

**FLUKE®**

# **5520A**

PQ Option

## Service Manual

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# 5520A-PQ Option

## Introduction

This manual contains the following information and service procedures for the 5520A-PQ Option:

- Specifications
- Theory of operation
- Maintenance
- Verification procedures
- Calibration procedures

## 5520A-PQ Option Specifications

These specifications apply only to the PQ Option. General specifications that apply to the Calibrator can be found in Chapter 1 of the *5520A Service Manual*. The specifications are valid under the following conditions:

- The Calibrator is operated under the conditions specified in Chapter 1 of the *5520A Service Manual*.
- The Calibrator has completed a warm-up of at least twice the length of time the calibrator was powered off, up to a maximum of 30 minutes.

## Composite Harmonic Function Specifications

Table 1. Composite Harmonic Function Specifications

<b>Maximum Number of Harmonics in a User Defined Waveform</b>	15
<b>Specified Fundamental Frequencies</b>	15-65 Hz, 400 Hz <sup>1</sup>
<b>Highest Harmonic Frequency</b>	5 kHz <sup>2</sup>
<b>Harmonic Amplitude Resolution</b>	0.1 % of fundamental
<b>Harmonic Phase Range (relative to fundamental)</b>	0 to 360°
<b>Harmonic Phase Resolution</b>	0.1° relative to fundamental
<b>Pre-loaded Industry Waveforms</b>	IEC A, IEC D, NRC7030, NRC 2 to 5
<sup>1</sup> AC Voltage outputs $\geq 33$ V, and Current outputs $\geq 3$ A have low frequency limits of 45 Hz. Other fundamental frequencies within the output limits of the 5520A can be used, but are not specified.	
<sup>2</sup> Current outputs with LCOMP ON have lower limits, as shown in the AC Current table below. Voltage outputs $> 33$ V have a 2 kHz limit.	

## AC Voltage Specifications

### Note

All harmonic specifications below include the fundamental. For waveforms with no harmonics other than the fundamental, the RMS uncertainty is the same as the non-PQ mode of the 5520A.

Table 2. AC Voltage Specifications

Composite Waveform Ranges	Harmonic Frequency	Harmonic Amplitude Range (% of Fundamental) <sup>1</sup>	Harmonic Amplitude Uncertainty (% of Fundamental + V)	Harmonic Phase Uncertainty (Relative to Fundamental) <sup>2</sup>	Absolute RMS Uncertainty of Composite Waveform (% RMS + V)
1 mV to 32.999 mV	15 Hz to 45 Hz	0.1 to 100 %	0.1 % + 10 μV	0.5°	0.20 % + 6 μV
	45 Hz to 900 Hz	0.1 to 100 %	0.1 % + 10 μV	0.5°	
	900 Hz to 2 kHz	0.1 to 100 %	0.1 % + 10 μV	1 °	
	2 kHz to 5 kHz	0.1 to 100 %	0.1 % + 30 μV	3°	
33 mV to 329.99 mV	15 Hz to 45 Hz	0.1 to 100 %	0.1 % + 60 μV	0.5°	0.20 % + 10 μV
	45 Hz to 900 Hz	0.1 to 100 %	0.1 % + 60 μV	0.5°	
	900 Hz to 2 kHz	0.1 to 100 %	0.1 % + 60 μV	0.8°	
	2 kHz to 5 kHz	0.1 to 100 %	0.1 % + 60 μV	2°	
0.33 V to 3.2999 V	15 Hz to 45 Hz	0.1 to 100 %	0.1 % + 400 μV	0.5°	0.20 % + 100 μV
	45 Hz to 900 Hz	0.1 to 100 %	0.1 % + 400 μV	0.3°	
	900 Hz to 2 kHz	0.1 to 100 %	0.1 % + 400 μV	0.5°	
	2 kHz to 5 kHz	0.1 to 100 %	0.1 % + 400 μV	2°	
3.3 V to 32.999 V	15 Hz to 45 Hz	0.1 to 100 %	0.1 % + 4 mV	0.5°	0.20 % + 1 mV
	45 Hz to 900 Hz	0.1 to 100 %	0.1 % + 4 mV	0.3°	
	900 Hz to 2 kHz	0.1 to 100 %	0.1 % + 4 mV	0.5°	
	2 kHz to 5 kHz	0.1 to 100 %	0.1 % + 4 mV	2°	
33 V to 329.99 V	45 Hz to 440 Hz	0.1 to 100 %	0.2 % + 20 mV	0.75°	0.20 % + 10 mV
	440 Hz to 660 Hz	0.1 to 30 %	0.25 % + 20 mV	1.2°	
	660 to 1.2 kHz	0.1 to 10 %	0.35 % + 25 mV <sup>3</sup>	3°	
	1.2 kHz to 2 kHz	0.1 to 5 %	0.5 % + 40 mV <sup>4</sup>	5°	
330 V to 1020 V	45 Hz to 440 Hz	0.1 to 100 %	0.25 % + 100 mV	0.75°	0.20 % + 100 mV
	440 Hz to 660 Hz	0.1 to 30 %	0.25 % + 100 mV	1.2°	
	660 to 1.2 kHz	0.1 to 10 %	0.4 % + 100 mV <sup>5</sup>	3°	
	1.2 kHz to 2 kHz	0.1 to 5 %	0.6 % + 160 mV <sup>6</sup>	5°	

<sup>1</sup> All frequencies can have harmonics that are up to 100 % of the fundamental, but uncertainties are not specified unless otherwise indicated.

<sup>2</sup> For harmonics that are < 1 % of the Fundamental, phase uncertainty is typical.

<sup>3</sup> When harmonics of this frequency band are combined with harmonics 45 Hz to 660 Hz, all 45 Hz to 660 Hz harmonics have an uncertainty of 0.35 % + 25 mV.

<sup>4</sup> When harmonics of this frequency band are combined with harmonics 45 Hz to 1.2 kHz, all 45 Hz to 1.2 kHz harmonics have an uncertainty of 0.4 % + 25 mV.

<sup>5</sup> When harmonics of this frequency band are combined with harmonics 45 Hz to 660 Hz, all 45 Hz to 660 Hz harmonics have an uncertainty of 0.4 % + 100 mV.

<sup>6</sup> When harmonics of this frequency band are combined with harmonics 45 Hz to 1.2 kHz, all 45 Hz to 1.2 kHz harmonics have an uncertainty of 0.5 % + 100 mV.

### AC Voltage Auxiliary Specifications (Dual Output Mode Only)

**Table 3. AC Voltage Auxiliary Specifications (Dual Output Mode Only)**

Range, Composite Waveform	Harmonic Frequency	Harmonic Amplitude Range ( % of Fundamental)	Harmonic Amplitude Uncertainty (% of Fundamental + V)	Harmonic Phase Uncertainty (Relative to Fundamental) <sup>1</sup>	Absolute RMS Uncertainty of Composite Waveform (% RMS + V)
10 mV to 329.99 mV	15 Hz to 45 Hz	0.1 to 100 %	0.1 % + 100 μV	0.5°	0.2 % + 100 μV
	45 Hz to 1 kHz	0.1 to 100 %	0.1 % + 100 μV	1°	
	1 kHz to 2 kHz	0.1 to 50 %	0.1 % + 100 μV	3°	
	2 kHz to 5 kHz	0.1 to 30 %	0.1 % + 500 μV	6°	
.33V to 3.2999 V	15 Hz to 45 Hz	0.1 to 100 %	0.1 % + 1 mV	0.5°	0.2 % + 1 mV
	45 Hz to 1 kHz	0.1 to 100 %	0.1 % + 1 mV	0.75°	
	1 kHz to 2 kHz	0.1 to 50 %	0.1 % + 1 mV	2°	
	2 kHz to 5 kHz	0.1 to 30 %	0.1 % + 2 mV	3°	
3.3 V to 5 V	15 Hz to 45 Hz	0.1 to 100 %	0.2 % + 3 mV	0.5°	0.2 % + 2 mV
	45 Hz to 1 kHz	0.1 to 100 %	0.2 % + 3 mV	0.75°	
	1 kHz to 2 kHz	0.1 to 50 %	0.2 % + 3 mV	2°	
	2 kHz to 5 kHz	0.1 to 30 %	0.3 % + 3 mV	3°	

<sup>1</sup> For harmonics that are < 1 % of the Fundamental, phase uncertainty is typical.

### AC Current Specifications, LCOMP OFF

**Table 4. AC Current Specifications, LCOMP OFF**

Range, Composite Waveform	Harmonic Frequency	Harmonic Amplitude Range ( % of Fundamental) <sup>1</sup>	Harmonic Amplitude Uncertainty (% of Fundamental + A)	Harmonic Phase Uncertainty (Relative to Fundamental) <sup>2</sup>	Absolute RMS Uncertainty of Composite Waveform (% RMS + A)
29 μA to 329.9 μA	15 Hz to 45 Hz	0.1 to 100 %	0.1 % + 0.1 μA	0.5°	0.2 % + 0.1 μA
	45 Hz to 900 Hz	0.1 to 100 %	0.1 % + 0.1 μA	2°	
	900 Hz to 2 kHz	0.1 to 50 %	0.1 % + 0.1 μA	3°	
	2 kHz to 5 kHz	0.1 to 30 %	0.1 % + 0.13 μA	6°	
0.33 mA to 3.299 mA	15 Hz to 45 Hz	0.1 to 100 %	0.1 % + 1 μA	0.5°	0.2 % + 1 μA
	45 Hz to 900 Hz	0.1 to 100 %	0.1 % + 1 μA	0.6°	
	900 Hz to 2 kHz	0.1 to 50 %	0.1 % + 1 μA	0.75°	
	2 kHz to 5 kHz	0.1 to 30 %	0.1 % + 1.3 μA	2°	
3.3 mA to 32.99 mA	15 Hz to 45 Hz	0.1 to 100 %	0.1 % + 10 μA	0.5°	0.2 % + 10 μA
	45 Hz to 900 Hz	0.1 to 50 %	0.1 % + 10 μA	0.6°	
	900 Hz to 2 kHz	0.1 to 30 %	0.1 % + 10 μA	0.75°	
	2 kHz to 5 kHz	0.1 to 100 %	0.1 % + 13 μA	2°	
33 mA to 329.9 mA	15 Hz to 45 Hz	0.1 to 100 %	0.1 % + 100 μA	0.5°	0.2 % + 100 μA
	45 Hz to 900 Hz	0.1 to 100 %	0.1 % + 100 μA	0.75°	
	900 Hz to 2 kHz	0.1 to 50 %	0.1 % + 100 μA	1.5°	
	2 kHz to 5 kHz	0.1 to 30 %	0.1 % + 130 μA	3°	

<sup>1</sup> All frequencies can have harmonics up to 100 % of the fundamental; uncertainties are not specified unless otherwise indicated.

<sup>2</sup> For harmonics that are < 1 % of the Fundamental, phase uncertainty is typical.

Table 4. AC Current Specifications, LCOMP OFF (continued)

Range, Composite Waveform	Harmonic Frequency	Harmonic Amplitude Range (% of Fundamental) <sup>1</sup>	Harmonic Amplitude Uncertainty (% of Fundamental + A)	Harmonic Phase Uncertainty (Relative to Fundamental) <sup>2</sup>	Absolute RMS Uncertainty of Composite Waveform (% RMS + A)
0.33A to 2.999 A	15 Hz to 45 Hz	0.1 to 100 %	0.1 % + 1 mA	0.5°	0.2 % + 1 mA
	45 Hz to 900 Hz	0.1 to 100 %	0.1 % + 1 mA	0.6°	
	900 Hz to 2 kHz	0.1 to 20 %	0.1 % + 1 mA	1°	
	2 kHz to 5 kHz	0.1 to 20 %	0.2 % + 1.3 mA	2°	
3A to 20.5A	15 Hz to 45 Hz	0.1 to 100 %	0.1 % + 10 mA	0.5°	0.2 % + 10 mA
	45 Hz to 900 Hz	0.1 to 100 %	0.1 % + 10 mA	0.6°	
	900 Hz to 2 kHz	0.1 to 20 %	0.1 % + 10 mA	1°	
	2 kHz to 5 kHz	0.1 to 20 %	0.2 % + 10 mA	3°	

<sup>1</sup> All frequencies can have harmonics up to 100 % of the fundamental; uncertainties are not specified unless otherwise indicated.

<sup>2</sup> For harmonics that are < 1 % of the Fundamental, phase uncertainty is typical.

**AC Current Specifications, LCOMP ON**

Table 5. AC Current Specifications, LCOMP ON\*

Range, Composite Waveform	Harmonic Frequency	Harmonic Amplitude Range (% of Fundamental) <sup>1</sup>	Harmonic Amplitude Uncertainty (% of Fundamental + A)	Harmonic Phase Uncertainty (Relative to Fundamental) <sup>2</sup>	Absolute RMS Uncertainty of Composite Waveform (% RMS + A)
29 µA to 329.99 µA	15 Hz to 65 Hz	0.1 to 30 %	0.5 % + 0.1 µA	0.5°	0.5 % + 1 µA
	65 Hz to 900 Hz	0.1 to 30 %	1.0 % + 0.1 µA	2°	
0.33 mA to 3.2999 mA	15 Hz to 65 Hz	0.1 to 30 %	0.5 % + 1 µA	0.5°	0.5 % + 1 µA
	65 Hz to 900 Hz	0.1 to 30 %	1.0 % + 1 µA	1°	
3.3 mA to 32.999 mA	15 Hz to 65 Hz	0.1 to 30 %	0.4 % + 10 µA	0.5°	0.5 % + 10 µA
	65 Hz to 900 Hz	0.1 to 30 %	0.6 % + 10 µA	1°	
33 mA to 329.9 mA	15 Hz to 65 Hz	0.1 to 30 %	0.4 % + 100 µA	0.5°	0.5 % + 100 µA
	65 Hz to 900 Hz	0.1 to 30 %	0.6 % + 100 µA	1°	
0.33 A to 2.999 A	15 Hz to 65 Hz	0.1 to 30 %	0.5 % + 1 mA	0.75°	0.5 % + 1 mA
	65 Hz to 440 Hz	0.1 to 30 %	1.0 % + 1 mA	1°	
3 A to 20.5 A	15 Hz to 65 Hz	0.1 to 30 %	0.5 % + 10 mA	0.75°	0.75 % + 10 mA
	65 Hz to 440 Hz	0.1 to 30 %	1.0 % + 10 mA	1°	

\* LCOMP ON is used to drive inductive loads like the 5500A/COIL and current clamps.

<sup>1</sup> All frequencies can have harmonics up to 100 % of the fundamental; uncertainties are not specified unless otherwise indicated.

<sup>2</sup> For harmonics that are < 1 % of the Fundamental, phase uncertainty is typical.

## Flicker Simulation Mode

**Table 6. Flicker Simulation Mode**

<b>Voltage Range</b>	1 mV to 1020V	
<b>Current Range</b>	29 $\mu$ A to 20.5A	
<b>Frequency of Fundamental</b>	50 and 60 Hz	
<b>Amplitude Modulation Range</b>	$\pm 100$ %	
<b>Frequency of Modulation</b>	0.1 Hz to 40 Hz	
<b>Type of Modulation</b>	Square or Sine	
<b>Short Term (10 minute) uncertainty of amplitude modulation</b>	$\pm 0.1$ % of nominal output + 0.05% of range	
<b>Flicker Modulation Timing Uncertainty</b>	$\pm 0.1$ ms	
<b>Settings for <math>P_{st} = 1</math></b>	Voltage Changes $\Delta V/V$ % <sup>1</sup>	
<b>Changes per minute:</b>	120V, 60 Hz	230V, 50 Hz
1 chg/min	3.166 %	2.724 %
2 chg/min	2.568 %	2.211 %
7 chg/min	1.695 %	1.459 %
39 chg/min	1.044 %	0.906 %
110 chg/min	0.841 %	0.725 %
1620 chg/min	0.547 %	0.402 %
4000 chg/min	N/A	2.40 %
4800 chg/min	3.920 %	N/A
<b>Trigger Event</b>	2 <sup>nd</sup> Push of OPER key, or Remote Command	
<sup>1</sup> Values shown are nominal values per IEC 61000-4-15. The 5520A-PQ has a limited resolution of 0.02 % in the Flicker Simulation Mode.		

## Sags & Swells Simulation Mode

**Table 7. Sags & Swells Simulation Mode**

<b>Voltage Range</b>	1 mV to 1020V
<b>Current Range</b>	29 $\mu$ A to 20.5A
<b>Frequency of Fundamental</b>	45 to 65 Hz
<b>Amplitude Modulation Range</b>	$\pm 100$ %
<b>Ramp-Up Time</b>	0.01 to 1 second
<b>Duration of Sag or Swell</b>	0.032 to 60 seconds
<b>Trigger Event</b>	2 <sup>nd</sup> Push of OPER key, or Remote Command

## Phase Specifications, Sinewave Outputs

The 5520A-PQ option has improved phase uncertainty in the normal, non-PQ, dual outputs as shown below. (See the 5520A specifications for all other output combinations.)

**Table 8. Phase Specifications, Sinewave Outputs**

Output Combinations, 45 Hz to 65 Hz			1-Year Absolute Uncertainty
<b>AC Voltage</b>	<b>AC Voltage (Auxiliary)</b>	<b>AC Current (LCOMP OFF)</b>	0.07°
0.65 V to 3.29999 V	0.65 V to 3.29999 V	6.5 mA to 32.999 mA	
6.5 V to 32.9999 V		65 mA to 329.99 mA	
65 V 329.9999 V		0.65 A to 10.9999 A	

## Nominal Amplitude and Phase Values for Preinstalled Composite Harmonic Waves

### Note

The IEC waves (IEC A and IEC D) are waveforms referred to by the International Electrotechnical Commission (IEC) in IEC 61000-3-2, Limits for Harmonic Current Emissions. The Fluke Corporation implementation is based on formulas provided by the National Physical Laboratory (NPL) in the United Kingdom.

The NRC waves (NRC7030, NRC 2, NRC 3, NRC 4, and NRC 5) are based on "A Calibration System for Evaluating the Performance of Harmonic Power Analyzers" and "An Efficient Test Method for Harmonic Measurement Equipment" authored by Rejean Arseneau and Dr. Peter Filipiski of the National Research Council of Canada, (NRC) Institute for National Measurement Standards, Ottawa, Ontario, K1A 0R8, Canada.

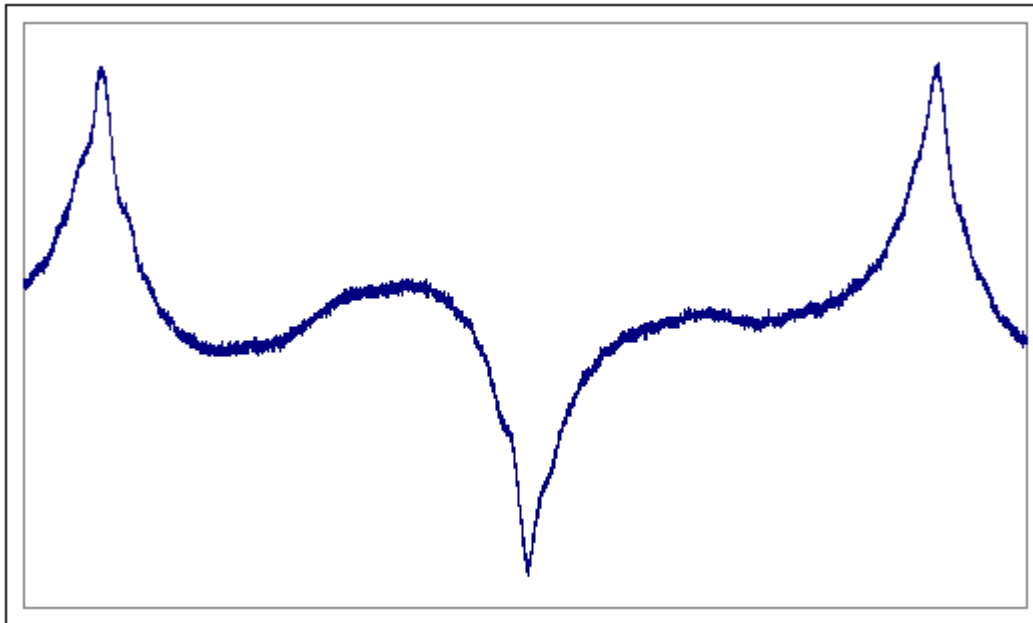
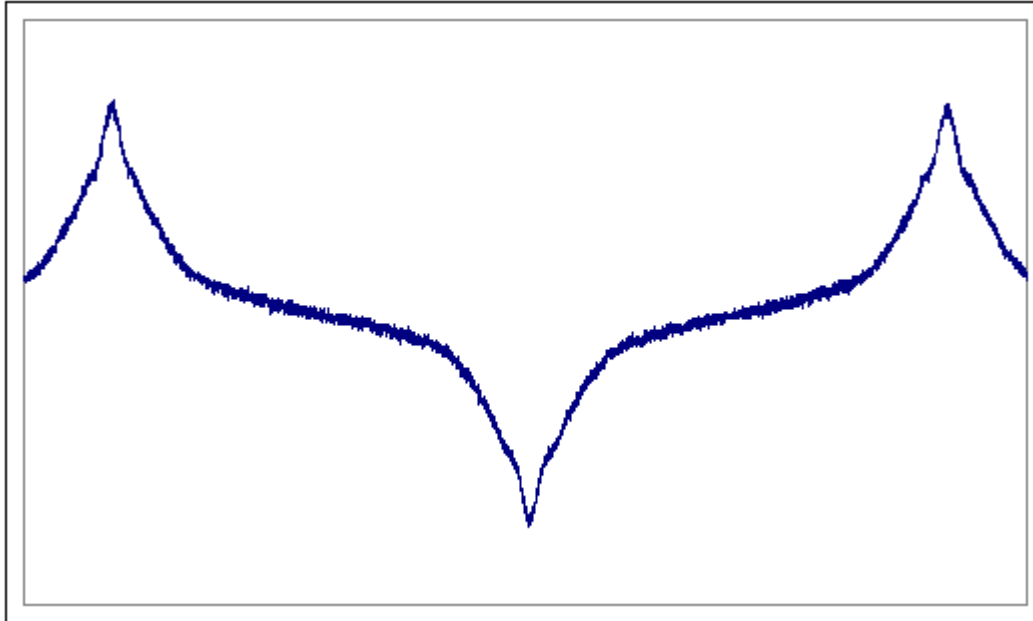


Figure 1. Preinstalled IEC A Composite Harmonic Waveform

nn370f.bmp

**Table 9. Nominal Amplitude and Phase Values for Preinstalled IEC A Composite Harmonic Waves**

<b>Wave</b>	<b>Harmonic</b>	<b>% of Fundamental</b>	<b>Phase</b>
IEC A	1st	100.0 %	0°
	2nd	47.00 %	0°
	3rd	100.00 %	180.0°
	4th	18.70 %	180.0°
	5th	49.60 %	0°
	6th	13.00 %	0°
	7th	33.50 %	180.0°
	8th	10.00 %	180.0°
	9th	17.40 %	0°
	10th	8.00 %	0°
	11th	14.30 %	180.0°
	12th	6.67 %	180.0°
	13th	9.13 %	0°
	14th	5.71 %	0°
	15th	6.52 %	180.0°
	16th	5.00 %	180.0°
	17th	5.75 %	0°
	18th	4.44 %	0°
	19th	5.15 %	180.0°
	20th	4.00 %	180.0°
	21st	4.66 %	0°
	22nd	3.64 %	0°
	23rd	4.25 %	180.0°
	24th	3.33 %	180.0°
	25th	3.91 %	0°
	26th	3.08 %	0°
	27th	3.62 %	180.0°
	28th	2.86 %	180.0°
	29th	3.37 %	0°
	30th	2.67 %	0°
	31st	3.16 %	180.0°
	32nd	2.50 %	180.0°
	33rd	2.96 %	0°
	34th	2.35 %	0°
	35th	2.80 %	180.0°
	36th	2.22 %	180.0°
	37th	2.64 %	0°
	38th	2.11 %	0°
	39th	2.51 %	180.0°
	40th	2.00 %	180.0°



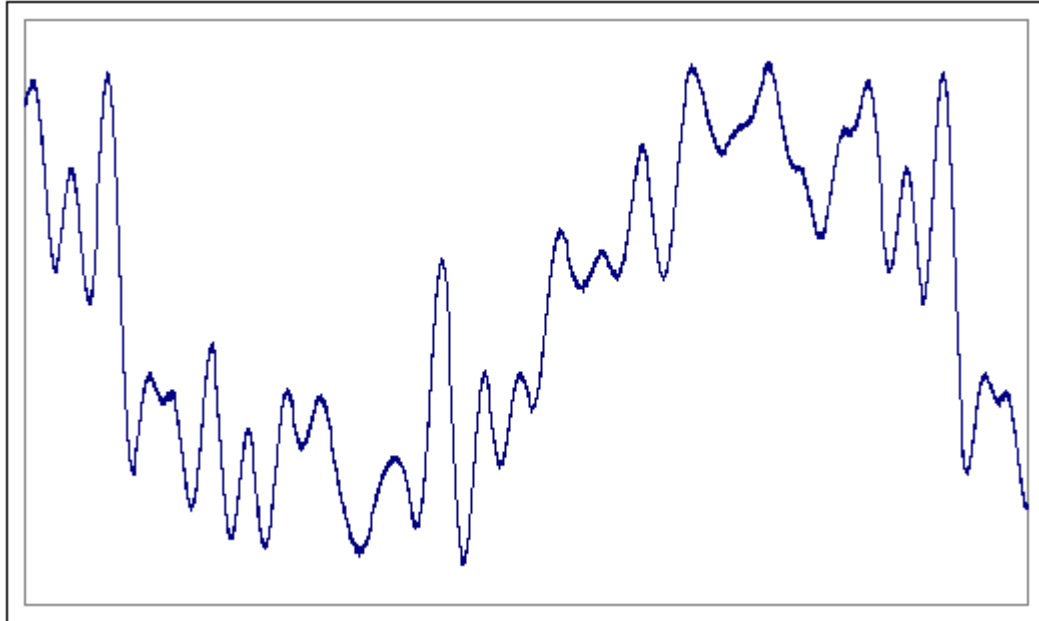
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Figure 2. Preinstalled IEC D Composite Harmonic Waveform

Table 10. Nominal Amplitude and Phase Values for Preinstalled Composite IEC D Harmonic Waves

Wave	Harmonic	% of Fundamental	Phase
IECD	1st	100.0 %	0°
	3rd	46.90 %	180.0°
	5th	26.20 %	0°
	7th	13.80 %	180.0°
	9th	6.90 %	0°
	11th	4.83 %	180.0°
	13th	4.09 %	0°
	15th	3.54 %	180.0°
	17th	3.13 %	0°
	19th	2.80 %	180.0°
	21st	2.53 %	0°
	23rd	2.31 %	180.0°
	25th	2.13 %	0°
	27th	1.97 %	180.0°
	29th	1.83 %	0°
	31st	1.71 %	180.0°
	33rd	1.61 %	0°
	35th	1.52 %	180.0°
	37th	1.44 %	0°
39th	1.36 %	180.0°	





nn376f.bmp

Figure 3. Preinstalled NRC7030 Composite Harmonic Wave

Table 11. Nominal Amplitude and Phase Values for Preinstalled NRC7030 Composite Harmonic Waves

Wave	Harmonic	% of Fundamental	Phase
NRC7030	1st	100.0 %	0°
	2nd	10.0 %	-115.5°
	3rd	10.0 %	1.1°
	4th	10.0 %	-179.6°
	5th	10.0 %	13.3°
	6th	10.0 %	9.3°
	7th	10.0 %	73.5°
	8th	10.0 %	152.1°
	9th	10.0 %	-19.9°
	10th	10.0 %	-167.8°
	11th	10.0 %	85.9°
	12th	10.0 %	-37.3°
	13th	10.0 %	16.1°
	14th	10.0 %	-28.1°
	15th	10.0 %	94.0°
	16th	10.0 %	-173.4°
	17th	10.0 %	129.5°
	18th	10.0 %	-113.9°
	19th	10.0 %	37.6°
	20th	10.0 %	-52.3°
	21st	10.0 %	1.5°
	22nd	10.0 %	14.3°
	23rd	10.0 %	150.2°
	24th	10.0 %	7.1°
	25th	10.0 %	161.3°

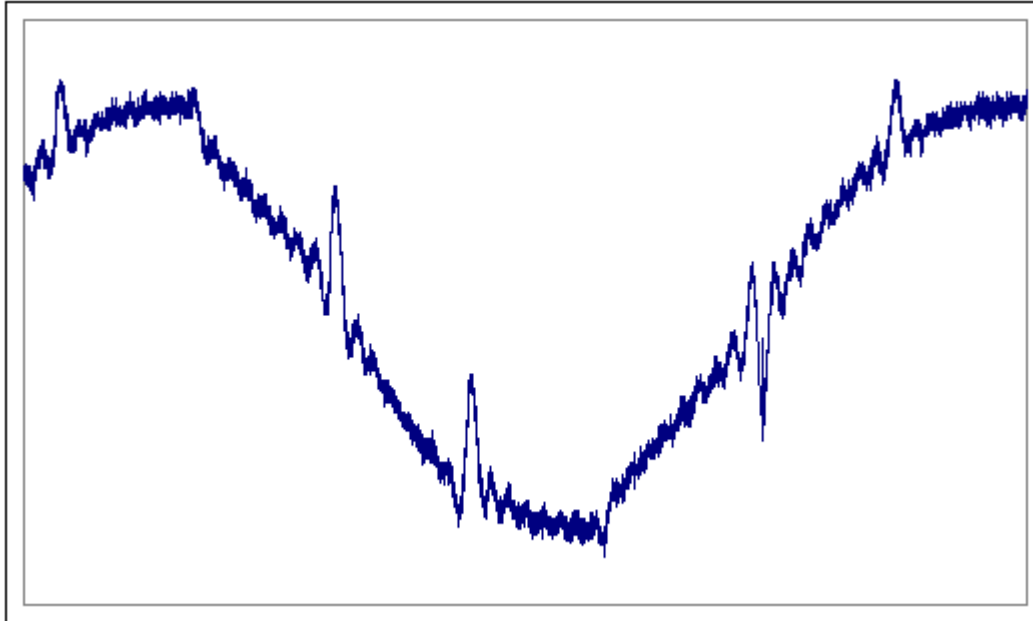


Figure 4. Preinstalled NRC2 Waveform

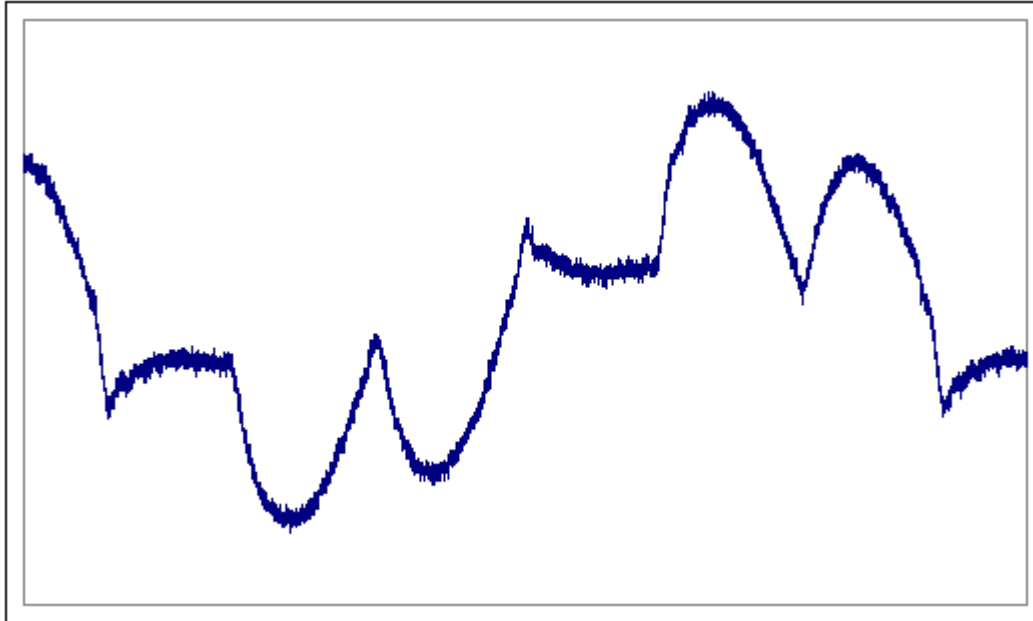
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Table 12. Nominal Amplitude and Phase Values for Preinstalled NRC2 Composite Harmonic Waves

Wave	Harmonic	% of Fundamental	Phase
NRC2	1st	100.0 %	0°
	2nd	1.22 %	-139.1°
	3rd	2.12 %	-150.3°
	4th	2.53 %	-159.0°
	5th	6.04 %	-75.5°
	6th	2.46 %	115.8°
	7th	1.53 %	-47.5°
	8th	0.54 %	-39.2°
	9th	1.77 %	-125.0°
	10th	2.22 %	-143.6°
	11th	2.68 %	-59.6°
	12th	2.72 %	139.9°
	13th	1.28 %	-76.3°
	14th	0.36 %	3.7°
	15th	2.03 %	-112.1°
	16th	2.05 %	-128.3°
	17th	1.53 %	-36.8°
	18th	3.02 %	167.4°
	19th	1.69 %	-62.1°
	20th	0.33 %	137.6°
	21st	2.35 %	-101.2°
	22nd	1.89 %	-120.9°

**Table 12. Nominal Amplitude and Phase Values for Preinstalled NRC2 Composite Harmonic Waves  
(continued)**

Wave	Harmonic	% of Fundamental	Phase
NRC2	23rd	0.68 %	-18.5°
	24th	3.31 %	-169.3°
	25th	1.66 %	-43.2°
	26th	1.01 %	172.7°
	27th	2.49 %	-89.3°
	28th	1.66 %	-120.3°
	29th	0.16 %	-157.6°
	30th	3.47 %	-150.0°
	31st	1.33 %	-22.7°
	32nd	1.62 %	-168.9°
	33rd	2.42 %	-74.3°
	34th	1.46 %	-124.8°
	35th	0.78 %	-158.8°
	36th	3.44 %	-128.8°
	37th	0.90 %	20.1°
	38th	2.12 %	-145.2°
	39th	2.31 %	-53.0°
	40th	1.70 %	-125.5°
	41st	1.40 %	-134.9°
	42nd	3.54 %	-113.5°
43rd	0.92 %	73.6°	
44th	2.78 %	-130.3°	
45th	2.12 %	-36.4°	
46th	2.25 %	-128.8°	
47th	1.80 %	-124.7°	
48th	3.25 %	-102.8°	
49th	1.13 %	122.2°	



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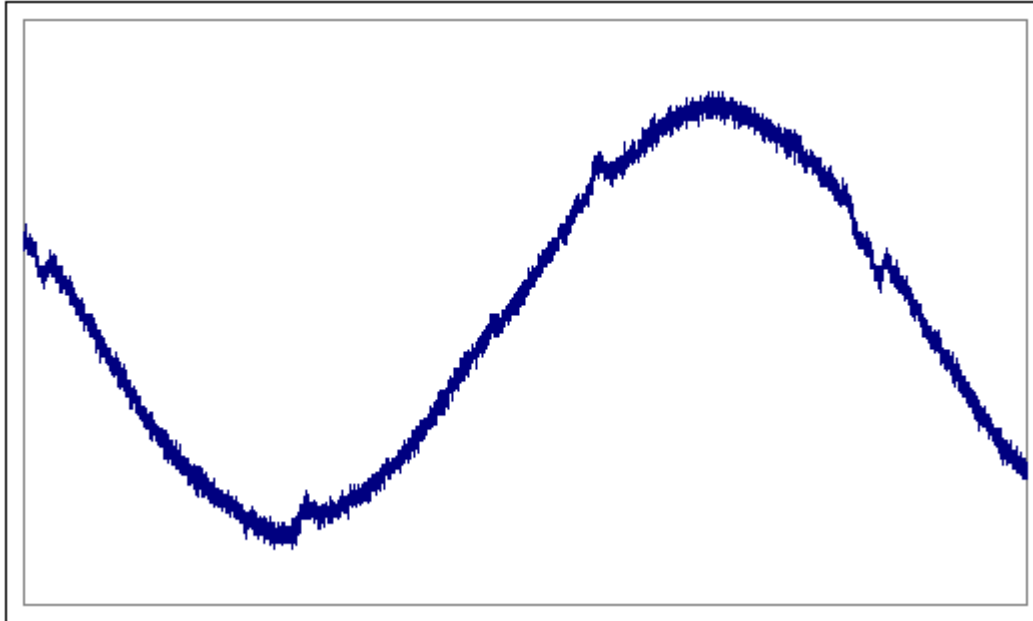
Figure 5. Preinstalled NRC3 Composite Harmonic Waveform

Table 13. Nominal Amplitude and Phase Values for Preinstalled NRC3 Composite Harmonic Waves

Wave	Harmonic	% of Fundamental	Phase
NRC3	1st	100.0 %	0°
	2nd	1.40 %	-146.6°
	3rd	1.32 %	-166.6°
	4th	4.62 %	106.8°
	5th	44.20 %	77.3°
	6th	4.20 %	-121.4°
	7th	7.96 %	-156.8°
	8th	0.74 %	-40.8°
	9th	0.18 %	177.6°
	10th	1.95 %	131.9°
	11th	10.40 %	103.6°
	12th	2.30 %	-88.1°
	13th	1.51 %	-125.3°
	14th	0.50 %	-49.9°
	15th	0.34 %	-127.5°
	16th	1.47 %	154.6°
	17th	4.86 %	134.3°
	18th	1.41 %	-52.6°
	19th	0.27 %	-177.4°
	20th	0.53 %	-34.9°

**Table 13. Nominal Amplitude and Phase Values for Preinstalled NRC3 Composite Harmonic Waves  
(continued)**

Wave	Harmonic	% of Fundamental	Phase
NRC3	21st	0.17 %	-146.7°
	22nd	1.21 %	-177.6°
	23rd	2.69 %	163.3°
	24th	0.90 %	-15.6°
	25th	0.52 %	160.4°
	26th	0.49 %	-15.4°
	27th	0.34 %	-158.6°
	28th	0.98 %	-153.9°
	29th	1.80 %	-169.7°
	30th	0.69 %	28.7°
	31st	0.68 %	176.9°
	32nd	0.54 %	9.5°
	33rd	0.39 %	-146.5°
	34th	0.79 %	-121.2°
	35th	1.22 %	-141.3°
	36th	0.50 %	73.1°
	37th	0.70 %	-157.2°
	38th	0.52 %	35.0°
	39th	0.49 %	-122.7°
	40th	0.63 %	-89.4°
	41st	0.94 %	-117.4°
	42nd	0.48 %	126.6°
	43rd	0.66 %	-126.4°
	44th	0.55 %	69.6°
	45th	0.57 %	-100.5°
	46th	0.49 %	-50.4°
	47th	0.74 %	-94.3°
	48th	0.48 %	168.0°
	49th	0.64 %	-95.5°



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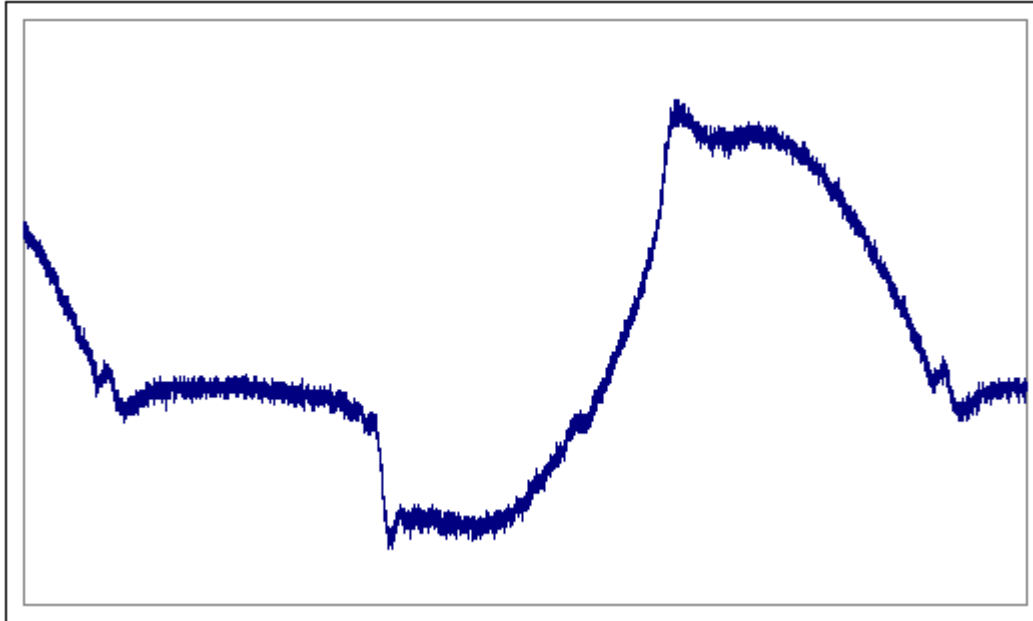
Figure 6. Preinstalled NRC4 Composite Harmonic Waveform

Table 14. Nominal Amplitude and Phase Values for Preinstalled NRC4 Composite Harmonic Waves

Wave	Harmonic	% of Fundamental	Phase
NRC4	1st	100.0 %	0°
	2nd	2.39 %	-164.6°
	3rd	0.78 %	-143.7°
	4th	0.49 %	-55.0°
	5th	0.78 %	-177.3°
	6th	0.70 %	-176.2°
	7th	1.92 %	-144.9°
	8th	1.00 %	81.5°
	9th	0.22 %	119.7°
	10th	0.84 %	123.9°
	11th	1.07 %	-39.8°
	12th	0.20 %	-113.8°
	13th	0.55 %	-16.5°
	14th	1.18 %	-160.1°
	15th	0.18 %	-159.9°
	16th	0.54 %	-132.4°
	17th	0.94 %	82.5°
	18th	0.08 %	172.7°

**Table 14. Nominal Amplitude and Phase Values for Preinstalled NRC4 Composite Harmonic Waves  
(continued)**

Wave	Harmonic	% of Fundamental	Phase
NRC4	19th	0.21 %	139.5°
	20th	0.71 %	-40.6°
	21st	0.02 %	-83.0°
	22nd	0.12 %	-113.8°
	23rd	0.65 %	-153.6°
	24th	0.14 %	-112.3°
	25th	0.11 %	108.3°
	26th	0.39 %	94.8°
	27th	0.08 %	174.1°
	28th	0.28 %	-46.1°
	29th	0.25 %	-40.5°
	30th	0.04 %	-5.7°
	31st	0.44 %	-146.1°
	32nd	0.22 %	-155.8°
	33rd	0.13 %	-105.7°
	34th	0.39 %	107.0°
	35th	0.05 %	30.1°
	36th	0.06 %	-167.6°
	37th	0.48 %	-20.9°
	38th	0.18 %	-117.4°
	39th	0.04 %	24.6°
	40th	0.55 %	-125.4°
	41st	0.21 %	121.3°
	42nd	0.10 %	-85.1°
	43rd	0.50 %	130.6°
	44th	0.27 %	-8.1°
	45th	0.10 %	-146.4°
	46th	0.49 %	5.9°
	47th	0.41 %	-110.6°
	48th	0.02 %	-50.0°
	49th	0.53 %	-97.3°



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Figure 7. Preinstalled NRC5 Composite Harmonic Waveform

Table 15. Nominal Amplitude and Phase Values for Preinstalled NRC5 Composite Harmonic Waves

Wave	Harmonic	% of Fundamental	Phase
NRC5	1st	100.00 %	0°
	2nd	57.40 %	-33.2°
	3rd	0.92 %	174.3°
	4th	6.00 %	-82.5°
	5th	11.30 %	-115.9°
	6th	1.07 %	-170.6°
	7th	5.91 %	159.0°
	8th	6.58 %	150.2°
	9th	0.29 %	176.4°
	10th	3.69 %	38.3°
	11th	3.13 %	44.0°
	12th	0.39 %	-79.1°
	13th	3.46 %	-76.5°
	14th	1.99 %	-62.4°
	15th	0.38 %	-149.3°
	16th	2.88 %	-178.0°
	17th	1.39 %	-141.7°
	18th	0.12 %	151.8°
	19th	2.08 %	72.7°
	20th	0.94 %	144.6°
	21st	0.27 %	-54.4°
	22nd	1.95 %	-36.5°
	23rd	0.71 %	39.4°
	24th	0.34 %	-132.3°
	25th	1.71 %	-131.5°
	26th	0.89 %	-56.7°



**Table 15. Nominal Amplitude and Phase Values for Preinstalled NRC5 Composite Harmonic Waves  
(continued)**

<b>Wave</b>	<b>Harmonic</b>	<b>% of Fundamental</b>	<b>Phase</b>
NRC5	27th	0.16 %	137.1°
	28th	1.30 %	132.0°
	29th	0.91 %	-140.7°
	30th	0.20 %	-35.0°
	31st	1.18 %	24.6°
	32nd	0.63 %	123.0°
	33rd	0.26 %	-106.4°
	34th	1.18 %	-69.4°
	35th	0.64 %	14.5°
	36th	0.11 %	171.9°
	37th	1.00 %	-159.3°
	38th	0.79 %	-75.3°
	39th	0.11 %	-33.4°
	40th	0.81 %	95.1°
	41st	0.67 %	-151.5°
	42nd	0.23 %	-77.2°
	43rd	0.90 %	-9.2°
	44th	0.54 %	103.1°
	45th	0.15 %	-172.2°
	46th	0.81 %	-100.8°
47th	0.69 %	1.4°	
48th	0.07 %	79.0°	
49th	0.69 %	163.8°	

## **Theory of Operation**

The 5520A-PQ is different from a standard 5520A as it uses an updated DDS Assembly (A6), Main CPU Assembly (A9), and outguard firmware version 3.0 or greater. This section provides an overview of the changes made to the DDS Assembly and the Main CPU.

### **DDS Assembly (A6)**

The 5520A-PQ uses the 5520A-PQ-7606 A6 PCA, P/N 1577331, as the DDS assembly. It utilizes 12-bit DACs (Digital to Analog converter) for both the voltage and current channels. A modified dual-channel DDS (Direct Digital Synthesis) chip is used to generate the Composite Harmonics and Delta Amplitude functions. Output accuracy of the Composite Harmonics is achieved with feedback through a precision ac converter. In the Composite Harmonics mode, the phase monitors normally used for simultaneous sinusoidal outputs are turned off.


The Delta Amplitude mode amplitude accuracy is dependent upon the performance of the voltage and current digital to analog converters (DACs). For that reason, a separate calibration adjustment is required for the PQ option, as described in the Maintenance section.

This DDS assembly can also be used in a standard 5520A with outguard firmware version 3.0 or greater.

### **Main CPU Assembly (A9)**

For the 5520A-PQ, the Main CPU assembly has additional RAM chips, U32 and U33. Depending upon serial number, standard 5520As may also have these additional RAM chips installed. The PQ option must have the additional RAM chips to function.

## **Maintenance**

There are no maintenance techniques or diagnostic remote commands for the PQ Option that are available to the user. If the PQ Option is installed, the two PQ sofkeys will appear when  is pressed. If the option is not installed, only the pressure softkey will be shown.

## **Equipment Required for Calibration and Verification**

Table 16 lists the equipment, recommended models, and minimum specifications required for each calibration and verification procedure.

**Table 16. 5520A -PQ Option Calibration and Verification Equipment**

<b>Instrument</b>	<b>Model</b>	<b>Minimum Use Specifications</b>
Digital Multimeter	HP 3458A	RMS measurements 300 $\mu$ A to 300 mA, 60 Hz. 0.1% uncertainty or better.
2 A and 20 A Shunt	Fluke Y5020 (or Measure Tech EL 7520) or Fluke A40 2A and 20A	RMS measurements of 2 A and 10 A, 60 Hz. 0.1% uncertainty or better
Harmonic Analyzer	LEM Norma D6000 with option 61E1 Harmonic Analyzer and plug-ins 61I1, 61U1, & 61U2, & 30mA-10A triaxial shunt	RMS measurement to 600 V, 10 A. Capability to measure harmonic amplitude and phase up to the 63 <sup>rd</sup> . Note: Option 61E1 is used for making optional PST measurements.
AC Measurement Standard	Fluke 5790A	RMS measurement from 30 mV to 1000 V, 60 Hz. 0.05% uncertainty or better.

## Performance Verification Tests

The following tests are used to verify the performance of the 5520A-PQ option. They should be performed after major instrument repair, and are optional tests after routine calibration. If an out-of-tolerance condition is found in the Composite Harmonics section, the instrument mainframe can be re-calibrated using the procedure described in the 5520A Service Manual. If an out-of-tolerance condition is found in the Delta Amplitude section, the PQ option can be re-calibrated as described in the Calibration section of this manual.

As stated, the Composite Harmonics tests are optional after routine calibration. The instrument required to perform these tests is a complex waveform analyzer similar to the LEM Norma D6000 with option 61E1 Harmonic Analyzer and plug-ins 61I1, 61U1, & 61U2, and the 30mA-10A triaxial shunt. The state-of-the-art performance of the 5520A-PQ does not always allow appropriate test uncertainty ratios (TURs) for all tests, without first characterizing the Norma D6000. You should therefore treat these tests as functional in nature unless your facility has the capability to support the measurement uncertainties required. An alternative, of course, is to send the instrument to a Fluke Service Center.

## Delta Amplitude Verification

The “Delta Amplitude” outputs of the 5520A-PQ are first checked in the static condition with either the Fluke 5790A or Hewlett Packard 3458A. Connect the measuring device to the Normal output terminals of the 5520A-PQ. In the Delta Amplitude mode, output the following values as shown in the table below. Be certain the Delta Amplitude setting is set to 0%. Refer to the following table.

**Table 17. Delta Amplitude Verification, Static Condition**

Output Amplitude	Frequency	Specification (V)
30V	60Hz	0.06
300V	50Hz	0.6

The Delta Amplitude mode should also be verified for Flicker performance after a major instrument repair. These tests are optional after routine calibration. The equipment required to perform these tests is either a LEM Norma D6000 or a Hewlett Packard 3458A. The verification procedure is to measure the change in amplitude during a Flicker output condition. Setup the 5520A-PQ according to the table below, and measure the “Delta V” using the normal ACV measurement mode of the Norma. Set the Norma Time Average to 0.3 s. Make note of the high and low readings, and compute the Delta V. A 3458A may also be used in the analog ACV function, using a NPLC = 1 setting. Be certain to rangelock the 3458A to the 1000V range. Refer to the following table.

**Table 18. Delta Amplitude Verification, Flicker Condition**

Output Amplitude	Frequency	Pst Setting	Nominal Delta V	Repeat Freq	Specification (of Delta V)
230 V	50 Hz	1	1.459 %	58.30 mHz	0.172 %
230 V	50 Hz	1	0.906 %	325.00 mHz	0.172 %
230 V	50 Hz	3	2.718 %	325.00 mHz	0.172 %
230 V	50 Hz	5	7.295 %	58.30 mHz	0.172 %

## Composite Harmonics Verification

These tables refer to waveforms that are described elsewhere in this manual, as well as other special waveforms that need to be created in the Composite Harmonics mode. Note that all tests should be performed with the 5520A EARTH key enabled.

**Table 19. Composite Harmonics Verification**

Verification Tests for AC Voltage		Harmonic	Fundamental	Phase	Amplitude (V)	Specification (V)	Specification (deg)
<b>Range</b>	329.99 mV	rms			0.12000	2.500E-04	
<b>Wave</b>	I	1	100.00%		0.03000	9.00E-5	
<b>RMS Output</b>	0.12 V	3	100.00%	0	0.03000	9.00E-5	0.5
<b>Frequency</b>	50.0 Hz	6	100.00%	0	0.03000	9.00E-5	0.5
		9	100.00%	0	0.03000	9.00E-5	0.5
		12	100.00%	0	0.03000	9.00E-5	0.5
		15	100.00%	0	0.03000	9.00E-5	0.5
		16	100.00%	0	0.03000	9.00E-5	0.5
		23	100.00%	0	0.03000	9.00E-5	0.8
		28	100.00%	0	0.03000	9.00E-5	0.8
		33	100.00%	0	0.03000	9.00E-5	0.8
		38	100.00%	0	0.03000	9.00E-5	0.8
		43	100.00%	0	0.03000	9.00E-5	2.0
		48	100.00%	0	0.03000	9.00E-5	2.0
		53	100.00%	0	0.03000	9.00E-5	2.0
		58	100.00%	0	0.03000	9.00E-5	2.0
		63	100.00%	0	0.03000	9.00E-5	2.0
<b>Range</b>	3.2999 V	rms			0.45000	0.001000	
<b>Wave</b>	I	1	100.00%		0.11250	0.000513	
<b>RMS Output</b>	0.45 V	3	100.00%	0	0.11250	0.000513	0.5
<b>Frequency</b>	60 Hz	6	100.00%	0	0.11250	0.000513	0.5
		9	100.00%	0	0.11250	0.000513	0.5
		12	100.00%	0	0.11250	0.000513	0.5
		15	100.00%	0	0.11250	0.000513	0.5
		16	100.00%	0	0.11250	0.000513	0.8
		23	100.00%	0	0.11250	0.000513	0.8
		28	100.00%	0	0.11250	0.000513	0.8
		33	100.00%	0	0.11250	0.000513	0.8
		38	100.00%	0	0.11250	0.000513	2.0
		43	100.00%	0	0.11250	0.000513	2.0
		48	100.00%	0	0.11250	0.000513	2.0
		53	100.00%	0	0.11250	0.000513	2.0
		58	100.00%	0	0.11250	0.000513	2.0
		63	100.00%	0	0.11250	0.000513	2.0
<b>Range</b>	32.999 V	rms			12.0000	0.0250	
<b>Wave</b>	I	1	100.00%		3.0000	0.0070	
<b>RMS Output</b>	12 V	3	100.00%	0	3.0000	0.0070	0.3
<b>Frequency</b>	60 Hz	6	100.00%	0	3.0000	0.0070	0.3
		9	100.00%	0	3.0000	0.0070	0.3

Table 19. Composite Harmonics Verification (continued)

Verification Tests for AC Voltage		Harmonic	Fundamental	Phase	Amplitude (V)	Specification (V)	Specification (deg)
		12	100.00%	0	3.0000	0.0070	0.3
		15	100.00%	0	3.0000	0.0070	0.3
		16	100.00%	0	3.0000	0.0070	0.5
		23	100.00%	0	3.0000	0.0070	0.5
		28	100.00%	0	3.0000	0.0070	0.5
		33	100.00%	0	3.0000	0.0070	0.5
		38	100.00%	0	3.0000	0.0070	2.0
		43	100.00%	0	3.0000	0.0070	2.0
		48	100.00%	0	3.0000	0.0070	2.0
		53	100.00%	0	3.0000	0.0070	2.0
		58	100.00%	0	3.0000	0.0070	2.0
		63	100.00%	0	3.0000	0.0070	2.0
<b>Range</b>	329.99 V	rms			210.0000	0.4300	
<b>Wave</b>	II	1	100.00%		91.6730	0.3917	
<b>RMS Output</b>	210 V	2	100.00%	0	91.6730	0.3917	0.75
<b>Frequency</b>	60 Hz	3	100.00%	0	91.6730	0.3917	0.75
		5	100.00%	0	91.6730	0.3917	0.75
		7	100.00%	0	91.6730	0.3917	0.75
		8	30.00%	0	27.5020	0.3917	1.2
		12	30.00%	0	27.5020	0.3917	3.0
		13	10.00%	0	9.1670	0.3917	3.0
		16	10.00%	0	9.1670	0.3917	3.0
		18	10.00%	0	9.1670	0.3917	3.0
		21	10.00%	0	9.1670	0.4984	5.0
		23	10.00%	0	9.1670	0.4984	5.0
		25	10.00%	0	9.1670	0.4984	5.0
		26	5.00%	0	4.5840	0.4984	5.0
		30	5.00%	0	4.5840	0.4984	5.0
		33	5.00%	0	4.5840	0.4984	5.0
<b>Range</b>	1020 V	rms			600.0000	1.300	
<b>Wave</b>	III	1	100.00%		241.796	1.310	
<b>RMS Output</b>	600 V	2	100.00%	0	241.796	1.310	0.75
<b>Frequency</b>	50 Hz	3	100.00%	0	241.796	1.310	0.75
		5	100.00%	0	241.796	1.310	0.75
		7	100.00%	0	241.796	1.310	0.75
		8	100.00%	0	241.796	1.310	1.2
		12	30.00%	0	72.539	1.310	1.2
		13	10.00%	0	24.180	1.310	1.2
		16	10.00%	0	24.180	1.310	3.0
		18	10.00%	0	24.180	1.310	3.0
		21	10.00%	0	24.180	1.310	3.0
		23	10.00%	0	24.180	1.310	3.0
		25	10.00%	0	24.180	1.610	5.0
		26	5.00%	0	12.090	1.610	5.0
		30	5.00%	0	14.1880	1.610	5.0
		33	5.00%	0	14.1880	1.610	5.0

**Table 19. Composite Harmonics Verification (continued)**

Verification Tests for AC Voltage		Harmonic	Fundamental	Phase	Amplitude (V)	Specification (V)	Specification (deg)
<b>Range</b>	329.99 V Normal Voltage Output	rms			140.0000	290.00 mV	0.75
<b>Wave</b>	IV	1	100.00%		50.985	122.58 mV	0.75
<b>RMS Output</b>	140 V	2	100.00%	0	50.985	122.58 mV	0.75
<b>Frequency</b>	50 Hz	3	100.00%	0	50.985	122.58 mV	0.75
		4	100.00%	0	50.985	122.58 mV	0.75
		5	100.00%	0	50.985	122.58 mV	0.75
		6	100.00%	0	50.985	122.58 mV	0.75
		7	100.00%	0	50.985	122.58 mV	0.75
		8	30.00%	0	15.296	122.58 mV	0.75
		9	30.00%	0	15.296	153.23 mV	1.2
		10	30.00%	0	15.296	153.23 mV	1.2
		11	30.00%	0	15.296	153.23 mV	1.2
		12	30.00%	0	15.296	153.23 mV	1.2
		13	30.00%	0	15.296	153.23 mV	1.2
<b>Range</b>	1020 V	rms			450.0000	1.0000	
<b>Wave</b>	IV	1	100.00%		163.880	0.5122	
<b>RMS Output</b>	450 V	2	100.00%	0	163.880	0.5122	0.75
<b>Frequency</b>	50 Hz	3	100.00%	0	163.880	0.5122	0.75
		4	100.00%	0	163.880	0.5122	0.75
		5	100.00%	0	163.880	0.5122	0.75
		6	100.00%	0	163.880	0.5122	0.75
		7	100.00%	0	163.880	0.5122	0.75
		8	30.00%	0	49.164	0.5122	0.75
		9	30.00%	0	49.164	0.5122	1.2
		10	30.00%	0	49.164	0.5122	1.2
		11	30.00%	0	49.164	0.5122	1.2
		12	30.00%	0	49.164	0.5122	1.2
		13	30.00%	0	49.164	0.5122	1.2
<b>Range</b>	32.999 V	rms			12.00000	0.02500	
<b>Wave</b>	SQUARE	1	100.00%		10.87300	0.01487	
<b>RMS Output</b>	12 V	3	33.30%	0	3.62100	0.01487	0.3
<b>Frequency</b>	60 Hz	5	20.00%	0	2.17500	0.01487	0.3
		7	14.30%	0	1.55500	0.01487	0.3
		9	11.10%	0	1.20700	0.01487	0.3
		11	9.10%	0	0.98948	0.01487	0.3
		13	7.70%	0	0.83725	0.01487	0.3
		15	6.70%	0	0.72852	0.01487	0.3
		17	5.90%	0	0.64153	0.01487	0.5
		19	5.30%	0	0.57629	0.01487	0.5
		21	4.80%	0	0.52193	0.01487	0.5
		23	4.30%	0	0.46756	0.01487	0.5
		25	4.00%	0	0.43494	0.01487	0.5
		27	3.70%	0	0.40232	0.01487	0.5
		29	3.40%	0	0.36970	0.01487	0.5
		31	3.20%	0	0.34795	0.01487	0.5

Table 19. Composite Harmonics Verification (continued)

Verification Tests for AC Voltage		Harmonic	Fundamental	Phase	Amplitude (V)	Specification (V)	Specification (deg)
<b>Range</b>	329.99 V	rms			230.0000	0.4700	
<b>Wave</b>	NRC 7030	1	100.00%		206.5460	0.8512	
<b>RMS Output</b>	230 V	2	10.00%	-115.5	20.6550	0.8512	0.75
<b>Frequency</b>	50 Hz	3	10.00%	1.1	20.6550	0.8512	0.75
		4	10.00%	-179.6	20.6550	0.8512	0.75
		5	10.00%	13.3	20.6550	0.8512	0.75
		6	10.00%	9.3	20.6550	0.8512	0.75
		7	10.00%	73.5	20.6550	0.8512	0.75
		8	10.00%	152.1	20.6550	0.8512	0.75
		9	10.00%	-19.9	20.6550	0.8512	1.2
		10	10.00%	-167.8	20.6550	0.8512	1.2
		11	10.00%	85.9	20.6550	0.8512	1.2
		12	10.00%	-37.3	20.6550	0.8512	1.2
		13	10.00%	16.1	20.6550	0.8512	3.0
		14	10.00%	-28.1	20.6550	0.8512	3.0
		15	10.00%	94	20.6550	0.8512	3.0
		16	10.00%	-173.4	20.6550	0.8512	3.0
		17	10.00%	129.5	20.6550	0.8512	3.0
		18	10.00%	-113.9	20.6550	0.8512	3.0
		19	10.00%	37.6	20.6550	0.8512	3.0
		20	10.00%	-52.3	20.6550	0.8512	3.0
		21	10.00%	1.5	20.6550	0.8512	3.0
		22	10.00%	14.3	20.6550	0.8512	3.0
		23	10.00%	150.2	20.6550	0.8512	3.0
		24	10.00%	7.1	20.6550	0.8512	3.0
		25	10.00%	161.3	20.6550	1.0700	5.0
<b>Verification Tests for AC Voltage (AUX)</b>							
<b>Range</b>	5 V	rms			1.90000	0.00580	
<b>Wave</b>	V	1	100.00%		0.58524	0.00417	
<b>RMS Output</b>	1.9 V	3	100.00%	0	0.58524	0.00417	0.75
<b>Frequency</b>	60 Hz	6	100.00%	0	0.58524	0.00417	0.75
		9	100.00%	0	0.58524	0.00417	0.75
		12	100.00%	0	0.58524	0.00417	0.75
		16	100.00%	0	0.58524	0.00417	0.75
		17	100.00%	0	0.58524	0.00417	2.0
		23	100.00%	0	0.58524	0.00417	2.0
		28	100.00%	0	0.58524	0.00417	2.0
		33	100.00%	0	0.58524	0.00417	2.0
		38	30.00%	0	0.17577	0.00476	3.0
		43	30.00%	0	0.17577	0.00476	3.0
		48	30.00%	0	0.17577	0.00476	3.0
		53	30.00%	0	0.17577	0.00476	3.0
		58	30.00%	0	0.17577	0.00476	3.0
		63	30.00%	0	0.17577	0.00476	3.0



**Table 19. Composite Harmonics Verification (continued)**

Verification Tests for AC Current		Harmonic	Fundamental	Phase	Amplitude (A)	Specification (A)	Specification (deg)
<b>Verification Tests for AC Current, LCOMP OFF</b>							
<b>Range</b>	329.9 mA	rms			0.11000	1.22E-03	
<b>Wave</b>	VI	1	100.00%		0.03821	1.38E-04	
<b>RMS Output</b>	0.11 A	3	100.00%	0	0.03821	1.38E-04	0.75
<b>Frequency</b>	50 Hz	6	100.00%	0	0.03821	1.38E-04	0.75
		9	100.00%	0	0.03821	1.38E-04	0.75
		12	100.00%	0	0.03821	1.38E-04	0.75
		15	100.00%	0	0.03821	1.38E-04	0.75
		18	100.00%	0	0.03821	1.38E-04	1.5
		23	50.00%	0	0.01910	1.38E-04	1.5
		28	50.00%	0	0.01910	1.38E-04	1.5
		33	50.00%	0	0.01910	1.38E-04	1.5
		38	30.00%	0	0.01146	1.38E-04	1.5
		43	30.00%	0	0.01146	1.68E-04	3.0
		48	30.00%	0	0.01146	1.68E-04	3.0
		53	30.00%	0	0.01146	1.68E-04	3.0
		58	30.00%	0	0.01146	1.68E-04	3.0
		63	30.00%	0	0.01146	1.68E-04	3.0
<b>Range</b>	2.999 A	rms			1.10000	0.00320	
<b>Wave</b>	VII	1	100.00%		0.40547	0.00141	
<b>RMS Output</b>	1.1 A	3	100.00%	0	0.40547	0.00141	0.6
<b>Frequency</b>	50 Hz	6	100.00%	0	0.40547	0.00141	0.6
		9	100.00%	0	0.40547	0.00141	0.6
		12	100.00%	0	0.40547	0.00141	0.6
		15	100.00%	0	0.40547	0.00141	0.6
		18	20.00 %	0	0.40547	0.00141	0.6
		23	20.00 %	0	0.08109	0.00141	1.0
		28	20.00 %	0	0.08109	0.00141	1.0
		33	20.00 %	0	0.08109	0.00141	1.0
		38	20.00 %	0	0.08109	0.00141	1.0
		43	20.00 %	0	0.08109	0.00211	2.0
		48	20.00 %	0	0.08109	0.00211	2.0
		53	20.00 %	0	0.08109	0.00211	2.0
		58	20.00 %	0	0.08109	0.00211	2.0
		63	20.00 %	0	0.08109	0.00211	2.0
<b>Range</b>	20.5 A	rms			4.50000	0.0190	
<b>Wave</b>	VII	1	100.00%		1.6590	0.0117	
<b>Rms Output</b>	4.5 A	3	100.00%	0	1.6590	0.0117	0.6
<b>Frequency</b>	50 Hz	6	100.00%	0	1.6590	0.0117	0.6
		9	100.00%	0	1.6590	0.0117	0.6
		12	100.00%	0	1.6590	0.0117	0.6
		15	100.00%	0	1.6590	0.0117	0.6
		18	100.00%	0	1.6590	0.0117	0.6
		23	20.00%	0	0.3317	0.0117	1.0
		28	20.00%	0	0.3317	0.0117	1.0
		33	20.00%	0	0.3317	0.0117	1.0
		38	20.00%	0	0.3317	0.0117	1.0
		43	20.00%	0	0.3317	0.0133	3.0
		48	20.00%	0	0.3317	0.0133	3.0

Table 19. Composite Harmonics Verification (continued)

Verification Tests for AC Current		Harmonic	Fundamental	Phase	Amplitude (A)	Specification (A)	Specification (deg)
		53	20.00%	0	0.3317	0.0133	3.0
		58	20.00%	0	0.3317	0.0133	3.0
		63	20.00%	0	0.3317	0.0133	3.0
<b>Range</b>	20.5 A	rms			4.80000	0.0196	
<b>Wave</b>	IECA	1	100.00%		2.89500	0.0129	
<b>RMS Output</b>	4.8 A	2	47.00%	0	1.35900	0.0129	0.6
<b>Frequency</b>	50Hz	3	100.00%	180	2.89500	0.0129	0.6
		4	18.70%	180	0.54123	0.0129	0.6
		5	49.60%	0	1.43500	0.0129	0.6
		6	13.00%	0	0.37760	0.0129	0.6
		7	33.50%	180	0.96918	0.0129	0.6
		8	10.00%	180	0.28950	0.0129	0.6
		9	17.40%	0	0.50347	0.0129	0.6
		10	8.00%	0	0.23160	0.0129	0.6
		11	14.30%	180	0.41536	0.0129	0.6
		12	6.70%	180	0.19300	0.0129	0.6
		13	9.10%	0	0.26432	0.0129	0.6
		14	5.70%	0	0.16543	0.0129	0.6
		15	6.50%	180	0.18880	0.0129	0.6
		16	5.00%	180	0.14475	0.0129	0.6
		17	5.80%	0	0.16659	0.0129	0.6
		18	4.40%	0	0.12867	0.0129	0.6
		19	5.10%	180	0.14905	0.0129	1.0
		20	4.00%	180	0.11580	0.0129	1.0
		21	4.70%	0	0.13486	0.0129	1.0
		22	3.60%	0	0.10527	0.0129	1.0
		23	4.30%	180	0.12313	0.0129	1.0
		24	3.30%	180	0.09650	0.0129	1.0
		25	3.90%	0	0.11328	0.0129	1.0
		26	3.10%	0	0.08908	0.0129	1.0
		27	3.60%	180	0.10489	0.0129	1.0
		28	2.90%	180	0.08271	0.0129	1.0
		29	3.40%	0	0.09766	0.0129	1.0
		30	2.70%	0	0.07720	0.0129	1.0
		31	3.20%	180	0.09136	0.0129	1.0
		32	2.50%	180	0.07237	0.0129	1.0
		33	3.00%	0	0.08582	0.0129	1.0
		34	2.40%	0	0.06812	0.0129	1.0
		35	2.80%	180	0.08092	0.0129	1.0
		36	2.20%	180	0.06433	0.0129	1.0
		37	2.60%	0	0.07654	0.0129	1.0
		38	2.10%	0	0.06095	0.0129	1.0
		39	2.50%	180	0.07262	0.0129	1.0
		40	2.00%	180	0.05790	0.0129	1.0

**Table 19. Composite Harmonics Verification (continued)**

Verification Tests for AC Current		Harmonic	Fundamental	Phase	Amplitude (A)	Specification (A)	Specification (deg)
<b>Range</b>	20.5 A	rms			5.80000	0.0216	
<b>Wave</b>	IECD	1	100.00%		5.04200	0.0150	
<b>RMS Output</b>	5.8 A	3	46.90%	180	2.36600	0.0150	0.6
<b>Frequency</b>	50Hz	5	26.20%	0	1.32200	0.0150	0.6
		7	13.80%	180	0.69600	0.0150	0.6
		9	6.90%	0	0.34800	0.0150	0.6
		11	4.80%	180	0.24360	0.0150	0.6
		13	4.10%	0	0.20612	0.0150	0.6
		15	3.50%	180	0.17864	0.0150	0.6
		17	3.10%	0	0.15763	0.0150	0.6
		19	2.80%	180	0.14103	0.0150	1.0
		21	2.50%	0	0.12760	0.0150	1.0
		23	2.30%	180	0.11651	0.0150	1.0
		25	2.10%	0	0.10719	0.0150	1.0
		27	2.00%	180	0.09924	0.0150	1.0
		29	1.80%	0	0.09250	0.0150	1.0
		31	1.70%	180	0.08644	0.0150	1.0
		33	1.60%	0	0.08120	0.0150	1.0
		35	1.50%	180	0.07656	0.0150	1.0
		37	1.40%	0	0.07242	0.0150	1.0
		39	1.40%	180	0.06871	0.0150	1.0
<b>Range</b>	20.5 A	rms			9.50000	0.0290	
<b>Wave</b>	NRC7030	1	100.00%		8.53100	0.0185	
<b>RMS Output</b>	9.5 A	2	10.00%	-115.5	0.85313	0.0185	0.6
<b>Frequency</b>	60Hz	3	10.00%	1.1	0.85313	0.0185	0.6
			0.00%	179.6	.85313	.0185	.6
			0.00%	3.3	.85313	.0185	.6
			0.00%	.3	.85313	.0185	.6
			0.00%	3.5	.85313	.0185	.6
			0.00%	52.1	.85313	.0185	.6
			0.00%	19.9	.85313	.0185	.6
		0	0.00%	167.8	.85313	.0185	.6
		1	0.00%	5.9	.85313	.0185	.6
		2	0.00%	37.3	.85313	.0185	.6
		3	0.00%	6.1	.85313	.0185	.6
		4	0.00%	28.1	.85313	.0185	.6
		5	0.00%	4	.85313	.0185	.6
		6	0.00%	173.4	.85313	.0185	.0
		7	0.00%	29.5	.85313	.0185	.0
		8	0.00%	113.9	.85313	.0185	.0
		9	0.00%	7.6	.85313	.0185	.0
		0	0.00%	52.3	.85313	.0185	.0
		1	0.00%	.5	.85313	.0185	.0
		2	0.00%	4.3	.85313	.0185	.0
		3	0.00%	50.2	.85313	.0185	.0
		4	0.00%	.1	.85313	.0185	.0
		5	0.00%	61.3	.85313	.0185	.0

## Calibration

The Delta Amplitude output of the 5520A-PQ requires calibration of the voltage and current outputs to bring them to their nominal values. This calibration should be performed after the mainframe has been calibrated using the procedure described in the *5520A Service Manual*. PQ calibration is independent of any oscilloscope option calibration, and can be performed either before or after oscilloscope calibration.

PQ calibration consists of three sections:

1. Normal AC Voltage
2. AUX AC Current
3. AUX AC Voltage

The equipment required for each section is a subset of the equipment required for the 5520A mainframe, listed in the “Calibration and Verification” section of that service manual. Review the equipment requirements for each PQ function before proceeding.

The calibration mode is entered by pressing the front panel blue softkeys in the following order: SETUP, CAL, CAL, OPTION CAL, and PQ CAL. If another section is to be calibrated, press the OPTIONS then NEXT SECTION blue softkeys. Within a section, each step displays the correct instrument connection and prompt for readings taken from the measuring device. The calibration may also be entered remotely by sending the command “CAL\_START PQ” through the host. (CAL\_START PQ is the only remote calibration command that is unique to the PQ.) Each time a calibration step is completed, “CAL\_NEXT <value>” must be sent to proceed.

### Normal AC Voltage

Measure AC voltage using the Fluke 5790A AC Measurement Standard. Enter the measured value into the 5520A-PQ for each of the corresponding nominal values listed in Table 20, when prompted to do so.

Table 20. Normal AC Volts

Step	5520A-PQ Normal Output
1	30 mV
2	300 mV
3	3 V
4	30 V
5	300 V
6	1000 V

### AUX AC Current

For nominal values of 300  $\mu$ A - 300 mA, measure the AC current using the Hewlett Packard 3458A. For nominal values of 2 A and 10 A, use the A40 2 A and 20 A current shunts, respectively. These shunts require dc characterization before they can be used. DC characterization can be performed with the 5520A, as long as the entire 5520A dc current calibration is performed first. See “AC Current Calibration” in the *5520A Service Manual* for full details. The 5790A or 3458A can be used as the detector. A 20 A dc/ac shunt such as the Fluke Y5020 or MeasureTech EL-7520 can also be used for both 2 A and 10 A outputs. Neither of these two shunts require the dc characterization process. Enter the measured value into the 5520A-PQ for each of the corresponding nominal values listed in Table 21 when prompted to do so.

**Table 21. Aux AC Current**

Step	5520A-PQ AUX Output
1	300 $\mu$ A
2	3 mA
3	30 mA
4	300 mA
5	2 A
6	2 A LCOMP ON
7	10 A
8	10 A LCOMP ON

### AUX AC Voltage

To calibrate the auxiliary AC voltage function, use the same technique previously described for the normal AC voltage output, substituting the AUX HI and LO terminals on the 5520A-PQ. The 5790A or 3458A can be used. Table 22 lists the calibration steps for AUX AC volts.

**Table 22. AUX AC Voltage**

Step	5520A-PQ AUX Output
1	300 mV
2	3 V
3	5 V

