV	-2.4438 mV
9.90 mV		9.835 mV	9.965 mV
-9.90 mV		-9.965 mV	-9.835 mV
24.9 mV		24.798 mV	25.002 mV
-24.9 mV		-25.002 mV	-24.798 mV
109.9 mV		109.585 mV	110.215 mV
-109.9 mV		-110.215 mV	-109.585 mV
499 mV		497.71 mV	500.29 mV
-499 mV		-500.29 mV	-497.71 mV
2.19 V		2.1845 V	2.1955 V
-2.19 V		-2.1955 V	-2.1845 V
6.599 V		6.5825 V	6.6155 V
-6.599 V		-6.6155 V	-6.5825 V

AC Voltage Amplitude Verification

This procedure uses:

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

For ac voltage verification, see Figure 7-3 for equipment connections.

Set the Calibrator to SCOPE mode, with the Volt menu shown in the display.

Verification at 1 MΩ

To do a 1 MΩ verification:

1. Connect the SCOPE connector of the Calibrator to the HP 3458A input, with the cable and the BNC(f) to Double Banana adapter.
2. Connect the TRIG OUT connector of the Calibrator to the EXT Trig connector on the rear panel of the HP3458A.
3. Make sure the Calibrator is set to 1 MΩ (The **Output @** softkey toggles the impedance between 50 Ω and 1 MΩ).
4. For ac voltage output at 1 kHz, set the HP 3458A to DCV, NPLC = .01, TRIG EXT.
5. Set the HP 3458A DELAY to .0007 for the top part of the waveform (or topline) measurement, and .0012 for the lower part of the waveform (or 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 related baseline measurements at each step.
6. Push the TRIG softkey on the Calibrator until **/1** shows in the display.
7. Measure the topline first as shown in Table 7-7. For each measurement, get samples for 2 seconds minimum, with the HP 3458A MATH functions to retrieve the average or mean value. See the “Setup for SC600 Edge and Wave Generator Measurements” section for more information.
8. Measure the baseline of each output after the topline measurement, as shown in Table 7-7. The peak-to-peak value is the difference between the topline and baseline measurements. Compare the result to the tolerance column.
9. When you make measurements at the other frequencies, set up the HP 3458A (NPLC and topline and baseline DELAY) as shown in Table 7-2. (See the “Setup for SC600 Voltage Square Wave Measurements” section.)

Table 7-7. AC Voltage Verification at 1 MΩ

Calibrator Output (1 kHz, or as noted)	HP3458A Range	Topline Measurement	Baseline Measurement	Peak-to-Peak	Tolerance (±V)
1 mV	100 mV dc				0.000041
-1 mV	100 mV dc				0.000041
10 mV	100 mV dc				0.00005
-10 mV	100 mV dc				0.00005
25 mV	100 mV dc				0.000065
-25 mV	100 mV dc				0.000065
110 mV	100 mV dc				0.00015
-110 mV	100 mV dc				0.00015
500 mV	1 V dc				0.00054
-500 mV	1 V dc				0.00054
2.2 V	10 V dc				0.00224
-2.2 V	10 V dc				0.00224
11 V	10 V dc				0.01104
-11 V	10 V dc				0.01104
130 V	1000 V dc				0.13004
-130 V	1000 V dc				0.13004
200 mV, 100 Hz	1 V dc				0.00024
200 mV, 1 kHz	1 V dc				0.00024
200 mV, 5 kHz	1 V dc				0.00054
200 mV, 10 kHz	1 V dc				0.00054
2.2 V, 100 Hz	10 V dc				0.00224
2.2 V, 5 kHz	10 V dc				0.00554
2.2 V, 10 kHz	10 V dc				0.00554

Verification at 50 Ω

To do a 50 Ω verification:

1. Connect the SCOPE connector of the Calibrator to the HP 3458A input, with the cable and the 50 Ω termination connected to the BNC(f) to Double Banana adapter.
2. Connect the TRIG OUT connector of the Calibrator to the EXT Trig connector on the rear panel of the HP3458A.
3. Make sure the Calibrator impedance is set to 50 Ω (The **Output @** softkey toggles the impedance between 50 Ω and 1 MΩ).
4. Set the HP 3458A to DCV, NPLC = .01, TRIG EXT.
5. Set the HP 3458A DELAY to .0007 for the top part of the waveform (topline) measurement, and .0012 for the lower part of the waveform (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 related baseline measurements at each step. See Table 7-8.
6. Push the TRIG softkey on the Calibrator until **/1** shows in the display.
7. Measure the topline first as shown in Table 7-8. For each measurement, get samples for 2 seconds minimum, with the HP 3458A MATH functions to retrieve the average or mean value. See the “Setup for SC600 Edge and Wave Generator Measurements” section for more information.
8. Measure the baseline of each output after the topline measurement, as shown in Table 7-8. The peak-to-peak value is the difference between the topline and baseline measurements. Compare the result to the tolerance column.

Table 7-8. AC Voltage Verification at 50 Ω

Calibrator Output (1 kHz)	HP3458A Range	Topline Measurement	Baseline Measurement	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

AC Voltage Frequency Verification

This procedure uses:

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

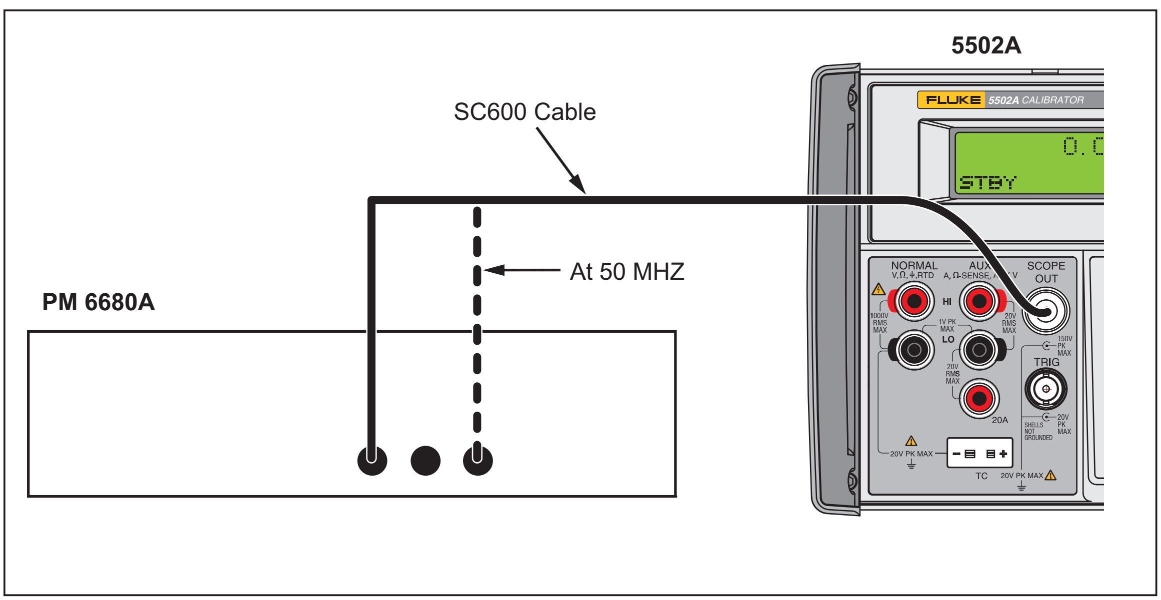

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Figure 7-7. AC Voltage Frequency Verification Setup

To do an ac voltage frequency verification:

1. Set the Calibrator to SCOPE mode, with the Volt menu shown in the display.
2. Push OPR on the Calibrator.
3. Set the FUNCTION of the PM 6680 to measure frequency on channel A with auto trigger, measurement time set to 1 second or longer, 1 MΩ impedance, and filter off.
4. Connect the SCOPE connector on the Calibrator to channel A of the PM 6680 with the output cable. See Figure 7-7.
5. Set the Calibrator to output 2.1 V at each frequency shown in Table 7-9.
6. Let the PM 6680 measurement become stable.
7. Record the PM 6680 measurement for each frequency shown in Table 7-9.
8. Compare to the tolerance column of Table 7-9.

Table 7-9. AC Voltage Frequency Verification

Calibrator Frequency	PM 6680 Measurement (Frequency)	Tolerance
10 Hz		0.000025 Hz
100 Hz		0.00025 Hz
1 kHz		0.0025 Hz
10 kHz		0.025 Hz

Edge Amplitude Verification

To do an edge amplitude verification:

1. Connect the SCOPE connector of the Calibrator to the HP 3458A input, with the cable and the 50 Ω termination connected to the BNC(f) to Double Banana adapter.
2. For ac voltage output at 1 kHz, set the HP 3458A to DCV, NPLC = .01, LEVEL 1, TRIG LEVEL. For ac voltage output of 10 kHz, change the NPLC to .001.
3. Set the HP3458A DELAY to .0002 for the top part of the waveform (topline) measurement, and .0007 for the lower part of the waveform (baseline).
4. Manually range lock the HP 3458A to the range that gives the most resolution for the baseline measurements. Use this same range for the related baseline measurements at each step. See Table 7-10.

Note

For the edge function, the topline is near 0 V and the baseline is a negative voltage.

5. For each measurement, get samples for 2 seconds minimum, with the HP 3458A MATH functions to retrieve the average or mean value. See the “Setup for SC600 Edge Wave Generator Measurements” section to learn more.

6. The peak-to-peak value of the waveform is the difference between the topline and baseline measurements. Multiply the measurements by (0.5 * (50 + Rload) / Rload), where Rload = the actual feedthrough termination resistance, to correct for the resistance error.
7. Record each measurement in Table 7-10.

Table 7-10. Edge Amplification Verification

Calibrator Edge Output	HP3458A Range	Topline Measurement	Baseline Measurement	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

Edge Frequency Verification

This procedure uses:

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

To do an Edge Frequency Verification:

1. Connect the equipment as shown in Figure 7-7.
2. Set the Calibrator to SCOPE mode, with the edge menu shown in the display.
3. Push OPR on the Calibrator.
4. Set the FUNCTION of the PM 6680 to measure frequency on channel A with auto trigger, measurement time set to 1 second or longer, 50 Ω impedance, and filter off.
5. Connect the SCOPE connector on the Calibrator to channel A of the PM 6680 with the output cable.
6. Set the Calibrator to output 2.5 V at each frequency shown in Table 7-11.
7. Let the PM 6680 measurement become stable.
8. Record the PM 6680 measurement for each frequency shown in Table 7-11.
9. Compare to the tolerance column of Table 7-11.

Table 7-11. Edge Frequency Verification

Calibrator Frequency (output @ 2,5 V p-p)	PM 6680 Measurement (Frequency)	Tolerance
1 kHz		0.0025 Hz
10 kHz		0.025 Hz
100 kHz		0.25 Hz

Table 7-11. Edge Frequency Verification (cont.)

Calibrator Frequency (output @ 2,5 V p-p)	PM 6680 Measurement (Frequency)	Tolerance
1 MHz		2.5 Hz
10 MHz		25 Hz

Edge Duty Cycle Verification

This procedure uses:

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

To do an Edge Duty Cycle Verification:

1. Connect the equipment as shown in Figure 7-7.
2. Set the Calibrator to SCOPE mode, with the edge menu shown in the display.
3. Push OPR on the Calibrator.
4. Set the FUNCTION of the PM 6680 to measure duty cycle on channel A with auto trigger, measurement time set to 1 second or longer, 50 Ω impedance, and filter off.
5. Connect the SCOPE connector on the Calibrator to channel A of the PM 6680 with the output cable.
6. Set the Calibrator to output 2.5 V at 1 MHz.
7. Let the PM 6680 measurement become stable.
8. Compare to the duty cycle measurement to 50 % ±5 %.

Edge Rise Time Verification

This verification is a test of the rise time of the edge function. Aberrations are also examined.

This procedure uses:

- 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)
- Output cable supplied with the SC600
- Second BNC cable

To do an edge rise time verification:

1. Connect the output cable to the SCOPE connector on the Calibrator. Connect the other end of the output cable to one of the BNC(f) to 3.5 mm (m) adapter and then to the sampling head of the DSO through the 3 dB attenuator.
2. Use the second BNC cable with the BNC(f) to 3.5 mm(m) adapter attached to connect the TRIG OUT of the Calibrator to the trigger input of the DSO. See Figure 7-8.

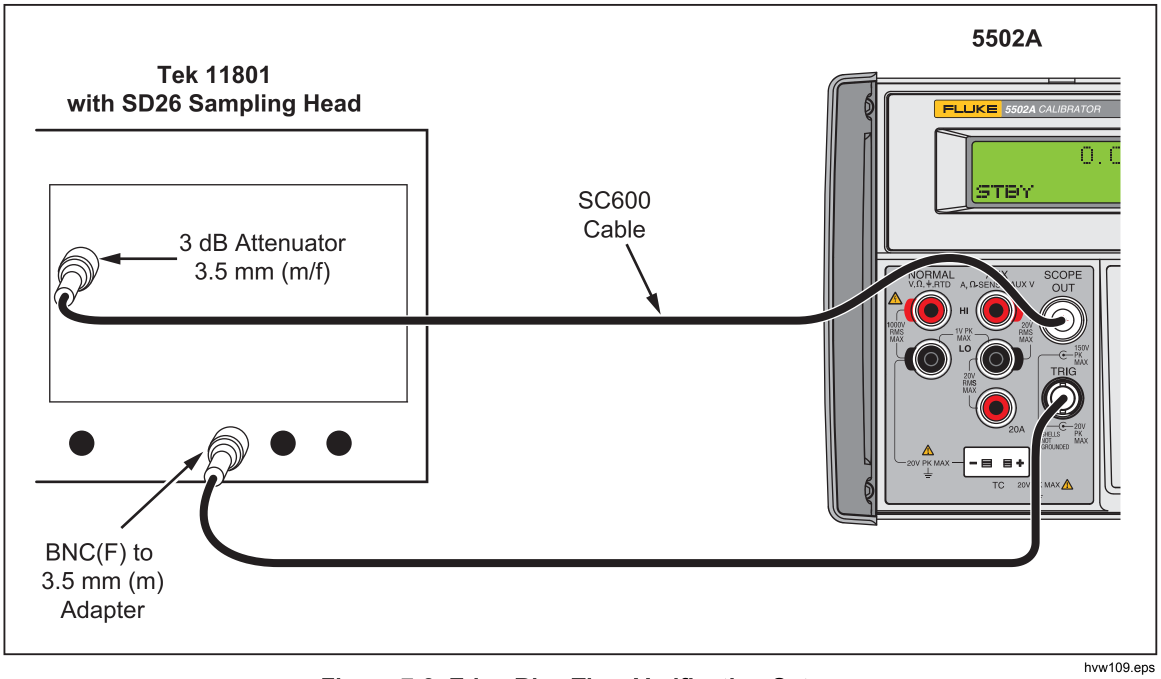

Figure 7-8. Edge Rise Time Verification Setup

3. Set the Calibrator to SCOPE mode, with the Edge menu shown in the display.
4. Push OPR on the Calibrator.
5. Push the TRIG softkey on the Calibrator until **/1** shows in the display.
6. Set the Calibrator output to 250 mV @ 1 kHz.
7. Set the DSO to:
   - Main Time Base: 40 ns
   - Horizontal scale: 500 ps/div
   - Measurement function: Rise Time
8. Set the Calibrator to output the voltage and frequency shown in Table 7-12.
9. Push OPR on the Calibrator.
10. Change the vertical scale of the DSO to the value shown in Table 7-12.
11. Adjust the main time base position and vertical offset until the edge signal is in the center of the DSO display.
12. Reacord the rise time measurement in column A of Table 7-12.

13. Correct the rise time measurement for the rise time of the SD-22/26 sampling head. The SD-22/26 rise time is specified as <28 ps.

$$\text{Column B} = \sqrt{(\text{Column A})^2 - (\text{SD-22/26 rise time})^2}$$

14. The measured edge rise time must be less than the time shown in Table 7-12.

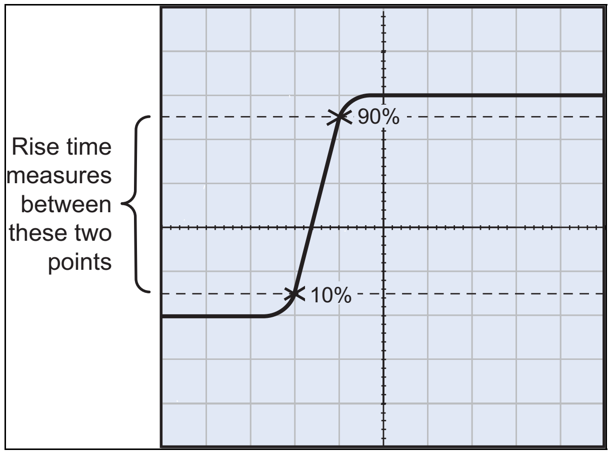

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Figure 7-9. Edge Rise Time

Table 7-12. Edge Rise Time Verification

Calibrator Output		DSO Vertical Axis (mV/div)	A 11801 Measurement	B Corrected Measurement	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

Edged Aberration Verification

This procedure uses:

- Tektronix 11801 oscilloscope with SC22/26 sampling head
- Output cable supplied with the SC600

To do edge aberration verification:

1. Make sure that the SC600 is in the edge mode (the edge menu is shown in the display), and set it to output 1 V p-p @ 1 MHz.
2. Push OPR.
3. Connect the Calibrator to the oscilloscope as shown in Figure 7-8.
4. Set the oscilloscope vertical gain to 10 mV/div and horizontal time base to 1 ns/div.
5. Set the oscilloscope to show the 90 % point of the edge signal. Use this point as the reference level.
6. Set the oscilloscope to show the first 10 ns of the edge signal with the rising edge at the left edge of the oscilloscope display.

Note

With this setup, each vertical line of the oscilloscope display shows a 1 % aberration.

7. Make sure the SC600 meets the specifications shown in Table 7-13.

Table 7-13. 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%)

Tunnel Diode Pulser Drive Amplitude Verification

This procedure uses:

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

To do a Diode Pulser Drive Amplitude verification:

1. Set the Calibrator to SCOPE mode, with the edge menu shown in the display.
2. Connect the SCOPE connector of the Calibrator to the HP 3458A input, with the cable and the BNC(f) to Double Banana adapter. See Figure 7-4.
3. Push the **TDPULSE** softkey on the Calibrator.
4. Set the output to 80 V peak-to-peak, 100 kHz, STANDBY.
5. Set the HP 3458A to DCV, NPLC = .01, LEVEL 1, TRIG LEVEL.

6. Set the HP3458A DELAY to .0012 for the top part of the waveform (i.e. topline) measurement, and .0007 for the lower part of the waveform (i.e. baseline).
7. Manually range lock the HP 3458A to the 100 V range.
8. Change the Calibrator Mainframe output frequency to 10 kHz.
9. Push OPR, and use the HP 3458A to measure the topline and baseline.
10. The peak-to-peak value is the difference between the topline and baseline. Record these values in Table 7-14, and compare against the tolerance.

Table 7-14. Tunnel Diode Pulser Amplitude Verification

Calibrator Edge Output	HP3458A Range	Topline Measurement	Baseline Measurement	Peak-to-Peak	Tolerance (±V)
80 V, 10 kHz	100 V dc				1.6

Leveled Sine Wave Amplitude Verification

This procedure uses:

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

To do a Leveled Sine Wave Amplitude Verification:

1. Connect the equipment as shown in Figure 7-4.
2. Set the Calibrator to SCOPE mode, with the Levsine menu shown in the display.
3. Push OPR.
4. Connect the output cable to the 50 Ω feedthrough termination.
5. Connect the one end of the output cable to the SCOPE connector of the Calibrator
6. Connect the 50 Ω feedthrough termination at the other end of the cable to input 2 of the 5790A with the BNC(f) to Double Banana adapter.
7. Set the 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.
8. Set the Calibrator to a value shown in column 1 of the Table 7-15.
9. Let the 5790A measurement become stable and then record the 5790A measurement in the table.
10. Multiply the rms measurement by the conversion factor of 2.8284 to get the peak-to-peak value.
11. Multiply the measurements by (0.5 * (50 + Rload) / Rload), where Rload = the actual feedthrough termination resistance, to correct for the resistance error.
12. Compare the result to the value in the tolerance column.

Table 7-15. Leveled Sine Wave Amplitude Verification

Calibrator Output (@ 50 kHz)	5790A Measurement (V rms)	5790A Measurement 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

Leveled Sine Wave Frequency Verification

This procedure uses:

- 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
- Output cable supplied with the SC600

To do a leveled sine wave frequency verification:

1. Connect the equipment as shown in Figure 7-7.
2. Set the Calibrator to SCOPE mode, with the Levsine menu shown in the display.
3. Set the PM 6680 to the measure frequency function with auto trigger, measurement time set to 1 second or longer, and 50 Ω impedance.
4. Connect one end of the output cable to the SCOPE connector of the Calibrator.
5. Connect the BNC(f) to Type N(m) adapter to the other end of the output cable.
6. Connect the Type N connector to the PM 6680 channel shown in Table 7-16.
7. Set the filter on the PM 6680 as shown in Table 7-16.
8. Set the Calibrator output to the parameters shown in Table 7-16.
9. Push OPR.

10. Let the PM 6680 measurement become stable and then record the frequency measurement in Table 7-16.

Table 7-16. Leveled Sine Wave Frequency Verification

Calibrator Frequency (@ 5.5 V p-p)	PM 6680 Settings		PM 6680 Measurement (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

Leveled Sine Wave Harmonics Verification

This procedure uses:

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

To do a Leveled Sine Wave Harmonics Verification:

1. Connect the equipment as shown in Figure 7-10.

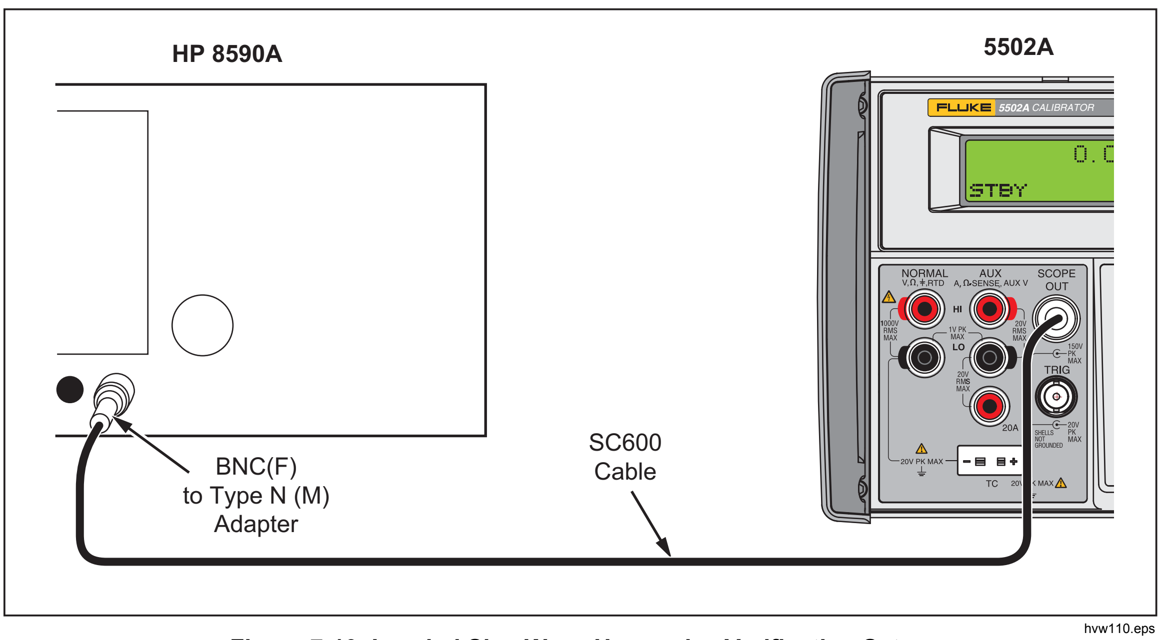

Figure 7-10. Leveled Sine Wave Harmonics Verification Setup

2. Set the Calibrator to Scope mode with the Levsine menu shown in the display.
3. Connect one end of the Output cable to the SCOPE connector of the Calibrator.
4. Connect the BNC(f) to Type N(m) adapter to the other end of the output cable.

5. Connect the Type N connector to the HP 8590A.
6. Set the Calibrator to output 5.5 V p-p at each frequency on Table 7-17.
7. Push OPR.
8. Set the HP 8590A start frequency to the Calibrator output frequency.
9. Set the HP 8590A stop frequency to 10 times the Calibrator output frequency.
10. Set the HP 8590A reference level at +19 dBm.
11. Record the harmonic level measurement for each frequency and harmonic shown in Table 7-17. For harmonics 3, 4, and 5, record the highest harmonic level of the three measured. Harmonics must be below the levels listed in the tolerance column of Table 7-17.

Table 7-17. Leveled Sine Wave Harmonics Verification

Calibrator Output Frequency (@ 5.5 V p-p)	Harmonic	HP 8590A Measurement (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

Table 7-17. Leveled Sine Wave Harmonics Verification (cont.)

Calibrator Output Frequency (@ 5.5 V p-p)	Harmonic	HP 8590A Measurement (dB)	Tolerance
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

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 a direct measurement in the low frequency band. You must do a “transfer” measurement at 10 MHz in the high frequency band to calculate a flatness relative to 50 kHz.

Equipment Setup for Low Frequency Flatness

All low frequency flatness procedures use:

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

1. Connect one end of the output cable to the SCOPE connector of the Calibrator.
2. Connect the BNC(f) to Type N(m) adapter to the other end of the output cable.
3. Connect the Type N connector to the HP 5790A WIDEBANC input. See Figure 7-11.
4. Set the HP 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.

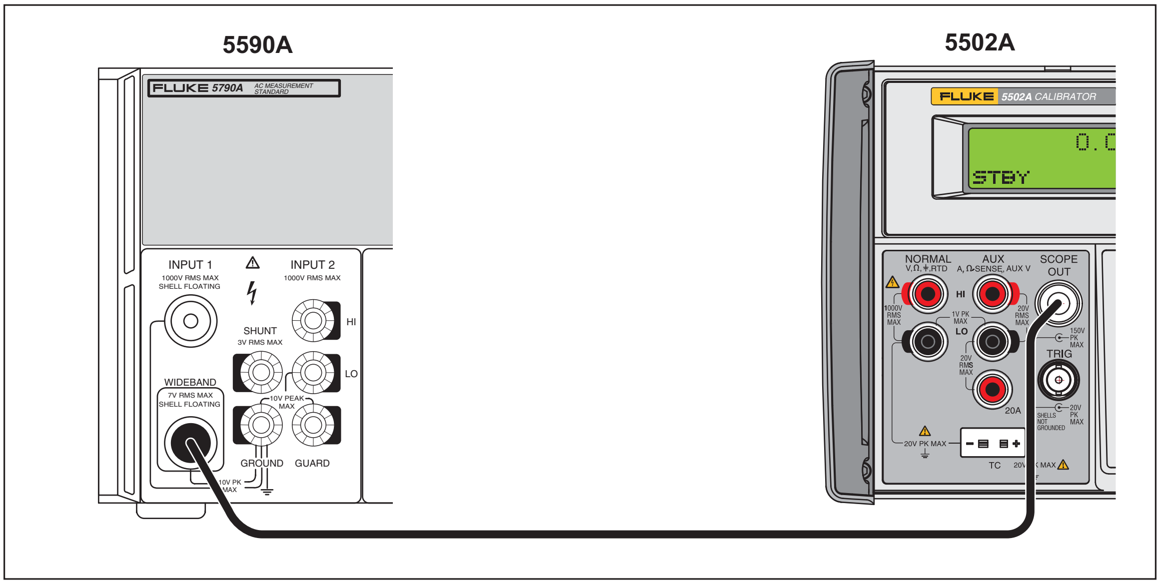

Figure 7-11. Calibrator to 5790A Measurement Standard Connections

Equipment Setup for High Frequency Flatness

All high frequency flatness procedures use:

- Hewlett-Packard 437B Power Meter
- Hewlett-Packard 8482A and 8481D Power Sensors
- BNC(f) to Type N(f) adapter
- Output cable supplied with the SC600

Note

When high frequencies at voltages less than 63 mV p-p are verified, use the 8481D Power Sensor. For voltages 63 mV p-p and higher, use the 8482A Power Sensor.

Connect the HP 437B Power Meter to the 8482A or the 8481D Power Sensor as shown in Figure 7-12. To learn more about how to connect these two instruments, refer to the operator manuals of the instruments.

Connect the power meter/power sensor combination to the SCOPE connector on the Calibrator. See Figure 7-13.

The HP 437B Power Meter must be configured with:

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

Zero and self-calibrate the power meter with the power sensor. Refer to the HP 437B operators manual to learn more.

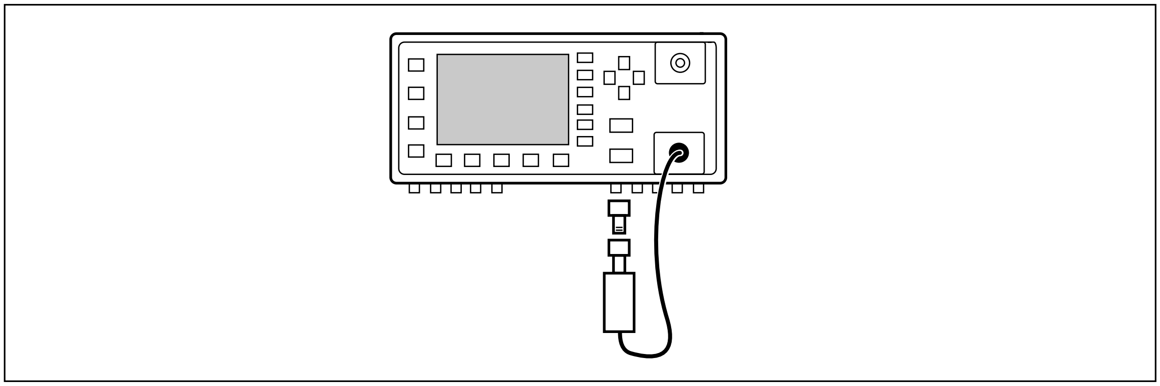

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Figure 7-12. HP 437B Power Meter to the HP 8482A or 8481D Power Sensor Connections

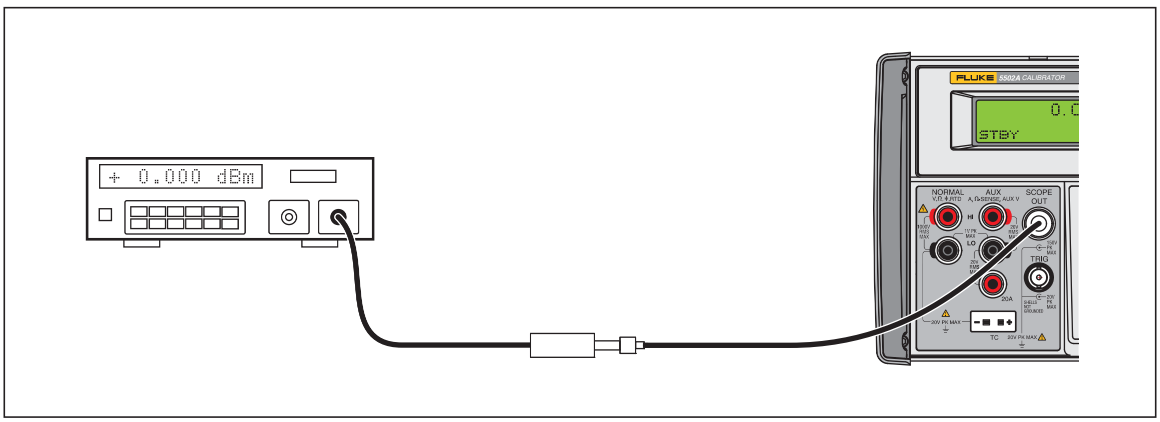

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Figure 7-13. Calibrator to the HP Power Meter and Power Sensor Connections

Low Frequency Verification

This procedure gives an example of a low frequency flatness test with a 5.5 V Calibrator output. Use the same procedure for other amplitudes. Compare the results with the flatness specification shown in Table 7-18.

1. Set the Calibrator to output of 5.5 V @ 500 kHz.
2. Push OPR.
3. Let the 5790A measurement become stable. The 5790A should display approximately 1.94 V rms.
4. Record the 5790A measurement in column A of Table 7-18.
5. Set the Calibrator frequency to 50 kHZ.
6. Let the 5790A measurement become stable and then record the 5790A measurement in column B of Table 7-18.
7. Set the Calibrator to the next frequency shown in Table 7-18.
8. Let the 5790A measurement become stabile and then record the measurement in column A of Table 7-18.
9. Set the Calibrator frequency to 50 kHZ.
10. Let the 5790A measurement become stabile and then record the 5790A measurement in column B of Table 7-18.
11. Do steps 7 through 10 again for all the frequencies shown in Table 7-18. Continue until you have completed Columns A and B.

After you fill in columns A and B for all rows of the table, push STBY. Use the recorded values in columns A and B to calculate and record the value in column C for all rows.

$$\text{Column C} = 100\left(\frac{\text{Column A} - \text{Column B}}{\text{Column B}}\right)$$

Compare column C to the specifications shown in the last column.

Table 7-18. Low Frequency Flatness Verification at 5.5 V

Calibrator Frequency	A	B 50 kHz	C	Calibrator Flatness Specification (%)
500 kHz				±1.50
1 MHz				±1.50
2 MHz				±1.50
5 MHz				±1.50
10 MHz				±1.50

Fill in Columns A through C as follows:
A Record 5790A measurement (mV) for the present frequency.
B Record 5790A measurement (mV) for 50 kHz.
C Compute and record the Calibrator Flatness deviation (%): 100 * ((Column A) – (Column B))/ Column B

High Frequency Verification

This procedure gives an example of a high frequency flatness test with a 5.5 V Calibrator output. Use the same procedure for other amplitudes. Compare the results with the flatness specification shown in Table 7-19.

1. Set the Calibrator to output of 5.5 V @ 30 MHz.
2. Push OPR.
3. Let the power meter measurement become stable. The power meter measurement should be approximately 75 mW.
4. Record the power meter measurement in column A of Table 7-19.
5. Set the Calibrator frequency to 10 MHz.
6. Let the power meter measurement become stable and then record the measurement in column B of Table 7-19.
7. Set the Calibrator to the next frequency shown in Table 7-19.
8. Let the power meter measurement become stable and then record the measurement in column A of Table 7-19.
9. Set the Calibrator frequency to 10 MHz.
10. Let the power meter measurement become stable and then record the measurement in column B of Table 7-19.
11. Do steps 7 through 10 again for all the frequencies shown in Table 7-19. Continue until you have completed Columns A and B.

When you have filled in columns A and B for all rows of the table, push STBY. Use the recorded values in columns A and B to calculate and record the value in column C for all rows.

Table 7-19. High Frequency Flatness Verification at 5.5 V

Calibrator Frequency (MHz)	A	B (10 MHz)	C	D	E	F	G	Calibrator Flatness Specification (%)
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

Fill in Columns A through G as follows:
- A Record the 437B present frequency measurement (W).
- B Record the 437B 10 MHz measurement (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 Calculate and record error relative to 10 MHz (%):
- F Record the 10 MHz rms error (%) for 5.5 V from Table 7-18, column C.
- G Calculate and record that Calibrator Flatness deviation (%): (Colum E entry) + (Colum F entry)

Time Marker Verification

This procedure uses:

- 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
- Output cable supplied with the SC600

To do a Time Marker Verification:

1. Connect the equipment as shown in Figure 7-7.
2. Set the PM 6680 to the measure frequency function with auto trigger, measurement time set to 1 second or longer, and 50 Ω impedance.
3. Set the Calibrator to SCOPE mode, with the Marker menu shown in the display.
4. Push OPR.
5. Set the Calibrator output to the parameters shown in Table 7-16.
6. Connect one end of the Output cable to the SCOPE connector of the Calibrator.
7. Connect the BNC(f) to Type N(m) adapter to the other end of the output

cable.

8. Connect the Type N connector to the PM 6680 channel shown in Table 7-16.
9. Set the filter on the PM 6680 as shown in Table 7-16.
10. Let the PM 6680 measurement become stable and then record the frequency measurement in Table 7-16.
11. Calculate the period of the frequency with Period = 1/frequency and record it on the table.
12. Compare the period value to the value in the tolerance column.

Table 7-20. Time Marker Verification

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

Wave Generator Verification

This procedure uses:

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

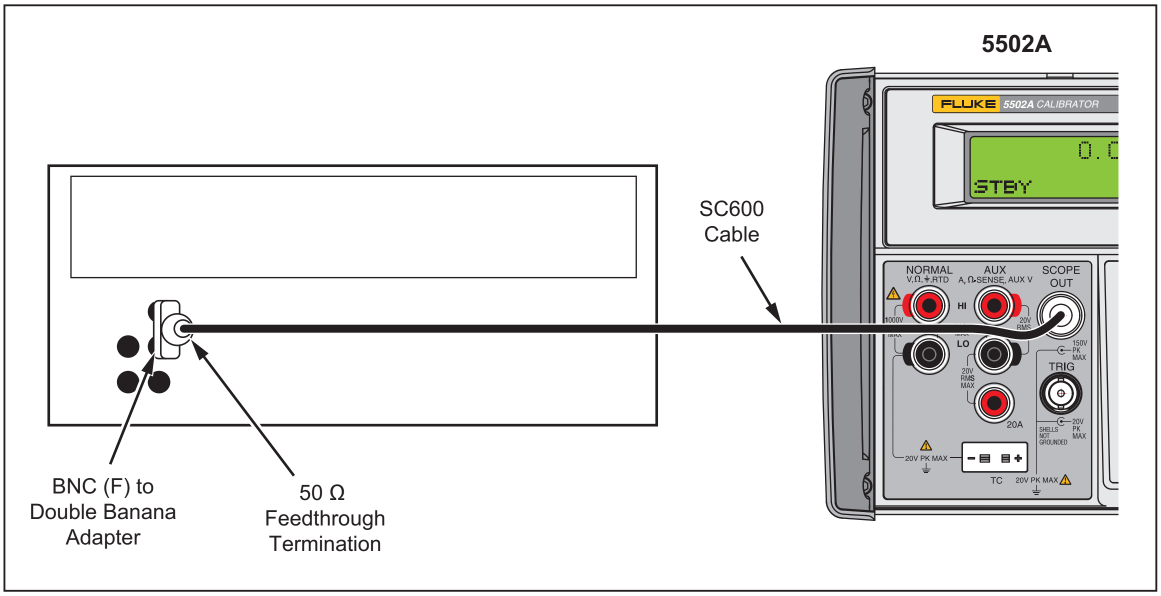

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Figure 7-14. Wave Generator Verification Connections

Wave Generator Verification is done at two different impedances: 1 MΩ and 50 Ω.

Wave Generator Verification Setup

To setup the equipment for wave generator verification:

1. Connect the equipment as shown in Figure 7-14.
2. Set the Calibrator to SCOPE mode, with the Wavegen menu shown in the display.
3. Push OPR.
4. Set offset to 0 mV.
5. Set the Calibrator frequency to 1 kHz.

Verification at 1 MΩ

1. Set the Calibrator to 1 MΩ.

Note

*The **SCOPEZ** softkey toggles the impedance between 50 Ω and 1 MΩ.*

2. Connect the one end of the output cable to the SCOPE connector of the Calibrator
3. Connect the other end of the cable to input 2 of the 5790A with the BNC(f) to Double Banana adapter.
4. Set the 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.
5. Set the Calibrator to output the wave type and voltage shown in Table 7-21.
6. Let the 5790A measurement become stable and then record the 5790A measurement for each wave type and voltage in Table 7-21.
7. Multiply the rms measurement by the conversion factor in Table 7-21 to convert the measurement to a peak-to-peak value.
8. Compare the result to the value in the tolerance column.

Verification at 50Ω

1. Set the Calibrator to 50 Ω.

Note

*The **SCOPEZ** softkey toggles the impedance between 50 Ω and 1 MΩ.*

2. Connect one end of the output cable to the 50 Ω feedthrough termination.
3. Connect the other end of the output cable to the SCOPE connector of the Calibrator
4. Connect the 50 Ω feedthrough termination at the other end of the cable to input 2 of the 5790A with the BNC(f) to Double Banana adapter.
5. Set the 5790A to AUTORANGE, digital filter mode to FAST, restart fine, and Hi Res on.
6. Set the Calibrator to output the wave type and voltage shown in Table 7-22.
7. Let the 5790A measurement become stable and then record the 5790A measurement for each wave type and voltage in Table 7-22.
8. Multiply the rms measurement by the conversion factor in Table 7-22 to convert the measurement to a peak-to-peak value.
9. 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.
10. Compare the result to the value in the tolerance column.

Table 7-21. Wave Generator Verification at 1 MΩ

Calibrator Wave Type	Calibrator Output (@ 10 kHZ)	5790A Measurement (V rms)	Conversion Factor	5790A Measurement 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

Table 7-21. Wave Generator Verification at 1 MΩ (cont.)

Calibrator Wave Type	Calibrator Output (@ 10 kHZ)	5790A Measurement (V rms)	Conversion Factor	5790A Measurement x Conversion Factor (V p-p)	Tolerance (V p-p)
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 7-22. Wave Generator Verification at 50 Ω

Calibrator Wave Type	Calibrator Output (@ 10 kHZ)	5790A Measurement (V rms)	Conversion Factor	5790A Measurement 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

Table 7-22. Wave Generation Verification at 50 Ω (cont.)

Calibrator Wave Type	Calibrator Output (@ 10 kHZ)	5790A Measurement (V rms)	Conversion Factor	5790A Measurement x Conversion Factor (V p-p)	V p-p value x correction	Tolerance (V p-p)
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

Pulse Width Verification

This procedure uses:

- 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)
- Output cable supplied with the SC600
- Second BNC cable

To do a pulse width verification:

1. Connect the equipment as shown in Figure 7-8.
2. Connect the output cable to the SCOPE connector on the Calibrator. Connect the other end of the output cable to one of the BNC(f) to 3.5 mm (m) adapter and then to the sampling head of the DSO through the 3 dB attenuator.
3. Use the second BNC cable with the BNC(f) to 3.5 mm(m) adapter attached to connect the TRIG OUT of the Calibrator to the trigger input of the DSO.
4. Set the Calibrator to SCOPE mode, with the Edge menu shown in the display.
5. Push OPR on the Calibrator.
6. Push the TRIG softkey on the Calibrator until **/1** shows in the display.
7. Set the DSO to:
   - Main Time Base: 40 ns
   - Vertical scale: 200 mV/div
   - Trigger: source = ext, level = 0.5 V, ext. atten. = x10, slope = +, mode = auto
   - Measurement function: positive width
8. Set the Calibrator to the pulse width and period shown in Table 7-23. Set the voltage to 1 V.
9. Change the horizontal scale on the DSO to the value shown in Table 7-23.
10. Adjust the main time base position and vertical offset until the pulse signal is in the center of the DSO display.
11. Record the width measurement.
12. Compare the width measurement to the value in the tolerance column of the table.

Table 7-23. Pulse Width Verification

Function/Range	Nominal Value	Measured Value	Low Limit	High Limit
2 µs Period/4.00 ns	4.000		1.80	6.20
20 µs Period/4.00 ns	4.000		1.80	6.20
200 µs Period/4.00 ns	4.000		1.80	6.20
2 ms Period/40.00 ns	40.000		36.00	44.00

Pulse Period Verification

This procedure uses:

- PM 6680 Frequency Counter with an ovenized timebase (Option PM 9690 or PM 9691)

- Output cable supplied with the SC600

To do a pulse period verification:

1. Connect the equipment as shown in Figure 7-7.
2. Set the Calibrator to SCOPE mode, with the Pulse menu shown in the display.
3. Push OPR on the Calibrator.
4. Set the PM 6680 to the measure period on channel A with auto trigger, measurement time set to 1 second or longer, 50 Ω impedance, and filter off.
5. Connect one end of the output cable to the SCOPE connector of the Calibrator.
6. Connect the other end of the output cable to the channel A input of the PM 6680.
7. Set the Calibrator to the pulse width and period shown in Table 7-24. Set the voltage to 2.5V.
8. Let the PM 6680 measurement become stable and then record the period measurement in Table 7-24.
9. Compare the result to the tolerance column.

Table 7-24. Pulse Period Verification

Calibrator Output		PM 6680 Measurement	
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

MeasZ Resistance Verification

The verification procedure for the MeasZ Resistance function is a resistance measurement of a known value resistance and then compare the measured resistance to the value of the resistor.

This procedure uses:

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

To do a measz resistance verification:

1. Set the Calibrator to SCOPE mode, with the MeasZ menu shown in the display.
2. Set the Calibrator MeasZ resistance range to the value shown in Table 7-25.

Note

The MeasZ softkey toggles the MeasZ ranges.

3. Connect one end of the output cable to the SCOPE connector of the Calibrator.
4. Connect the resistor shown in Table 7-25 to the other end of the output cable.

See Figure 7-6.

Note

The resistor must make a solid connection to a BNC(f) connector. The resistance value must be known at this BNC(f) connector. Fluke uses an HP 3458A DMM to make a 4-wire measurement at the BNC(f) connector to get the actual resistance.

5. Let the Calibrator measurement become stable.
6. Record the measurement in Table 7-25.
7. Compare the measured resistance value to the actual resistance of the resistor and the value in the tolerance column of the table.

Table 7-25. MeasZ Resistance Verification

Calibrator MeasZ Range	Nominal Resistance Value	Calibrator Resistance Measurement	Actual Resistance Value	Tolerance
res 50Ω	40 Ω			0.04 Ω
res 50Ω	50 Ω			0.05 Ω
res 50Ω	60 Ω			0.06 Ω
res 1MΩ	600 kΩ [1]			600 Ω
res 1MΩ	1 MΩ			1 kΩ
res 1MΩ	1.5 MΩ			1.5 kΩ
[1] 600 kΩ is made with the 1.5 MΩ and 1 MΩ resistors connected in parallel.				

MeasZ Capacitance Verification

The verification procedure for the MeasZ Capacitance function is a capacitance measurement of a known value capacitance and then compare the measured capacitance to the value of the capacitance.

This procedure uses:

- Adapter and capacitors to make 5 pF, 29 pF, and 49 pF nominal values at the end of a BNC(f) connector.
- Output cable supplied with the SC600

To do a MeasZ capacitance verification:

1. Set the Calibrator to SCOPE mode, with the MeasZ menu shown in the display.
2. Set the Calibrator MeasZ capacitance range to **cap**.

Note

The MeasZ softkey toggles the MeasZ ranges.

3. Connect one end of the output cable to the SCOPE connector of the Calibrator. Do not connect anything to the other end of this cable.
4. Let the Calibrator measurement become stable and then push the **SET OFFSET** softkey to zero the capacitance measurement.
5. Connect the other end of the cable to the capacitance shown in Table 7-26. See Figure 7-6.

6. Let the Calibrator measurement become stable.
7. Record the measurement in Table 7-26.
8. Compare the measured capacitance value to the actual capacitance and the value in the tolerance column of the table.

Table 7-26. MeasZ Capacitance Verification

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

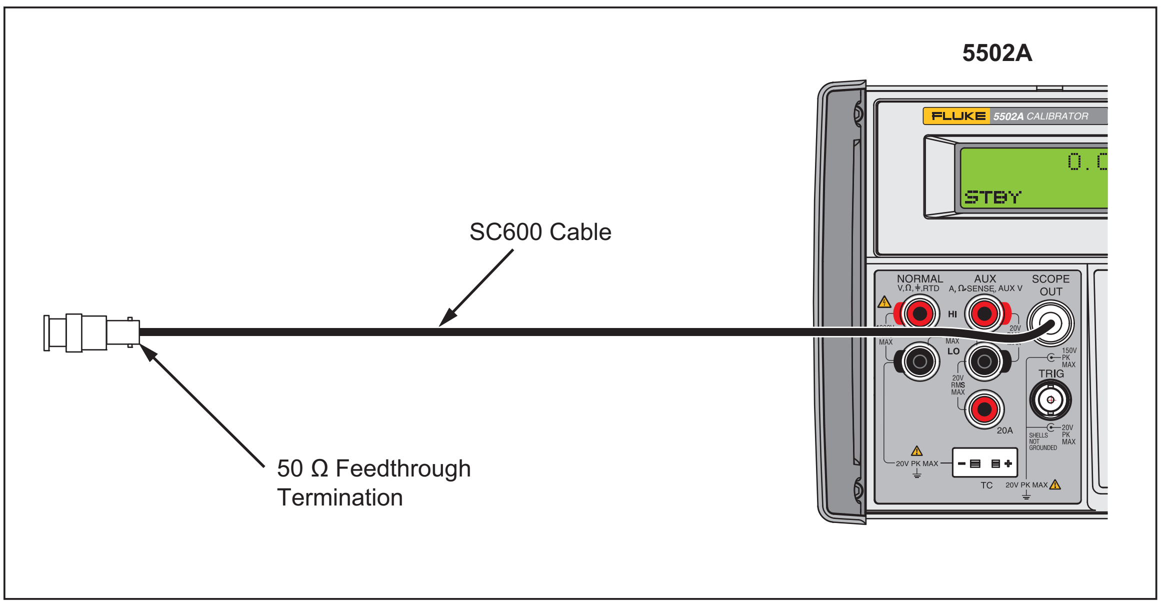
Overload Function Verification

This procedure uses:

- 50 Ω feedthrough termination
- Output cable supplied with the SC600

To do an overload function verification:

1. Connect the output cable and 50 Ω feedthrough termination to the Calibrator as shown in Figure 7-15.



hvw112.eps

Figure 7-15. Overload Function Verification Connections

2. Set the Calibrator to SCOPE mode, with the Overload menu shown in the display.
3. Connect one end of the output cable to the 50 Ω feedthrough termination.
4. Connect the other end of the output cable to the SCOPE connector of the Calibrator.
5. Set the Calibrator to output 5.000 V, dc (**OUT VAL** softkey), and time limit =

60 s (**T LIMIT** softkey).

6. Push OPR on the Calibrator and make sure the OPR timer display increments.
7. Remove the 50 Ω feedthrough termination before 60 seconds and make sure the Calibrator goes to standby (**STBY**).
8. Replace the 50 Ω feedthrough termination on the end of the output cable.
9. Set the Calibrator output to 5.000 V, ac (**OUT VAL** softkey).
10. Push OPR on the Calibrator and make sure the OPR timer display increments.
11. Remove the 50 Ω feedthrough termination before 60 seconds and make sure the Calibrator goes to standby (**STBY**).

SC600 Hardware Adjustments

Hardware adjustments must be made to the leveled sine and edge functions each time the SC600 is repaired. This section contains the adjustment procedures and a test equipment list with recommended models that are necessary to do these adjustments. Equivalent models can be used if necessary.

Necessary Equipment

To do the hardware adjustments in this section, you must have:

- Standard adjustment tool to adjust 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)
- Output cable supplied with the SC600
- Spectrum Analyzer (Hewlett-Packard 8590A)

Note

The models shown in this list are recommended to get accurate results.

How to Adjust the Leveled Sine Wave Function

There are two adjustment procedures that you must do 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.

Equipment Setup

This procedure uses the spectrum analyzer. Before you start this procedure, make sure that the Calibrator is in leveled sine wave mode (the Levsine menu shows in the display), and set it to output 5.5 V p-p @ 600 MHz.

1. Push OPR.
2. Connect the equipment as shown in Figure 7-10.
3. Adjust the Spectrum Analyzer so that it shows one peak across its horizontal center line in the display. The far right of the peak is fixed at the far right of the center line, as shown in Figure 7-16.

How to Adjust the Leveled Sine Wave VCO Balance

To adjust leveled sine wave VCO balance:

Note

The equipment must be setup as described in the Equipment Setup section.

1. Set the Calibrator to 5.5 V @ 600 MHz.
2. Set the Spectrum Analyzer to:
   - Start frequency 10 MHz
   - Stop frequency: 800 MHz
   - Resolution bandwidth: 30 kHz
   - Video Bandwidth: 3 kHz
   - Reference level: 20 dBm

   The spectrum analyzer will show a spur at 153 MHz. See Figure 7-16 to identify the spur.
3. Turn R1 counterclockwise until the spur is at minimum amplitude.

Note

As you turn R1, the spur will move down the waveform in the display. Stop the adjustment with the spur is at minimum amplitude. If you adjust too far, the spur will disappear.

The signal is balanced between the VCOs and the adjustment is complete when the spur is at minimum amplitude.

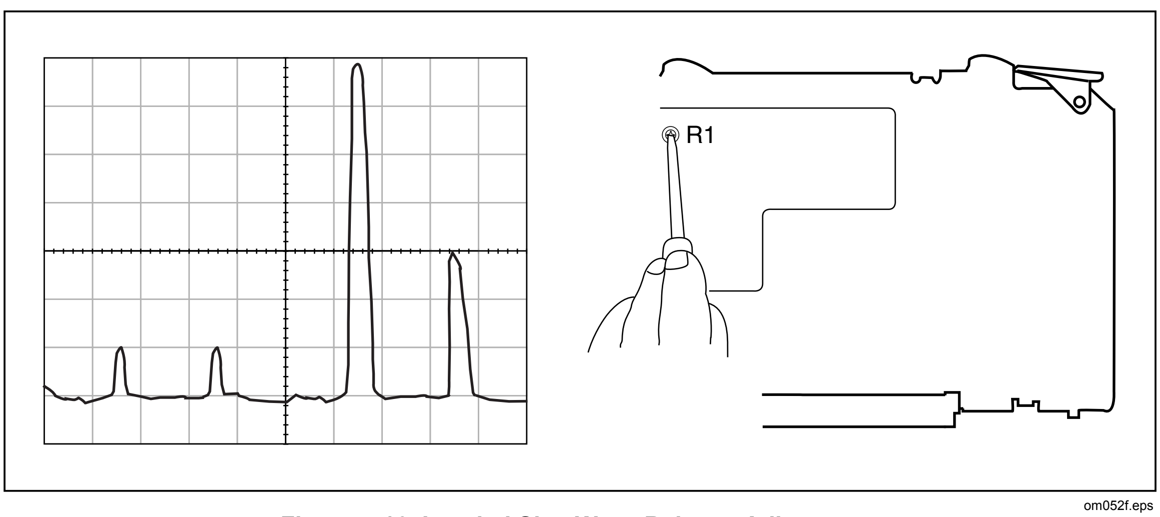


Figure 7-16. Leveled Sine Wave Balance Adjustment

How to Adjust the Leveled Sine Wave Harmonics

To adjust the leveled sine wave harmonics:

Note

The equipment must be setup as described in the “Equipment Setup” section.

1. Set the Calibrator to 5.5 V @ 600 MHz.

2. Set the Spectrum Analyzer to:
    - Start frequency 50 MHz
    - Stop frequency: 500 MHz
    - Resolution bandwidth: 3 MHz
    - Video Bandwidth: 3 kHz
    - Reference level: 20 dBm
3. Use the Peak Search function of the spectrum analyzer to find the reference signal. The spectrum analyzer will show the fundamental and second and third harmonics. The harmonics must be adjusted so that the second harmonic is at 40 dBc and the third harmonic is typically at 50 dBc as shown in Figure 7-17.
4. Adjust R8 until the peaks of the second and third harmonics are at the correct dB level.

Note

As you adjust, it is possible the second harmonic will be at 40 dBc but the third harmonic is not at 50 dBc. Continue to adjust R8. The second harmonic will change, but there is a point at which the harmonics will be at the correct decibel level.

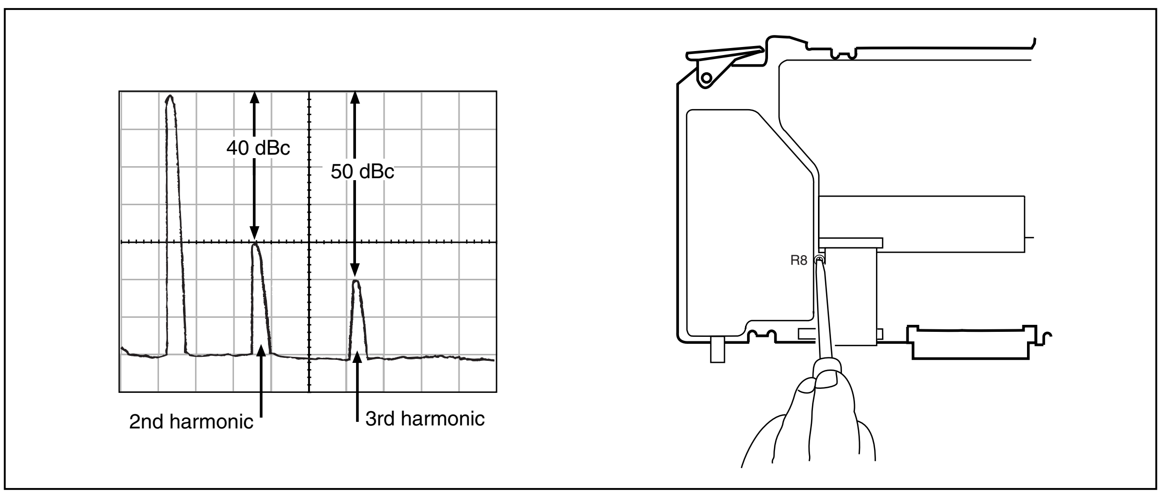


Figure 7-17. Leveled Sine Wave Harmonics Adjustment

How to Adjust the Aberrations for the Edge Function

You must do the adjustment procedure after you repair the edge function.

Note

To make sure the edge aberrations are set to national standards, you must send the Calibrator to Fluke, or other company that has traceability for aberrations. Fluke has a reference pulse that is sent to the National Institute of Standards and Technology (NIST) for characterization. This data is then sent to high speed sampling heads, which are used to adjust and verify the SC600.

Equipment Setup

This procedure uses:

- 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 an equivalent
- Output cable supplied with the SC600

Before you start the aberration adjustment procedure:

1. Connect the equipment as shown in Figure 7-8.
2. Set the Calibrator to SCOPE mode, with the Edge menu shown in the display.
3. Set the Calibrator to 1 V p-p @ 1 MHz.
4. Push OPR.
5. Set the DSO to:
   - Vertical scale: 10 mV/div
   - Horizontal scale: 1 ns/div
6. Set the DSO to show the 90 % point of the edge signal. Use this point as the reference level.
7. Set the DSO to show the first 10 ns of the edge signal with the rising edge at the left edge of the oscilloscope display.

How to Adjust the Edge Aberrations

See Figure 7-18 while you do the adjustment procedure.

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 subsequent 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 to occur between 2 ns and 10 ns to the reference level set above.
5. Adjust A90R36 and A90R35 again to get equal amplitudes for the first, second, and third aberrations.
6. Adjust A90R13 to set the edge signal to occur between 0 ns and 2 ns to the reference point set above. Put the aberrations in the center so the peaks are equal above and below the reference level.
7. Adjust A90R12 again if necessary to keep the edge signal to occur between 2 ns and 10 ns at the reference level.
8. Adjust A90R13 again if necessary to keep the edge signal to occur 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. Examine the aberrations.
10. Connect the 10 dB attenuator to the oscilloscope input. Connect the UUT to the attenuator and set the UUT output to 2.5 V.
11. Set the oscilloscope vertical to 5 mV/div. Examine the aberrations.

12. Make sure the rise time is <300 ps at 250 mV, 1 V, and 2.5 V outputs.

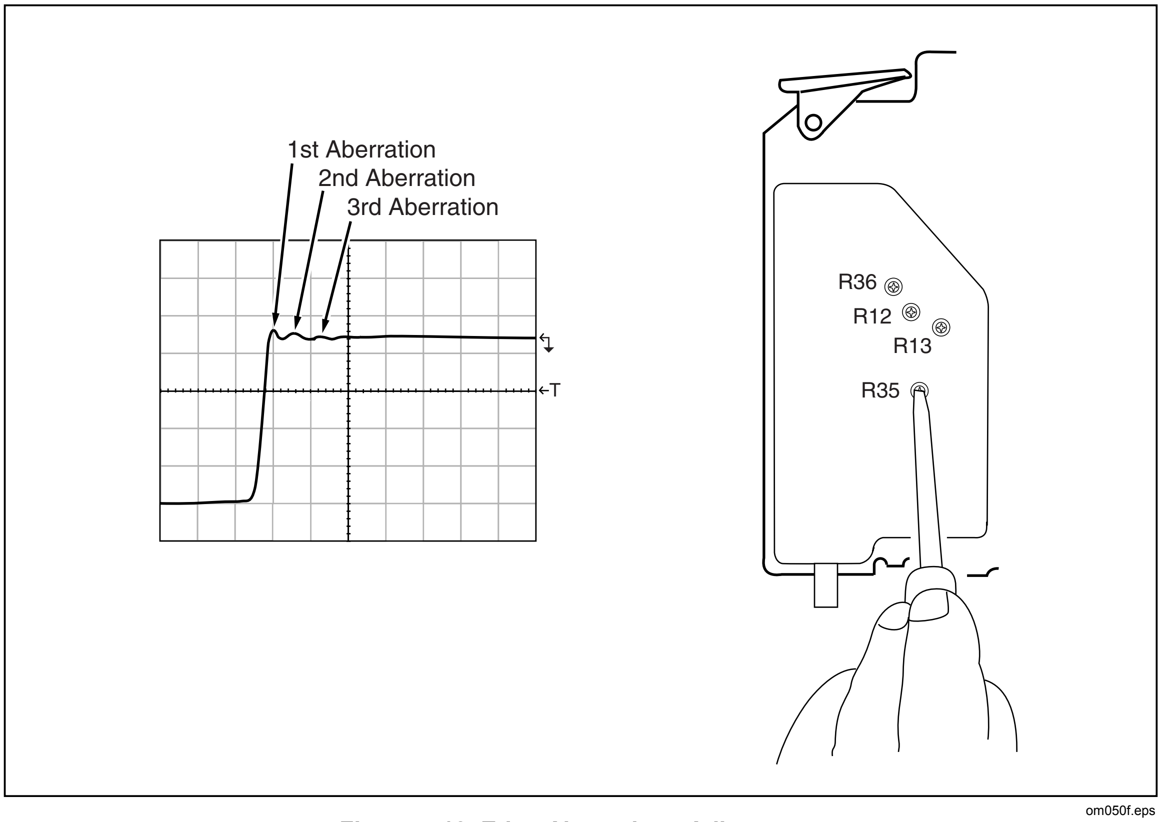


Figure 7-18. Edge Aberrations Adjustment