FLUKE®

5520A
PQ Option

Operators Manual

PN 1608366
May 2001

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

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Safety Information

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

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

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

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

SYMBOLS MARKED ON THE CALIBRATOR

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

GROUND Ground terminal to chassis (earth).

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

AC POWER SOURCE

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

USE THE PROPER FUSE

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

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

GROUNDING THE CALIBRATOR

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

USE THE PROPER POWER CORD

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

Use only a power cord that is in good condition.

Refer power cord and connector changes to qualified service personnel.

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

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

CHECK INSULATION RATINGS

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

DO NOT REMOVE COVER DURING OPERATION

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

DO NOT ATTEMPT TO OPERATE IF PROTECTION MAY BE IMPAIRED

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

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5520A PQ Option

Introduction

The Power Quality (PQ) option provides calibration functions to maintain power quality monitoring equipment. The following functions are provided:

- **Harmonic Distortion simulation (Composite Harmonics Function)**
  Allows the user to specify up to 15 tones (harmonics) including all even and odd values to the 63rd. For each harmonic value, the user may enter the amplitude and phase relative to the fundamental. There are also 7 preinstalled waveforms with up to 49 harmonics. The harmonic waveforms are available in V, A, V-A, and V-V modes.
- **Flicker simulation (Delta (Δ) Amplitude, "flicker")**
  Provided by means of rectangular or sinewave modulation of the output signal. The repeat frequency and amplitude deviation are selectable. Flicker is available in V, A, V-A, and V-V modes.
- **Sags & Swells simulation (Delta (Δ) Amplitude, "single")**
  In this mode, the user can output a one-time (single), amplitude deviation over a specified time interval. The user may select three parameters: the ramp time, width of the event, and % amplitude deviation. The ramp time is the period of time over which the output value changes from its nominal setting to the select modified value. The width of the event is selectable from 0.032 seconds to 60.0 seconds. The amplitude deviation is selected as a percentage of the nominal. This function is available in V, A, V-A, and V-V modes.

5520A PQ Option Specifications

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	1.0°	
	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)	Harmonic 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 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 329.99 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.*

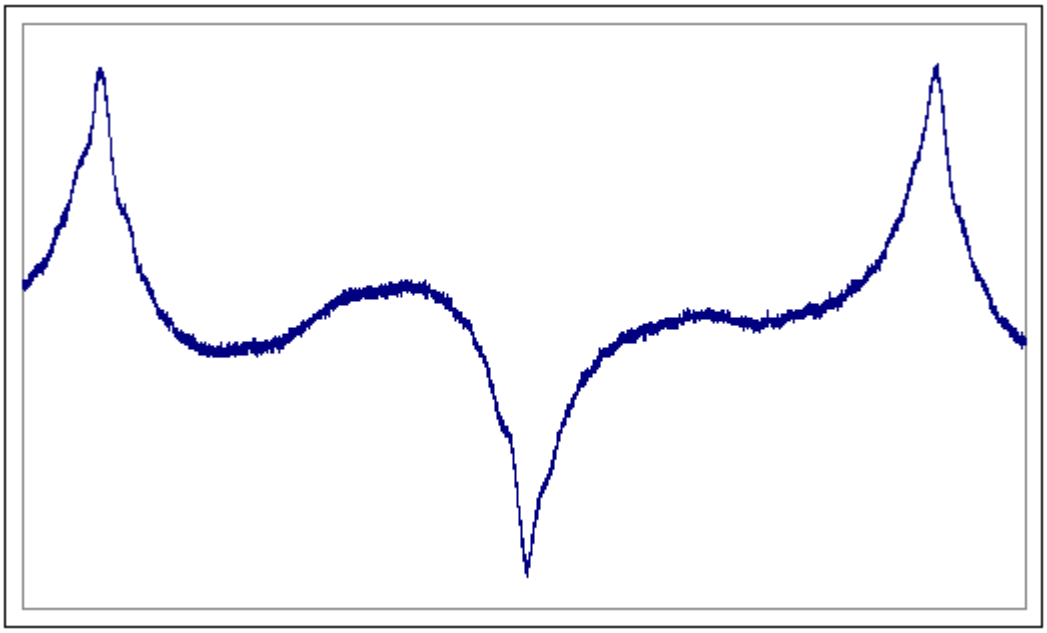

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Figure 1. Preinstalled IEC A Composite Harmonic Waveform

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°

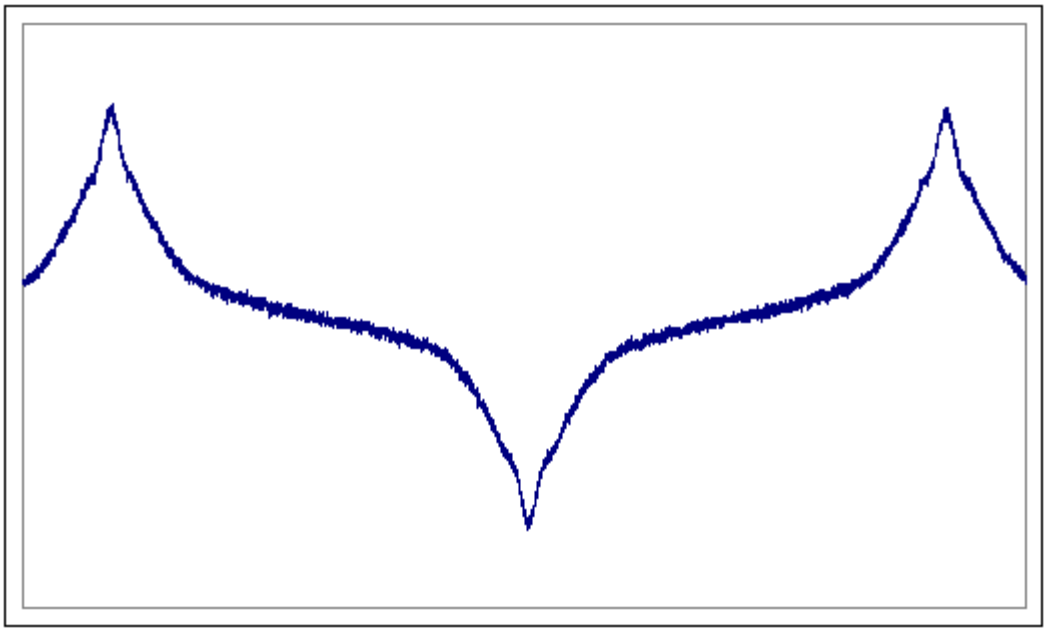

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Figure 2. Preinstalled IEC D Composite Harmonic Waveform

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°

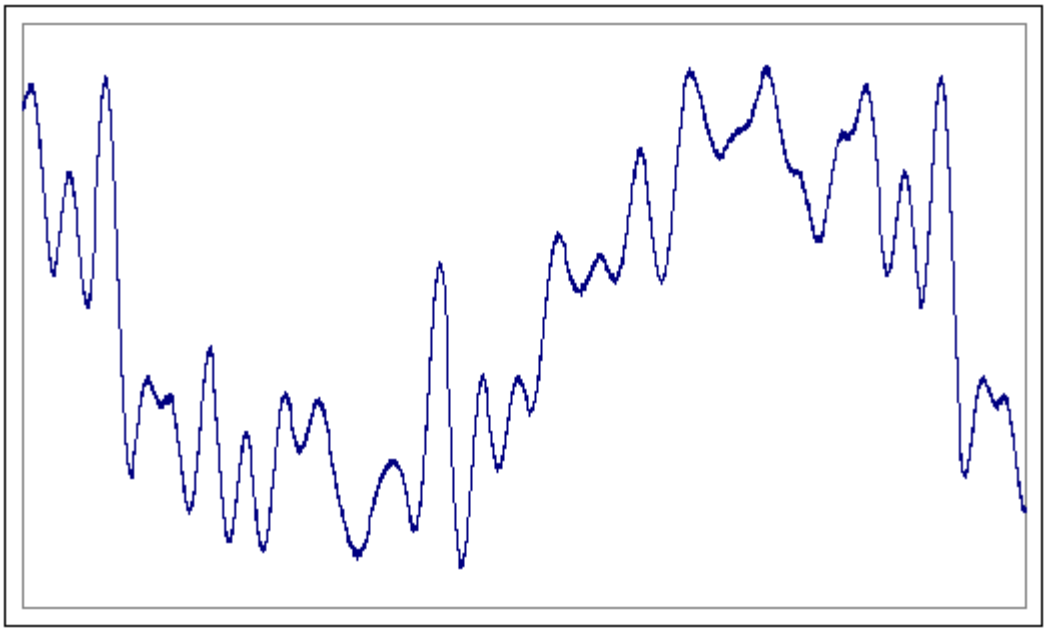

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Figure 3. Preinstalled NRC7030 Composite Harmonic Wave

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°

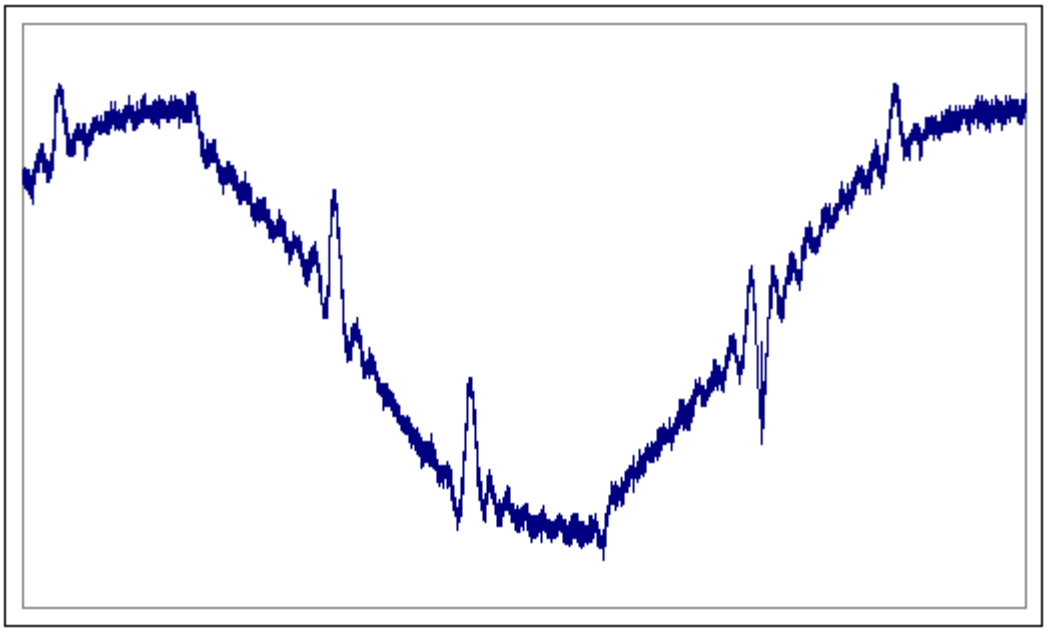

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Figure 4. Preinstalled NRC2 Waveform

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°

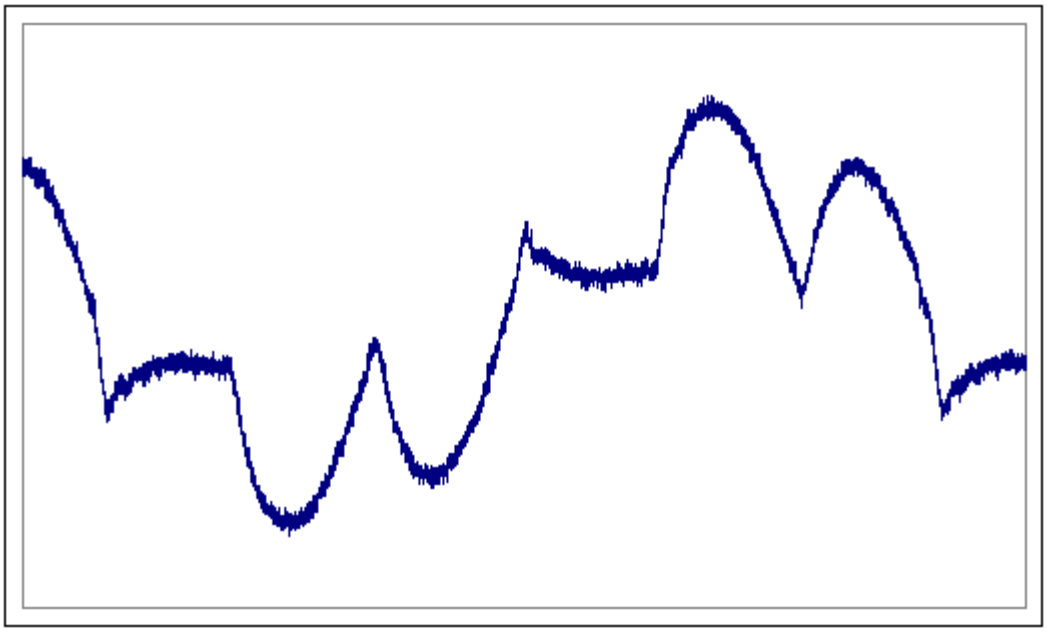

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Figure 5. Preinstalled NRC3 Composite Harmonic Waveform

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

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°

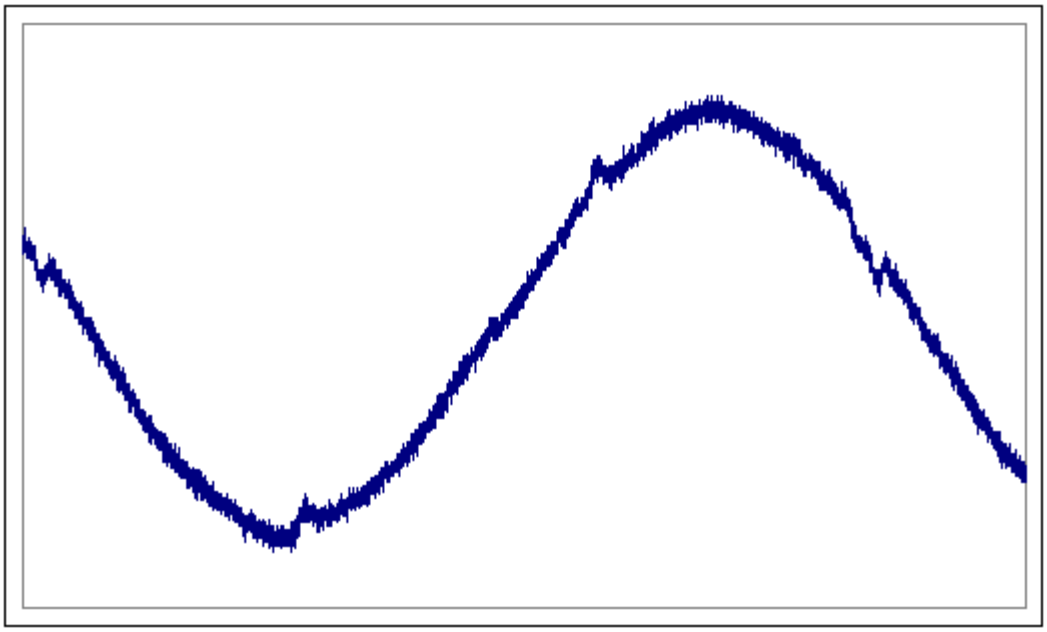

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Figure 6. Preinstalled NRC4 Composite Harmonic Waveform

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°

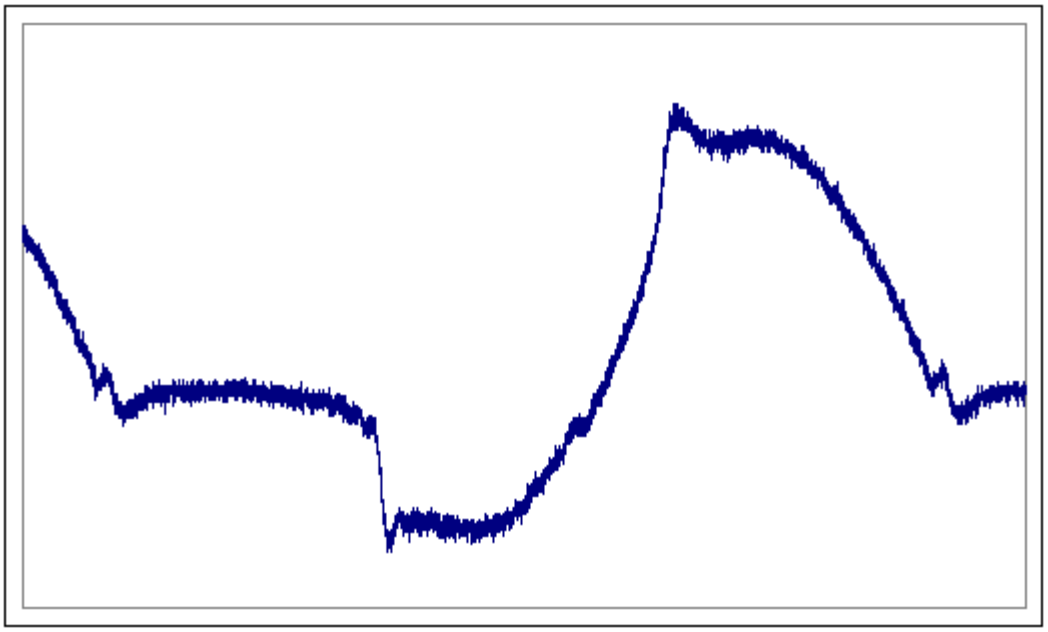

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Figure 7. Preinstalled NRC5 Composite Harmonic Waveform

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)

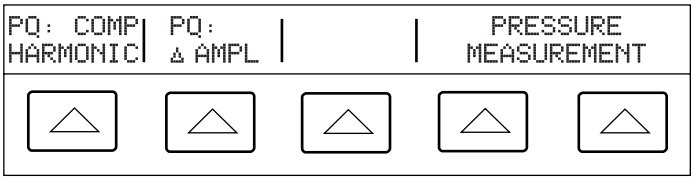
Wave	Harmonic	% of Fundamental	Phase
NRC5	27th	0.16 %	137.1°
	28th	1.30 %	132.0°
	29th	0.91 %	-140.7°
	30th	0.20 %	-35.0°
	31st	1.18 %	24.6°
	32nd	0.63 %	123.0°
	33rd	0.26 %	-106.4°
	34th	1.18 %	-69.4°
	35th	0.64 %	14.5°
	36th	0.11 %	171.9°
	37th	1.00 %	-159.3°
	38th	0.79 %	-75.3°
	39th	0.11 %	-33.4°
	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°

Composite Harmonics Function (Volts)

This section describes the Composite Harmonics Function in the Volts Mode. Amps, Volt-Volt, and Volt-Amp Modes, have similar menus and operation.

Entering the PQ Modes

To gain access to the power quality (PQ) functions, press MORE MODES on the front panel. The More Modes Menu, shown below, appears in the Control Display. Enter the PQ mode by selecting the desired function, PQ:COMP HARMONIC or PQ: ΔAMPL. The PQ:COMP HARMONIC mode accesses the Composite Harmonics Function and the PQ: ΔAMPL mode accesses flicker and sags & swells simulation.



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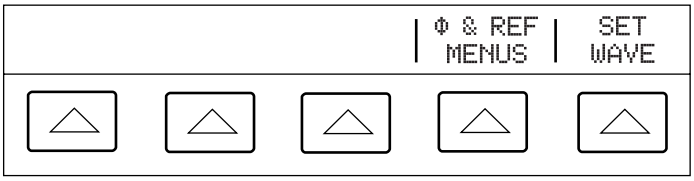
Note

When PQ:COMP HARMONIC or PQ: ΔAMPL mode is selected, the Output Display reads "1.0000 V 60Hz" as a default.

Creating Composite Harmonic Waveforms

Press the PQ:COMP HARMONIC blue softkey. The top-level PQ:COMP HARMONIC Menu, shown below, appears.



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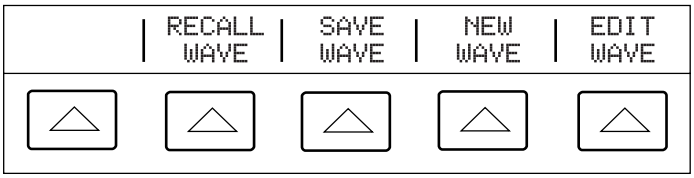
From this menu, composite harmonic waveforms can be created and stored for later use. 7 pre-loaded waveforms may also be recalled from this point. To recall, edit, or create a composite harmonic wave, press the SET WAVE blue softkey. The Wave Selection Menu, as it appears in the Control Display, is shown below.



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The Wave Selection Menus

From the Wave Selection Menu, the user has four choices:

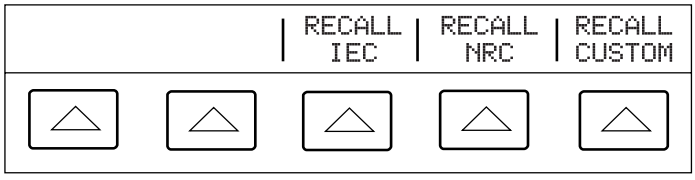
1) RECALL WAVE
2) SAVE WAVE
3) NEW WAVE
4) EDIT WAVE

A brief explanation of each of these menus follows. More detailed explanations are later in this section.

RECALL WAVE

Pressing the RECALL WAVE blue softkey displays the menu shown below. From this menu, the user can:

- recall the 2 preinstalled IEC waves
- recall the 5 preinstalled NRC waves
- recall up to five custom user-created waves



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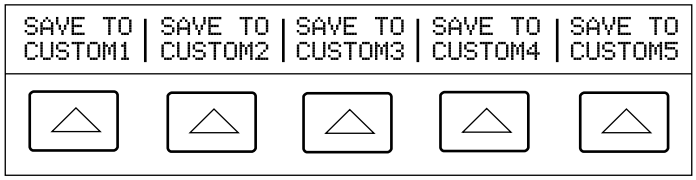
SAVE WAVE

Pressing the SAVE WAVE blue softkey displays the menu shown below. From this menu, the user can save up to 5 custom-made waves, storing them in the calibrator non-volatile memory.



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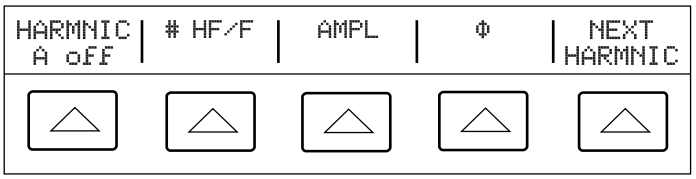
NEW WAVE

Pressing the NEW WAVE blue softkey displays the menu shown below. From this menu, the user can create new waves and adjust their individual parameters. More on this menu can be found by referring to "Setting the Waves (Harmonics)" later in this section.



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EDIT WAVE

Pressing the EDIT WAVE blue softkey also displays the menu shown above, or a similar menu if a wave is already in use. From this menu, the user can adjust the individual parameters of the waveform that is currently active. If no waveform has been selected from one of the predefined sets or created using the NEW WAVE feature, the values are initialized to their "off" states.

Creating New Waves

Note

The procedures for creating a new wave and editing an existing wave are essentially the same. The difference between the NEW WAVE and EDIT WAVE menus is that under the NEW WAVE section, all harmonic parameters default at "0" until the user changes those parameters thus, creating a new wave.

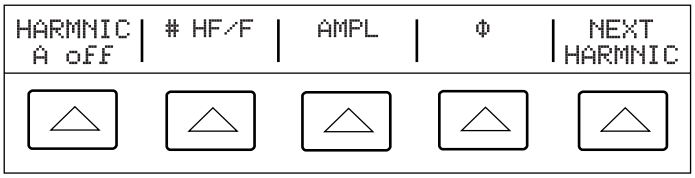
In the EDIT WAVE Menu, a wave that has either been in use, or a wave that has been recalled can be edited. Although it is possible to define a new waveform using the EDIT WAVE menu option, it is not recommended as the user will have to check harmonics A through O to ensure they are all off.

After entering the PQ Mode and accessing the Wave Selection Menus (explained previously in this section), complex waveforms can be created and /or modified. To create a new waveform, press the NEW WAVE blue softkey. Pressing the NEW WAVE blue softkey will ensure that any previously entered harmonic values will not be present.

The menu shown below appears in the Control Display. This menu allows the user to specify:

- any integer harmonic, from the second to the 63rd
- up to 15 harmonics can be entered, labeled HARMNIC A through HARMNIC O
- the amplitude of the harmonic, as a percentage of the fundamental
- the phase of the harmonic relative to the fundamental

Press the HARMNIC A off blue softkey and notice that the off/on display changes to "on".



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Harmonic Number

To specify or edit the harmonic number, press the # HF/F blue softkey and enter the desired harmonic. For example, press 3 then ENTER to select the 3rd harmonic.

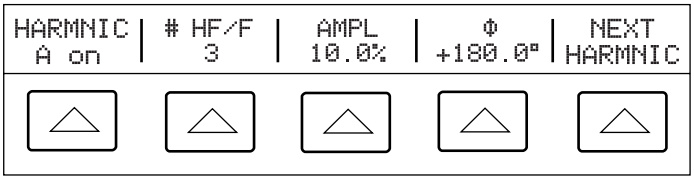
Harmonic Amplitude

Press the AMPL blue softkey to enter the amplitude of the harmonic as a percentage of the fundamental. For example, press 10 then ENTER for 10 %.

Phase

To specify or edit the phase of the harmonic, press the ϕ blue softkey to set the phase. Continue with the example by entering a phase of 180 degrees.

Following this example, the Control Display will now show the following:



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To enter another harmonic, press the NEXT HARMNIC blue softkey and repeat the previous procedure. A maximum of 15 harmonics may be entered. When complete, the NEXT HARMNIC blue softkey may be pressed repeatedly to examine the contents of each wave.

Once certain that all values are properly entered, press PREV MENU . The waveform will not take effect until PREV MENU is pressed. If the calibrator is in Operate Mode, the new waveform will be re-computed and the calibrator will pause while it builds the composite waveform. If the calibrator is in Standby Mode, the new waveform will not be built until OPR is pressed.

Note

The resultant waveform has the RMS value as shown on the left-hand display of the calibrator. Depending upon how many harmonics were entered, this value is most likely different than the fundamental value.

Note

The build time that the calibrator requires is dependent upon the complexity of the waveform. Waveforms with only HARMNIC A activated take the shortest time. Waveforms with five tones (i.e. HARMNIC A – E activated) take longer. The longest build time is for custom waveforms with more than five tones. The preinstalled IEC and NRC waveforms, because they have up to 49 harmonics, take over 1.5 minutes to build.

To minimize the build time of a waveform, leave the calibrator in Standby whenever recalling, editing, or creating waveforms. The unit should be in Operate Mode only when it is certain that the waveform is defined.

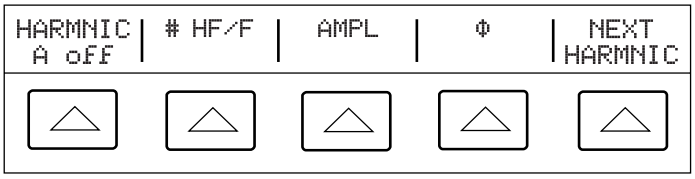
After building a waveform, pressing the "V" key will display the value of the fundamental and also the range the calibrator is in.

Editing Waves

Note

The procedures for creating a new wave and editing a wave are essentially the same. The difference between the NEW WAVE and EDIT WAVE menus is that under the NEW WAVE section, all harmonic parameters default at "0" until the user changes those parameters. In the EDIT WAVE Menu, a wave that has either been in use, or a wave that was recalled can be edited.

To edit existing wave parameters, press the EDIT WAVE blue softkey. The Control Display will change to the menu shown below. Press the HARMNIC A off blue softkey and notice that the off/on display changes to "on". If there is already a composite harmonic waveform in use, it may be edited from this menu.



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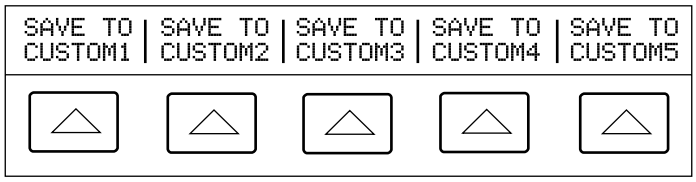
Refer to "Creating New Waves" for a detailed description of how wave parameters can be added and edited.

Note

Only the first 15 harmonics of a recalled IEC or NRC wave may be changed or edited. Upon entering the EDIT WAVE menu, all harmonics greater than 15 are removed from the waveform. Once the user exists the EDIT WAVE menu (i.e. the HARMNIC A …. NEXT HARMNIC level), a new waveform is built, since this wave does not have harmonics greater than 15.

Saving Waves

Once a wave has been created or edited, the user may wish to save it for future use. To do this, follow the steps for creating waves and editing wave harmonics. Then, from the Wave Selection Menu, press the SAVE WAVE blue softkey. The Save Menu, shown below, appears on the display.



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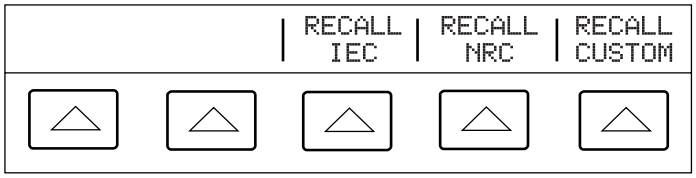
From the SAVE Menu, 5 waves can be saved. For example, press the SAVE TO CUSTOM1 blue softkey. The calibrator will store the wave in non-volatile memory and the menu will revert to the Wave Selection Menu.

Recalling Saved Waves

From the Wave Selection Menu, press the RECALL WAVE blue softkey. The menu shown below appears in the Control Display.



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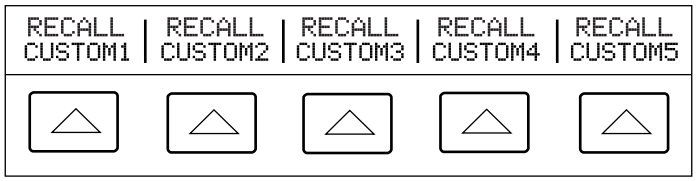
From the Recall Wave Menu select the RECALL CUSTOM blue softkey. The Custom Wave Menu shown below appears in the Control Display.



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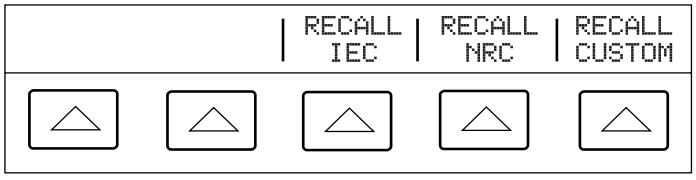
Select the Custom Wave blue softkey designating where the created wave was stored (RECALL CUSTOM1-5). The Control Display will change to the RECALL WAVE Menu (shown below), and the calibrator will output the recalled wave.



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Preinstalled Waves

The calibrator comes with 7 preinstalled waves. There are two IEC waves, and five NRC waves.

IEC Waves

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. These formulas specify limits for harmonic current emissions. The IEC A waveform is the limit for Class A equipment. The IEC D waveform is the limit for Class D equipment. These waveforms, when used in the PQ current output mode, are particularly useful for checking the performance of instruments that are designed to check these limits.

NRC Waves

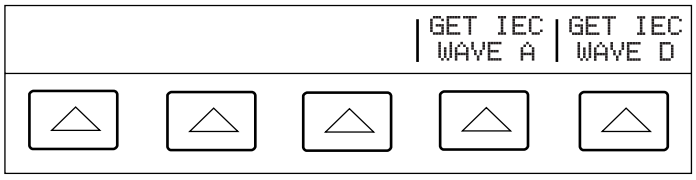
NRC 2 and NRC 4 are voltage waveforms captured in actual fieldwork by the NRC. NRC 3 and NRC 5 are current waveforms captured in actual fieldwork by the NRC. NRC 2 and NRC 3, and NRC 4 and NRC 5 are voltage and current combinations. Waveforms 2 to 5 have up to 49 harmonics, with many of these with amplitudes less than 1 % of the fundamental.

NRC7030 is a synthesized waveform with rich harmonic content (25 harmonics) and a low crest factor, to give the measuring instrument the best signal to noise ratio. All 25 harmonics have an amplitude that is 10 % of the fundamental. This waveform is useful in both the voltage and current mode to check the performance of power quality analyzers.

Recalling Preinstalled IEC Waves

From the Wave Selection Menu, press the RECALL WAVE blue softkey. The Recall Wave Menu appears in the Control Display. Press the RECALL IEC blue softkey. The IEC Wave Menu, shown below, appears in the Control Display.

After choosing "IEC A" or "IEC D", if the calibrator is in Standby mode, the RECALL Menu appears again. The recalled wave will not be built until the calibrator is placed in Operate Mode. Because of the complexity of these waves, the building process for these waves is over one minute. If the calibrator is already in Operate Mode, the recomputing message shows on the Control Display, then the RECALL Menu appears.



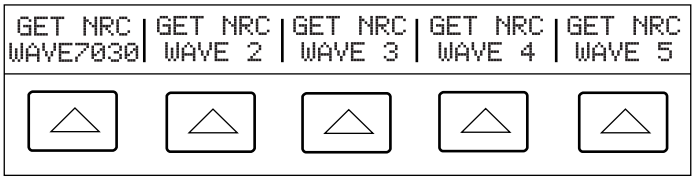
nn357f.eps

Recalling Preinstalled NRC Waves

From the Wave Selection Menu, press the RECALL WAVE blue softkey. The Recall Wave Menu appears in the Control Display. Press the RECALL NRC blue softkey. The NRC Wave Menu, shown below, appears in the Control Display.

If the calibrator is in Standby Mode, the RECALL Menu appears. The recalled wave will not be built until the calibrator is placed in Operate Mode. Because of the complexity of these waves, the building process for these waves is over one minute. If the calibrator is

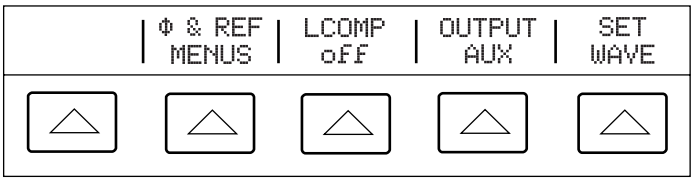
already in Operate Mode, the recomputing message shows on the Control Display, then the RECALL Menu appears.



nn358f.eps

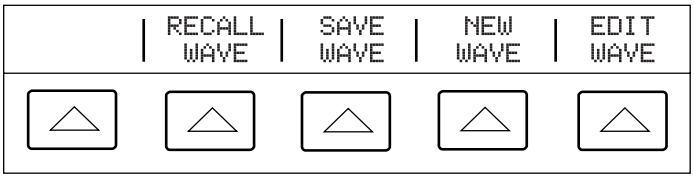
Composite Harmonics Function (Amps)

Creating and editing waves for current outputs is similar to editing waves for voltage outputs described previously. After entering the PQ Mode and accessing Composite Harmonic Function, create a composite harmonic current waveform by entering the desired current into the calibrator. For example, press “1 A” ENTER. The following menu appears:



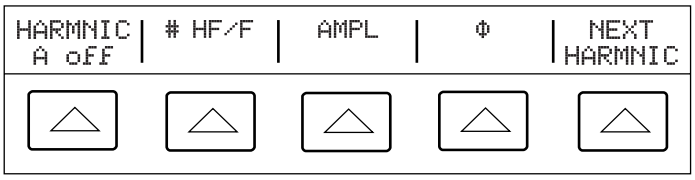
nn336f.eps

Because the calibrator is now set up to output current, any previously created wave is removed. A new wave can be created by pressing the SET WAVE blue softkey. The menu shown below appears.



nn353f.eps

Press the NEW WAVE or EDIT WAVE blue softkey. The menu shown below appears in the Control Display.



nn334f.eps

From this menu, the user may edit the wave harmonics. Refer to "Creating Wave Harmonics" earlier in this section.

Setting LCOMP

The LCOMP blue softkey enables/disables internal compensation for inductive loads such as multi-turn coils. Refer to "Setting AC Current Output" in Chapter 4 of this manual for a detailed discussion of this feature. Note that setting LCOMP to "on" degrades the accuracy of higher frequency harmonics as indicated in the specifications.

Output AUX

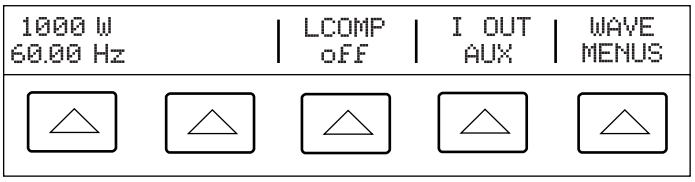
This indicator is for information purposes only. The indicator displays which current output is presently being used by the calibrator. The Control Display will show the Output Information Menu (I OUT AUX when current is present at the AUX output and I OUT 20A if the current is present at the 20A output).

In the PQ mode, the operation of the Output Information Menu behaves slightly different than in the normal operating mode described in Chapter 4. In the Composite Harmonic mode, the calibrator does not update the Output Information Menu until the waveform is built. For example, if the calibrator is presently set at 10A, 60Hz, with STBY showing in the Output Display, and the user wishes to output 1 A by pressing "1A ENTER ", the Output Information menu will not automatically change to OUTPUT AUX until OPR is pressed.

When in the SET WAVE menus, the Output Information menu is not shown. In those menus, if OPR is pressed and the Control Display shows an overcompliance message, it is because the output location has changed. Clear the message and move the unit under test to the proper terminals.

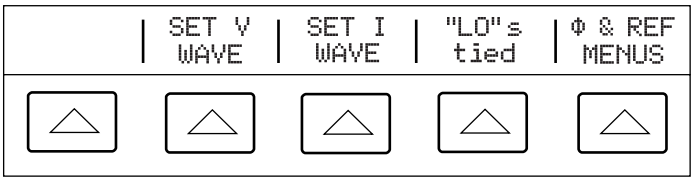
Composite Harmonics Function (Volts and Amps)

The operation of this mode is similar to the Composite Harmonics Mode described for voltage outputs. After entering the PQ Mode and accessing the Composite Harmonic Function, explained previously in this section, enter the desired voltage and current into the calibrator. For example, 1 V and 1 A. The following menu appears:



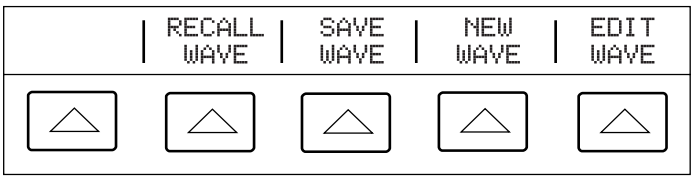
nn359f.eps

Because the calibrator is now set up to output voltage and current, any previously created wave is removed. A new wave can be created by pressing the WAVE MENUS blue softkey. The menu shown below appears.



nn360f.eps

Begin editing either the volt or current wave by pressing the SET V WAVE or SET I WAVE blue softkey. The Wave Selection Menu shown below appears.



nn353f.eps

From this menu, the user may edit the wave harmonics. Refer to "Editing Wave Harmonics" earlier in this section.

Note

Building a wave can be time consuming, especially if using one of the preinstalled waves. To minimize the time the calibrator uses to rebuild the waveform, leave the calibrator in Standby Mode whenever recalling or creating waves. Only when OPR *is pressed will the calibrator recompute the waveform.*

Setting LCOMP

The LCOMP softkey enables/disables internal compensation for inductive loads such as multi-turn coils. Refer to "Setting AC Current Output" in Chapter 4 of this manual for a detailed discussion of this feature. Note that setting LCOMP to ON degrades the accuracy of higher frequency harmonics as indicated in the specifications.

Output AUX

This indicator is for information purposes only. The indicator displays which current output is presently being used by the calibrator. The Control Display will show I OUT AUX when current is present at the AUX output and I OUT 20A if the current is present at the 20A output.

In the PQ mode, the operation of the Output Information behaves slightly different than in the normal operating mode described in Chapter 4. In the Composite Harmonic mode, the calibrator does not update the Output Information Menu until the waveform is built. For example, if the calibrator is presently set at 10A, 60Hz, with STBY showing in the Output Display, and the user wishes to output 1 A by pressing "1A ENTER ", the Output Information menu will not automatically change to OUTPUT AUX until OPR is pressed.

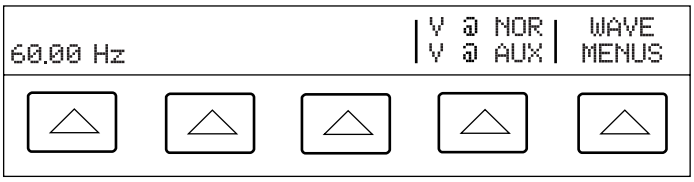
When in the SET WAVE menu, the Output Information Menu is not shown. In those menus, if OPR is pressed and the Control Display shows an overcompliance message, it is because the output location has changed. Clear the message and move the unit under test to the proper terminals.

Φ *& REF Menus*

In the Volts and Current Dual Output mode, phase between the voltage and current outputs can be specified by the user. These menus operate in the same fashion as the normal dual output mode, as described in Chapter 4.

Composite Harmonics Function (Volts and Volts)

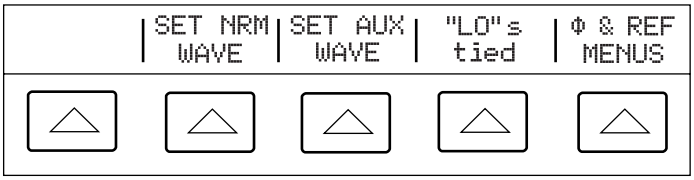
After entering the PQ Mode and accessing Composite Harmonic Function (explained previously in this section), enter the correct voltages into the calibrator. For example, 1 V and 2 V. The following menu appears:



nn361f.eps

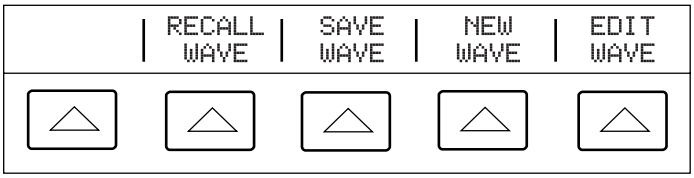
The V @ NOR and V @ AUX indicators on the Control Display are for information purposes only. This message is letting the user know that there is voltage present at the NORMAL or AUX output terminals.

Because the calibrator is now set up to output voltage and current, any previously created wave is removed. A new wave can be created by pressing the WAVE MENUS blue softkey. The menu shown below appears.



nn362f.eps

Begin editing either voltage wave by pressing the SET NRM WAVE or SET AUX WAVE blue softkeys. The Wave Selection Menu shown below appears.



nn353f.eps

From this menu, the user may edit the wave harmonics. Refer to "Editing Wave Harmonics" earlier in this section.

Note

Building a wave can be time consuming, especially if using one of the preinstalled waves. To minimize the time the calibrator has to rebuild the waveform, leave the calibrator in Standby Mode whenever recalling or creating waves. Only when OPR *is pressed will the calibrator recompute the waveform.*

Φ & REF Menus

In the Volts and Volts dual output mode, phase between the voltage and current outputs can be varied by the user. These menus operate in the same fashion as the normal dual output mode, as described in Chapter 4.

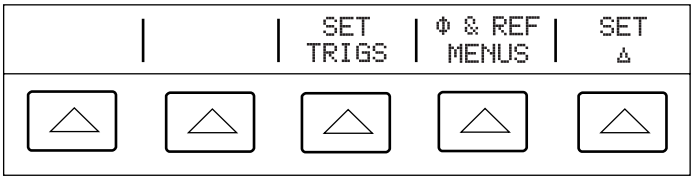
Delta (Δ)Amplitude, Flicker Function (Volts)

Note

Before starting this section, refer to "Entering the PQ Modes earlier in this chapter.

Delta (Δ) Amplitude Mode (Volts)

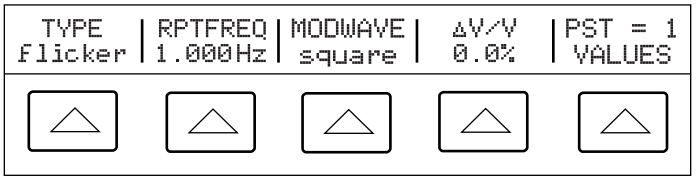
Enter the PQ Delta (**Δ**) Amplitude Mode. From this mode, the user can simulate a continuous change in amplitude of the output (flicker), or a single (one time) change in output amplitude (sag & swell condition). The **Δ** AMPL mode menu, shown below, appears in the Control Display.



nn363f.eps

Selecting the Flicker Function

From the PQ: **Δ** AMPL Menu, select SET **Δ**. The Flicker Menu, shown below appears in the Control Display.



nn344f.eps

The TYPE blue softkey specifies the function, "flicker" for the flicker function and "single" for the Sags & Swells function. Ensure that the TYPE is set to flicker.

Setting the Repeat Frequency

From the Flicker Menu, press the RPTFREQ blue softkey to enter the frequency of the flicker event. This period is also referred to as the flicker modulation frequency.

Setting the Modulation Pattern

Press the MODWAVE blue softkey to select either squarewave or sinewave modulation.

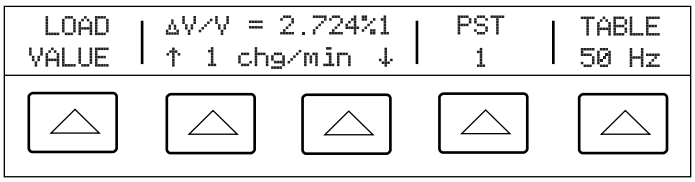
Setting the Flicker Amplitude

The **Δ**V/V blue softkey brings up a screen in the Control Display allowing the user to specify the amplitude of the deviation as a percentage of the nominal output value. The percentage value may be positive or negative.

P_{ST} Values

IEC 61000-4-15 (“Flickermeter – Functional and Design Specifications”) defines the severity of flicker in terms of a short term (“st”) observation period of 10 minutes. For both 50 HZ and 60 Hz, the calibrator has 7 combinations of amplitude changes and frequency to give a Pst reading of 1 on a flickermeter. These 7 values can be accessed by pressing the P_{st} = 1 VALUES blue softkey.

When the P_{st} = 1 VALUES blue softkey is pressed, the menu shown below appears.



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Use the ↑ and ↓ blue softkeys to navigate back and forth between the 7 installed P_{st} values. Select the desired P_{st} value then press the LOAD VALUE blue softkey. The Control Display will now revert back to the Flicker Menu. Notice that the new P_{st} value has now been loaded.

The P_{st} 1 softkey chooses classifiers that effectively change the flickermeter P_{st} readings from 1 to the chosen values. There are 1-5 classifiers.

The Table 60Hz softkey chooses the appropriate delta voltage and time combinations for either 60 Hz or 50 Hz operation. Note that this selection also changes the output frequency of the calibrator.

Setting Phase and Reference in the ΔAMPL Function

For a detailed description of this procedure, refer to "Setting the Output" in Chapter 4 of this manual.

Delta (Δ) Amplitude, Flicker Function (Current)

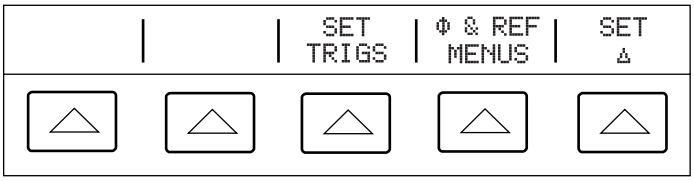
Simulating flicker for a current output is similar to a voltage output . There are additional menus (e.g. LCOMP and OUTPUT) that pertain to the current output. Refer to the previous section for more information.

Note

Before starting this section, refer to "Entering the PQ Modes " earlier in this chapter.

Delta (Δ) Amplitude Mode (Amps)

Enter the PQ Delta (Δ) Amplitude mode (PQ: ΔAMPL). Press the ΔAMPL softkey to access the Delta (Δ) amplitude functions. The ΔAMPL Menu, shown below, appears in the Control Display. From this mode the flicker and sags/swells functions are accessible by pressing the SETΔ blue softkey.



nn363f.eps

More Information

For more information regarding the Delta (Δ) Amplitude and Flicker Function in Current mode, refer to "Delta (Δ) Amplitude, Flicker Function (Volts)".

Delta (Δ) Amplitude, Single (Sags & Swells) Function (Volts)

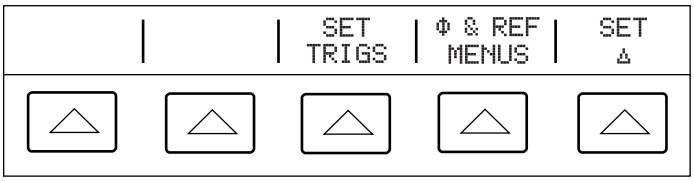
This mode allows the user to output a single or one-time amplitude deviation. From this mode, the user can specify the RAMP-UP time, the WIDTH of the event, and the % deviation.

Note

Before starting this section, refer to "Entering the PQ Modes " earlier in this chapter.

Delta (Δ) Amplitude Mode (Volts)

Press the ΔAMPL softkey to access the Delta (Δ) amplitude functions. From this mode the flicker and single (sags & swells) functions are accessible. The ΔAMPL Menu, shown below, appears in the Control Display.

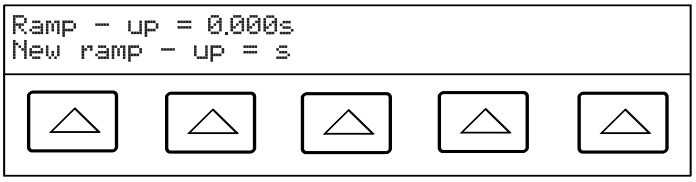


nn363f.eps

Press the TYPE flicker blue softkey. This will put the calibrator in the single (Sag & Swells) Mode.

Setting the Ramp-up Period

Press the RAMP-UP blue softkey. The Control Display changes to a screen, shown below, instructing the user to enter the period over which the output ramps to the selected value.



nn365f.eps

Setting the Sag & Swell Width

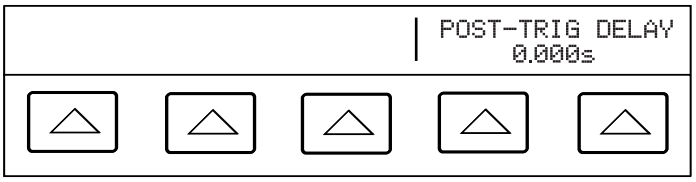
The WIDTH blue softkey allows the user to specify the duration of the sag or swell event in seconds.

Setting the Sag/Swell Amplitude

The ΔI/I softkey allows the user to specify the amplitude of the deviation as a percentage of the nominal output value. The value is positive for swell events and negative for sags.

Setting Triggers

Press the SET TRIGS blue softkey. The SET TRIGS menu, shown below, appears in the Control Display. The Post Trigger Delay is used to provide a variable-length delay after the calibrator receives a *TRG command over the remote interface or manually from the front panel.



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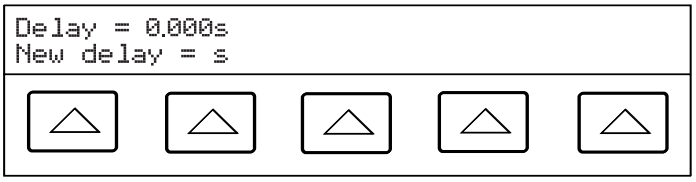
Press either of the last two blue softkeys and the Control Display changes to the screen shown below. This screen prompts the user for the new delay value. Enter the new value and press the PREV MENU button to load the value. The trigger is now set. To activate the trigger, press OPR.



nn364f.eps

Example

Assume a specified sag event with the following characteristics:

- The Post Trigger Delay has been set to 3 seconds, which means the event will not begin until 3 seconds after the trigger has occurred.
- A nominal output voltage of 120 V @ 60 Hz has been entered
- The ramp up period is set to 1.0 second
- The event width is set to 5 seconds with a Delta (Δ) amplitude of -25 %

Assuming the calibrator is in Operate Mode and a *TRG command is received over the remote interface, the calibrator will delay for 3 seconds and then begin ramping the output down, over a 1.0 second interval to 90 Volts. The output will remain at 90 Volts for 5 seconds after which it will return immediately to the nominal value, in this case 120 V. If using the PQ from the front panel, pushing OPR will trigger this event.

Delta (Δ) Amplitude, Single (Sags & Swells) Function (Current)

Creating and editing waves for current outputs is similar to editing waves for voltage outputs described previously.

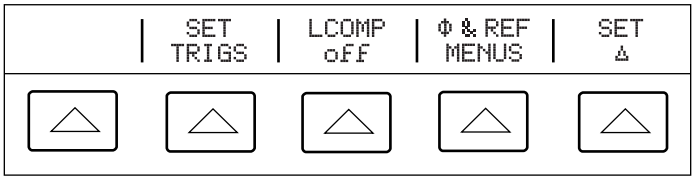
Note

Before starting this section, refer to "Entering the PQ Modes " earlier in this chapter.

Delta (Δ) Amplitude Mode (AMPS)

Press the ΔAMPL softkey to access the Delta (Δ) amplitude functions. From this mode the Flicker and Sags/Swells functions are accessible.

The ΔAMPL Menu, shown below, appears in the Control Display, assuming a current (amps) value has been entered.



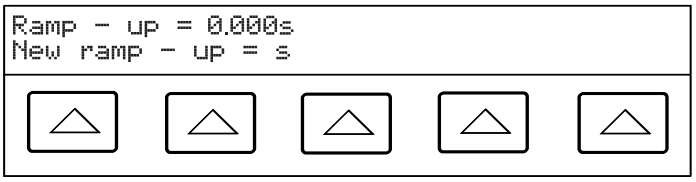
nn351f.eps

Setting Triggers

Refer to "Setting Triggers" earlier in this chapter.

Setting the Ramp-up Period

Press the RAMP-UP blue softkey. The Control Display changes to the screen, shown below, instructing the user to enter the period over which the output ramps to the selected value. The ramp period applies for both Sags and Swells.



nn365f.eps

Setting the Sag/Swell Width

The WIDTH blue softkey allows the user to specify the duration of the SAG or Swell event in seconds.

Setting the Sag/Swell Amplitude

The ΔI/I softkey allows the user to specify the amplitude of the deviation as a percentage of the nominal output value. The value is positive for swell events and negative for sags.

Delta (Δ)Amplitude Mode (Volts and Amps)

The Delta (Δ) Amplitude Mode may also be used for voltage and current dual outputs. The following example demonstrates how to do this.

Example

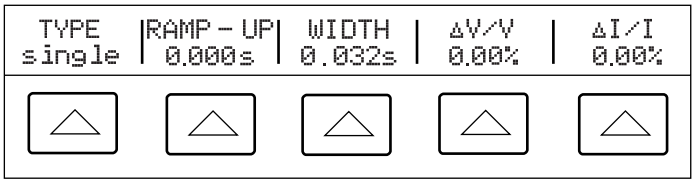
Assume a specified Sag event with the following characteristics:

- 10 Volts, 1 Amp, at 60 Hz
- A Post Trigger Delay set to 3 seconds
- The event width is set to 5 seconds with a voltage delta (Δ) amplitude of -25 % and a current delta (Δ) amplitude of -50 %.
- The ramp up period is set to 1.0 second

To create this complex waveform, follow these steps:

1. Press the PQ:ΔAMPL blue softkey
2. Enter 10 Volts, 1 A, 60 Hz
3. Press the MORE OPTIONS blue softkey
4. Press SET Δ.

The following menu appears:



nn366f.eps

This menu allows editing of the delta (Δ) amplitude of both the volts and the current in the single (sag or swells) mode.

5. To edit the delta (Δ) volts part of this waveform, press the ΔV/V blue softkey. At the prompt, enter -25 percent, then press ENTER, and finally PREV MENU.
6. To edit the delta (Δ) current part of this waveform, press the ΔI/I blue softkey. At the prompt, enter -50 percent, then press ENTER, and finally PREV MENU.
7. Press the RAMP-UP blue softkey and select 1 second, then PREV MENU.
8. Press the WIDTH blue softkey and enter 3, then PREV MENU.

Assuming the calibrator is in Operate Mode and a remote *TRG command is received, the calibrator will delay for 3 seconds and then begin ramping the output down, over a 1.0 second interval to 7.5 Volts and 0.5 Amps. The output will remain at this level for 5 seconds after which it will return immediately to the nominal value, in this case 10 V and 1 A.

Remote Commands

This section documents the IEEE-488/RS-232 remote commands for the 5520A PQ option. Remote commands duplicate activities that can be initiated from the front panel in local operation. The following is an alphabetical listing of the PQ option remote commands with examples. For more information on using remote commands, see Chapter 5, "Remote Operation".

Note

SEC (or Secondary) refers to the output of the AUX jacks when using dual outputs from the 5520A. When a dual output is in use, the NORMAL jacks will be the PRI (or Primary) output and the AUX jacks will be the SEC (secondary) output. If the AUX jacks are used for single outputs, they are the PRI output.

Commands

CHIEC <OUTPUT CH.>, <IEC WAVEFROM NUMBER>

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

Set composite harmonic wave to a preset IEC wave.

<OUTPUT CH.> is PRI or SEC

<IEC WAVEFROM NUMBER> is 1 or 2

Example: CHIEC PRI,2 ---- sets primary output wave to IEC waveform number 2.

CHM? <PRESET NUMBER>

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

Return the contents of one of the 5 composite harmonic preset waveforms.

<PRESET NUMBER> is 1 to 5. The return format is the same as CHTONES?

Example: CHM? 2

CHMRECALL <OUTPUT CH.>, <USER DEFINED WAVEFROM NUMBER>

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

Set composite harmonic wave to a previously memorized preset.

<OUTPUT CH.> is PRI or SEC
<USER DEFINED WAVEFROM NUMBER> is 1 to 5
Example: CHMRECALL PRI,2 sets primary output wave to preset 2

CHMSAVE <OUTPUT CH.>, <USER DEFINED WAVEFROM NUMBER>

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

Save the current wave as a user defined preset waveform.

<OUTPUT CH.> is PRI or SEC

<USER DEFINED WAVEFROM NUMBER> is 1 to 5

Example: CHMSAVE PRI,2 saves primary output wave as preset 2

CHNRC <OUTPUT CH.>, <NRC WAVEFROM NUMBER>

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

Set composite harmonic wave to a preset NRC wave.

<OUTPUT CH.> is PRI or SEC

<NRC WAVEFROM NUMBER> is 1 to 5. NRC7030 is 1.

Example: CHNRC PRI,2 ---- sets primary output wave to NRC waveform number 2

CHTONES <OUTPUT CH.>, <HARMONIC>, <HARMONIC AMPLITUDE>, <HARMONIC PHASE>, <...>,<...>, ...

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

Specify up to 15 harmonic/amplitude/phase groups

<OUTPUT CH.> is PRI or SEC

<HARMONIC> is 2 - 63

<HARMONIC AMPL> is 0.1 % to 100 %

Harmonic amplitude as proportion of fundamental; the PCT unit may be used; if no unit, a fraction is implied (i.e. 30PCT and 0.3 both indicate the harmonic amplitude should be 30 % of the fundamental.

<HARMONIC PHASE> is +/- 0.1 to 360.0 degrees Harmonic phase relative to fundamental in degrees. Numbers outside +/- 180 are automatically forced into that range by adding or subtracting a multiple of 360.

Example: CHTONES PRI,3,33pct,0,5,20pct,0,7,16pct,0,9,11pct,0,11,9pct,0

Example: CHTONES SEC,3,0.11,-180,5,0.04,0,7,0.02,-180,0,0,0,0,0,0

CHTONES? <OUTPUT CH.>

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

Return present settings for harmonics in the format of harmonic number, amplitude, and phase. All harmonics that are not set return to a 0 value.

<OUTPUT CH.> is PRI or SEC

Example: CHTONES? PRI
Example of return string: 2, 0.10, 30, 3, 0.02, -150, …

DELTAMAG <OUTPUT CH.>, <DELTA_AMPLITUDE>

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

Set the amplitude deviation in Delta Amplitude modes (Sags/Swells & Flicker).

<OUTPUT CH.> is PRI or SEC

<DELTA_AMPLITUDE> is 0.01 % to 100.0 %

Example: DELTAMAG PRI, 0.1 deviate the Primary channel output by +10 %

Example: DELTAMAG SEC, -0.1 deviate the Primary channel output by +10 %

DELTAMAG? <OUTPUT CH.>

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

Return the amplitude deviation of the selected channel in Delta Amplitude modes.

<OUTPUT CH.> is PRI or SEC

Example: DELTAMAG? PRI

DURATION <EVT_DURATION>

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

Set the event duration in Single (Sag/Swell) Delta Amplitude mode.

<DELTA_DURATION> is .032 Sec. to 60 Sec.

Example: DURATION 49.0s --- Set the event duration to 49 Seconds

Example: DURATION 10.3 --- Set the event duration to 10.3 seconds (S is optional)

DURATION?

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

Return the event duration in Single (Sag/Swell) Delta Amplitude mode.

Example: DURATION?

EVTMODE <E_MODE>

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

Set the event mode for Delta Amplitude operation

<E_MODE> is REPEAT --- Flicker operation

SINGLE --- Sag/Swell operation

Example: EVTMODE SINGLE

EVTMODE?

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

Returns the event mode in Delta Amplitude operation.

SINGLE --- for Sag/Swell operation
REPEAT --- for flicker operation

Example: EVTMODE?

FLICKWAV <F_WAVE>

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

Set the flicker modulation type; Sine or Square.

<F_WAVE> is SINE or SQUARE

Example: FLICKWAV SQUARE

Example: FLICKWAV SINE

FLICKWAV?

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

Return the flicker modulation type; Sine or Square.

FUND?

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

Returns the amplitude of the fundamental in composite harmonic mode.

Returns all zeros if not in a composite harmonic function.

1. (Float) Output amplitude
2. (Character) Units (V or A)
3. (Float) Second output amplitude for dual output functions 0 if no second amplitude)
4. (Character) Units of second amplitude (0 if no second amplitude)

Example: 1.883000E-01,A,0.000000E+00,0

PQ <MODE>

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

Enter/Exit the Power Quality mode.

<MODE> is OFF --- for normal 5520 mode

CH --- for Composite Harmonic mode

DAMPL --- for Sag/Swell or Flicker mode

Example: PQ CH --- Enter the Composite Harmonics mode

PQ?

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

Returns the Power Quality calibration mode.

OFF --- currently operating in normal 5520 mode

CH --- currently in composite Harmonic mode

DAMPL --- currently in Sag/Swell or Flicker mode

Example: PQ?

POSTTRIGDELAY <D_TIME>

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

Set a post trigger delay in Single (Sag/Swell) mode.

<D_TIME> is 0.001 Sec to 60 Sec

Example: POSTTRIGDELAY 3

POSTTRIGDELAY?

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

Read the post trigger delay in Single (Sag/Swell) mode.

Example: POSTTRIGDELAY?

RAMPTIME <R_TIME>

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

Set the period over which the output amplitude is "ramped" up/down to the selected Delta V / V value in Single (Sag/Swell) mode.

<R_TIME> is 0.001 Sec to 60.0 Sec

Example: RAMPTIME 5.3

RAMPTIME?

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

Read the current Ramptime setting.

Example: RAMPTIME?

RPTFREQ <MOD_FREQ>

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

Set the modulation frequency in Flicker mode.

<MOD_FREQ> 0.001Hz to 30.0Hz

Example: RPTFREQ 10Hz

Example: RPTFREQ 5

RPTFREQ?

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

Return the modulation frequently in Flicker mode.

Example: RPTFREQ?

TRIGGED?

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

Returns 0 if no trig even, 1 if triggered

Example Strings

The following sets up a Flicker output on the primary channel, with a square wave modulation frequency of 0.65 Hz and a delta V/V of 0.91 %. The output voltage is 120 V, 60 Hz:

```
pq dampl; evtmode repeat; flickwav square; rptfreq .65;
deltamag pri, .0091;  out 120v, 60hz; oper
```

Performance Tests

To verify the PQ option meets its specifications, refer to the performance tests in this section. The tables are for use by qualified metrology personnel only.

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.

Verification Table

Table 16. Verification Table

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 16. Verification Table (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	1.0
		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 16. Verification Table (continued)

Verification Tests for AC Voltage		Harmonic	Fundamental	Phase	Amplitude (V)	Specification (V)	Specification (deg)
Range	329.99 V	rms			150.0000	0.3100	
Wave	IV	1	100.00%		54.627	0.1299	
RMS Output	150 V	2	100.00%	0	54.627	0.1299	0.75
Frequency	50 Hz	3	100.00%	0	54.627	0.1299	0.75
		4	100.00%	0	54.627	0.1299	0.75
		5	100.00%	0	54.627	0.1299	0.75
		6	100.00%	0	54.627	0.1299	0.75
		7	100.00%	0	54.627	0.1299	0.75
		8	30.00%	0	16.388	0.1624	0.75
		9	30.00%	0	16.388	0.1624	1.0
		10	30.00%	0	16.388	0.1624	1.0
		11	30.00%	0	16.388	0.1624	1.0
		12	30.00%	0	16.388	0.1624	1.0
		13	30.00%	0	16.388	0.1624	1.0
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 16. Verification Table (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	1.0
		10	10.00%	-167.8	20.6550	0.8512	1.0
		11	10.00%	85.9	20.6550	0.8512	1.0
		12	10.00%	-37.3	20.6550	0.8512	1.0
		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 16. Verification Table (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 16. Verification Table (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 16. Verification Table (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
		4	10.00%	-179.6	0.85313	0.0185	0.6
		5	10.00%	13.3	0.85313	0.0185	0.6
		6	10.00%	9.3	0.85313	0.0185	0.6
		7	10.00%	73.5	0.85313	0.0185	0.6
		8	10.00%	152.1	0.85313	0.0185	0.6
		9	10.00%	-19.9	0.85313	0.0185	0.6
		10	10.00%	-167.8	0.85313	0.0185	0.6
		11	10.00%	85.9	0.85313	0.0185	0.6
		12	10.00%	-37.3	0.85313	0.0185	0.6
		13	10.00%	16.1	0.85313	0.0185	0.6
		14	10.00%	-28.1	0.85313	0.0185	0.6
		15	10.00%	94	0.85313	0.0185	0.6
		16	10.00%	-173.4	0.85313	0.0185	1.0
		17	10.00%	129.5	0.85313	0.0185	1.0
		18	10.00%	-113.9	0.85313	0.0185	1.0
		19	10.00%	37.6	0.85313	0.0185	1.0
		20	10.00%	-52.3	0.85313	0.0185	1.0
		21	10.00%	1.5	0.85313	0.0185	1.0
		22	10.00%	14.3	0.85313	0.0185	1.0
		23	10.00%	150.2	0.85313	0.0185	1.0
		24	10.00%	7.1	0.85313	0.0185	1.0
		25	10.00%	161.3	0.85313	0.0185	1.0