FLUKE®

5520A
PQ Option

Service Manual

PN 1629170
October 2001
© 2001 Fluke Corporation, All rights reserved. Printed in USA
All product names are trademarks of their respective companies.

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.

Fluke authorized resellers shall extend this warranty on new and unused products to end-user customers only but have no authority to extend a greater or different warranty on behalf of Fluke. Warranty support is available only if product is purchased through a Fluke authorized sales outlet or Buyer has paid the applicable international price. Fluke reserves the right to invoice Buyer for importation costs of repair/replacement parts when product purchased in one country is submitted for repair in another country.

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).

THIS WARRANTY IS BUYER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. FLUKE SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OR LOSSES, INCLUDING LOSS OF DATA, ARISING FROM ANY CAUSE OR THEORY.

Since some countries or states do not allow limitation of the term of an implied warranty, or exclusion or limitation of incidental or consequential damages, the limitations and exclusions of this warranty may not apply to every buyer. If any provision of this Warranty is held invalid or unenforceable by a court or other decision-maker of competent jurisdiction, such holding will not affect the validity or enforceability of any other provision.

Fluke Corporation
P.O. Box 9090
Everett, WA 98206-9090
U.S.A.

Fluke Europe B.V.
P.O. Box 1186
5602 BD Eindhoven
The Netherlands

11/99

Table of Contents

Title **Page**

Introduction 1
5520A-PQ Option Specifications 1
Composite Harmonic Function Specifications 1
AC Voltage Specifications 2
AC Voltage Auxiliary Specifications (Dual Output Mode Only) 3
AC Current Specifications, LCOMP OFF 3
AC Current Specifications, LCOMP ON 4
Flicker Simulation Mode 5
Sags & Swells Simulation Mode 5
Phase Specifications, Sinewave Outputs 5
Nominal Amplitude and Phase Values for Preinstalled Composite Harmonic Waves 6
Theory of Operation 18
DDS Assembly (A6) 18
Main CPU Assembly (A9) 18
Maintenance 18
Equipment Required for Calibration and Verification 19
Performance Verification Tests 20
Delta Amplitude Verification 20
Composite Harmonics Verification 21
Calibration 28
Normal AC Voltage 28
AUX AC Current 29
AUX AC Voltage 29

List of Tables

Table	Title	Page
1.	Composite Harmonic Function Specifications	1
2.	AC Voltage Specifications	2
3.	AC Voltage Auxiliary Specifications (Dual Output Mode Only)	3
4.	AC Current Specifications, LCOMP OFF	3
5.	AC Current Specifications, LCOMP ON	4
6.	Flicker Simulation Mode	5
7.	Sags & Swells Simulation Mode	5
8.	Phase Specifications, Sinewave Outputs	5
9.	Nominal Amplitude and Phase Values for Preinstalled IEC A Composite Harmonic Waves	7
10.	Nominal Amplitude and Phase Values for Preinstalled Composite IEC D Harmonic Waves	8
11.	Nominal Amplitude and Phase Values for Preinstalled NRC7030 Composite Harmonic Waves	9
12.	Nominal Amplitude and Phase Values for Preinstalled NRC2 Composite Harmonic Waves	10
13.	Nominal Amplitude and Phase Values for Preinstalled NRC3 Composite Harmonic Waves (continued)	12
14.	Nominal Amplitude and Phase Values for Preinstalled NRC4 Composite Harmonic Waves	14
15.	Nominal Amplitude and Phase Values for Preinstalled NRC5 Composite Harmonic Waves	16
16.	5520A-PQ Option Calibration and Verification Equipment	19
17.	Delta Amplitude Verification, Static Condition	20
18.	Delta Amplitude Verification, Flicker Condition	20
19.	Composite Harmonics Verification	21
20.	Normal AC Volts	28
21.	Aux AC Current	29
22.	AUX AC Voltage	29

List of Figures

Figure	Title	Page
1.	Preinstalled IEC A Composite Harmonic Waveform	6
2.	Preinstalled IEC D Composite Harmonic Waveform	8
3.	Preinstalled NRC7030 Composite Harmonic Wave	9
4.	Preinstalled NRC2 Waveform	10
5.	Preinstalled NRC3 Composite Harmonic Waveform	12
6.	Preinstalled NRC4 Composite Harmonic Waveform	14
7.	Preinstalled NRC5 Composite Harmonic Waveform	16

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

Maximum Number of Harmonics in a User Defined Waveform	15
Specified Fundamental Frequencies	15-65 Hz, 400 Hz [1]
Highest Harmonic Frequency	5 kHz [2]
Harmonic Amplitude Resolution	0.1 % of fundamental
Harmonic Phase Range (relative to fundamental)	0 to 360°
Harmonic Phase Resolution	0.1° relative to fundamental
Pre-loaded Industry Waveforms	IEC A, IEC D, NRC7030, NRC 2 to 5

[1] AC Voltage outputs ≥ 33 V, and Current outputs ≥ 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.

[2] Current outputs with LCOMP ON have lower limits, as shown in the AC Current table below. Voltage outputs > 33V 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)[1]	Harmonic Amplitude Uncertainty (% of Fundamental + V)	Harmonic Phase Uncertainty (Relative to Fundamental)[2]	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 [3]	3°	
	1.2 kHz to 2 kHz	0.1 to 5 %	0.5 % + 40 mV [4]	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 [5]	3°	
	1.2 kHz to 2 kHz	0.1 to 5 %	0.6 % + 160 mV [6]	5°	

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

[2] For harmonics that are < 1 % of the Fundamental, phase uncertainty is typical.

[3] 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.

[4] 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.

[5] 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.

[6] 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)	armonic Phase Uncertainty (Relative to Fundamental)[1]	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°	

[1] 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)[1]	Harmonic Amplitude Uncertainty (% of Fundamental + A)	Harmonic Phase Uncertainty (Relative to Fundamental)[2]	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°	

[1] All frequencies can have harmonics up to 100 % of the fundamental; uncertainties are not specified unless otherwise indicated.

[2] 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)[1]	Harmonic Amplitude Uncertainty (% of Fundamental + A)	Harmonic Phase Uncertainty (Relative to Fundamental)[2]	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°	

[1] All frequencies can have harmonics up to 100 % of the fundamental; uncertainties are not specified unless otherwise indicated.

[2] 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 mplitude Range (% of Fundamental)[1]	Harmonic Amplitude Uncertainty (% of Fundamental + A)	Harmonic Phase Uncertainty (Relative to Fundamental)[2]	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.

[1] All frequencies can have harmonics up to 100 % of the fundamental; uncertainties are not specified unless otherwise indicated.

[2] For harmonics that are < 1 % of the Fundamental, phase uncertainty is typical.

Flicker Simulation Mode

Table 6. Flicker Simulation Mode

Voltage Range	1 mV to 1020V	
Current Range	29 μA to 20.5A	
Frequency of Fundamental	50 and 60 Hz	
Amplitude Modulation Range	± 100 %	
Frequency of Modulation	0.1 Hz to 40 Hz	
Type of Modulation	Square or Sine	
Short Term (10 minute) uncertainty of amplitude modulation	± 0.1 % of nominal output + 0.05% of range	
Flicker Modulation Timing Uncertainty	± 0.1 ms	
Settings for P_{st} = 1	Voltage Changes ΔV/V % [1]	
Changes per minute:	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
Trigger Event	2nd Push of OPER key, or Remote Command	

[1] 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

Voltage Range	1 mV to 1020V
Current Range	29 μA to 20.5A
Frequency of Fundamental	45 to 65 Hz
Amplitude Modulation Range	± 100 %
Ramp-Up Time	0.01 to 1 second
Duration of Sag or Swell	0.032 to 60 seconds
Trigger Event	2nd 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

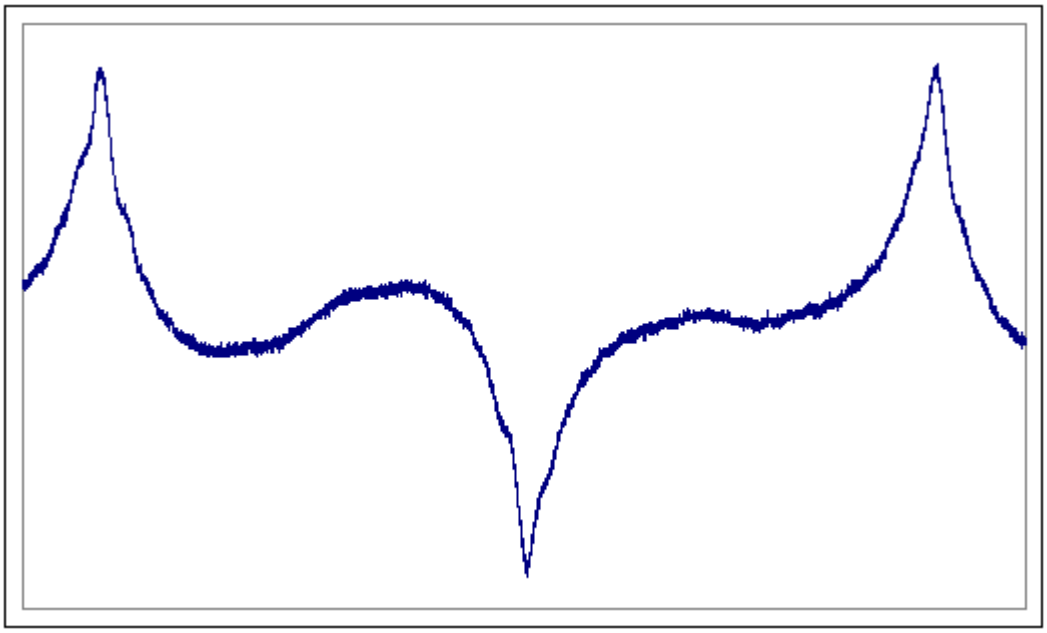
Output Combinations, 45 Hz to 65 Hz			**1-Year Absolute Uncertainty**
AC Voltage	**AC Voltage (Auxiliary)**	**AC Current (LCOMP OFF)**	
0.65 V to 3.29999 V	0.65 V to 3.29999 V	6.5 mA to 32.999 mA	0.07°
6.5 V to 32.9999 V		65 mA to 329.99 mA	
65 V 329.9999 V		0.65 A to 10.9999 A	

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 Filipski of the National Research Council of Canada, (NRC) Institute for National Measurement Standards, Ottawa, Ontario, K1A OR8, Canada.*

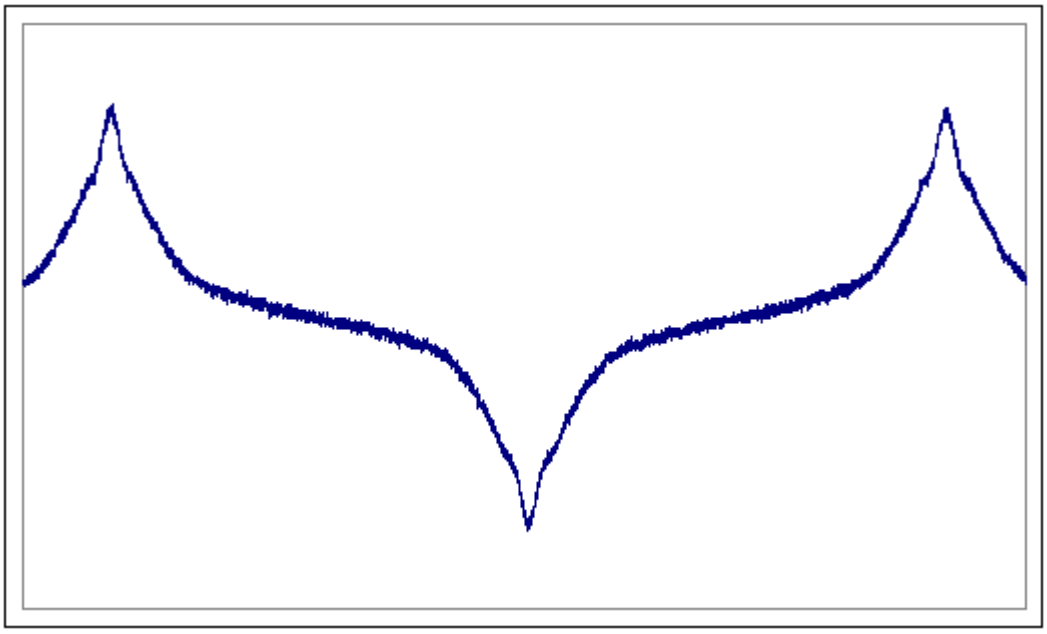


nn370f.bmp

Figure 1. Preinstalled IEC A Composite Harmonic Waveform

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

Wave	Harmonic	% of Fundamental	Phase
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°

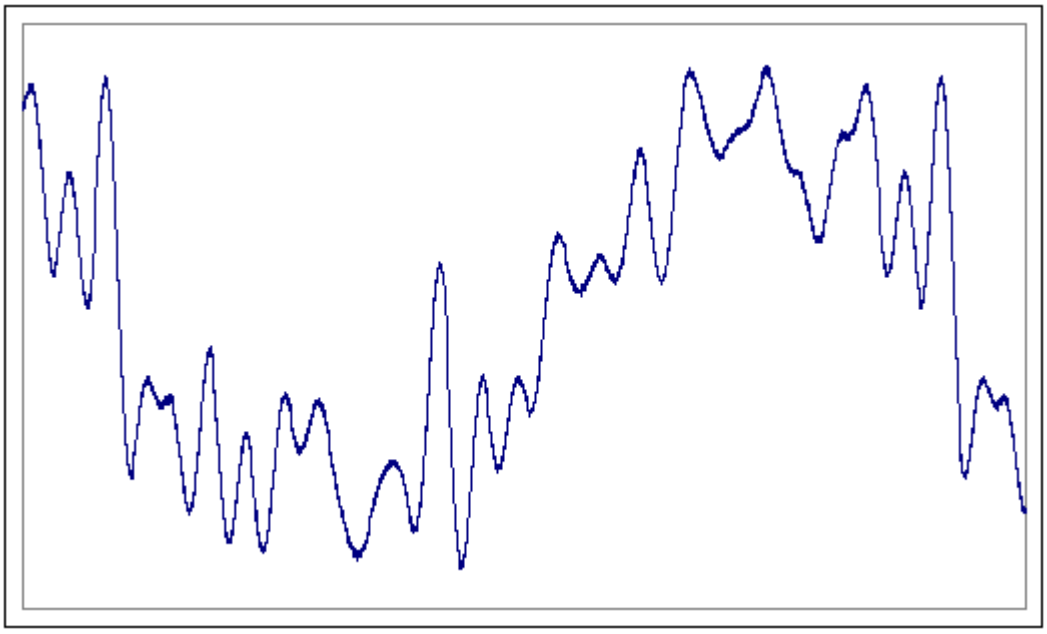


nn371f.bmp

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°

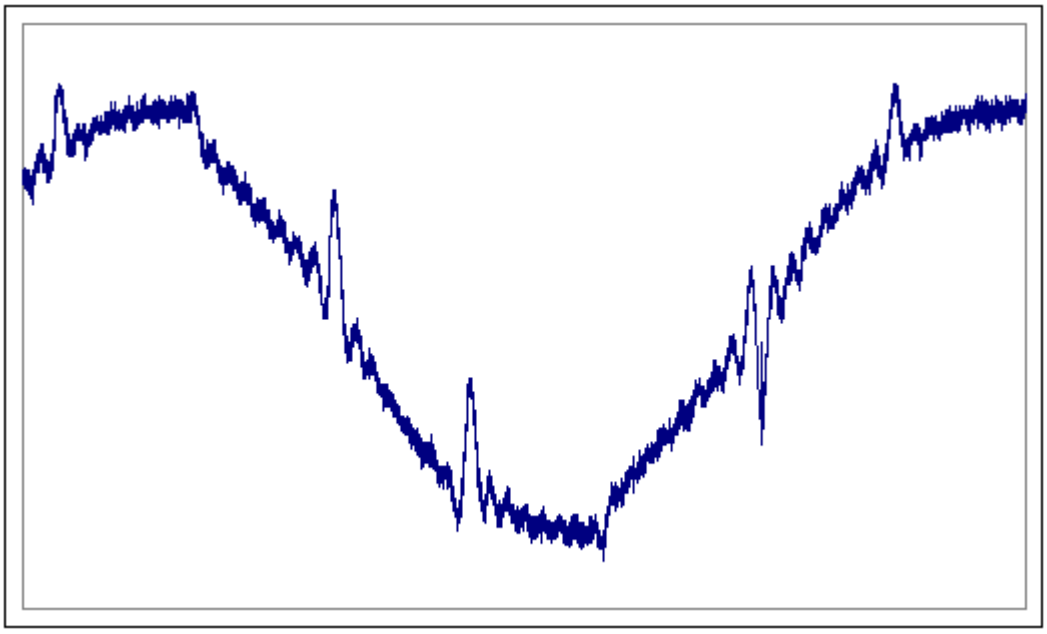


nn376f.bmp

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°



nn372f.bmp

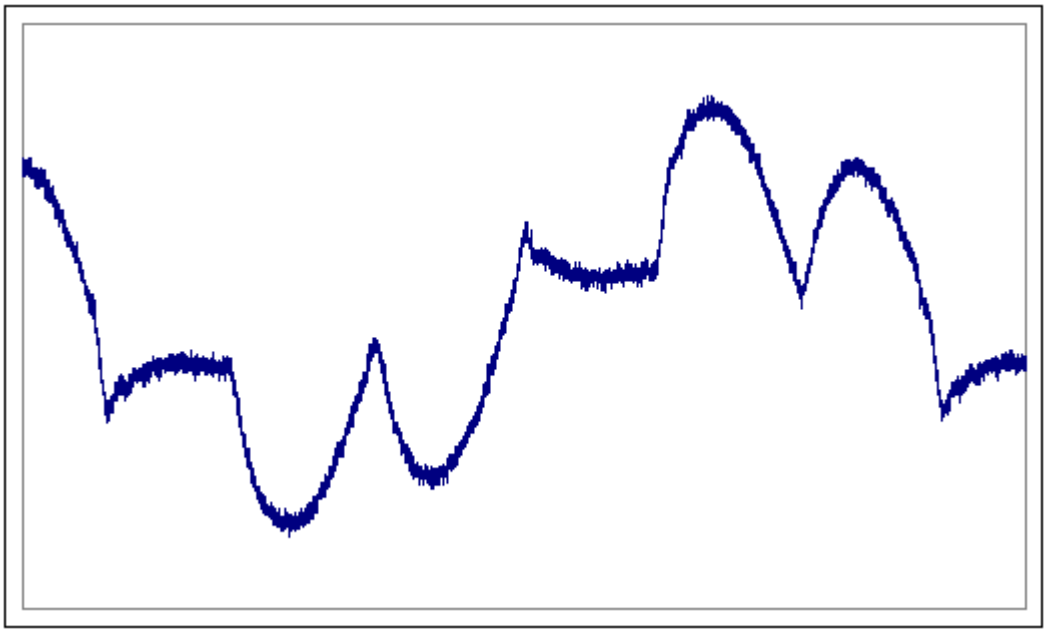
Figure 4. Preinstalled NRC2 Waveform

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°



nn373f.bmp

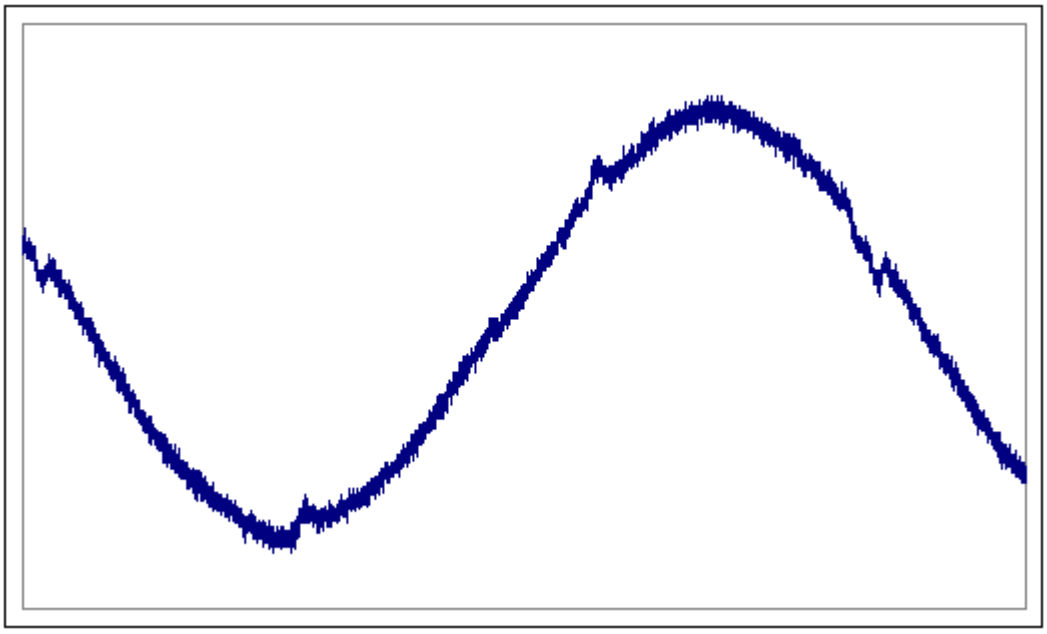
Figure 5. Preinstalled NRC3 Composite Harmonic Waveform

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°



nn374f.bmp

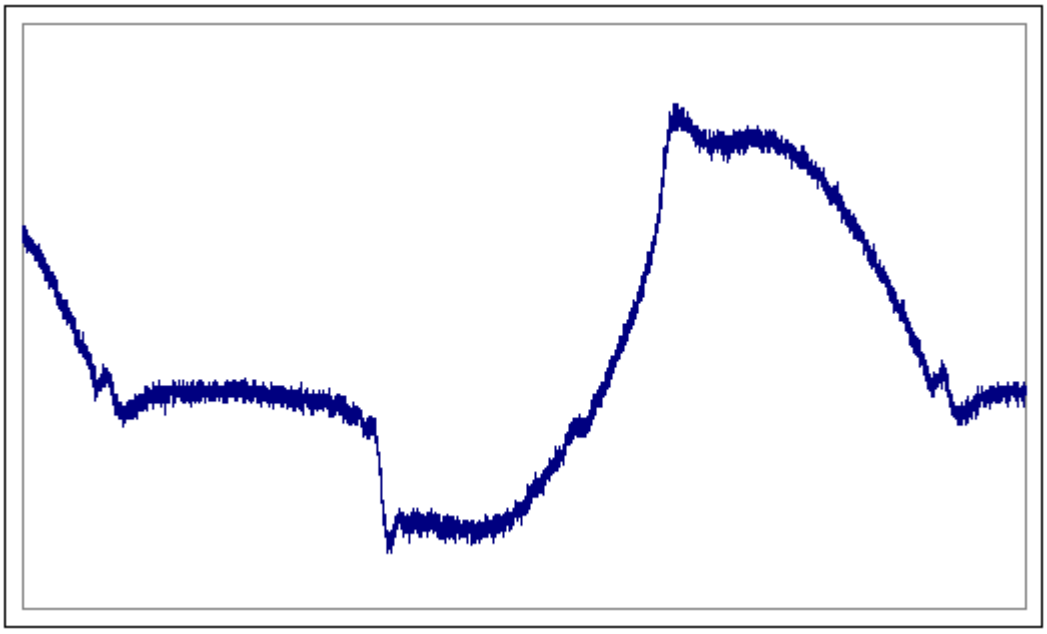
Figure 6. Preinstalled NRC4 Composite Harmonic Waveform

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°



nn375f.bmp

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)

Wave	Harmonic	% of Fundamental	Phase
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 simulatneous 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 MORE MODES 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

Instrument	Model	Minimum Use Specifications
Digital Multimeter	HP 3458A	RMS measurements 300 μA 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 63rd. 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)
Range	329.99 mV	rms			0.12000	2.500E-04	
Wave	I	1	100.00%		0.03000	9.00E-5	
RMS Output	0.12 V	3	100.00%	0	0.03000	9.00E-5	0.5
Frequency	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
Range	3.2999 V	rms			0.45000	0.001000	
Wave	I	1	100.00%		0.11250	0.000513	
RMS Output	0.45 V	3	100.00%	0	0.11250	0.000513	0.5
Frequency	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
Range	32.999 V	rms			12.0000	0.0250	
Wave	I	1	100.00%		3.0000	0.0070	
RMS Output	12 V	3	100.00%	0	3.0000	0.0070	0.3
Frequency	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
Range	329.99 V	rms			210.0000	0.4300	
Wave	II	1	100.00%		91.6730	0.3917	
RMS Output	210 V	2	100.00%	0	91.6730	0.3917	0.75
Frequency	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
Range	1020 V	rms			600.0000	1.300	
Wave	III	1	100.00%		241.796	1.310	
RMS Output	600 V	2	100.00%	0	241.796	1.310	0.75
Frequency	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)
Range	329.99 V Normal Voltage Output	rms			140.0000	290.00 mV	0.75
Wave	IV	1	100.00%		50.985	122.58 mV	0.75
RMS Output	140 V	2	100.00%	0	50.985	122.58 mV	0.75
Frequency	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
Range	1020 V	rms			450.0000	1.0000	
Wave	IV	1	100.00%		163.880	0.5122	
RMS Output	450 V	2	100.00%	0	163.880	0.5122	0.75
Frequency	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
Range	32.999 V	rms			12.00000	0.02500	
Wave	SQUARE	1	100.00%		10.87300	0.01487	
RMS Output	12 V	3	33.30%	0	3.62100	0.01487	0.3
Frequency	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)
Range	329.99 V	rms			230.0000	0.4700	
Wave	NRC 7030	1	100.00%		206.5460	0.8512	
RMS Output	230 V	2	10.00%	-115.5	20.6550	0.8512	0.75
Frequency	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
Verification Tests for AC Voltage (AUX)							
Range	5 V	rms			1.90000	0.00580	
Wave	V	1	100.00%		0.58524	0.00417	
RMS Output	1.9 V	3	100.00%	0	0.58524	0.00417	0.75
Frequency	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)
Verification Tests for AC Current, LCOMP OFF							
Range	329.9 mA	rms			0.11000	1.22E-03	
Wave	VI	1	100.00%		0.03821	1.38E-04	
RMS Output	0.11 A	3	100.00%	0	0.03821	1.38E-04	0.75
Frequency	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
Range	2.999 A	rms			1.10000	0.00320	
Wave	VII	1	100.00%		0.40547	0.00141	
RMS Output	1.1 A	3	100.00%	0	0.40547	0.00141	0.6
Frequency	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
Range	20.5 A	rms			4.50000	0.0190	
Wave	VII	1	100.00%		1.6590	0.0117	
Rms Output	4.5 A	3	100.00%	0	1.6590	0.0117	0.6
Frequency	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
Range	20.5 A	rms			4.80000	0.0196	
Wave	IECA	1	100.00%		2.89500	0.0129	
RMS Output	4.8 A	2	47.00%	0	1.35900	0.0129	0.6
Frequency	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)
Range	20.5 A	rms			5.80000	0.0216	
Wave	IECD	1	100.00%		5.04200	0.0150	
RMS Output	5.8 A	3	46.90%	180	2.36600	0.0150	0.6
Frequency	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
Range	20.5 A	rms			9.50000	0.0290	
Wave	NRC7030	1	100.00%		8.53100	0.0185	
RMS Output	9.5 A	2	10.00%	-115.5	0.85313	0.0185	0.6
Frequency	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 μA - 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 μA
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