6100B/6105A

Electrical Power Standards

Users Manual

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Introduction

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1-1. Introduction

The Fluke Electrical Power Standards, "the Instruments" or "The Instrument", are precise instruments for the calibration of Watthour meters and energy reference standards and measuring devices used to determine the magnitude and quality of power supplied to consumers. The range of power standards includes the 6100B, 6105A Master Instruments and 6101B and 6106A Auxiliary Instruments.

Note

Unless otherwise stated, the use of "6100B" in this manual refers to the entire product family.

The Instruments can each be used to provide a single phase of electrical power quality and energy. Adding one to three 6101B or 6106A Auxiliary Instruments extends a system to up to four phases. For greater flexibility, the 6100B and 6105A Master units can also be configured as Auxiliaries by connecting one cable externally. The 6105A and 6106A are high-accuracy versions of the 6100B and 6101B respectively.

1-2. Contacting Fluke

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

- Technical Support USA: 1-800-44-FLUKE (1-800-993-5853)
- Calibration/Repair USA: 1-888-99-FLUKE (1-888-993-5853)
- Canada: 1-800-36-FLUKE (1-800-363-5853)
- Europe: +31 402-675-200
- Japan: +81-3-3434-0181
- Singapore: +65-738-5655
- Anywhere in the world: +1-425-446-5500

Or, visit Fluke's website at www.fluke.com.

To register your product, visit http://register.fluke.com.

To view, print, or download the latest manual supplement, visit http://us.fluke.com/usen/support/manuals.

1-3. General Safety Summary

This manual contains information and warnings that must be observed to ensure safe operation and keep the Instrument in a safe condition. Operation or service in conditions or in a manner other than specified could compromise safety. For the correct and safe use of this Instrument, it is essential that both operating and service personnel follow accepted safety procedures in addition to the safety precautions specified.

In this manual, a **Warning** identifies conditions and actions that pose hazard(s) to the user; a **Caution** identifies conditions and actions that may damage the Instrument or the test equipment.

⚠⚠**Warning**

To avoid electrical shock, personal injury, or fire hazard:

- **The Instrument must not be switched on if it is damaged or suspected to be faulty.**

- **Do not operate the Instrument in damp, wet, condensing, dusty, or explosive gas conditions.**

- **If the equipment is used in a manner not specified in this manual, the protection provided by the Instrument may be impaired.**

- **Whenever it is likely that safety protection has been impaired, the Instrument must be made inoperative and be secured against any unintended operation. Inform qualified maintenance or repair personnel.**

- **Safety protection is likely to be impaired if, for example, the Instrument shows visible damage or fails to operate normally.**

1-4. *Explanation of Safety-Related Symbols and Terms*

The symbols in Table 1 are found on the Instrument or in this manual.

Table 1-1. Symbols

Symbol	Explanation
⚠	Hazardous voltage. Risk of electrical shock.
⚠	Risk of danger. Important information. See manual.
⏚	Earth ground.
℅℗⒭	Conforms to relevant Canadian Standards Association directives.
CE	Conforms to relevant European Union directives.
🗑	Do not dispose of this product as unsorted municipal waste. Go to Fluke's website for recycling information.

1-5. *Protective Earth (Grounding)*

Protection Class 1 - The Instrument must be operated with a protective earth/ground connection via the protective earth/grounding conductor of the ac line supply cable. The protective earth/ground connects before the ac line and neutral connections when the supply plug is inserted into the Instrument's rear panel ac line supply socket. If the final connection to the ac line supply is made elsewhere, ensure that the protective earth/ground connection is made before ac line and neutral.

If there is a possibility the protective earth/ground connection might not be made before the ac line and neutral connections, or the output terminals are connected to a potentially hazardous live circuit, the separate protective earth/ground connection stud on the rear panel of the Instrument must be connected to a suitable protective earth/ground.

⚠⚠Warning

To avoid electrical shock or personal injury, do not intentionally or unintentionally interrupt the protective ground conductor inside or outside the Instrument. Interrupting the protective ground conductor is likely to make the Instrument dangerous. Intentional interruption is prohibited.

1-6. Features

The Instruments feature the following:

- Traceable power and energy signals

- Configurable from one to four independent phases

- Full independent control of voltage and current on each phase

- 1 kV and 21 A available on each phase (50 A with the 50 A option, 80 A with the 80 A option) on each phase. By default, the N phase is limited to 33 V rms. This can be overridden by the user. Setting up voltage and current waveforms are described in later in this manual.

- Up to 100 harmonics and dc on either or both voltage and current channels.

- Fluctuating harmonics and interharmonics to IEC 61000-4-7 and 61000-4-13, 61000-4-13 and 61000-4-14

- Dips and swells to IEC 61000-4-11

- Flicker to 61000-4-15

- Simultaneous power quality phenomena to IEC61000-4-30 and 61000-4-34

- Built-in IEC 61036 and IEC 62053 series current waveforms for static Watthour meter testing.

- User-definable waveforms

- User-selectable reactive power calculation method

- >13 V peak compliance on all current outputs up to 21 A

- Soft start options to handle inrush current taken by instruments that take power from the voltage signal

- Complex Instrument configurations can be saved to internal memory or to a USB memory device for transfer to other 6105A0B systems

- The optional Energy Comparator provides for calibration of energy meters

- 10 MHz or 20 MHz reference clock output option

1-7. About this Manual

This manual provides complete information for installing the Electrical Power Standard and operating it from the front panel and remotely. It also provides a glossary of terms as well as detailed specifications. The following topics are covered in this manual:

- Installation

- Operating controls and features

- Front panel operation

- Remote operation (IEEE-488.2)

- Data transfer via external storage

- Operator maintenance, including calibration

- Glossary of Terms

1-8. Specifications

The following sections give the Instrument's general and detailed specifications.

1-9. General Specifications

1-10. Input Power

Voltage	100 V - 240 V with up to ±10 % fluctuations
Transient overvoltages	Impulse withstand (overvoltage) category II of IEC 60364-4-443
Frequency	47 Hz - 63 Hz
Max. Consumption	1000 VA max from 100 - 130 V, 1250 VA max from 130 V - 260 V

1-11. Dimensions

	6100B, 6101B, 6105A, and 6106A	With 50 A or 80 A Options
Height	233 mm (9.17 inches)	324 mm (12.8 inches)
Height (without feet)	219 mm (8.6 inches)	310 mm (12.2 inches)
Width	432 mm (17 inches)	432 mm (17 inches)
Depth	630 mm (24.8 inches)	630 mm (24.8 inches)
Weight	23 kg (51 lb)	30 kg (66 lb)

1-12. Environment

Operating temperature	5 °C - 35 °C
Calibration temperature (tcal) range	16 °C - 30 °C
Storage temperature	0 °C - 50 °C
Transit temperature	-20 °C - 60 °C <100 hours
Warm up time	1 hour
Safe Operating Max. Relative Humidity (non-condensing)	<80 % 5 °C - 31 °C ramping linearly down to 50 % at 35 °C
Storage Max Relative Humidity (non-condensing)	<95 % 0 °C - 50 °C
Operating altitude	0 m - 2,000 m
Non-operating altitude	0 m - 12,000 m
Shock	MIL-PRF-28800F class 3
Vibration	MIL-PRF-28800F class 3
Enclosure	MIL-PRF-28800F class 3

1-13. Safety

- Designed to EN61010-1: 2001, CAN/CSA 22.2 No 1010.1-92, UL61010A-1

- Indoor use only, pollution degree 2; installation category II

- CE marked and CSA listed

1-14. EMC

EN61326: 2002, class A, FCC rules part 15, sub-part B, class A (Class A equipment is suitable for use in establishments other than domestic, and those directly connected to a low voltage power supply network which supplies buildings used for domestic purposes).

1-15. General Electrical Specifications

Voltage/Current amplitude setting resolution	6 digits
Range of fundamental frequencies	16 Hz - 850 Hz
Line frequency locking	45 Hz - 65.9 Hz at user's discretion
Frequency accuracy	±10 ppm
Frequency setting resolution	0.1 Hz
Warm up time to full accuracy	1 hour or twice the time since last warmed up
Settling time following change to the output	0 to 10 seconds
Nominal angle between voltage phases	120 °
Nominal angle between voltage and current of a phase	0 °
Phase angle setting	±180 °, ± π radians [1]
Phase angle setting resolution	0.001 °, 0.00001 radians [1]
Maximum number of voltage harmonics	100 including the 1st (fundamental frequency)
Maximum number of current harmonics	100 including the 1st (fundamental frequency)

[1] Switching between phase set in degrees, phase set in radians and back may not be consistent because of calculation rounding errors.

1-16. Amplitude/Frequency Limits

- If the 50 A or 80 A option is fitted, the range minimum settable fundamental frequency is 40 Hz and the maximum harmonic frequency is 3 kHz.
- Although the minimum settable fundamental frequency is 16 Hz, modulated waveforms may generate frequency components below that, including DC.
- A DC component of up to 50 % of range may be added to all voltage and current ranges except 50 A and 80 A.
- If the bandwidth limit is enabled, maximum frequency is 1.5 kHz.

1-17. Open and Closed Loop Operation

Full accuracy for pure sine or sine plus harmonics is achieved by using analog and digital feedback systems (closed loop). When any of: Flicker, Fluctuating harmonics, Dip/Swell or Interharmonics are applied, the digital system is automatically uncoupled (open loop). Initial performance is as described in the 1-year accuracy column but performance degrades with time as described by the stability column. Full accuracy can be restored by momentarily disabling whichever of Flicker, Fluctuating harmonics, Dip/Swell or Interharmonics are enabled, or by changing the value of the sine wave or any harmonic for that channel.

1-18. Electrical Specifications

1-19.   Voltage Specifications

1-20.   Voltage Channel Maximum Capacitive Loading for Output Stability

The voltage output will remain stable with 100 nF load but may not be able to drive that capacitance at all voltage/frequency/harmonic combinations due to burden current limitations.

1-21.   Voltage Range Limits and Burden

Full Range (FR)	23 V	45 V	90 V	180 V	360 V	650 V [4]	1008 V
Max peak [1][2]	32.5 V	63.6 V	127.2 V	254.5 V	509 V	919 V	1425 V
Maximum Burden (peak current) [3]	1 A	1 A	1 A	1 A	1 A	1 A	71 mA
Maximum Burden (RMS current) [3]	500 mA	500 mA	500 mA	250 mA	150 mA	110 mA	60 mA

[1]   These values apply to sinusoidal, distorted and modulated wave-shapes.

[2]   Voltage harmonic phase angle significantly affects the peak value of a non-sinusoidal waveform.

[3]   To achieve specifications in 4-wire sense, resistance in the sense lead must be less than 1 Ω and resistance in the power leads less than 1.5 Ω.

[4]   6105A and 6101B only.

[5]   The peak current cannot be sustained and is dependent on the voltage level at which it is requested. It will not be possible to achieve this current when the output is at 0 V but it will be achievable as the voltage approaches the peak level of the waveform. High peak current capability is provided to drive meters that take pulses of current from the signal.

1-22. Voltage Sine Amplitude Specifications

Ranges	Frequency	Voltage [5]	6105A & 6106A 1-Year Accuracy, tcal [4] ±5 °C ± (ppm of output + mV) [1][6]		6100B & 6101B 1-Year Accuracy, tcal [4] ±5 °C ± (ppm of output + mV) [1][6]		6100B, 6101B, 6105A & 6106A Open Loop 24-Hour Stability ± (ppm of output + mV) [2][3]	
1.0 V - 23 V	45 Hz - 65 Hz	15 V - 17 V	42	0	112	1	75	0.8
		1.0 V - 23 V	42	0.2				
	16 Hz - 850 Hz	1.0 V - 23 V	60	0.2				
3 V - 45 V	45 Hz - 65 Hz	28 V - 32 V	42	0	112	2	75	0.8
		3 V - 45 V	42	0.4				
	16 Hz - 850 Hz	3 V - 45 V	60	0.4				
6.3 V - 90 V	45 Hz - 65 Hz	56 V - 64 V	42	0	112	2.2	75	0.8
		6.3 V - 90 V	42	0.8				
	16 Hz - 850 Hz	6.3 V - 90 V	60	0.8				
13 V - 180 V	45 Hz - 65 Hz	110 V - 128 V	44	0	112	4.4	75	1.5
		13 V - 180 V	44	1.6				
	16 Hz - 850 Hz	13 V - 180 V	60	1.6				
25 V - 360 V	45 Hz - 65 Hz	215 V - 246 V	44	0	112	8.8	75	3
		25 V - 360 V	60	3.2				
	16 Hz - 850 Hz	25 V - 360 V	61	3.2				
46 V - 650 V	45 Hz - 65 Hz	425 V - 490 V	44	0	-	-	75	6
		46 V - 650 V	60	5.8				
	16 Hz - 850 Hz	46 V - 650 V	61	5.8				
70 V - 1008 V	45 Hz - 65 Hz	740 V - 850 V	44	0	150	26	75	10
		70 V - 1008 V	60	10				
	16 Hz - 850 Hz	70 V - 1008 V	61	10				

[1]   Four-wire sense only, for two-wire operation, add an additional voltage = 0.3 Ω x maximum burden current to the accuracy specification.

[2]   For ±1 °C and constant load and connection conditions.

[3]   When Flicker, Fluctuating harmonics, Dip/Swell or Interharmonics are applied, Open Loop Stability specification must be added to the 1-year accuracy specification as described in "Open and Closed Loop Operation".

[4]   tcal = temperature of last calibration.

[5]   Output levels less than the range minimum can be set but are not specified.

[6]   These specifications assume a "sampling" measuring instrument. Some rms sensing instruments have voltage input bandwidths of several MHz. The 6100B specification should be expanded by the non-harmonic noise floor in the "Voltage Distortion and Noise" table for rms sensing devices.

1-23. *Voltage DC and Harmonic Amplitude Specifications*

Range	Output [4][5]	Frequency	6105A & 6106A 1-Year Accuracy, tcal [4] ±5 °C ±(ppm of output + mV) [1][6]		6100B & 6101B 1-Year Accuracy, tcal [4] ±5 °C ±(ppm of output + mV) [1][6]		Open Loop 24-Hour Stability ± (ppm of output + mV) [2][3]	
1.0 V - 23 V	0 V - 11.5 V	DC	91	2	122	5	75	1.8
	0 V - 6.9 V	16 Hz - 850 Hz	58	1	122	1	75	0.8
		850 Hz - 6 kHz	451	1	512	1	150	0.8
3 V - 45 V	0 V - 22.5 V	DC	91	4	122	10	75	3.3
	0 V - 13.5 V	16 Hz - 850 Hz	58	2	122	2	75	0.8
		850 Hz - 6 kHz	451	2	512	2	150	0.8
6.3 V - 90 V	0 V - 45 V	DC	91	8	122	24	75	8
	0 V - 27 V	16 Hz - 850 Hz	60	2.2	122	2.2	75	0.8
		850 Hz - 6 kHz	451	2.2	512	2.2	150	0.8
13 V - 180 V	0 V - 90 V	DC	91	16	122	50	75	15
	0 V - 54 V	16 Hz - 850 Hz	60	4.4	122	4.4	75	1.5
		850 Hz - 6 kHz	451	4.4	512	4.4	150	1.5
25 V - 360 V	0 V - 180 V	DC	91	32	122	100	75	30
	0 V - 108 V	16 Hz - 850 Hz	60	12	122	12	75	3
		850 Hz - 6 kHz	451	12	512	12	150	3
46 V - 650 V	0 V - 325 V	DC	92	60	-	-	75	65
	0 V - 195 V	16 Hz - 850 Hz	61	22	-	-	75	6
		850 Hz - 6 kHz	451	22	-	-	150	6
70 V - 1008 V	0 V - 504 V	DC	92	100	166	300	75	100
	0 V - 302 V	16 Hz - 850 Hz	61	33	166	33	75	10
		850 Hz - 6 kHz	451	33	524	33	150	10

[1] Four-wire sense only, for two-wire operation, add an additional voltage = 0.3 Ω x maximum burden current to the accuracy specification.

[2] For ±1 °C and constant load and connection conditions.

[3] When Flicker, Fluctuating harmonics, Dip/Swell or Interharmonics are applied, "Open loop" stability specification must be added to the 1-year accuracy specification as described in "Open and Closed Loop Operation".

[4] These specifications are only applicable if the combined voltage rms output is greater than the range minimum. If the combined output is below the range minimum the output is not specified.

[5] The maximum value for a single harmonic (2nd to 100th) below 2850 Hz is 30 % of range. See "Amplitude/Frequency Limits" for profile above 2850 Hz.

[6] tcal = temperature of last calibration.

1-24.   Voltage Distortion and Noise

Range and Frequency		Maximum Harmonic Distortion [1] Either:				Non-harmonic Noise Floor (relative to full range)	
Full Range	**Frequency**	the largest of		or the largest of		16 Hz - 4 MHz	
		dB	**Volts**	**% Setting**	**% Range**	**dB**	**%**
23 V	16 Hz - 850 Hz	-76	480 µV	0.016	0.003	-66	0.05
	850 Hz - 6 kHz	-52	2.4 mV	0.25	0.015	-66	0.05
45 V	16 Hz - 850 Hz	-76	990 µV	0.016	0.003	-70	0.032
	850 Hz - 6 kHz	-52	5.0 mV	0.25	0.015	-70	0.032
90 V	16 Hz - 850 Hz	-76	2.3 mV	0.016	0.003	-72	0.025
	850 Hz - 6 kHz	-52	11 mV	0.25	0.015	-72	0.025
180 V	16 Hz - 850 Hz	-76	5.0 mV	0.016	0.003	-76	0.016
	850 Hz - 6 kHz	-52	25 mV	0.25	0.015	-76	0.016
360 V	16 Hz - 850 Hz	-76	10 mV	0.016	0.003	-66	0.05
	850 Hz - 6 kHz	-52	50 mV	0.25	0.015	-66	0.05
650 V	16 Hz - 850 Hz	-76	20 mV	0.016	0.003	-60	0.1
	850 Hz - 6 kHz	-52	100 mV	0.25	0.015	-60	0.1
1008 V	16 Hz - 850 Hz	-76	30 mV	0.016	0.003	-60	0.1
	850 Hz - 6 kHz	-52	151 mV	0.25	0.015	-60	0.1
[1] dB harmonic distortion increases linearly between 850 Hz and 6 kHz.							

1-25.   Current Range Limits

Full Range (FR)	0.25 A	0.5 A	1 A	2 A	5 A	10 A	21 A	50 A	80 A
Max Peak [1][2]	0.353 A	0.707 A	1.414 A	2.828 A	7.07 A	14.14 A	29.7 A	70.7	113 A
Maximum Compliance Voltage at FR (Vpk) [3][4]	14 V	14 V	14 V	14 V	14 V	14 V	12.5 V	3 V	2 V
Maximum Inductive Load, Hi Bandwidth [5]	300 µH	300 µH	300 µH	300 µH	300 µH	30 µH	30 µH	30 µH	30 µH
Maximum Inductive Load, Lo Bandwidth [5][6]	2 mH	2 mH	1 mH	1 mH	500 µH	360 µH	500 µH	250 µH	250 µH

[1]   These values apply to sinusoidal, distorted and modulated wave-shapes.

[2]   Current harmonic phase angle significantly affects the peak value of a non-sinusoidal waveform.

[3]   Above 450 Hz, the instrument will drive current outputs that develop maximum compliance voltage across the load, but an "adder" to the accuracy specification in "Current DC and Harmonic Amplitude Specifications" and "Current Distortion and Noise" may be required. Calculation of the "adders" is described below.

[4]   Compliance voltage at the end of connecting leads will be reduced by the IR drop in the cables.

[5]   The current output will remain stable with the inductive loads shown but may not be able to drive that inductance at all current/frequency/harmonic combinations due to voltage burden limitations. The inductive load due to connecting cables may be decreased by reducing their loop area, for example, by tying the cables together or shortening the cables.

[6]   In low bandwidth mode maximum frequency is 1.5 kHz.

1-26. Load Regulation Specification "adder"

The finite output impedance of the current amplifier causes a "load regulation" effect that must be taken into consideration. Let V_F = the peak voltage developed across the load due to current I_F at frequency F. Let I_{FR} be the maximum current and V_{max} the maximum compliance peak voltage for the range in use.

If $V_F/V_{max} \leq I_F/I_{FR}$ no specification adder is required. Otherwise, the adder is calculated:

if $V_F/V_{max} > I_F/I_{FR,}$ add: $\dfrac{I_{FR} \times F \times V_F}{20 \times V_{max}} \mu A$

Example: The output is a 800 Hz, 0.5 A rms sine wave on the 5 A range. The 6100B current specification from "Current Sine Amplitude Specifications" is:

139 ppm + 120 µA = 70 µA + 120 µA

The voltage across the output is 6 V peak and maximum compliance is 14 V, for example, $V_F/V_{max} > I_F/I_{FR}$. The "adder" is:

$$\frac{5 \times 800 \times 6}{20 \times 14} = 85 \ \mu A$$

The current specification becomes:

70 µA + 120 µA + 85 µA = 275 µA

1-27. Current Sine Amplitude Specifications

Range (Amps)	Frequency	Current (Amps) [4]	6105A & 6106A 1-Year Accuracy, tcal [3] ±5 °C ±(ppm of output + µA)		6100B & 6101B 1-Year Accuracy, tcal [3] ±5 °C ±(ppm of output + µA)		Open Loop 24-Hour Stability ±(ppm of output + µA) [1][2]	
0.25 A	45 Hz to 65 Hz	0.1 A - 0.25 A	46	2.5	139	6	75	3
		0.25 A	46	1.5	130	6	75	3
	16 Hz - 850 Hz	0.01 A - 0.1 A	60	5	139	6	75	3
		0.1 A - 0.25 A	60	5	130	6	75	3
0.5 A	45 Hz to 65 Hz	0.2 A - 0.5 A	46	5	139	12	75	5
		0.5 A	46	3	130	12	75	5
	16 Hz - 850 Hz	0.05 A - 0.2 A	61	10	139	12	75	5
		0.2 A - 0.5 A	61	10	130	12	75	5
1 A	45 Hz to 65 Hz	0.4 A - 1.0 A	47	10	139	24	75	10
		1 A	47	6	130	24	75	10
	16 Hz - 850 Hz	0.1 A - 0.4 A	61	20	139	24	75	10
		0.4 A - 1 A	61	20	130	24	75	10
2 A	45 Hz to 65 Hz	0.8 - 2 A	46	20	139	48	75	20
		2 A	46	12	130	48	75	20
	16 Hz - 850 Hz	0.2 A - 0.8 A	61	40	139	48	75	20
		0.8 A - 2 A	61	40	130	48	75	20

[1]   For ±1 °C and constant load and connection conditions.

[2]   When Flicker, Fluctuating harmonics, Dip/Swell or Interharmonics are applied, "Open loop" stability specification must be added to the 1-year accuracy specification as described in "Open and Closed Loop Operation".

[3]   tcal = temperature of last calibration.

[4]   Output levels less than the range minimum can be set but are not specified.

[5]   These specifications assume a "sampling" measuring instrument. Some rms sensing instruments have voltage input bandwidths of several MHz. The 6100B specification should be expanded by the non-harmonic noise floor in "Current Distortion and Noise" for rms sensing devices.

[6]   Settling time (TS) of 21 A, 50 A, and 80 A ranges depends on rms output as a proportion of full range and can be calculated from: TS = %FR2 x 180 seconds. Settling magnitude will not exceed 50 ppm at FR.

Range (Amps)	Frequency	Current (Amps) [4]	6105A & 6106A 1-Year Accuracy, tcal [3] ±5 °C ±(ppm of output + µA)		6100B & 6101B 1-Year Accuracy, tcal [3] ±5 °C ±(ppm of output + µA)		Open Loop 24-Hour Stability ±(ppm of output + µA) [1][2]	
5 A	45 Hz to 65 Hz	2 - 5 A	49	50	139	120	75	50
		5 A	49	30	130	120	75	50
	16 Hz - 850 Hz	0.5 A - 2 A	64	100	139	120	75	50
		2 A - 5 A	64	100	130	120	75	50
10 A	45 Hz to 65 Hz	4 - 10 A	49	100	191	240	75	50
		10 A	49	60	164	240	75	50
	16 Hz - 850 Hz	1 A - 4 A	65	200	191	240	75	100
		4 A - 10 A	65	200	164	240	75	100
21 A	45 Hz to 65 Hz	8 A - 21 A	49	200	213	720	75	300
		21 A	49	120	189	720	75	300
	16 Hz - 850 Hz	2 A - 8 A	69	400	213	720	75	300
		8 A - 21 A	69	400	189	720	75	300
50 A	45 Hz to 65 Hz	20 A - 50 A	49	500	213	1800	500	750
		50 A	49	300	189	1800	500	750
	16 Hz - 850 Hz	3.2 A - 20 A	74	1000	213	1800	500	750
		20 A - 50 A	74	1000	189	1800	500	750
80 A	40 Hz - 450 Hz	8 A - 32 A	106	2800	265	2800	1000	1200
		32 A - 80 A	106	2800	250	2800	1000	1200
	450 Hz - 850 Hz	8 A - 32 A	112	2800	300	2800	1000	1200
		32 A - 80 A	118	2800	280	2800	1000	1200

[1] For ±1 °C and constant load and connection conditions.
[2] When Flicker, Fluctuating harmonics, Dip/Swell or Interharmonics are applied, "Open loop" stability specification must be added to the 1-year accuracy specification as described in "Open and Closed Loop Operation".
[3] tcal = temperature of last calibration.
[4] Output levels less than the range minimum can be set but are not specified.
[5] These specifications assume a "sampling" measuring instrument. Some rms sensing instruments have voltage input bandwidths of several MHz. The 6100B specification should be expanded by the non-harmonic noise floor in "Current Distortion and Noise" for rms sensing devices.
[6] Settling time (TS) of 21 A, 50 A, and 80 A ranges depends on rms output as a proportion of full range and can be calculated from: TS = %FR2 x 180 seconds. Settling magnitude will not exceed 50 ppm at FR.

1-28. Current DC and Harmonic Amplitude Specifications

Range	Current [4]	Frequency	6105A & 6106A 1-Year Accuracy, tcal [3] ±5 °C ± (ppm of output + μA)		6100B & 6101B 1-Year Accuracy, tcal [3] ±5 °C ± (ppm of output + μA)		Open Loop 24-Hour Stability ± (ppm of output + μA) [1][2]	
0.01 A - 0.25 A	0 A - 0.125 A	DC	89	25	139	75	100	11
	0 A - 0.075 A	16 Hz - 850 Hz	61	5	139	6	75	3
		850 Hz - 6 kHz	401	5	400	6	150	3
0.05 A - 0.5 A	0 A - 0.25 A	DC	89	50	139	150	100	22
	0 A - 0.15 A	16 Hz - 850 Hz	61	10	139	12	75	5
		850 Hz - 6 kHz	401	10	400	12	150	5
0.1 A -1 A	0 A - 0.5 A	DC	89	100	139	300	100	45
	0 A - 0.3 A	16 Hz - 850 Hz	61	20	139	24	75	10
		850 Hz - 6 kHz	401	20	400	24	150	10
0.2 A - 2 A	0 A - 1 A	DC	89	200	139	600	100	90
	0 A - 0.6 A	16 Hz - 850 Hz	61	40	182	48	75	20
		850 Hz - 6 kHz	401	40	400	48	150	20
0.5 A - 5 A	0 A - 2.5 A	DC	89	500	139	1500	100	225
	0 A - 1.5 A	16 Hz - 850 Hz	61	100	139	120	75	50
		850 Hz - 6 kHz	401	100	400	120	150	50
1 A - 10 A	0 A - 5 A	DC	89	1000	191	3000	100	450
	0 A - 3 A	16 Hz - 850 Hz	64	200	191	240	75	100
		850 Hz - 6 kHz	402	200	400	240	150	100
2 A - 21 A	0 A - 10 A	DC	90	2000	191	6000	100	900
	0 A - 6 A	16 Hz - 850 Hz	65	400	191	720	75	300
		850 Hz - 6 kHz	402	400	400	720	150	300
5 A - 50 A	0 A - 15 A	16 Hz - 850 Hz	69	1000	250	2800	500	750
		850 Hz - 3 kHz	403	1000	400	2800	750	1200
8 A - 80 A	0 A - 24 A	16 Hz - 850 Hz	112	2000	265	2800	500	1200
		850 Hz - 3 kHz	405	2000	400	2800	750	1200

[1] For ±1 °C and constant load and connection conditions.

[2] When Flicker, Fluctuating harmonics, Dip/Swell or Interharmonics are applied, "Open loop" stability specification must be added to the 1-year accuracy specification as described in "Open and Closed Loop Operation".

[3] tcal = temperature of last calibration.

[4] These specifications are only applicable if the combined voltage rms output is greater than the range minimum. If the combined output is below the range minimum the output is not specified.

[5] The maximum value for a single harmonic (2nd to 100th) below 2850 Hz is 30 % of range. See "Amplitude/Frequency Limits" for profile above 2850 Hz.

1-29. Current Distortion and Noise

Range and Frequency		Maximum Harmonic Distortion [1] Either:				Non-Harmonic Noise Floor (relative to full range)	
Full Range	Frequency	the largest of		or the largest of		16 Hz - 4 MHz	
		dB	Amps	% Setting	% Range	dB	%
0.25 A	16 Hz - 850 Hz	-80	7.5 µA	0.01	0.003	-50	0.316
	850 Hz - 6 kHz	-60	25 µA	0.1	0.01	-50	0.316
0.5 A	16 Hz - 850 Hz	-80	15 µA	0.01	0.003	-60	0.100
	850 Hz - 6 kHz	-60	50 µA	0.1	0.01	-60	0.100
1 A	16 Hz - 850 Hz	-80	30 µA	0.01	0.003	-60	0.100
	850 Hz - 6 kHz	-60	100 µA	0.1	0.01	-60	0.100
2 A	16 Hz - 850 Hz	-80	60 µA	0.01	0.003	-65	0.056
	850 Hz - 6 kHz	-60	200 µA	0.1	0.01	-65	0.056
5 A	16 Hz - 850 Hz	-80	150 µA	0.01	0.003	-65	0.056
	850 Hz - 6 kHz	-60	500 µA	0.1	0.01	-65	0.056
10 A	16 Hz - 850 Hz	-80	300 µA	0.01	0.003	-50	0.316
	850 Hz - 6 kHz	-60	1.0 mA	0.1	0.01	-50	0.316
21 A	16 Hz - 850 Hz	-80	600 µA	0.01	0.003	-50	0.316
	850 Hz - 6 kHz	-60	2.0 mA	0.1	0.01	-50	0.316
50 A	16 Hz - 850 Hz	-80	2.0 mA	0.01	0.003	-50	0.316
	850 Hz - 6 kHz	-60	5.0 mA	0.1	0.01	-50	0.316
80 A	16 Hz - 850 Hz	-80	2.4 mA	0.1	0.003	-70	0.032
	850 Hz - 3 kHz	-60	8.0 mA	0.1	0.01	-70	0.032

[1]   dB harmonic distortion increases linearly between 850 Hz and 6 kHz.

1-30. Voltage from the Current Terminals

1-31. Range Limits and Impedances

Full Range (FR)	0.25 V	1.5 V	10 V
Max Peak [1][2]	0.353 V	2.121 V	14.14 V
Source Impedance	1 Ω	6.67 Ω	40.02 Ω
Minimum load impedance to maintain specification [3]	40 kΩ	260 kΩ	1.5 MΩ

[1]   These values apply to sinusoidal, distorted and modulated wave shapes.
[2]   Harmonic phase angle significantly affects the peak value of a non-sinusoidal waveform.
[3]   For a load less than specified, calculate error from parallel combination of source and load impedance.

1-32. Sine Specifications

Range	Frequency	Output Component [3]	6105A & 6106A 1-Year Accuracy, tcal [4] ±5 °C ± (ppm of output + µV) [5]		6100B & 6101B 1-Year Accuracy, tcal [4] ±5 °C ± (ppm of output + µV) [5]		Open Loop 24-Hour Stability ± (ppm of output + µV) [1][2]	
0.05 V - 0.25 V	45 Hz - 65 Hz	0.1 V - 0.25 V	73	10	200	10	90	15
	16 Hz - 850 Hz	0.05 V - 0.25 V	82	10	200	10	90	15
0.15 V - 1.5 V	45 Hz - 65 Hz	0.6 V - 1.5 V	53	50	200	50	75	25
	16 Hz - 850 Hz	0.6 V - 1.5 V	66	50	200	50	75	25
1 V - 10 V	45 Hz - 65 Hz	4 V - 10 V	52	200	200	200	75	150
	16 Hz - 850 Hz	4 V - 10 V	66	200	200	200	75	150

[1]   For ±1 °C and constant load and connection conditions.
[2]   When Flicker, Fluctuating harmonics, Dip/Swell or Interharmonics are applied, "Open loop" stability specification must be added to the 1-year accuracy specification as described in "Open and Closed Loop Operation".
[3]   Output levels less than the range minimum can be set but are not specified.
[4]   tcal = temperature of last calibration.
[5]   These specifications assume a "sampling" measuring instrument. Some rms sensing instruments have voltage input bandwidths of several MHz. The 6100B specification should be expanded by the non-harmonic noise floor in "Current Distortion and Noise" for rms sensing devices.

1-33. DC and Harmonic Amplitude Specifications

Range	Output [4][5]	Frequency	6105A & 6106A 1-Year Accuracy, tcal [4] ±5 °C ± (ppm of output + μV) [5]		6100B & 6101B 1-Year Accuracy, tcal [4] ±5 °C ± (ppm of output + μV) [5]		Open Loop Stability ± (ppm of output + μV) per Hour [2][3]	
0.05 V - 0.25 V	0 V - 0.125 V	DC	91	35	200	15	100	15
	0 V - 0.075 V	16 Hz - 850 Hz	82	10	200	15	60	15
		850 Hz - 6 kHz	400	30	1000	15	150	15
0.15 V - 1.5 V	0 V - 0.75 V	DC	93	210	200	75	100	75
	0 V - 0.45 V	16 Hz - 850 Hz	66	160	200	25	50	25
		850 Hz - 6 kHz	400	50	1000	25	150	25
1 V - 10 V	0 V - 5 V	DC	93	1000	200	450	100	450
	0 V - 3 V	16 Hz - 850 Hz	65	200	200	150	50	150
		850 Hz - 6 kHz	400	300	1000	150	150	150

[1]   tcal = temperature of last calibration.

[2]   For ±1 °C and constant load and connection conditions.

[3]   When Flicker, Fluctuating harmonics, Dip/Swell or Interharmonics are applied, "Open loop" stability specification must be added to the 1-year accuracy specification as described in "Open and Closed Loop Operation".

[4]   These specifications are only applicable if the combined voltage rms output is greater than the range minimum. If the combined output is below the range minimum the output is not specified.

[5]   The maximum value for a single harmonic (2nd to 100th) below 2850 Hz is 30 % of range. See "Amplitude/Frequency Limits" for profile above 2850 Hz.

1-34. Voltage from Current Terminals, Distortion and Noise

Range and Frequency		Maximum Harmonic Distortion [1] Either				Non-harmonic Noise Floor (relative to full range)	
Full Range	Frequency	the largest of		or the largest of		16 Hz - 4 MHz	
		dB	Volts	% Setting	% Range	dB	%
0.25 V	16 Hz - 850 Hz	-80	2.5 μV	0.010	0.001	-50	0.316
	850 Hz - 6 kHz	-60	25 μV	0.100	0.01	-50	0.316
1.5 V	16 Hz - 850 Hz	-80	15 μV	0.010	0.001	-60	0.100
	850 Hz - 6 kHz	-60	150 μV	0.100	0.01	-60	0.100
10 V	16 Hz - 850 Hz	-80	100 μV	0.010	0.001	-60	0.100
	850 Hz - 6 kHz	-60	1 mV	0.100	0.01	-60	0.100

[1]   dB harmonic distortion increases linearly between 50 Hz and 6 kHz.

1-35. Current to Voltage Phase Specifications

For Voltage from the Current terminals, use the 0.25 A to 21 A phase specification.

For All Voltage Ranges (23 V - 1008 V)		6105A /6106A Voltage and Current Components >40 % of Range		6100B / 6101B Voltage and Current Components >40 % of Range		Voltage or Current Component 0.5 % - 40 % of Range [5]	
Current Range	Frequency	1-Year Accuracy, tcal [4] ±5 °C [1][2]	Open Loop 24-Hour Stability [2][3]	1-Year Accuracy, tcal [4] ±5 °C [1][2]	Open Loop 24-Hour Stability [2][3]	1-Year Accuracy, tcal ±5 °C [1][2]	Open Loop 24-Hour Stability [2][3]
0.25 A - 21 A	45 Hz - 65 Hz	0.0023 °	0.0002 °	0.003 °	0.0002 °	0.010 °	0.001 °
	16 Hz - 69 Hz	0.003 °	0.0002 °	0.003 °	0.0002 °	0.010 °	0.001 °
	69 Hz - 180 Hz	0.007 °	0.0002 °	0.009 °	0.0002 °	0.017 °	0.002 °
	180 Hz - 450 Hz	0.018 °	0.0005 °	0.023 °	0.0005 °	0.050 °	0.005 °
	450 Hz - 850 Hz	0.033 °	0.0008 °	0.043 °	0.0008 °	0.070 °	0.007 °
	850 Hz - 3 kHz	0.115 °	0.0010 °	0.150 °	0.0010 °	0.200 °	0.020 °
	3 kHz - 6 kHz	0.230 °	0.0010 °	0.300 °	0.0010 °	0.450 °	0.045 °
21 A - 50 A	45 Hz - 65 Hz	0.0023 °	0.0002 °	0.004 °	0.0003 °	0.010 °	0.001 °
	16 Hz - 69 Hz	0.003 °	0.0003 °	0.004 °	0.0003 °	0.010 °	0.001 °
	69 Hz - 180 Hz	0.007 °	0.0003 °	0.012 °	0.0003 °	0.017 °	0.002 °
	180 Hz - 450 Hz	0.018 °	0.0005 °	0.030 °	0.0005 °	0.050 °	0.005 °
	450 Hz - 850 Hz	0.033 °	0.0010 °	0.050 °	0.0010 °	0.070 °	0.007 °
	850 Hz - 3 kHz	0.115 °	0.0015 °	0.200 °	0.0015 °	0.200 °	0.020 °
	3 kHz - 6 kHz	0.230 °	0.0025 °	0.300 °	0.0025 °	0.450 °	0.045 °
20 A - 80 A	45 Hz - 65 Hz	0.003 °	0.0002 °	0.004 °	0.0005 °	0.010 °	0.001 °
	16 Hz - 69 Hz	0.003 °	0.0005 °	0.004 °	0.0005 °	0.016 °	0.002 °
	69 Hz - 180 Hz	0.008 °	0.0005 °	0.012 °	0.0005 °	0.028 °	0.003 °
	180 Hz - 450 Hz	0.025 °	0.0010 °	0.030 °	0.0010 °	0.080 °	0.008 °
	450 Hz - 850 Hz	0.050 °	0.0015 °	0.050 °	0.0015 °	0.100 °	0.010 °
	850 Hz - 3 kHz	0.250 °	0.0025 °	0.200 °	0.0025 °	0.300 °	0.030 °

[1] Current phase angle errors are relative to the voltage channel of the same phase. For example, L2 current is relative to L2 voltage.

[2] Phase angle contribution to power accuracy varies with set phase angle see "Power Specifications" below.

[3] For constant load and connection conditions.

[4] tcal = temperature of last calibration.

[5] Phase performance at less than 0.5 % of full range degrades as output components approach the resolution limit of the digital feedback system.

1-36. Multi-Phase Operation

1-37. Voltage to Voltage Phase Specifications

For All Voltage Ranges (23 V - 1008 V)	6105A /6106A Voltage and Current Components >40 % of Range		6100B / 6101B Voltage and Current Components >40 % of Range		Voltage or Current Component 0.5 % - 40 % of Range [5]	
Frequency	1-Year Accuracy, tcal [4] ±5 °C [1][2]	Stability per hour [2][3]	1-Year Accuracy, tcal [4] ±5 °C [1][2]	Stability per hour [2][3]	1-Year Accuracy, tcal ±5 °C [1][2]	Stability per hour [2][3]
16 Hz - 69 Hz	0.005 °	0.0002 °	0.005 °	0.0002 °	0.010 °	0.001 °
69 Hz - 180 Hz	0.007 °	0.0002 °	0.007 °	0.0002 °	0.017 °	0.002 °
180 Hz - 450 Hz	0.025 °	0.0005 °	0.025 °	0.0005 °	0.050 °	0.005 °
450 Hz - 850 Hz	0.043 °	0.0008 °	0.050 °	0.0008 °	0.070 °	0.007 °
850 Hz - 3 kHz	0.150 °	0.0010 °	0.170 °	0.0010 °	0.200 °	0.020 °
3 kHz - 6 kHz	0.300 °	0.0010 °	0.350 °	0.0015 °	0.450 °	0.045 °

[1]   Current phase angle errors are relative to the voltage channel of the same phase. For example, L2 current is relative to L2 voltage.

[2]   Phase angle contribution to power accuracy varies with set phase angle see "Power Specifications" below.

[3]   For constant load and connection conditions.

[4]   tcal = temperature of last calibration.

[5]   Phase performance at less than 0.5 % of full range degrades as output components approach the resolution limit of the digital feedback system.

1-38. Energy Specifications

1-39. Pulse Inputs

Max frequency	5 MHz (100 Hz for debounced inputs)
Min pulse width	100 ns
Max counts per channel	232-1 (4,294,967,295)

1-40. Pulse and Gate Inputs

Input Low level max	1 V
Input High level min	3 V
Internal pull-up values	135 Ω and 940 Ω to 4.5 V nominal
	(Approximately equivalent to 150 Ω/1k Ω to 5 V nominal)
Max input voltage	28 V (clamped @ 30 V approximately) [1]
Min input voltage	0 V (clamped @ -0.5 V approximately) [1]

1-41. Pulse Output

Drive	Open-collector with optional internal 470 Ω pull-up
Frequency range	1 mHz - 5 MHz
Frequency accuracy	± (10 ppm + 100 nHz)
External pull-up voltage	30 V MAX (clamped) [1]
Sink current	150 mA MAX

1-42. Gate Output

Drive	Open-drain
Internal Pull-up	As Gate-Input
External pull-up voltage	30 V MAX (clamped) [1]
Sink current	1 A MAX

[1]   Input/Output protection: 30 V / -0.5V (approximately) clamped, up to 120 mA per signal or 300 mA maximum total all signals.

1-43.   Accuracy

Counted/Timed timing accuracy	± (10 ppm + 100 ns) [2]
Gated mode accuracy	± (10 ppm + 100 ns) [2]
Packet mode accuracy (ppm) [3]	± (output power (ppm) + 10 ppm + 110,000/Test Duration (secs))
[2] Accuracy depends on the period between the application of power (pressing the OPER key) and the gate signal becoming active being greater than 2 seconds.	
[3] Specification not valid if "Soft Start" is enabled.	

1-44.   Test Duration

Maximum test duration	1000 hours

1-45.   Power Specifications

The example power specifications below are only valid for rms values greater than 40 % of range for voltage and current and frequency less than 450 Hz. They are not valid when any of: Flicker, Fluctuating harmonics, Dip/Swell or Interharmonics are applied to the voltage or current channel of that 6100B.

1-46.   6105A and 6106A Sinusoidal Power Accuracy at 45 Hz to 65 Hz; Power Factor 1.0 (ppm) [1]

Current	Power with Current at 90 % of Range			Power with Current at 50 % of Range		
	Voltage at 62 % to 70 % of Range		650 V & 1008 V Ranges; 70 % to 75 %	Voltage at 7 % to 100 % of Range		650 V & 1008 V Ranges; 70 % to 75 %
	23 V to 90 V	180 V & 360 V		23 V to 90 V	180 V & 360 V	
0 A to 2 A	62	64	64	72	74	74
5 A to 50 A	65	66	66	74	75	75
80 A	147	148	148	181	181	181
[1] For Energy specification add 1 ppm Note: 100 ppm = 0.01 %						

1-47.   6105A and 6106A Sinusoidal Power Accuracy at 45 Hz to 65 Hz; Power Factor 0.5 (ppm) [1]

Current	Power with Current at 90 % of Range			Power with Current at 50 % of Range		
	Voltage at 62 % to 70 % of Range		650 V & 1008 V Ranges; 70 % to 75 %	Voltage at 7 % to 100 % of Range		650 V & 1008 V Ranges; 70 % to 75 %
	23 V to 90 V	180 V & 360 V		23 V to 90 V	180 V & 360 V	
0 A to 5 A	93	94	94	100	101	101
10 A to 50 A	95	96	96	102	102	102
80 A	163	163	163	194	194	194
[1] For Energy specification add 1 ppm Note: 100 ppm = 0.01 %						

1-48. 6100B and 6101B Sinusoidal Power Accuracy at 45 Hz to 65 Hz; Power Factor 1.0 (ppm) [1]

Current	Power with Current at 90 % of Range		Power with Current at 50 % of Range	
	23 V to 360 V Ranges; 62 % to 70 % Range	1008 V Range; 740 V to 850 V	23 V to 360 V Ranges; 62 % to 70 % Range	1008 V Range; 740 V to 850 V
0 A to 2 A	236	239	252	239
5 A to 50 A	236	239	252	239
80 A	322	339	404	417
[1] For Energy specification add 1 ppm Note: 100 ppm = 0.01 %				

1-49. 6100B and 6101B Sinusoidal Power Accuracy at 45 Hz to 65 Hz; Power Factor 0.5 (ppm) [1]

Current	Power with Current at 90 % of Range		Power with Current at 50 % of Range	
	23 V to 360 V Ranges; 62 % to 70 % Range	1008 V Range; 740 V to 850 V	23 V to 360 V Ranges; 62 % to 70 % Range	1008 V Range; 740 V to 850 V
0 A to 5 A	246	249	262	249
10 A to 50 A	246	249	262	249
80 A	329	346	409	423
[1] For Energy specification add 1 ppm Note: 100 ppm = 0.01 %				

1-50. 6105A and 6106A Sinusoidal Power Accuracy with 20 % THD at Power Factor 1.0 (ppm) [1]

Accuracy Depends on Harmonic Order and Amplitudes

Current	Power with Current at 90 % of Range			Power with Current at 50 % of Range		
	Voltage at 62 % to 70 % of Range			Voltage at 7 % to 100 % of Range		650 V & 1008 V Ranges; 70 % to 75 %
	23 V to 90 V	180 V & 360 V	650 V & 1008 V Ranges; 70 % to 75 %	23 V to 90 V	180 V & 360 V	
0 A to 5 A	97	98	98	103	105	105
10 A to 50 A	98	99	99	105	105	105
80 A	165	165	165	196	196	196
[1] For Energy specification add 1 ppm Note: 100 ppm = 0.01 %						

1-51. 6100B and 6101B Non-sinusoidal Power Accuracy with 20 % THD at Power Factor 1.0 (ppm) [1]

Accuracy Depends on Harmonic Order and Amplitudes

V Range	Power with Current at 90 % of Range		Power with Current at 50 % of Range	
Current (80 to 100 % of Range)	23 V to 360 V; 62 % to 70 % Range	1008 V Range; 740 V to 850 V	23 V to 360 V Ranges; 62 % to 70 % Range	1008 V Range; 740 V to 850 V
0 A to 5 A	242	255	258	255
10 A to 50 A	242	255	258	255
80 A	326	350	408	426
[1] For Energy specification add 1 ppm Note: 100 ppm = 0.01 %				

Power Factor <0.5

For Power Factor less than 0.25, phase angle dominates power specifications and voltage and current accuracy becomes negligible. Calculate Power uncertainty from:

$$u(P) = (1 - \frac{\cos(\Phi + u(\phi))}{\cos(\Phi)}) \times 10^6 \; ppm$$

where Φ is the set phase angle and $u(\phi)$ is the phase uncertainty.

Reactive Power

For reactive Power (Q) calculate $u(Q)$ from

$$u(Q) = (1 - \frac{\sin(\Phi + u(\phi))}{\sin(\Phi)}) \times 10^{-6} \; ppm$$

The method used for calculation of reactive power in non-sinusoidal conditions is user selectable.

Reactive Power Calculation Methods

Under pure sinusoidal conditions, Apparent Power (S), Power (P) and Reactive power (Q) are related by:

$S^2 = P^2 + Q^2$. This relationship is known as the Power Triangle. When either the voltage or current waveform is not sinusoidal, the power triangle is not satisfied by this equation. This has lead to various attempts to better define Reactive Power (Q) but no single definition has been agreed. The difficulty is that Q is used for a number of different calculations including transmission line efficiency and voltage line drop. The 6100B allows users to select the definition that best meets their needs. The following methods are supported:

Budeanu	Fryze
Kusters and Moore	Shepherd and Zakikhani
Sharon / Czarnecki	IEEE working group

Because of the complexity of the subject, definition of the methods listed is beyond the scope of this document. References to relevant documentation are provided at the reference.

1-52. *Voltage and Current Sinusoidal and Rectangular Modulation Flicker Specification*

Setting range		±30 % of set value within range values (60 % ΔV/V)
Flicker modulation depth accuracy		0.025 %
Modulation depth setting resolution		0.001 %
Shape of modulation envelope		Rectangular, Square or Sinusoidal
Duty cycle (shape = rectangular)		0.01 % to 99.99 %; accuracy = ±31 µs
Modulation units Either:	Frequency	0.5 Hz to 40 Hz
	or Changes per minute	1.0 CPM to 4800 CPM
Modulating frequency accuracy [1][2]		<0.13 % (1 CPM to 4800 CPM)

[1] Rectangular modulation accuracy is ±{(10 + 31 x modulating frequency) ppm + 10 µHz}

[2] Sine modulation accuracy is ±(10 ppm +10 µHz)

Pst and Pinst Indication Accuracy

P_{st} and P_{inst} values are from IEC 61000-4-15, (amendment 1). Note that P_{st} and P_{inst} indications are only valid for 230 V and 120 V, 50 Hz and 60 Hz. P_{st} values are not valid for the current channel.

Voltage Setting	P_{st} Indication Accuracy
220 V - 240 V	±0.25 %
115 V - 125 V	±0.25 %

Note that long term flicker (P_{lt}) can be simulated either by a steady P_{st} over a suitable period, or by changing P_{st} and calculating P_{lt} from:

$$P_{lt} = \sqrt[3]{\frac{\sum_{i=1}^{N} P_{sti}^3}{N}}$$

where P_{sti} (i=1,2,3, ...) are different consecutive readings of P_{st}. See IEC61000-4-15 for details.

Other Flicker Modes

Extended Flicker functions are provided. The accuracy of these signals is better than 1 %:

- Frequency Changes
- Distorted voltage with multiple zero crossings
- Harmonics with side band
- Phase jumps
- Rectangular voltage changes with duty ratio

1-53. *Fluctuating Harmonic Specifications*

Fluctuating harmonics are available on voltage and current outputs. Fluctuating Harmonics are not available on a voltage or current channel if Flicker is already enabled on that channel.

Number of harmonics to fluctuate	Any number from 0 to all set harmonics can fluctuate
Modulation depth setting range [1]	0 % to 100 % of nominal harmonic voltage
Fluctuation accuracy (0 % to ±30 % modulation)	±0.025 %
Modulation depth setting resolution	0.001 %
Shape	Rectangular or Sinusoidal
Duty cycle (shape = rectangular)	0.1 % to 99.99 %
Modulating Frequency range	0.008 Hz to 30 Hz
Sine modulating frequency accuracy	±(10 ppm + 10 µHz)
Rectangular modulating frequency accuracy	<1300 ppm [2]
Modulating Frequency setting resolution	0.001 Hz

[1] Fluctuation accuracy is not specified for modulation depth >±30 %.

[2] Accuracy is ±{(50 + 31 x modulating frequency) ppm + 10 µHz}.

1-54. *Interharmonic Specifications*

Interharmonics are available on voltage and current outputs

Frequency accuracy	±500 ppm
Amplitude accuracy 16 Hz to <6 kHz	±1 %
Amplitude accuracy >6 kHz	4 %
Maximum value of a single interharmonic	The maximum value for an interharmonic <2850 Hz is 30 % of range. See "Amplitude/Frequency Limits" for profile above 2850 Hz.
Frequency range of interharmonic	16 Hz to 9 kHz

1-55. *Dip/Swell Specifications*

Although Dips and Swells are primarily voltage phenomena, the 6100B provides the same facility on its current output.

Trigger-in requirement	TTL falling edge remaining low for 10 µs
Either: Trigger-in delay OR	0 to 60 s ±31 µs
Phase-angle synchronization with respect to channel fundamental frequency zero crossing	±180 ° ±31 µs
Dip/Swell Min duration	1 ms
Dip/Swell Max duration	1 minute
Dip Min amplitude	0 % of the nominal output
Swell Max amplitude	The least of full range value and 140 % of the nominal output
Ramp up/down period	Settable 100 µs to 30 s
Optional repeat with delay	0 to 60 s ±31 µs
Starting level amplitude accuracy	±0.025 % of level
Dip/Swell level amplitude accuracy [1]	±0.25 % of level
Trigger out delay	0 to 60 s ±31 µs from start of dip/swell event
Trigger out	TTL falling edge co-incident with end of trigger out delay, remaining low for 10 µs to 31 µs

[1] Accuracy not specified below 10 % of starting level or below the range minimum value.

1-56.   *Determining Non-sinusoidal Waveform Amplitude Specifications*

The rms value of the combination of voltage components is:

$$V_{RMS}^2 = \sum_{i=1}^{N} V_i^2$$ and, assuming symmetrical uncertainties, $u(V)_i$, for each of V_i,

Note that the uncertainties of the components of a 6100B non-sinusoidal voltage (or current) waveform are correlated so must be combined by linear addition.

$$(V_{RMS} + u(V_{RMS}))^2 = \sum_{i=1}^{N} (V_i + u(V_i))^2$$

$$V_{RMS}^2 + 2V_{RMS}u(V_{RMS}) + u^2(V_{RMS}) =$$

$$V_1^2 + 2V_1 u(V_1) + u^2(V)_1 + V_2^2 + 2V_2 u(V_2) + u^2(V_2) \ldots V_n^2 + 2V_n u(V_n) u^2 V_n$$

But $$V_{RMS}^2 = \sum_{i=1}^{N} V_i^2,$$

and, where uncertainties are relatively small (as in the 6100B), $u^2 v_i$ components become negligible. The uncertainty of the combined waveform becomes:

$$2V_{RMS}u(V_{RMS}) = 2V_1 u(V_1) + 2V_2 u(V_2) \ldots 2V_n u(V_n)$$

which simplifies to give u_c as the combined uncertainty:

$$u_c(V_{RMS}) = \sum_{i=1}^{N} c_i u(V_i)$$

where $c_i = \dfrac{V_i}{V_{RMS}}$ and is known as the sensitivity coefficient.

1-57.   *Non-sinusoidal Voltage Example*

The waveform is a 60 Hz, 110 V rms waveform, from the 168 V range, comprising 10 % 95th harmonic, 30 % 3rd harmonic with the remainder contributed by the fundamental frequency. Using the 6100B voltage uncertainty values in "Voltage and Sine Amplitude Specifications" and "Voltage DC and Harmonic Specifications", determine the 1-year accuracy.

3rd Harmonic rms voltage = 0.3 x 110 = 33 V

95th Harmonic rms voltage = 0.1 x 110 = 11 V

Fundamental rms voltage = $\sqrt{(110^2 - 33^2 - 11^2)}$ = 104.3552 V

Accuracy contribution from the fundamental:

112 ppm of output +4.4 mV = (104.3552 x 0.000112) + 0.0044 = 0.011688 + 0.0044 = 0.016088 V

Modified by the sensitivity coefficient = 0.016088 x 104.3552 ÷ 110 = 0.015262 V

Accuracy contribution from the 3rd Harmonic (180 Hz):

122 ppm of 3rd harmonic value +4.4 mV = (0.000122 x 33) + 0.0044 = 0.008426 V

Modified by the sensitivity coefficient = 0.008426 x 33 ÷ 110 = 0.002528 V

Accuracy contribution from the 95th Harmonic (5700 Hz):

512 ppm of 95th harmonic value + 4.4 mV = (0.000512 x 11) + 0.0044 = 0.010032 V

Modified by the sensitivity coefficient = 0.010032 x 11 ÷ 110 = 0. 001003 V

Combining the uncertainties:

Total amplitude uncertainty = 0.015262 + 0.002528 + 0.010032 = 0.018793 V

Voltage Accuracy = 110 ±0.018793 *V*

1-58.   *Apparent Power (S) Accuracy Calculations*

For the purpose of calculation of apparent power (S) for non-sinusoidal outputs the following equations are used:

$$S = \sqrt{\sum_n V_n^2 \sum_n I_n^2} \ \ \text{VA}$$

To calculate the accuracy of apparent power (S), the amplitude accuracy specifications of voltage harmonic components must be combined as described in "Determining Non-Sinusoidal Waveform Amplitude Specifications" above. Current components are combined using the same method. As apparent power is the product of two different quantities, uncertainties are conveniently combined using relative values. Note that 6100B voltage and current components are generated independently and are therefore largely uncorrelated.

As $S^2 = V_{RMS}^2 . I_{RMS}^2$;

$$\frac{u_c^{\ 2}(S)}{S^2} = [\frac{u(V_{RMS})}{V_{RMS}}]^2 + [\frac{u(I_{RMS})}{I_{RMS}}]^2$$

where $u_c(S)$ is the combined uncertainty of the apparent Power,

$u(V_{RMS})$ is the uncertainty of the rms voltage and

$u(I_{RMS})$ is the uncertainty of the rms current.

1-59.   *Apparent Power Example*

Voltage channel fundamental frequency output is 109 V on the 1 V range at 60 Hz. A 15 V 3rd harmonic has been added. The current channel output is 7 A at 60 Hz on the 10 A range with 3rd and 5th harmonics at 0.7 A and 0.3 A respectively. Phase angles are not relevant to the calculation of apparent power. Voltage uncertainty values are given in "Voltage and Sine Amplitude Specifications" and "Voltage DC and Harmonic Specifications", current uncertainty values are given in "Current Sine Amplitude Specifications" and "Current DC and Harmonic Amplitude Specifications". The accuracy used is that of the 6100B.

The voltage rms value is $\sqrt{109^2 + 15^2} = 110.02727 \ V$

Accuracy contribution from the voltage fundamental:

112 ppm of 109 V + 4.4 mV = (109x0.000112) + 0.0044 = 0.012208 + 0.0044 = 0.016608 V

Modified by the sensitivity coefficient = 0.016608 x 109 ÷ 110.02727 = 0.016453 V

Accuracy contribution from the voltage 3rd harmonic:

122 ppm of 15 V + 4.4 mV = (15x0.000112) + 0.0044 = 0.01830 + 0.0044 = 0.006230 V

Modified by the sensitivity coefficient = 0.006230 x 15 ÷ 110.02727 = 0.000849 V

Combined voltage uncertainty:

$$\frac{u(V_{RMS})}{V_{RMS}} = \frac{0.016453 + 0.000849}{110.02727} = 0.000157 \text{ (or 157 ppm)}.$$

The current rms value is $\sqrt{7^2 + 0.7^2 + 0.3^2} = 7.041307$

Accuracy contribution from the current fundamental:

164ppm of 7 A + 240 μA = (7x0.000164) + 0.000240 = 0.001148 + 0.000240 = 0.001388

Modified by the sensitivity coefficient = 0.001388 x 7 ÷ 7.041307 = 0.001380 A

Accuracy contribution from the current 3rd harmonic:

191 ppm of 0.7 A + 240 μA = (0.7x0.000191) + 0. 000240 = 0.000134 + 0.000240 = 0.000374

Modified by the sensitivity coefficient = 0. 000374 x 0.7 ÷ 7.041307 = 0.000037 A

Accuracy contribution from the current 5th harmonic:

191 ppm of 0.3 A + 240 μA = (0.3x0.000191) + 0. 000240 = 0.000058 + 0.000240 = 0.000297

Modified by the sensitivity coefficient = 0.000297 x 0.3 ÷ 7.041307 = 0.000013 A

Combined current uncertainty:

$$\frac{u(I_{RMS})}{I_{RMS}} = \frac{0.001388 + 0.000037 + 0.000013}{7.041307} = 0.000204 \text{ (or 204 ppm)}.$$

Now, $S^2 = V_{RMS}^2 . I_{RMS}^2 = 110.02727 \times 7.041307 = 774.7358 \ VA$

Apparent Power uncertainty:

$$\frac{u(S)}{S} = \sqrt{[\frac{u(V_{RMS})}{V_{RMS}}]^2 + [\frac{u(I_{RMS})}{I_{RMS}}]^2} = \sqrt{0.000157^2 + 0.000204^2} = 0.0002574$$

giving:

$$u_c(S) = 0.0002574 \times 774.735748 = 0.1994 \ VA$$

Apparent Power Accuracy = 774.7358± 0.1994 *VA*

1-60. Power (P) Accuracy Calculations

Real power is the sum of the products of volt/current/phase-angle at each harmonic frequency.

$$P = \sum V_n I_n \cos \Phi_n \text{ Watts}$$

where *n* is the harmonic order of the components.

Calculation of power accuracy uses the same techniques shown previously. The uncorrelated uncertainty components of voltage, current and phase are combined using root sum of squares for each frequency.

$$\frac{u^2(P_f)}{P_f^2} = [\frac{u(V_f)}{V_f}]^2 + [\frac{u(I_f)}{I_f}]^2 + [u(phase_f)]^2$$

where $u(x)$ is the uncertainty of the component x and $phase$ is the phase angle between the current and voltage

at frequency f. It is easiest to express each of these contributions as ppm.

The contribution of phase angle accuracy varies with the set phase angle as shown below.

$$u(phase) = 1 - \frac{\cos(\Phi + u(\phi))}{\cos \Phi}$$

where Φ is the set phase angle and $u(\phi)$ is the phase accuracy.

The power uncertainties for each frequency, modified by the appropriate sensitivity coefficient c_i, are then linearly summed to give the combined uncertainty u_c (linearly summed because voltage components are correlated, as are those of current and phase).

$$u_c(P) = \sum_{i=1}^{N} c_i u(P_i)$$

1-61. Power Example

Voltage channel output is 109 V on the 180 V range at 60 Hz with 3rd harmonic at 15 V. The voltage 3rd harmonic has 0 ° phase angle relative to the voltage fundamental.

The current channel output is 7 A on the 10 A range at 60 Hz with 3rd and 5th harmonics at 0.7 A and 0.3 A respectively. The current fundamental phase angle is 12 ° relative to the voltage fundamental. The current 3rd harmonic has a phase angle of +25 ° relative to the current fundamental, for example, the phase angle between the 3rd current harmonic and the 3rd voltage harmonic is 25 ° + (3 x 12 °) = 61 °. As the current 5th harmonic is not matched by a voltage 5th harmonic, there is no 5th harmonic power contribution.

Voltage uncertainty values are given in "Voltage and Sine Amplitude Specifications" and "Voltage DC and Harmonic Specifications", current uncertainty values are given in "Current Sine Amplitude Specifications" and "Current DC and Harmonic Amplitude Specifications". Phase uncertainty values are given in "Current to Voltage Phase Specifications". The accuracy used is that of the 6100B.

Converting all values to ppm, accuracy contribution at the fundamental frequency

$$u(V_1) = 112\,ppm + \frac{0.0044\ V \times 10^6}{109\ V} = 152\,ppm$$

$$u(I_1) = 164\,ppm + \frac{0.00024\ A \times 10^6}{7\ A} = 198\,ppm$$

$$u(phase_1) = \left(1 - \frac{\cos(12 + 0.003)}{\cos(12)}\right) \times 1e6 = 11\,ppm$$

Combined accuracy for the fundamental frequency components:

$$u(P_1) = \sqrt{152^2 + 198^2 + 11^2} = 250\,ppm$$

Power in the fundamental frequency:

$$P_1 = V_1 I_1 \cos\Phi_1 = 109 \times 7 \times 0.9781476 = 746.3266\ Watts \text{ so:}$$

$$u(P_1) = 250 \times 10^{-6} \times 746.3266 = 0.1866\ Watts$$

Accuracy contribution for the 3rd harmonic

$$u(V_3) = 122\,ppm + \frac{0.0044\ V \times 10^6}{15\ V} = 415\,ppm$$

$$u(I_3) = 191\,ppm + \frac{0.00024\ A \times 10^6}{0.7\ A} = 534\,ppm$$

$$u(phase_3) = \left(1 - \frac{\cos(61 + 0.009)}{\cos(61)}\right) \times 1e6 = 283\,ppm$$

Combined accuracy for the 3rd harmonic components

$$u(P_3) = \sqrt{415^2 + 534^2 + 283^2} = 733\,ppm$$

Power in the 3rd harmonic components:

$$P_3 = V_3 I_3 \cos\Phi_3 = 15 \times 0.7 \times 0.484810 = 5.0905\ Watts \text{ so:}$$

$$u(P_3) = 733 \times 10^{-6} \times 5.0905 = 0.003732\ Watts$$

Total power $P = P_1 + P_3 = 746.3266 + 5.0905 = 751.4171$ Watts

From:

$$u_c(P) = \sum_{i=1}^{N} c_i . u(P_i)$$

$$u_c(P) = \frac{746.3266}{751.4171} \times 0.1866 + \frac{5.0905}{751.4171} \times 0.003731 = 0.1854\ Watts$$

$$Power\ Accuracy = 751.4171 \pm 0.1854\ Watts$$

1-62. References

6100B reactive power calculations are guided by the published work of Dr. Stefan Svensson:
Svensson, S., (1999), Power Measurement Techniques for Nonsinusoidal Conditions, Chalmers

Other pertinent papers are:

Budeanu, C., (1927), "Reactive and fictitious powers", *Rumanian National Institute*, No.2.

Czarnecki, L. S., (1885), "Considerations on the reactive power in nonsinusoidal situations", *IEEE Trans. on Inst. and Meas.*, Vol. 34, No. 3, pp399-404, Sept.

Czarnecki, L. S., (1987), "What is wrong with the Budeanu concept of reactive and distortion power and why it should be abandoned", *IEEE Trans. on Inst. and Meas.*, Vol. 36, No. 3, pp834-837, Sept

Filipski, P., (1980), "A new approach to reactive current and reactive power measurements in nonsinusoidal systems", *IEEE Trans. on Inst. and Meas.*, Vol. 29, No. 4, pp423-426, Dec.

Fryze, S., (1932), "Wirk- Blind- und Scheinleistung in elektrischen Stromkreisen mit nichtsinusformigen Verlauf von Strom und Spannung", *Elektrotechnische Zeitschrift*, No25, pp 596-99, 625-627, 700-702.

Kusters, N. L. and Moore, W. J. M., (1980), "On the definition of reactive power under nonsinusoidal conditions", *IEEE Transaction on Power Apparatus and Systems*, Vol PAS-99, No. 5, pp1845-1854, Sept/Oct.

Sharon, D., (1973), "Reactive power definition and power factor improvement in non-linear systems", *PROC. IEE,* Vol. 120, No. 6, pp 704-706, July.

Shepherd, W. and Zakikhani, P., (1972), "Suggested definition of reactive power for nonsinusoidal systems", *PROC. IEE,* Vol. 119, No. 9, pp 1361-1362, Sept.

IEC, Reactive power in nonsinusoidal situations, Report TC 25/wg7.

Chapter 2
Installation

2-1. Introduction

⚠⚠Warning

To avoid electrical shock, personal injury, use extreme caution when working with the Instrument binding posts. The Instruments can supply lethal voltages to the binding posts of both Master and Auxiliary Instruments.

This chapter provides instructions for unpacking and installing the Instrument. The procedures for fuse replacement, and connection to line power are provided here. Read this chapter before you operate the Instrument.

Instructions for cable connections other than line power connection can be found in the following chapters of the manual:

- Voltage and Current output connections and instructions for use of the 6100B lead set is in Chapter 4.

- IEEE-488 interface bus connection information is in Chapter 5.

2-2. Unpack and Inspection

The Instruments are shipped in a container designed to prevent damage during shipping.

Inspect the Instrument carefully for damage, and immediately report any damage to the shipper. Instructions for inspection and claims are included in the shipping container.

A packing list is included in the packaging. When you unpack the Instrument, check for all the standard equipment listed and check the shipping order for any additional items ordered. Report any shortage to the place of purchase or to the nearest Fluke Service Center.

2-3. To Reship the Instrument

A transit case can be purchased from Fluke. The Fluke part number is 1887580. This container is suitable for most handling conditions but provides less shock protection than the original cardboard packaging. It is recommended that the original container be used when possible.

2-4. Placement

This Instrument is designed to operate in controlled electromagnetic environments such as calibration and measurement laboratories i.e. where R.F. transmitters such as mobile telephones are not be used in close proximity.

The Instrument is suitable for bench top use, as long as there is sufficient space on either side to allow adequate ventilation.

The Instrument can be rack mounted using Fluke part number 1887571. Details of the rack mounting kit and fitting instructions are provided with the kit. Note that the airflow through the Instrument is from left to right as viewed from the front. If mounted in a rack, the airflow must be in the same direction.

2-5. Cooling Considerations

⚠Caution

Damage caused by overheating may occur if the area around the air intake is restricted, the intake air is too warm, or the air filter becomes clogged.

The Instrument must be at least 4 inches from nearby walls or rack enclosures on both sides. The inlet and exhaust perforations on the sides must be clear of obstruction.

The air entering the instrument must be between 5 °C and 35 °C. Make sure that exhaust from another instrument is not directed into the fan inlet.

Clean the air filter every 30 days or more frequently if the Instrument is operated in a dusty environment. Instructions for cleaning the air filter are in the Users Manual.

2-6. Line Voltage

The Instrument has automatic mains sensing in the range 100-240 V, so no user line voltage selection is required. The fuse specified covers this voltage range. The Users Manual describes fuse access.

2-7. Connect to Line Power

⚠⚠Warning

To avoid electrical shock, personal injury, or fire hazard, connect the factory-supplied three conductor line-power cord to a properly grounded power outlet.

Do not use a two conductor adapter or extension cord; this will break the protective ground connection. If a two conductor power cord must be used, a protective grounding wire must be connected between the ground terminal on the rear panel and ground before connecting the power cord or operating the instrument.

The power outlets supplying the Instrument system should be controlled by an emergency switch so that power can be switched off if a hazard arises.

The line current requirement of the Instrument may exceed the capacity of standard 10 A IEC connectors so the unit is fitted with a 16 A power receptacle at the rear.

A suitable supply lead is provided. Ensure that the room supply outlet is suited to delivering the 1250 VA maximum power requirements and that the Instrument is connected to a properly grounded three prong outlet.

Note

Typical maximum power requirement at 115 V is 1000 VA.

If a supply lead is provided WITHOUT a mains connector, please observe the following color coding when wiring up your own mains connector - line = brown, neutral = blue, earth = green/yellow.

Table 2-1. Line Cords by Country

Country	Fluke Line Cord Part Number
UK	1998167
Europe	1998171
Australia, New Zealand, China	1998198
USA, Japan	1998209
Other (no plug fitted)	1998211

2-8. Connect Auxiliary Units

The 6100B and 6105A instruments are Master units capable of controlling any combination of up to three Auxiliary units. The 6100B and 6105A Master units can be configured as Master or Auxiliary but the 6101B or 6106A can only operate as Auxiliary units.

Each Auxiliary unit provides an additional phase of voltage and current. Control connections are made by interconnection cable part number 2002080 supplied with each instrument. Figure 2-1 shows the layout of connections on the rear of a Master instrument. 6101B and 6106A have one Auxiliary Control Input.

The older 6101A can also be added as Auxiliary units to 6100B and 6105A Master units. When upgraded to firmware issue 4.10 or greater the older 6100A Master can control any of 6105A, 6106A, 6100B, and 6101B as Auxiliary units.
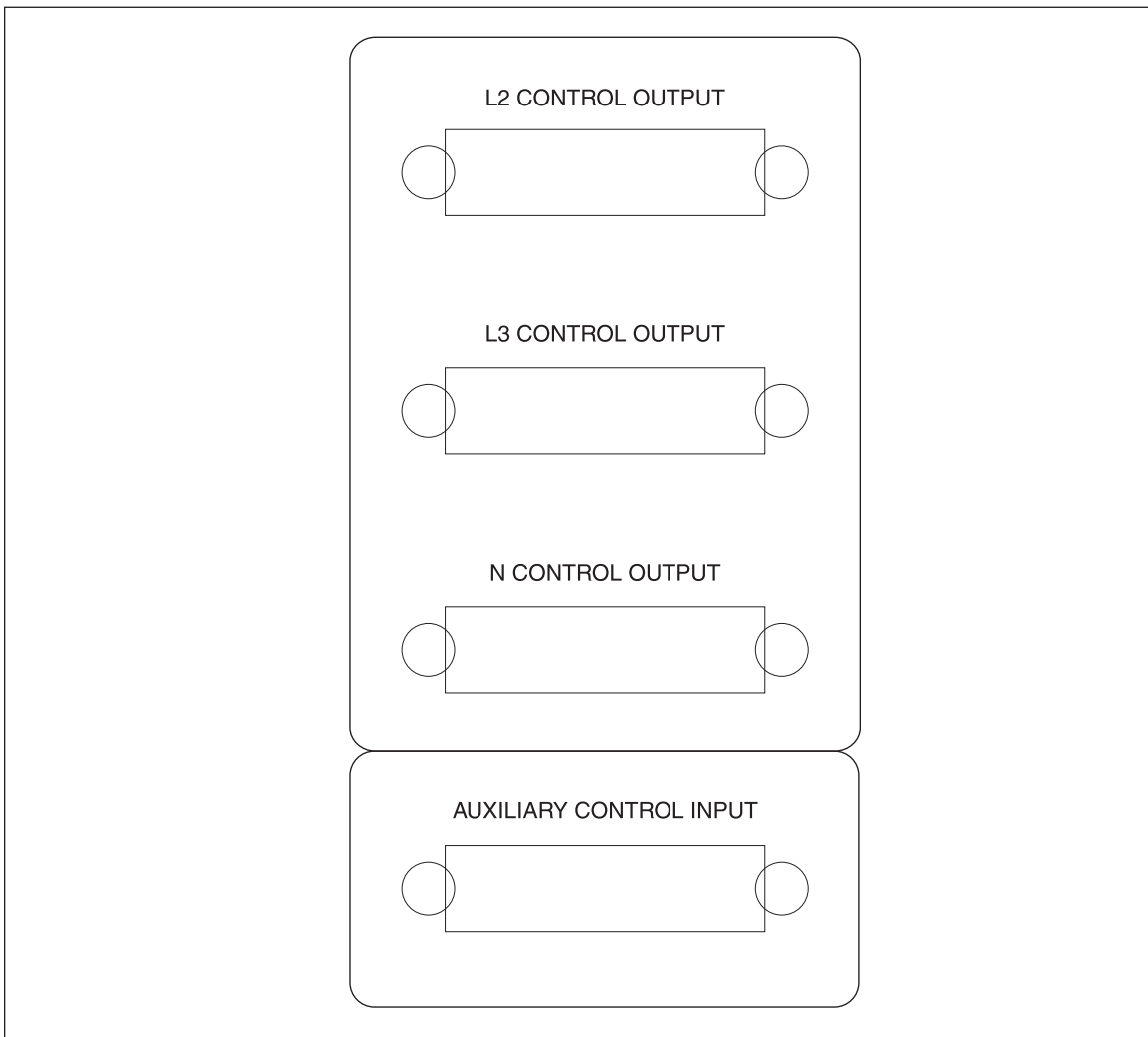
gdw01.eps

Figure 2-1. Auxiliary Unit Connectors on the 6105A Rear Panel

2-9. Allocation of Phases

The 6105A or 6100B is always L1 in a multiphase system. Auxiliary units are allocated phase depending on which auxiliary control output they are connected to. The Auxiliary unit connected to L2 Control Output becomes L2 etc. See the Users Manual for an overview of instrument control and the user interface.

This section is a reference for the functions and locations of the 6100B front and rear panel features, and provides brief descriptions of each feature for quick access.

Complete front-panel operating instructions and remote operating instructions for the 6100B are provided in the Users Manual.

Please read this information before operating the 6100B.

2-10. Connection and Power-Up Sequence

Power-Up

When working with poly-phase systems you should connect the control cables between Auxiliary and Master units first. Then switch ON power to the Auxiliary units, then the Master.

Power-Down

Turn off the Master unit first when powering down. Damage will not occur if the sequence is not followed but error messages may show on the User Interface.

Title   **Page**

3-1. Introduction

This chapter is a reference for the functions and locations of the Instruments front and rear-panel features, and provides brief descriptions of each feature for quick access.

Please read this information before operating the Instrument.

Front-panel operating instructions for the Instrument are provided in Chapter 4, and Remote operating instructions are in Chapter 5.

3-2. Front-Panel Features

Front-panel features (including all controls, displays, indicators, and terminals) are shown in Figure 3-1. Each front-panel feature is briefly described in Table 3-1.
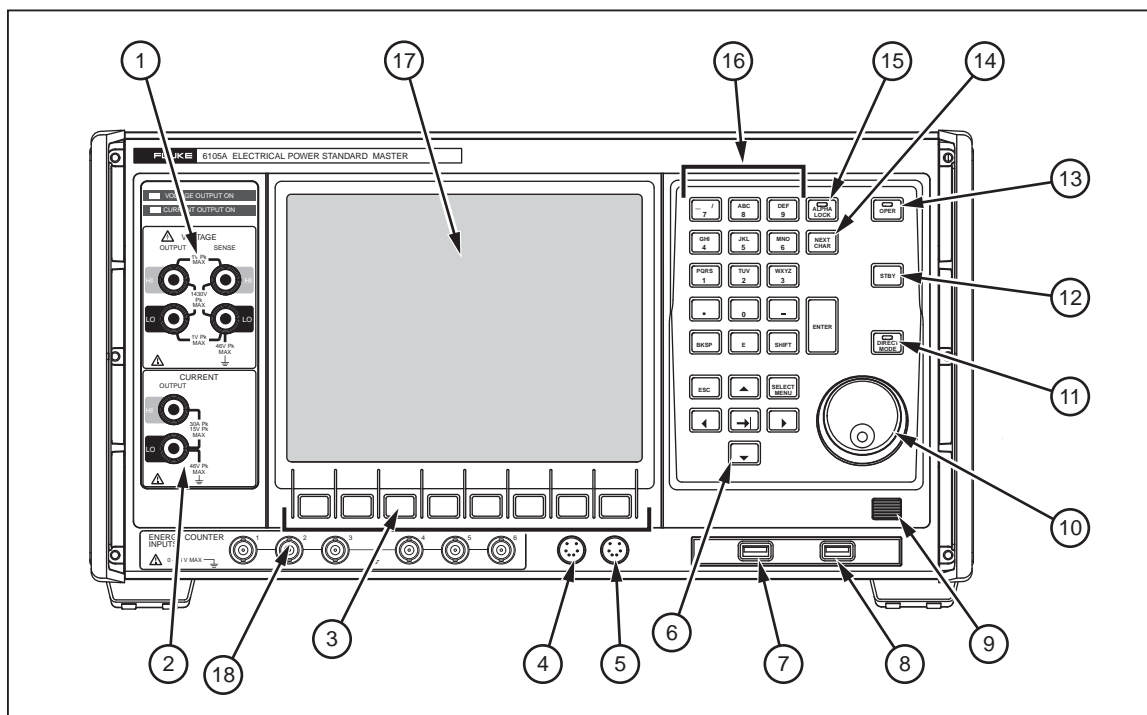
gdw03.eps

Figure 3-1. 6100B Front Panel

Table 3-1. Front-Panel Features

Number	Description
(1)	Voltage Binding Posts - The HI and LO Output Voltage Binding Posts provide connections for voltage outputs. The HI and LO Sense Binding Posts provide External Sensing for best accuracy. Two-wire sensing may be selected via the Global Settings Menu. See Chapter 4.
(2)	Current Binding Posts - Output Currents
(3)	Softkeys - Provide direct access to setup functions. If an external keyboard is connected, the keyboard function keys (F1-F8) provide the same navigation technique. See Chapter 4.
(4)	Keyboard Connector - PS/2 connector for an external keyboard if preferred.
(5)	Mouse Connector - PS/2 connector for a mouse if preferred.
(6)	Navigation Keypad [SELECT MENU] switches between the three main menus: Output, Global Settings and Waveform. [ESC] (escape) changes the softkey level up through the control hierarchy. It also escapes from pop-up screens. [→|] moves focus from control to control within the selected menu area. [◄] [►] and [▲] [▼] allow selection of values in data entry and selection fields.
(7)(8)	Two USB Ports - For saving and reloading of waveform configurations. Connect mouse or keyboards or update firmware.
(9)	Power On/Off Switch -Turns the power on and off. The switch remains locked inwards when the power is on. Pushing the switch again unlocks it and turns the power off. Note: this controls the power supply electronically and is not an isolation switch. The Main Power On-Off switch is on the rear panel.
(10)	Dual action Spin Wheel - Provides quick data entry within a field. When rotated without pushing, scrolls the value of the currently highlighted numeric character in an input field. When rotated and pushed inwards, moves the cursor along the characters in the field.
(11)	[DIRECT MODE]- In Direct Mode, the key LED is lit and all waveform changes take immediate effect. When Direct Mode is not active, the 6100B is in Deferred mode. In Deferred mode changes to waveforms are stored but not applied. Stored changes can be applied simultaneously or undone.
(12)	[STBY] (standby) - Turns the output OFF.
(13)	[OPER] (operate) - Turns the outputs of enabled channels ON. The LEDs above the terminals indicate which outputs are ON.

Table 3-1. Front-Panel Features (cont.)

Number	Description
(14)	[NEXT CHAR] - In text input mode (Alpha Lock LED lit), key text using a combination of [NEXT CHAR] and the Alphanumeric keypad (15). This operates much in the manner of a cell phone, allowing one alpha key to source more than one text character by being pushed repeatedly until the required character is displayed. Use [NEXT CHAR] to move onto the next position you wish to key. Push |ENTER| to finish the text entry.
(15)	[ALPHA LOCK] - Switches between text and numeric input. In numeric input mode. The Alpha Lock light is out. In text input mode the Alpha Lock light is lit.
(16)	Alphanumeric Keypad - Provides text and numeric input. Use [ALPHA LOCK] (14) to switch between numeric and text input. In numeric input mode (Alpha Lock light out), key numeric values directly (the E key allows exponents to be entered). In text input mode (Alpha Lock light lit), key text using a combination of the Alphanumeric keypad and the [NEXT CHAR] ((13)). This operates much in the manner of a cell phone, allowing one alpha key to source more than one text character.
(17)	Windows User Interface - The setup of waveforms and other functions of the Electrical Power Standard has been implemented as a Windows program.
(18)	Energy Option Connectors (if option is fitted)-Six BNC inputs for receiving pulses from Energy meters.

3-3. The Main User Interface Areas

The user interface is divided into five areas. There are three Menu panes, a message window, and at the bottom, the context-sensitive softkey indicators. See Figure 3-2.
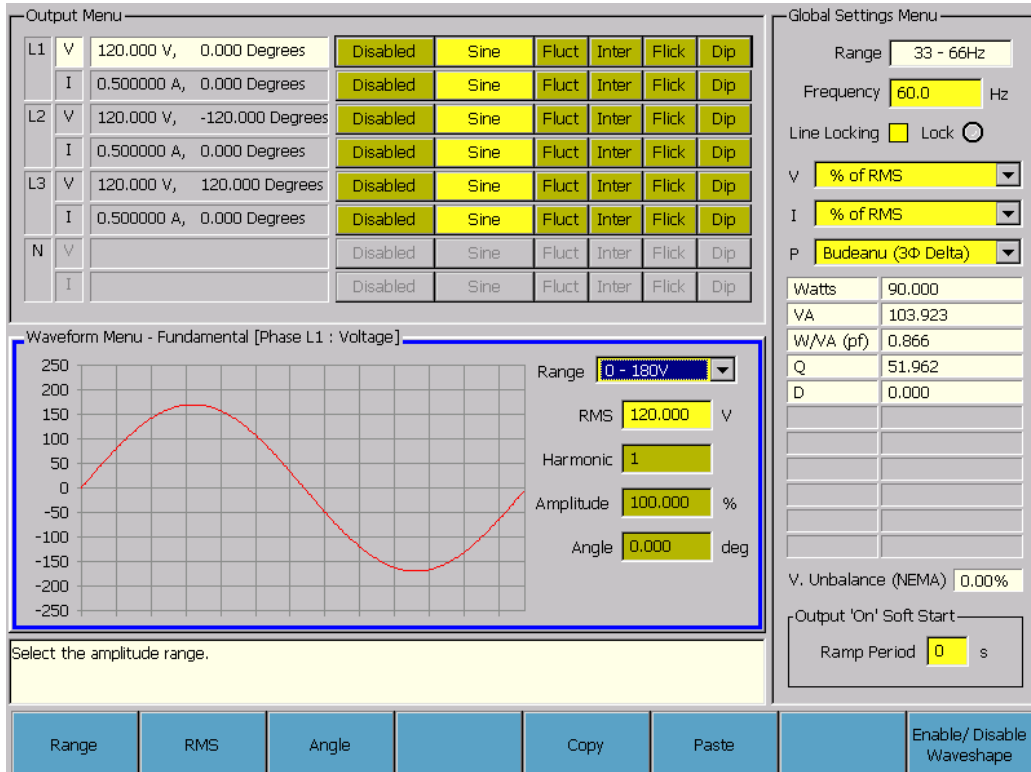
gdw04.bmp

Figure 3-2. Graphical User Interface

The Menu fields are accessed sequentially clockwise by pushing [SELECT MENU]. A blue border indicates the active Menu. As the focus changes between the menus, the actions of the context-sensitive softkeys change accordingly.

- The Output Menu at the top left of the screen allows selection of the channel that will be operated upon by actions in the Waveform Menu. The channel being set-up is indicated by a white background. The voltage or current and phase angle for all connected phases is shown here. The Output Menu always shows the actual values that are at the voltage and current binding posts (or will be when [OPER] is pushed).

- The Global Settings Menu at the right of the display sets up common configurations on the Master unit and all connected Auxiliary units.

- The Waveform Menu is the area where the waveform for a channel is constructed. This part of the user interface shows what the output will be when the settings are enabled.

- Under the Waveform Menu is the Message Window which provides context-sensitive help and warning and error messages. The background of this area is white for help messages and orange for warnings. Warnings include messages indicating that invalid data has been entered or operating boundaries would be exceeded if a set up request were processed. Messages with red background report serious fault conditions.

- Eight softkeys which may be used to initiate actions appear across the bottom of the screen. Some of these actions may cause a pop-up screen to appear. The context of the softkeys transfers to the pop-up while it is on screen.

3-4.   Data Entry from the Front Panel

Refer to Figure 3-2 and Table 3 for the items in this section.

- The keys under the screen (③) operate the softkeys shown on screen. There is a keypad area to the right of the screen. This comprises of the blue navigation keys (⑥), the alphanumeric keys (⑬,⑭,⑮), the dual action Spin Wheel (⑨) and the output control keys (⑩,⑪,⑫).

- `SELECT MENU` ((⑥)) moves focus around the three Menu areas.

- `→|` ((⑥)) moves focus around the controls within a Menu area.

- Within the Menu panes, access to the individual controls is via the softkeys or by moving with `→|`. Pushing and holding `SHIFT` while using `→|` reverses the direction of movement.

- The softkeys (③) provide a one-push alternative to using `→|` to access items within the Menu areas.

- Sometimes softkeys have multiple levels of control. When more than one action is appropriate for a particular context, a further level of softkeys will be revealed when the key is pushed. The most complex activities may have several layers of softkeys. Use `ESC` to reverse upwards through the hierarchy of softkey levels.

- `ESC` ((⑥)) moves context up through a softkey hierarchy. Pushing `ESC` also escapes from pop-up screens.

- Only data fields with yellow background are directly editable. Some are drop-down-list controls and some numeric entry. When a drop-down-list has focus, the background becomes blue. `▲` and `▼` in the navigation group shift through the list items. Pushing `→|` or `ENTER` completes the selection and moves focus to the next control.

- There are three ways to change the values in the numeric entry controls. The numeric keys (⑮) allow direct entry which is completed by pushing `ENTER` or `→|`. `BKSP` (backspace) removes the digit to the left of the entry point each time it is pushed.

- `◄` and `►` move the data entry point along the current value. `▲` and `▼` increment or decrement the digit at the entry point. The Spin Wheel (⑨) can perform the same actions as `◄` and `►` and `▲` and `▼`. Push the Spin Wheel in and rotate to move the data entry point. Release the Spin Wheel and rotate it to increment/decrement the digit at the entry point. It is not necessary to push `→|` or `ENTER` to complete the change.

- Alpha mode is used when naming files before saving to memory or an external USB device. Shift the Alpha Numeric keys to alpha characters and back to numeric by pushing ⌈ALPHA LOCK⌉. ⌈ALPHA LOCK⌉ is lit when Alpha mode is selected. Each key push changes the character at the entry point to the next in the three or four available from that key. For example: the first push of the **TUV** key in Alpha mode inserts a **T**. The entry changes to **U** at the second push and **V** at the third. To repeat a character, **TT**, for example, push ⌈NEXT CHAR⌉ to move the entry point and then the **TUV** key a second time.

3-5. Direct/Indirect Mode

Changes to 6100B settings will usually be made one at a time. Sometimes it is necessary to make a number of changes all at once. Consider a three phase system where all three voltage phases are set to 120 V. To change each phase voltage individually in sequence would cause the three phase system to become unbalanced. This may be detrimental.

In Direct Mode, ⌈DIRECT MODE⌉ is lit and all changes are applied immediately. The opposite of Direct Mode is Deferred Mode. In Deferred Mode ⌈DIRECT MODE⌉ is not lit. Data field changes are not applied immediately. In changed fields the background is orange rather than yellow to show what the output will be after changes are applied. The changes can be applied in one of two ways:

1. If the output is already on, push ⌈OPER⌉.

2. Push softkey **Apply All** (this is only visible when the Output Menu has focus).

Changes are applied virtually simultaneously when ⌈OPER⌉ or ⌈DIRECT MODE⌉ is pushed. There is a small delay of a few milliseconds while the changes are applied.

To undo deferred actions without applying them, select the **Undo all** softkey (when Output Menu has focus). Pushing ⌈DIRECT MODE⌉ without applying the changes as described above will also undo deferred actions.

3-6. Using an External Keyboard and Mouse

Note

Keyboard/mouse plugged into the PS2 ports on the front panel must be in place before the Instrument is powered up. This restriction does not apply to the USB ports.

In most menu and entry pop-up screens the mouse can be used to point and click on a data field to give it focus. Some mouse operations are not available in some rarely used screens, the calibration/adjustment pop-up screen, for example.

An external keyboard can replicate most of the actions available from the Instrument front panel. Numeric Alpha characters 0-9; a-z; A-Z and the characters '.', '/', '_' and '-' are entered as if they came from a 6100B key. All other external keyboard text characters and punctuation are ignored.

External keyboard **Tab**, **Enter**, **Esc**, **Backspace** and cursor keys work as they do from the Instrument front panel.

The external keyboard space key can be used to check and uncheck selection boxes when they have focus.

Some Function keys are assigned to perform operations. **F1** to **F8** act as softkeys one to eight (counting from the left). **F9** acts as ⌈SELECT MENU⌉ to shift focus around the three Menu panes clockwise.

3-7. *Sample Reference Signal and F10*

The external keyboard **F10** key replicates the "OUTPut:ROSCillator" ON/OFF GPIB command. Pushing **F10** toggles the Sample Reference signal output ON and OFF.

The Sample Reference signal can be used to synchronize sampling instrumentation in a measurement system. See Chapter 7.

3-8. *Set Up Exercise*

A 6100B or 6105A is required to perform the following training exercise. The task is to set up the current channel to output 2.0 A. After following the power up instructions earlier in this manual, the L1 voltage channel (L1 V) output values are shown with a white background. See Figure 3-3. Note the L3, L3 and N channels are grayed out as Auxiliary units are not connected.

gdw08a.bmp

Figure 3-3. The Output Menu (L1 Voltage Selected)

This exercise is divided into seven sections:
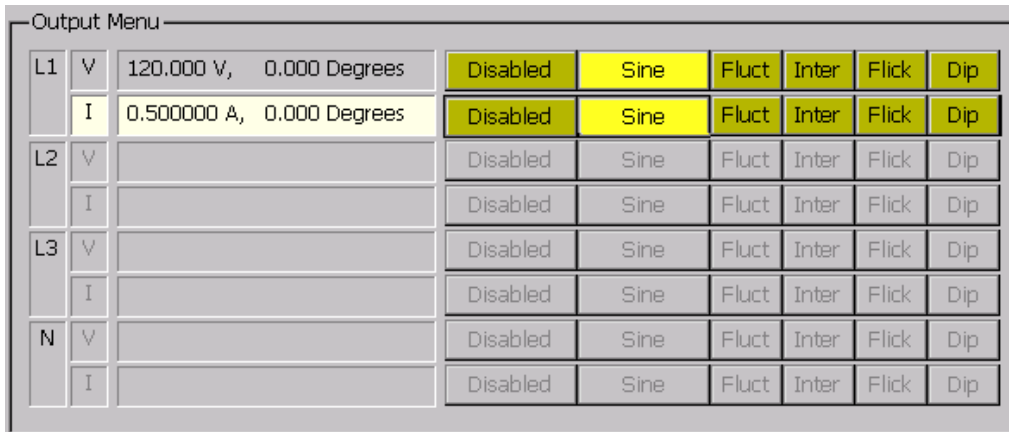
1. Switch to the Current Output
2. Enable the Current Channel
3. The Current Channel is Enabled but not Operating
4. Set up the L1 Current Channel
5. Over Compliance Warning Message
6. Complete the Current Circuit and Turn the Output On
7. Turn the Output Off

An explanation of each section follows.

3-9. *Switch to the Current Output*

The focus must be on the current channel to set it up. After power up the Menu focus will be on the Waveform Menu (blue border).

1. Push ⌧ (or **F9**) once to move the focus to the Output Menu.

2. Use ▾ to change the Output Menu control focus to L1 current (L1 I). Note the white background shifts to the active channel. Leave the focus on L1 current. See Figure 3-4.

gdw10a.bmp

Figure 3-4. The Output Menu (L1 Current Selected)
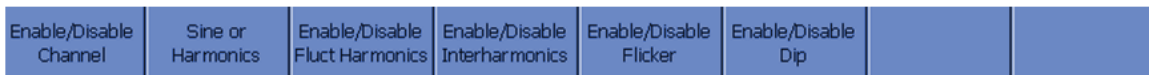
3-10. *Enable the Current Channel*

A channel must be enabled before an output is placed at the Instrument binding posts. Both the L1 voltage and current channels both show "Disabled". Before an output can appear at the output terminals the relevant channel must be "Enabled".

When the Output Menu has focus you can enable the L1 current channel using the softkeys. See Figure 3-5.

Note

If in the future the Menu focus is on the Output Menu but the softkeys are not as expected, push ⌫ to move up to the next softkey level. Pushing ⌫ then has no effect once the top level is reached.

gdw06a.bmp

Figure 3-5. The Output Menu Softkeys

Push the **Enable/Disable** softkey and the L1 current row in the Output Menu shows as "Enabled". See Figure 3-6.
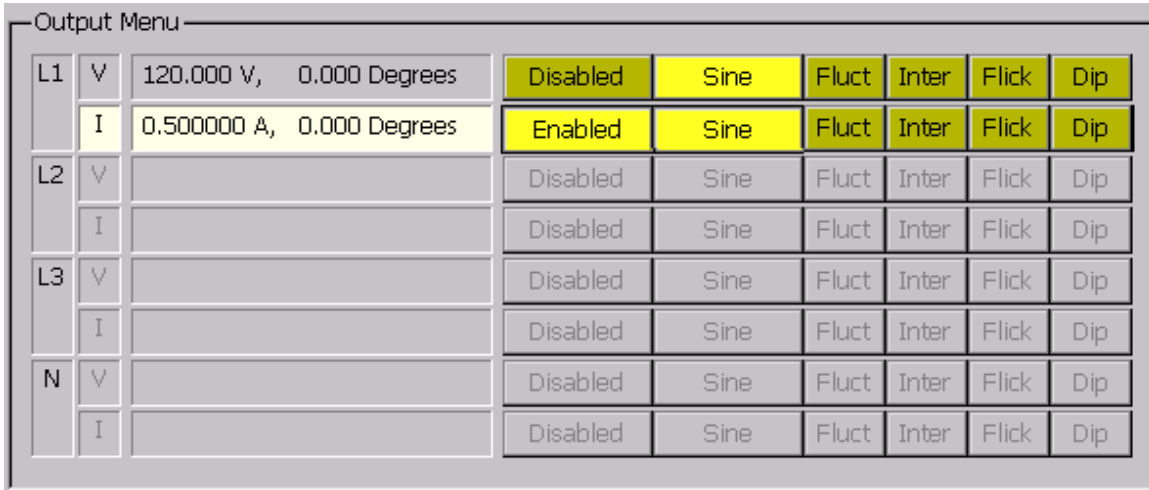
gdw09a.bmp

Figure 3-6. The Output Menu (L1 Current Selected)

3-11. The Current Channel is Enabled but Not Operating

There is not yet output at the Instrument output terminals. The system must be set to Operate mode to achieve this. If the system was set to operate at this point, nothing would appear at the voltage terminals because that channel is not enabled. The system would attempt to output 0.5 A from the current terminals but this would generate a warning message as the output is open-circuit. This will be addressed once the Current channel is set up.

3-12. Set Up the L1 Current Channel

To change the settings for an output channel, first move the Menu focus to the Waveform menu:

1. Push [SELECT MENU] twice. The Menu focus shifts to the Waveform menu. See Figure 3-7.
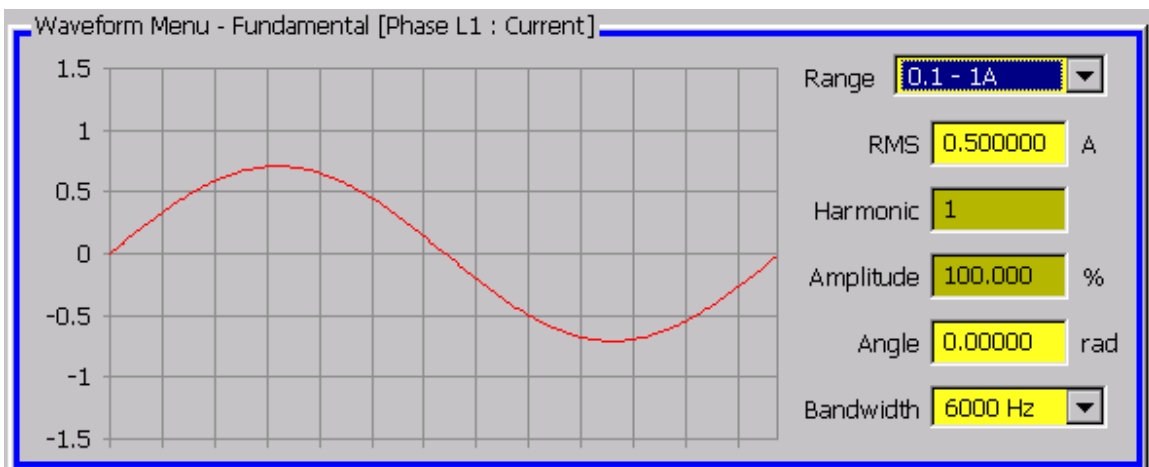
gdw11a.bmp

Figure 3-7. Waveform Menu, Fundamental

2. The Range control has focus (blue background).

3. Use the [▲] and [▼] or the Scroll Wheel to set the range to 2 A. Push [ENTER] or [→|] to complete the entry and move focus to the RMS field.

4. Set the output RMS value to 2.0 A using the controls as described in "Data Entry from the Front Panel" above. Note that focus shifts to the Bandwidth limit control. Leave that setting as it is.

3-13. *Over-Compliance Warning Message*

If the current channel output is turned on while the current terminals are open circuit, the over-compliance voltage trips will be activated. The output will turn off and an orange background warning will be displayed. The reason for this is that without a load the current cannot be established because the voltage compliance limit will be exceeded. Simply put, the voltage is developed across a load is determined by OHMS law, i.e., $V = I \times Z$. As the terminals are open, the output sees very high impedance which requires very high voltage. The 6100B 10 V limit is exceeded so the over compliance trips will be activated.

Turn the output ON by pushing [OPER]. Almost immediately, the trips operate and an orange background warning message appears. See Figure 3-8.
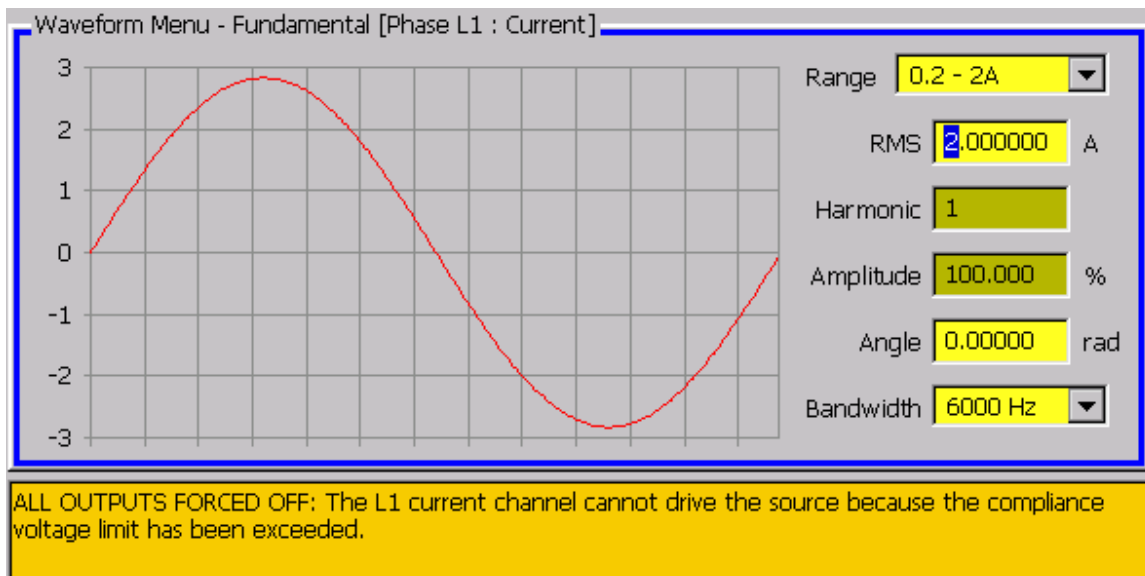
gdw12a.bmp

Figure 3-8. Over Compliance Warning Message

Complete the Current Circuit and Turn the Output On

1. Fit a short circuit across the Instrument output terminals.

2. Push [OPER] again. The output remains on this time and the Instrument is in Operate mode. Notice that the Output Menu Enabled and Sine blocks for L1 current are green. See Figure 3-9. The green indicator light for current (above the output terminals) is illuminated and [OPER] shows a green light.

gdw13.abmp

Figure 3-9. Waveform Menu, Current Output

3-14. Turn the Output Off

To turn the output off, push ⌷STBY⌷. The on indications disappear.

The Set up exercise is complete.

3-15. Two-Wire / Four-Wire Voltage Settings

The Instrument voltage output can be configured for either two-wire or four-wire sensing. The default mode is two-wire sense.

⚠⚠**Warning**

When the Instrument voltage channel is enabled and operating, full voltage output may be present at the VOLTAGE SENSE terminals even when they are not externally connected. To avoid electrical shock, personal injury, use caution when using the instrument under these conditions.

The 6100B is provided with a four to two-wire lead set for voltage. Irrespective of two-wire / four-wire configuration, the four plugs at the 6100B end of the lead should always be plugged in when the lead is in use. The sense wires will always be at the same potential as the output wires.

For measurement accuracy it is important that the two-wire / four-wire setting is correct. In particular, setting four-wire sensing but only connecting two wires will cause voltage errors in the order of 1.2 V. If you are not familiar with four-wire voltage sensing please read the description below.

3-16. Four-Wire Sense

In two-wire sensing, the sense point for the control system feedback loop is at the back of the terminals. Any current flowing in the leads connecting the OUTPUT terminals to the load causes a volt drop in the leads. As a result, the voltage at the load is less than at the terminals and accuracy is compromised. This problem is solved by using four-wire sensing as shown in Figure 3-10.

The input impedance of the feedback amplifier is very high so very little current flows in the sense leads. The voltage input to the SENSE terminals therefore accurately represents the voltage across Z_{Load} and this is used to correct the voltage at the OUTPUT terminals.
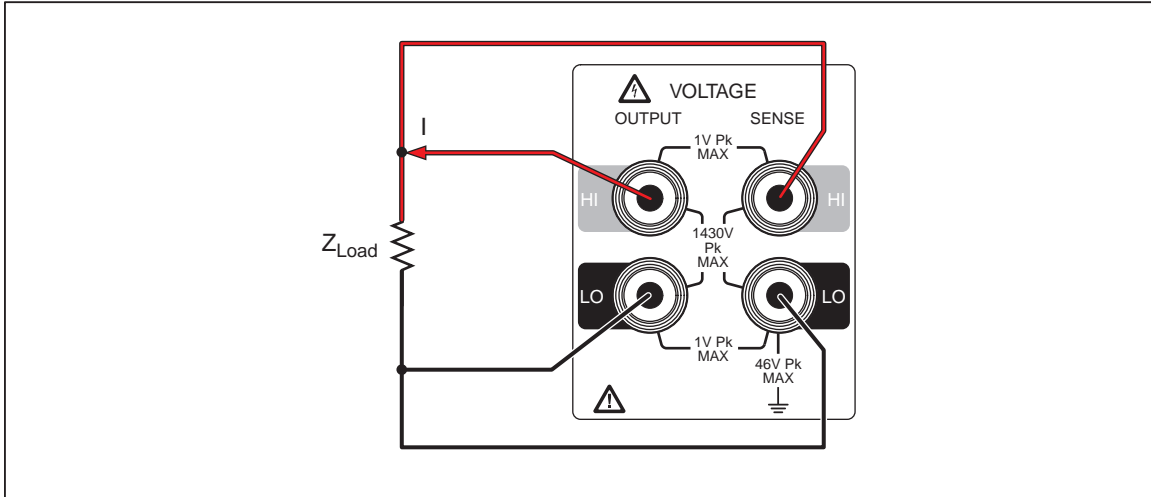
gdw08.eps

Figure 3-10. Four-wire Sense Configuration

3-17. Two-Wire / Four-Wire Configuration Settings

The two-wire / four-wire configuration applies to all connected Master and Auxiliary units. The configuration is made via a pop-up menu called from the Global Settings Menu top-level softkeys. See Figure 3-11.
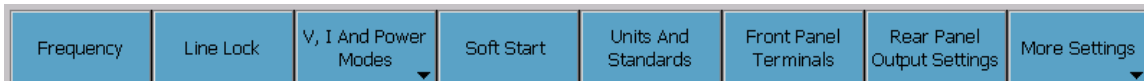
gdw14a.bmp

Figure 3-11. Global Settings Menu Top-level Softkeys

Push the **Front Panel Terminals** softkey to open the pop-up screen. See Figure 3-12.
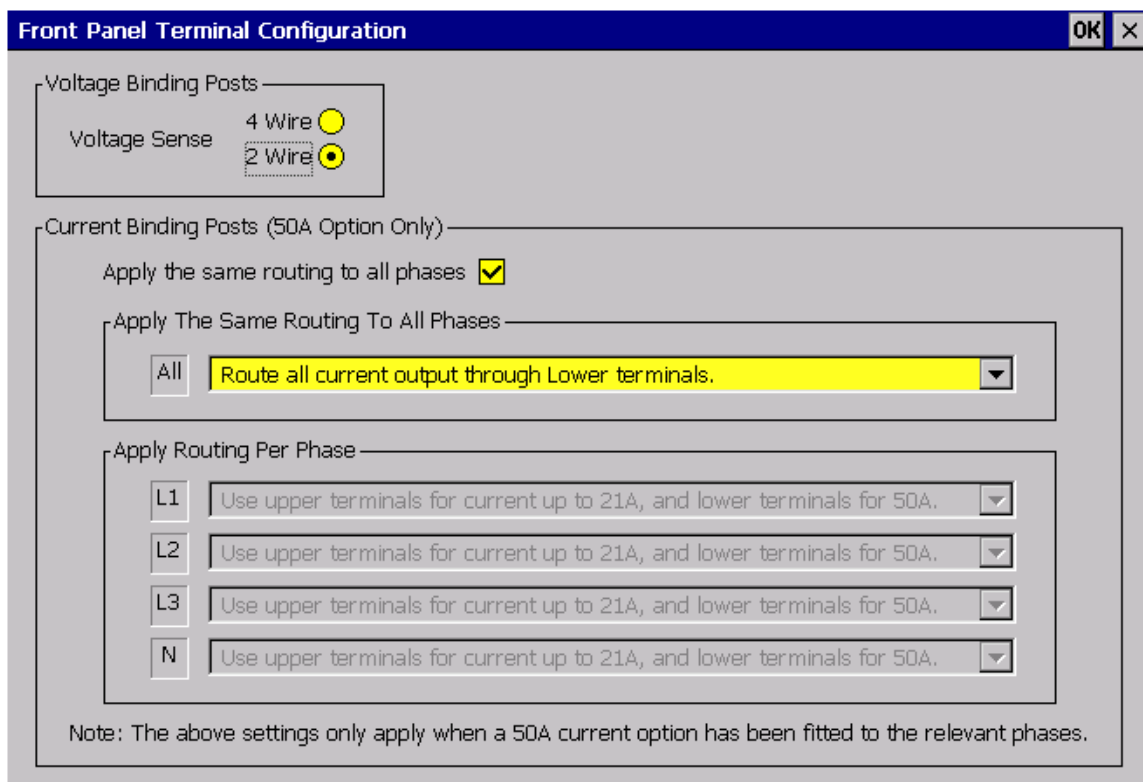
gdw15a.bmp

Figure 3-12. Front-Panel Configuration Softkeys

Note that the softkeys have changed. Select two or four wire using the softkeys, or with
[▲] and [▼] or the Scroll Wheel when the Voltage Binding Posts group has focus. Two
wire is the initial default setting but the setting is non-volatile. If four wire is selected, the
next time the instrument is powered up it will be in four-wire mode.

3-18. Rear-Panel Features

Figure 3-13 and Table 3-2 show and explain the rear-panel features.
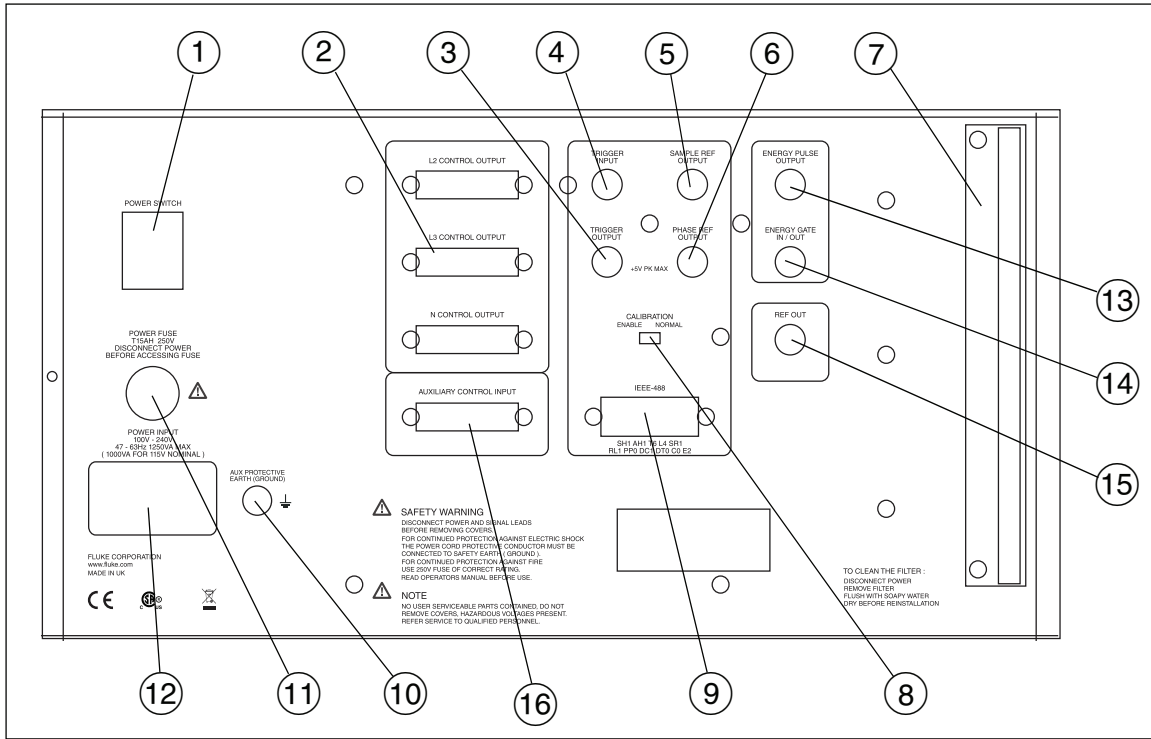
gdw07.eps

Figure 3-13. Rear-Panel Features

Table 3-2. Rear-Panel Features

Number	Description
1	Main Power On-Off Switch -This is a true mains isolating switch.
2	Auxiliary Unit Control Connectors - Connection to Auxiliary units via Fluke supplied cable.
3	Trigger Out Connector - The Trigger Output Connector has a +5 V CMOS logic drive providing a falling edge time marker intended to synchronize external equipment to the dip/swell function. The point at which the falling edge occurs is controlled by the Trigger Output Delay. After the falling edge the signal will remain low for a minimum of 10 μs.
4	Trigger Input Connector- Is a TTL-compatible input which can be selected to initiate a dip/swell on a falling edge. The falling edge can either start the user programmable initial delay timer or arms the user settable output waveform phase angle comparator. These are mutually exclusive. When the timer delay has expired or the comparator has found the required angle of the output waveform the Ramp In section of the dip/swell will commence. The input must remain low for 10 μs after the falling edge to be recognized properly.

Table 3-2. Rear-Panel Features (cont.)

Number	Description
(5)	Sample Ref Output Connector - The Sample Reference can be used to synchronize sample measurements with the 6100B internal sample clock. When activated the Sample Reference is provided at this connecter. The Signal Reference is a falling edge active +5 V to 0 V CMOS logic signal. The Sample Reference output can be enabled from the Global Menu or via the GPIB. When the Sample Ref Output is enabled, the output signal is held high until the next rising zero crossing of the L1 voltage fundamental. The signal will then continue until disabled.
(6)	Phase Reference Output Connector- has a +5 V CMOS logic drive providing a rising edge synchronous to the rising zero crossing of the L1 fundamental voltage. This signal has a 50 % duty.
(7)	Air Filter – See Chapter 6 for air filter maintenance procedure.
(8)	Calibration Enable Switch
(9)	IEEE 488 Connector - For connection into a GPIB system.
(10)	Ground Binding Post - Auxiliary protective earth/ground connection stud.
(11)	Fuse – See Chapter 6 for fuse replacement procedure.
(12)	Mains Power Receptacle – 16 A mains connector.
(13)	Energy Pulse Out connector (if fitted)- When the Energy option is fitted, the Energy pulse output provides pulses proportional to output power. See Chapter 8 for specifications and description. Blanked if the Energy option is not fitted.
(14)	Energy Gate In/Out connector (if fitted)- A bidirectional input or output gate control used with the Energy option. See Chapter 8 for specifications and description. Blanked if the Energy option is not fitted.
(15)	Reference Signal Output when CLK option is fitted.- TTL compatible 10 MHz or 20 MHz reference output signal derived from the system master clock. Blanked if the CLK option is not fitted.
(16)	Auxiliary Control Input - Two Master units (6100B/6105A) can be connected together to act as Master and Auxiliary. For example, the interconnection cable would be plugged into the L2 Control output of the Master and into the Auxiliary Control Input of the unit delegated to be the Auxiliary.

Chapter 4
Front-Panel Operation

4-1. Introduction

This chapter describes operating the 6100B from the front panel, including all aspects of setting up and configuring the Instrument.

Before following the procedures in this chapter, familiarize yourself with the front-panel controls, displays, and terminals, which are identified and described in detail in Chapter 3. For information about 6100B remote commands, see Chapter 5.

⚠⚠Warning

The Instrument is capable of supplying lethal voltages. Do not make connections to the output terminals when any voltage is present. Placing the instrument in standby may not be enough to avoid shock hazard. Disconnect the GPIB cable from the instrument to avoid remote commands setting unexpected outputs.

4-2. Power up

⚠⚠Warning

To avoid electric shock, make sure Instrument is grounded as described in Chapter 2.

Note

After switching power ON, it may take up to 2 seconds for the main display to illuminate and the cooling fans to start.

4-3. Warm up

The Instrument must be allowed to warm up to ensure it meets the specifications listed in Chapter 1. Warm up periods are described in the specifications in Chapter 1.

4-4. *Basic Setup Procedures*

Refer to Chapter 3 for an explanation of how to navigate though the user interface and how to set up text and numeric values. When the Instrument start-up sequence is complete, the instruments main setup page is displayed. See Figure 4-1.

gdw05.bmp

Figure 4-1. Main Setup Page

This main setup page contains the Output Menu at the top left. Below the Output Menu is the Waveform Menu whose content will change depending on the waveform parameter that is being edited.

Note

The Waveform Menu displays the waveform that will be used once the channel is enabled. See also "Edit Mode" later in this chapter.

Navigate between the menus using `SELECT MENU`*. The focus will move clockwise around the three Menus.*

4-5. Global Settings

Navigate to the Global Settings Menu using ⌈SELECT MENU⌉. See Figure 4-2.

gdw33.bmp

Figure 4-2. Global Menu Softkeys

4-6. Frequency

Set the required output frequency. An attempt to set frequency outside the active band when any output is ON will cause a warning message to be displayed.

4-7. Line Locking

For correct operation, it is essential that line locking is not selected unless the selected frequency is the same as the nominal input line frequency. Select line locking by checking the line lock box. The Lock indication shows green when the system is locked to line frequency. Red indicates that the Instrument has not locked to line frequency. See Figure 4-3.

gdw06.bmp
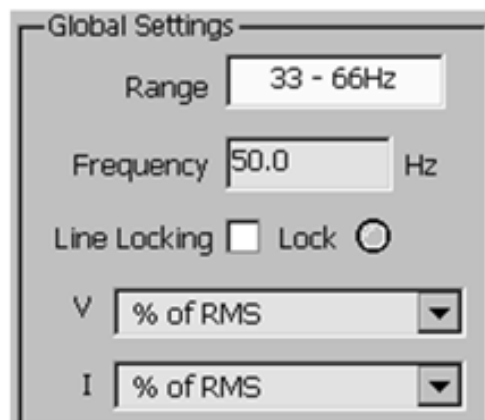
Figure 4-3. Frequency, Line Locking

4-8. Harmonic Edit Mode

If necessary navigate to the Global Settings Menu using ⌈SELECT MENU⌉. Press the **V**, **I** and **Power Modes** softkey to access the Harmonic mode softkeys. Return to the top-level softkeys by pressing escape. Select the way voltage and current harmonics are entered. The edit modes are as follows:

- Harmonics entered as % of RMS value

  Here the RMS value is maintained constant by reducing the level of the fundamental frequency component as harmonics are added. Changing the RMS value alters each harmonic accordingly.

- Harmonics entered as % of the fundamental (first harmonic) value

  Here the fundamental value is constant and the RMS value changes as harmonics are added.

Note

An error message will be generated if the peak value of the waveform exceeds the range maximum.

Changing the fundamental value alters all harmonics accordingly.

- Harmonics entered as dB down value from the fundamental value

This mode acts in the same way as % of fundamental.

Note
0 dB is an invalid entry as it exceeds the 30 % limit for harmonics.
The maximum value for a harmonic is -10.5 dB

- Harmonics entered as absolute RMS values

The RMS value of the output waveform increases as harmonics are added.

Note

An error message will be generated if the peak value of the waveform exceeds the range maximum.

4-9. Reactive Calculations

Select the reactive power calculation method and choose to display single phase power calculations or three phase power calculation for WYE or DELTA loads. Three phase power calculation is only available when two or more Auxiliary units are connected to the Master. Navigate to the Global Settings Menu using ⌹. Press the **V**, **I** and **Power Modes** softkeys to access the Power Calculation mode softkeys. Press ⌈ESC⌉ to return to the top-level softkeys. Select the reactive power calculation method most suitable for your purpose. See Figure 4-4.
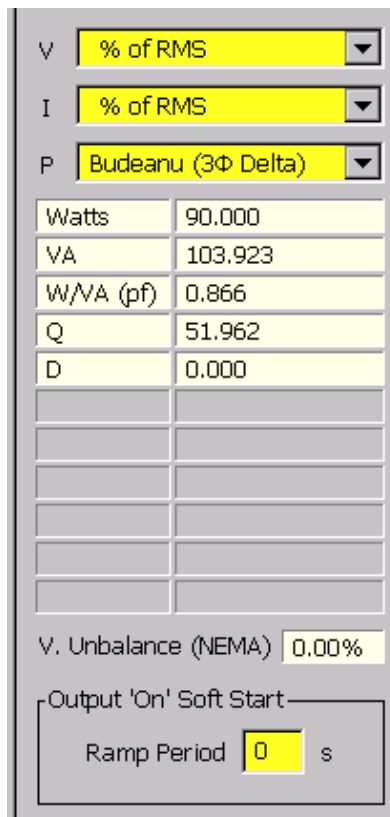
gdw07.bmp

Figure 4-4. Reactive Power Calculation

4-10. *Soft Start*

The Soft Start feature reduces the likelihood of internal over-voltage/current-detector trips caused by *inrush* current. Inrush current occurs when a device connected to the voltage terminals takes its operating power from the Instrument voltage signal. As the power supply smoothing capacitors begin to charge very high, short duration peaks of current are taken from the Instrument. This levels off to a low level once the capacitors reach operating voltage. The soft start ramp-up period can be set between 0 and 10 seconds as required.

The Energy mode warm up period should exceed the soft start ramp period to avoid energy counting inaccuracy.

4-11. *Units and Standards*

The **Units and Standards** softkey gives access to settings for phase angle (degrees or Radians), timing for dips (seconds or phase angle), flicker (2003 edition of 61000-4-15 or the latest) and the calculation method for three phase systems unbalance (NEMA or IEC). See Figure 4-5.
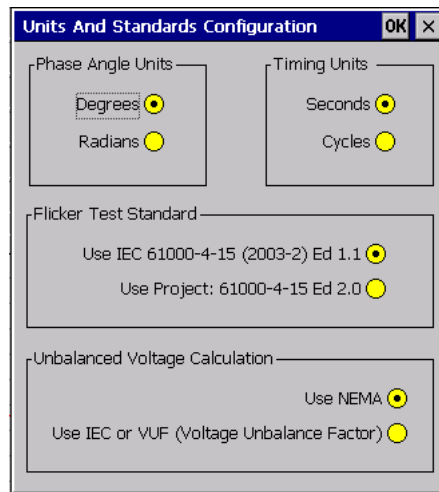
gdw42.bmp

Figure 4-5. Units and Standards Configuration

4-12. *Front-Panel Terminals*

Push the **Front Panel Terminals** softkey to open the pop-up screen for configuring the voltage terminals. The current binding posts selections apply only when the 50 A option is fitted. Currents up to 21 A can be routed through the normal 4 mm binding posts or, if preferred, through the same terminals that provide the 50 A output (lower terminals). The individual phases can be configured individually or all together. Figure 4-6 shows the front-panel terminal configuration screen.
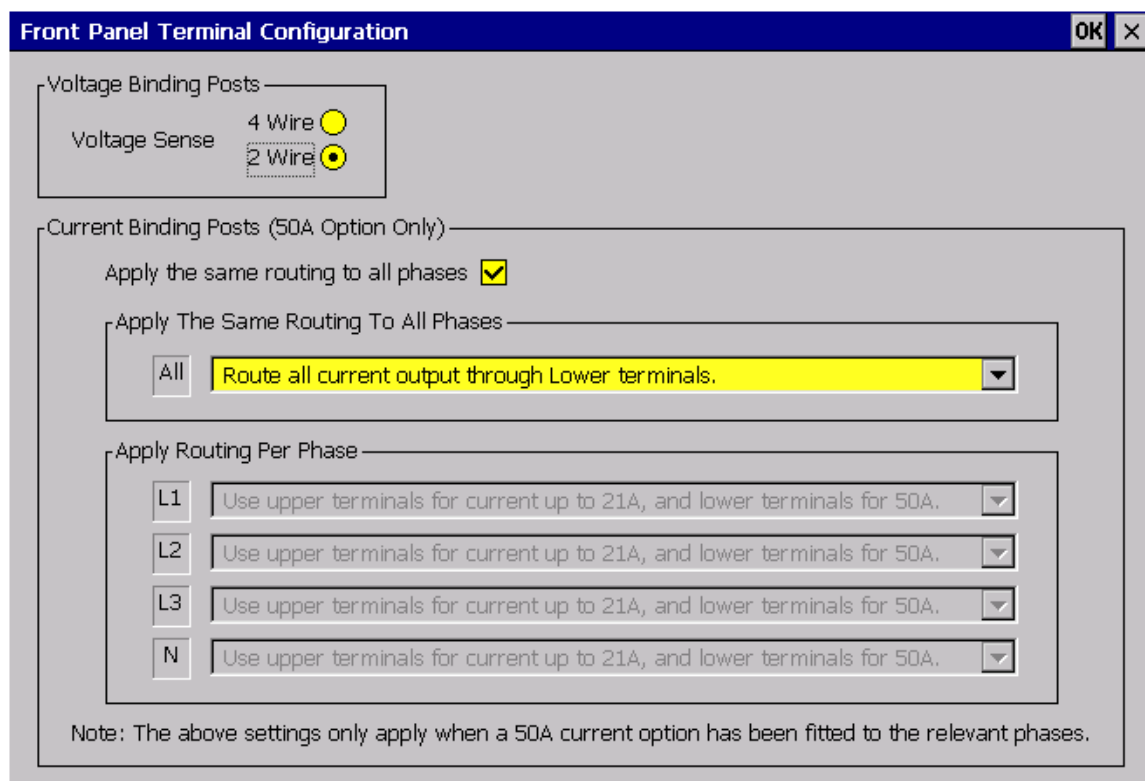
gdw43.bmp

Figure 4-6. Front-Panel Terminal Configuration

Note

The two-wire / four-wire configurations apply to all connected Master and Auxiliary units. See Figure 4-2. Select two or four wire using the soft keys, with the Up/Down keys or the scroll wheel when the voltage binding posts group has focus. Two wire is the initial default setting but the setting is non-volatile, meaning that, if four wire is selected, the next time the instrument is powered up it will be in four-wire mode. Push [ESC] *to return to the previous soft key level.*

⚠⚠Warning

The voltage sense binding posts are at output potential even when two wire is selected.

The Instrument is provided with a four to two wire lead set for voltage. Irrespective of two-wire / four-wire configuration the four plugs at the 6100B end of the lead should always be plugged in when the lead is in use. The sense wires will always be at the same potential as the output wires.

> *Note*
>
> *For measurement accuracy it is important that the two-wire / four-wire setting is correct. In particular, setting four-wire sensing but only connecting two wires will cause voltage errors in the order of 1.2 V or more. If you are not familiar with four-wire voltage sensing please read the description in Chapter 3.*

4-13. Rear-Panel Output Settings

The Rear-Panel Output Settings screen allows the sample reference signal to be turned on and off. See the description of the relationship between this signal and the Phase Reference in Chapter 7. See Figure 4-7.

This pop up screen also controls the Reference Clock Output option (if fitted). The Reference Clock Out option provides a reference signal derived from the master processor clock frequency and may be used to synchronize systems to the 6100B. The reference may be switched between off, 10 MHz, and 20 MHz.
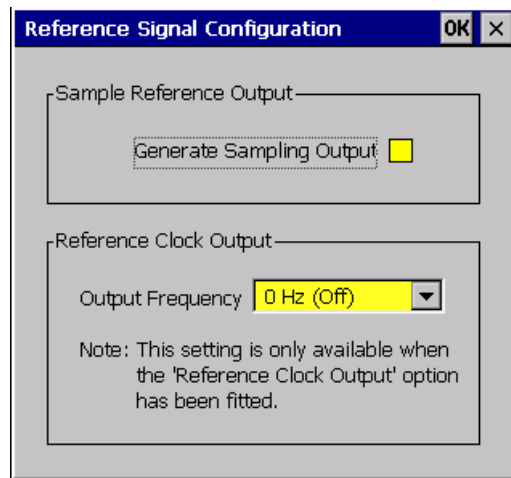
gdw52.bmp

Figure 4-7. Reference and Signal Configuration

Note

6100A setups are not transferrable to 6100B and 6105A and vice versa.

4-17. Set Date and Time

Date and time are adjusted via the Date and Time softkey.

4-18. GPIB Settings

Bus address, Event Status Enable (ESE), Status Register Enable (SRE) and Power On status Clear (PSC) can be configured with the GPIB Settings pop-up screen.

4-19. Set Factory Defaults

Set **Factory Defaults** resets all settings including harmonics to the factory default setting.

4-20. About

The About screen provides information about the current hardware and software configuration.

4-21. Edit Mode

[DIRECT MODE] controls Edit Mode. The next sections explain Edit Mode in detail.

4-22. Direct Mode

In Direct Mode, [DIRECT MODE] is lit. All waveform changes take immediate effect.

4-23. Deferred Mode

When [DIRECT MODE] is not lit, the Instrument is in Deferred Mode. In this mode, changes made are stored for later invocation. When in deferred mode, if the output for the channel being modified is ON, modification to fields that affect the output waveform are notified by an orange background color.

Note

Operations which are invalid when the output is ON are also invalid when Deferred Mode is active, even if the output is OFF. For example, you cannot change range in Deferred Mode even if the output is OFF.

To activate Deferred Mode changes, select the Output Menu softkey **Apply All** or, if the output is already ON, press [OPER].

The following actions undo all pending changes:

- Push the **Undo All** softkey,

- Push [STBY]

  Or

- Push [DIRECT MODE] (edit mode changes to Direct)

4-24. Changes that are not Deferred

In Deferred Mode, changes to all fields are deferred with the following exceptions:

- Line Locking

- Change of harmonic edit mode (e.g. Absolute RMS, % of RMS etc)

- Power calculation method

- Selection of Phase Units (Degrees/Radians)

- Selection of two-wire/4 Wire (terminal configuration cannot be changed when the

output is on)

- Global settings Time/Date and GPIB settings cannot be changed in deferred mode

- Load/Save setup is not available in deferred mode

Note

Entry into Calibration mode automatically selects Direct mode.

4-25. Setting up Voltage and Current Waveforms

The following describes setting up voltage waveforms but applies equally to current.

Use 🔲 to navigate to the Output Menu and use 🔺 and 🔻 until the voltage or current channel to be set up is highlighted. Notice that the N-phase voltage channel is, by default, limited to 33 V. The N-phase channel can be set to provide up to 1000 V if required. See Figure 4-10.

⚠️⚠️ Warning

To avoid electrical shock hazard, disconnect the 'N' phase voltage Hi terminal from any 6140A Lo terminal before electing to override the limit.

To override the limit:

1. Select the N-phase voltage channel in the Output Menu.

2. Select the Waveform Menu.

3. With the N-phase output set to OFF, check the Override Limit box.
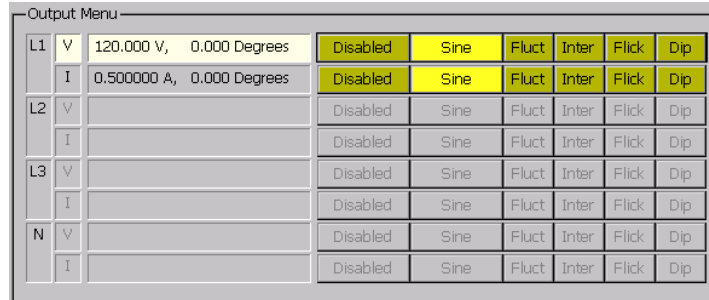
gdw08.bmp

Figure 4-10. Channel Selection

Note

A channel must be enabled and 🔲 pressed for an output to appear at the binding posts. If the output is already on but the active channel is not enabled, pushing the **Enable/Disable Channel** *softkey will cause the output to appear at the relevant binding posts.*

Push ⌈SELECT MENU⌉ to navigate to the Waveform Menu. If necessary, push ⌈ESC⌉ until the top level softkeys are shown. See Figure 4-11. Select **Edit Harmonics**, **Fluctuating Harmonics**, **Interharmonics Flicker** or **Dip** by pressing the appropriate softkey.

Edit Harmonics	Edit Fluct Harmonics	Edit Interharmo

gdw34.bmp

Figure 4-11. Waveform Top Level

4-26. Harmonics, DC and Sine

The following sections explain the Harmonics, dc, and Sine Menus.

4-27. Definition

A Harmonic is an integer multiple of the fundamental frequency. In the 6100B, harmonic number 1 is the fundamental frequency. DC is denoted by harmonic 0.

4-28. Access to Edit Harmonics

Use ⌈SELECT MENU⌉ to navigate to the Waveform menu and select **Edit Harmonics** from the softkeys.

4-29. 6100B Capability

Harmonics	2nd to 100th up to 6 kHz
Simultaneous Harmonics	99 (excluding dc and the 1st)
Max. Amplitude of a Single Harmonic	The maximum value for a harmonic < 2850 Hz is 30 % of range. (See Chapter 1 for the profile above 2850 Hz)
Current channel bandwidth setting	1.5 kHz or 6 kHz (1.5 kHz or 3 kHz for high current options if fitted)

Note

Selecting the lower bandwidth setting reduces the number of harmonics that can be set but increases inductive drive capability.

4-30. Sine/Harmonic Mode

Pushing the **Enable/Disable Waveshape** softkey toggles between Sine and Harmonics mode.

Note

The Output Menu will show either "Sine" or "Harmonic".

In Sine mode only Range, RMS and Angle fields can be edited. The one exception is the voltage channel of L1 where the phase angle is fixed at 0.000 degrees. Select the required entry field using the softkeys or ⌈→|⌉.

DC is not available in Sine mode.

Figure 4-12 below shows the Harmonic mode with time domain waveform selected. The same set up is shown in Figure 4-13 but here the frequency domain representation of the signal is shown.

Note that Figure 4-10 shows the L2 voltage channel in sine mode. Figures 4-12 and 4-13 show L1 voltage in Harmonics mode.

gdw10.bmp

Figure 4-12. Harmonics with Time Domain Graph

gdw11.bmp
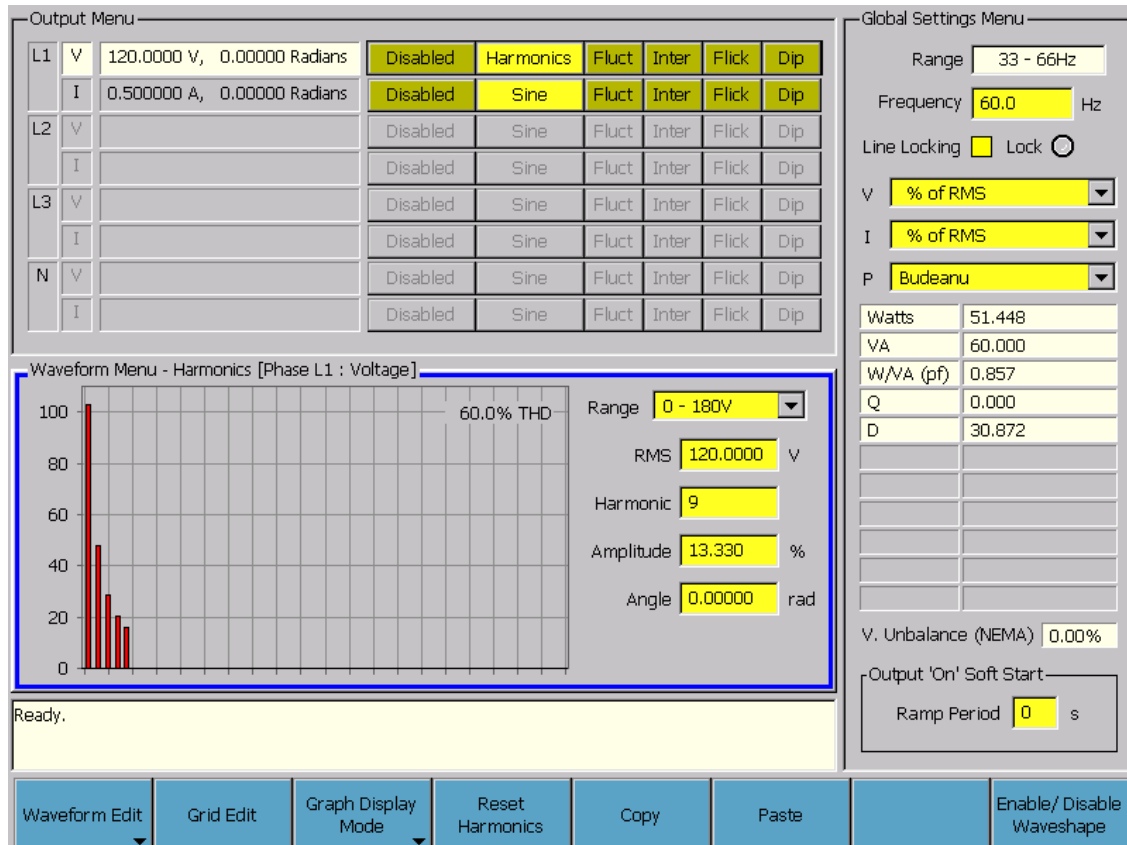
Figure 4-13. Harmonics with Frequency Domain Graph

4-31. Setting up Harmonics and DC

If the Global Settings are set to "percentage of RMS value", the fundamental amplitude is automatically adjusted as harmonics are added, in order to maintain the RMS value constant.

There are two ways to setup harmonics. The Waveform Edit mode provides a choice of time or frequency domain indication of wave shape. The Grid Edit mode provides a view of both voltage and current harmonics in adjacent grids. Press the **Harmonics** softkey to access the Harmonics Edit Mode softkeys. See Figure 4-14.
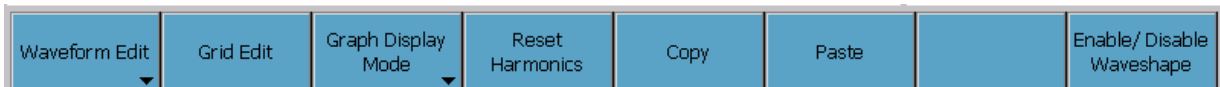
gdw54.bmp

Figure 4-14. Harmonics Edit Mode Softkeys

To use the Waveform Edit mode, push the **Waveform Edit** softkey. To add a harmonic, push the **Harmonics** softkey. A new set of softkeys are presented. Push the **Next Harmonic** softkey and enter values for harmonic number, amplitude and phase angle. The default phase angle for harmonics is 0 degrees (0 radians). Harmonic number of 0 represents a dc component.

Each time the value in the Harmonic field is changed and its amplitude is set to a non-zero value, a new harmonic is added to the wave shape and displayed in the graph. Harmonics do not appear at the output unless Harmonics mode is enabled for that channel.

Review the selections via the **Previous Harmonic** and **Next Harmonic** softkeys.

4-15

The **Reset Harmonics** softkey removes all harmonics from the active channel.

To remove a single harmonic from the set-up, set its amplitude to 0 % or use the **Remove Harmonic** softkey. See Figure 4-15.

gdw12.bmp

Figure 4-15. Softkeys for Waveform Edit mode

If harmonics are set up they are retained when harmonics are disabled by selecting **Sine** (Enable/Disable Waveshape). This allows the output to be easily switched back and forth between a distorted and sine wave output.

> *Note*
>
> *Change between Harmonics and Sine mode is also available from the Output Menu softkeys.*

> *Note*
>
> *When Sine is selected, the wave shape shown in the Waveform Menu reflects the harmonics which would be present if Harmonics were enabled. This means that the actual output will be a Sine wave, but the Waveform Menu will show a distorted wave shape if harmonics other than the fundamental are not zero.*
>
> *Before a range change is allowed, the Instrument checks that the RMS value of the <u>potential</u> output in Harmonics mode is within the capability of the new range. It may be that changing to a lower range will cause the limits of the new range to be exceeded. For example: 1 A dc is set up on the 2 A range in Harmonic mode. The dc value of 1 A represents 50 % of the 2 A range and this is the maximum dc content allowed. If Sine mode is selected the dc value remains set but the output reverts to a Sine wave. An attempt to select the 1 A range change will cause an error message to be generated because if Harmonics mode were selected, the dc content of the distorted waveform (1 A) exceeds the 50 % of range maximum for the 1 A range.*

4-32. Grid Edit Mode

> *Note*
>
> *Only the settings of the selected phase are visible in Grid Edit Mode. For the safety of personnel, the Grid Edit Mode cannot be entered if the output is ON. Similarly, when in Grid Edit Mode, the output cannot be turned ON.*

If necessary, press ⎡ESC⎤ to get to the top-softkey level. Select the **Grid Edit** softkey. The mode is primarily designed to be used with an external keyboard and mouse for rapid entry of several harmonics. The Grid Edit mode allows the Phase (L1, L2, etc) and Channel (V or I) to be selected without changing focus back to the Output menu. The range and RMS values for the voltage and current of the selected phase may be set. If required, the voltage and current harmonics grid may be locked together to display matching orders. See Figure 4-16.
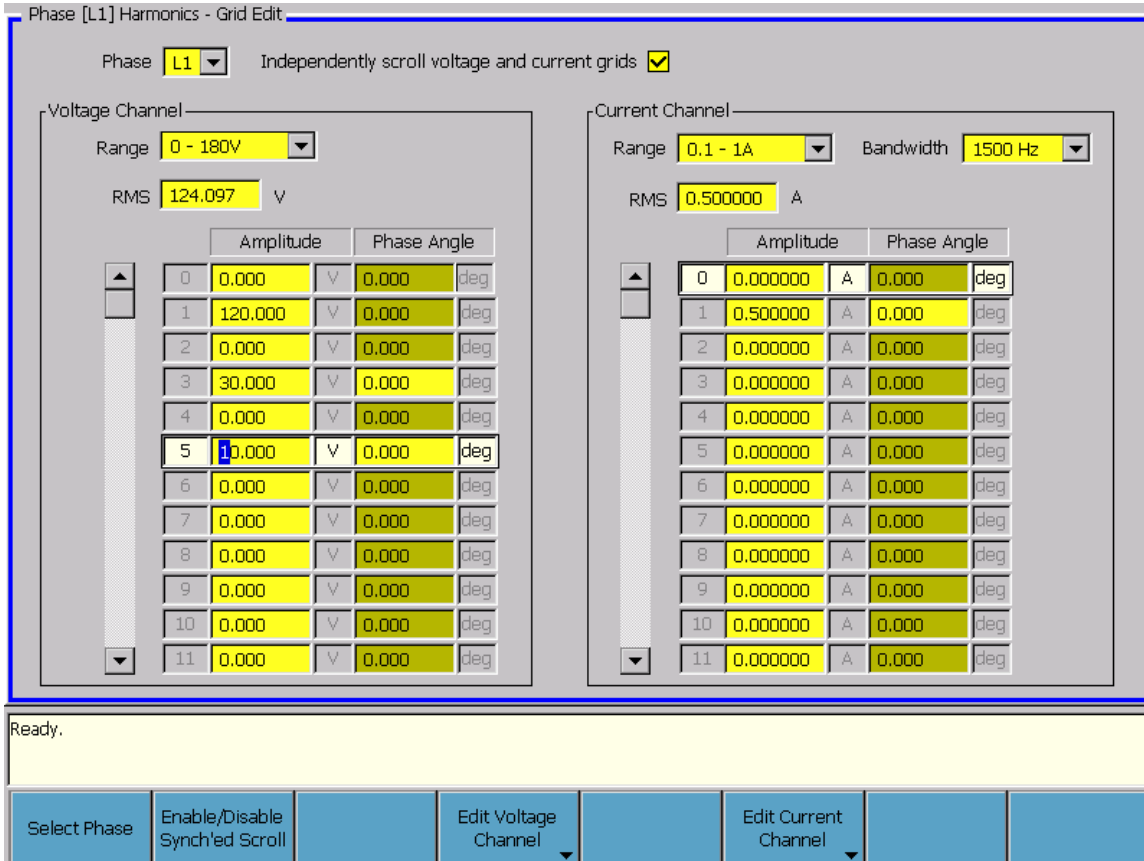
gdw56.bmp

Figure 4-16. Grid Edit Screen

Use the **Edit Voltage Channel** or **Edit Current Channel** softkeys to choose or edit the voltage or current channel. Figure 4-17 shows the softkeys for editing the Voltage channel.

gdw58.bmp

Figure 4-17. Second-Level Grid Edit Mode Softkeys

An external mouse and keyboard can be used to navigate around the grid and enter values for amplitude and phase angle. If preferred, the Instrument front panel can be used without external keyboard or mouse. Push the **Navigate Voltage Grid** softkey to open the bottom-level Grid Edit softkeys. See Figure 4-18.
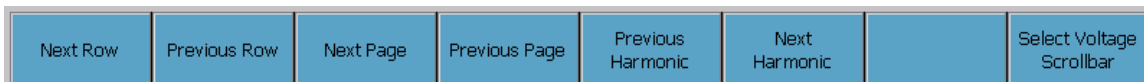
gdw58a.bmp

Figure 4-18. Bottom-Level Grid Edit Softkeys

One the required harmonics have been entered, the resultant waveform can be viewed by reversing up to the Waveform Edit menu.

4-33. Interharmonics
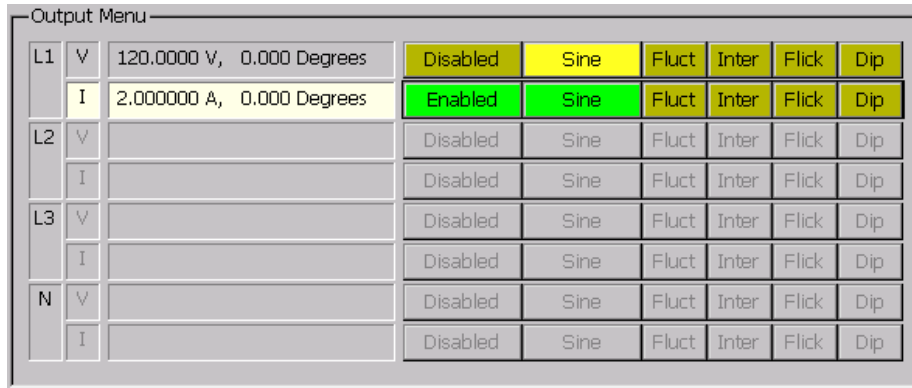
4-34. Definition

A frequency component of a periodic quantity (ac waveform) that is not an integer

multiple of the frequency at which the system is operating (for example, if the fundamental frequency is 60 Hz, an 83 Hz component in the waveform is an interharmonic).

4-35. Access to Edit Interharmonics

Use [SELECT MENU] to navigate to the Waveform Menu and select the **Edit Interharmonics** softkey. See Figure 4-19.

gdw13.bmp

Figure 4-19. Waveform Menu for Interharmonics

4-36. 6100B Capability
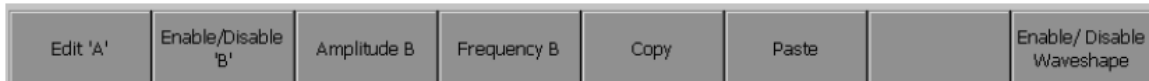
Maximum value of a single interharmonic	The maximum value for an interharmonic <2850 Hz is 30 % of range. (See Chapter 1 for the profile above 2850 Hz)
Frequency range of interharmonic	16 Hz to 9 kHz

4-37. Setting Up Interharmonics

Two interharmonic phenomena can be applied simultaneously.

Set the required amplitude and frequency of each and enable them with the check box. Values entered outside the specified range result in an error message.

Use the **Enable/Disable Waveshape** softkey to turn this function on or off from the Waveform Menu. Alternatively use the **Enable/Disable Interharmonics** softkey in the Output Menu. See Figure 4-20.

gdw14.bmp

Figure 4-20. Softkeys for Interharmonics

4-38. Fluctuating Harmonics

The following sections explain the Fluctuating Harmonics Menus.

4-39. *Definition*

Fluctuating harmonics are those that maintain their fixed harmonic relationship with the fundamental, but vary in amplitude over time. If all components of a waveform vary in amplitude over time, this is equivalent to Flicker.

4-40. *Access to Fluctuating Harmonics*

Use [SELECT MENU] to navigate to the Waveform Menu and select **Edit Fluct Harmonics** from the softkeys. See Figure 4-21.
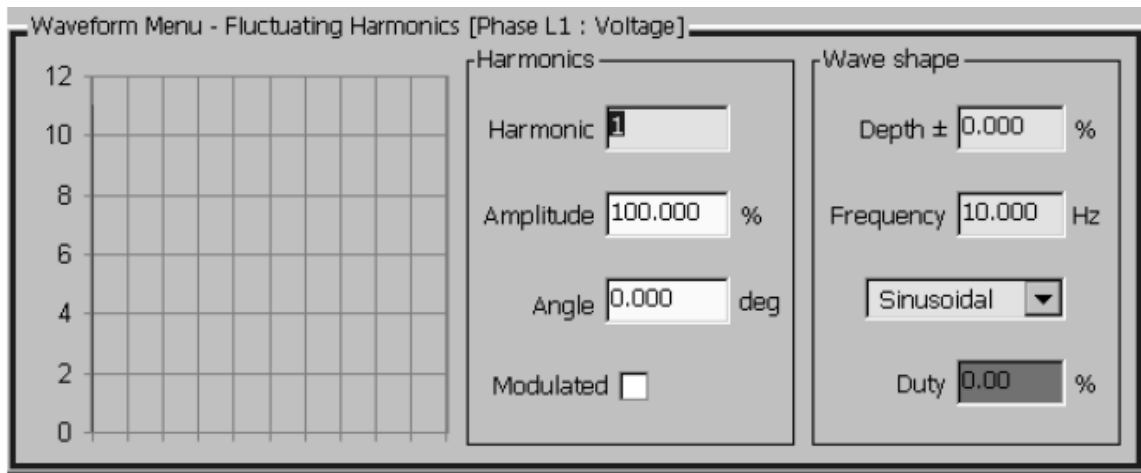
gdw15.bmp

Figure 4-21. Waveform Menu for Fluctuating Harmonics

4-41. *6100B Capability*

Number of harmonics to fluctuate	Any number from 0 to all set harmonics can fluctuate
Modulation depth setting range	0 % to 100 % of nominal harmonic voltage
Modulation depth setting resolution	0.001 %
Shape	Rectangular or Sinusoidal
Duty cycle (shape = rectangular)	0.1 % to 99.99 %
Modulating Frequency range	0.008 Hz to 30 Hz
Modulating Frequency setting resolution	0.001 Hz

4-42. *Setting Up Fluctuating Harmonics*

It is only possible to set up Fluctuating Harmonics properties for existing harmonics.

Select **Edit Fluct Harmonics** from the Waveform Menu softkeys.

Select the harmonic that fluctuation is to be applied to using the **Previous Harmonic**, **Next Harmonic** or the **Harmonic** softkeys. The **Modulated** softkey toggles the modulated check box. See Figure 4-22.

gdw16.bmp

Figure 4-22. Softkeys for Fluctuating Harmonics

The **Waveshape** softkey provides access to a further softkey menu allowing control of depth, frequency and shape of the modulation. See Figure 4-23.

gdw17.bmp

Figure 4-23. Waveshape Softkeys

Use the **Enable/Disable Waveshape** softkey to turn this function on or off from the Waveform Menu. Alternatively use the **Enable/Disable Fluct Harmonics** softkey in the Output Menu.

4-43. Dips and Swells

Dips and swells are primarily a voltage phenomenon but are also provided for the 6100B current channel. An example of using dip in the current channel is to set up the "Burst Fired" waveform required by IEC 61036 and the 62053 series of standards. The following sections explain the Dips and Swells Menu.

4-44. Definition

A dip is a sudden decrease of voltage at a point in the electrical system, followed by voltage recovery after a short period, from half a cycle to a few tens of seconds. A swell is an increase.

When triggered externally, dip/swell events occur simultaneously on all channels that have dip enabled.

4-45. Access to Dips and Swells

Use $\boxed{\text{SELECT MENU}}$ to navigate to the Waveform Menu and select **Edit Dip** from the Softkeys. See Figure 4-24.

gdw18.bmp
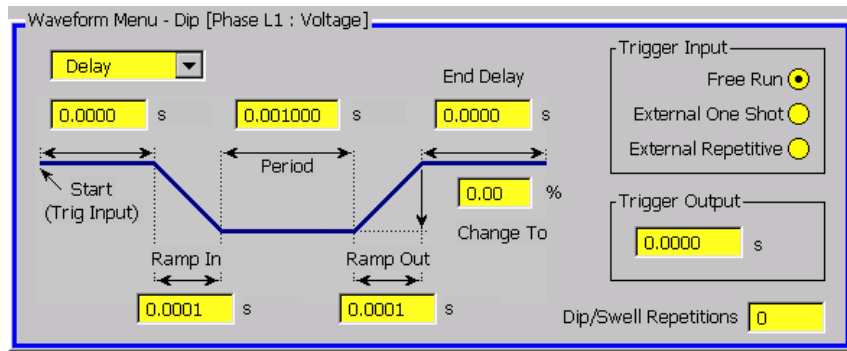
Figure 4-24. Waveform Menu for Dip

4-46. 6100B Capability

Trigger in requirement	TTL falling edge remaining low for 10 µs at the Trigger input connector on the rear panel.
Either:	
Trigger in delay	0 to 60 seconds
Or	
Phase angle synchronization with respect to channel fundamental frequency zero crossing	±180 °
Dip/Swell Min duration	1 ms
Dip/Swell Max duration	1 minute
Dip Min amplitude	0 % of the nominal output
Swell Max amplitude	The least of full range value and 140 % of the nominal output
Ramp up/down period	Settable 100 µs to 30 seconds
Optional end delay	0 to 60 seconds ± 31 µs
Trigger out delay	0 to 60 seconds from start of dip/swell event
Trigger out	TTL falling edge co-incident with end of trigger out delay, remaining low for 10 µs to 31 µs
Dip/Swell Repetitions	0 to 1000

4-47. Setting Up Dips/Swells

The top level Dip/Swell softkeys are shown in Figure 4-25. The **Waveshape** softkey opens the lower level softkeys for the various parameters that control the shape of the Dip/Swell. Under **Trigger** various Dip/Swell trigger options can be set. **Dip/Swell Repetitions** determines how many Dip/Swell events will occur when a trigger occurs in External Trigger (One Shot) mode. **Copy** and **Paste** allow transfer of the current settings to another 6100B phase. Use the **Enable/Disable Waveshape** softkey to turn Dip/Swell on or off.

gdw19.bmp

Figure 4-25. Top Level Dip Softkeys

Waveshape Parameters

The start of the dip/swell can be set to start after a delay (in seconds) or at a particular phase angle. All other parameters can be set in seconds or cycles. See Figure 4-26 and Table 4-1.

gdw20.bmp

Figure 4-26. Dip Waveshape Softkeys

Table 4-1. Dip Waveshape Softkey Function

Softkey	Function
Start On Delay	Start a fixed time period after an external trigger
Start on Phase Angle	Start determined by phase angle. *Note: to ensure all phases start simultaneously, this is the phase angle of the L1 phase irrespective of which phases dips are programmed on.*
Start Delay or Angle	Set selected value for delay or phase angle
Ramp In	Ramp in period
Period	Time at the Dip/swell 'change to' level
Ramp Out	Ramp out period
Change To	The value to dip to as a percentage of the starting level
End delay	Minimum end period before a re-trigger can occur

Trigger Control

There are three trigger-input modes. See Figure 4-27.
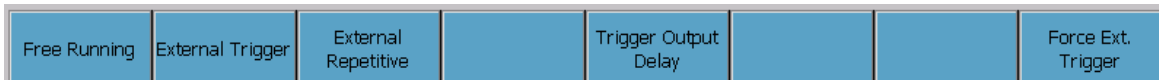
gdw21.bmp

Figure 4-27. Dip Trigger Softkeys

1. **Free Running**

    The dip/swell is triggered internally, and is controlled by the set parameters and repeats indefinitely. In a multiphase system, the relative start of dips on each phase may be unpredictable if dip event durations, including all delays, exceeds 1 cycle. In other words, the relative phase of dips on L1, L2, and L3 may vary, as parameters contributing to dip event durations are changed when free running trigger mode is selected.

2. **External Trigger (One Shot)**

    The dip/swell is triggered once by external trigger applied to the TRIGGER INPUT connector on the 6100B rear panel. The trigger signal must be TTL compatible. The low going transition causes a trigger starting the first number of Dips/Swells set in the Dip/Swell repetitions control. A trigger can also be initiated with the **Force Ext. Trigger** softkey.

3. **External Repetitive**

The dip/swell is triggered by a single external low going trigger applied to the TRIGGER INPUT connector and repeats in free running mode until stopped by a change to any dip/swell parameter.

An output trigger is provided to control external equipment. This trigger appears on the TRIGGER OUTPUT connector on the rear of any 6100B or 6101B producing a dip or swell. The output trigger may be set to occur at the same time as the input trigger (0 seconds delay), or delayed by a time set in the Trigger Output control field. When either Free Running or External Repetitive trigger input mode is selected, the trigger output delay must be less than the total combined dip/swell event time for a trigger output signal to be generated.

When an External Trigger mode is active, pressing the **Force Ext. Trigger** softkey causes a trigger event without an external signal to the rear panel.

4-48. Flicker

Flicker is primarily a voltage phenomenon but is also provided for current outputs in the 6100B. The following sections explain the Flicker Menu.

4-49. Definition

Repetitive (voltage) level variation in the range to cause the physiological phenomenon of flicker. Flicker severity is described by perception level. This is either perception level for a short term called P_{st} (nominally 10 minutes) or long term called P_{lt}. P_{st} indications are valid for voltage at 120 V and 230 V, 50 Hz and 60 Hz. P_{st} values, where the modulating frequency is as tabulated in IEC 61000-4-15 but $\Delta V/V$ is some other value, are valid. In this case, the P_{st} value is proportional to the ratio of the tabulated and set $\Delta V/V$ values. P_{st} values are never valid for the Current channel.

4-50. Access to Flicker

Use $\boxed{\text{SELECT MENU}}$ to navigate to the Waveform Menu and select **Edit Flicker** from the softkeys. The Flicker softkeys appear. Figure 4-28 shows the Flicker editing softkeys.

gdw22.bmp

Figure 4-28. Flicker Softkeys

Note

Edition 2 of the IEC 61000-4-15 Flicker standard will be released in 2010 or 2011. The 6100B provides the P_{st} and P_{inst} values for both the 2003 amendment 1.1; and for Flickermeter development teams; the values under review by the project team for the Amendment 2.0 standard. The amendment 2.0 proposal includes some new Flickermeter tests which the 6100B presents as 'Extended' functions.

4-51. 6100B Capability

The implementation of Flicker is separated into two groups- Basic Functions and Extended Functions. The Basic Functions group allow the depth and frequency of rectangular and Sine to be chosen for calibration of Flickermeters at the settings in IEC 61000-4-15. See Table 4-2.

Table 4-2. Basic Flicker Function

Function		Explanation
Setting range		±30 % of set value within range values (60 % ΔV/V)
Shape of modulation envelope		Rectangular, Square or Sinusoidal
Modulation units Either:	Frequency	0.05 Hz to 40 Hz
Or:	Changes per minute	1.0 CPM to 4800 CPM

The Extended Functions provide additional tests with distorted waveforms and combinations of frequency, amplitude and phase angle changes.

4-52. Setting Up Basic Flicker

Select the **Basic Functions** softkey from the top level Flicker menu. The Flicker panel has three sections. The Modulation and Waveform panes set the modulation shape. The Flicker severity pane shows the P_{st} and P_{inst} values that the Flickermeter should display.

Flicker parameters can be set within the ranges specified in the previous table. Note that change rate units can be set to frequency (Hz) or changes per minute (CPM). See Figures 4-30, 4-31, and 4-29.

gdw25.bmp

Figure 4-29. Basic Flicker Softkeys

gdw23.bmp
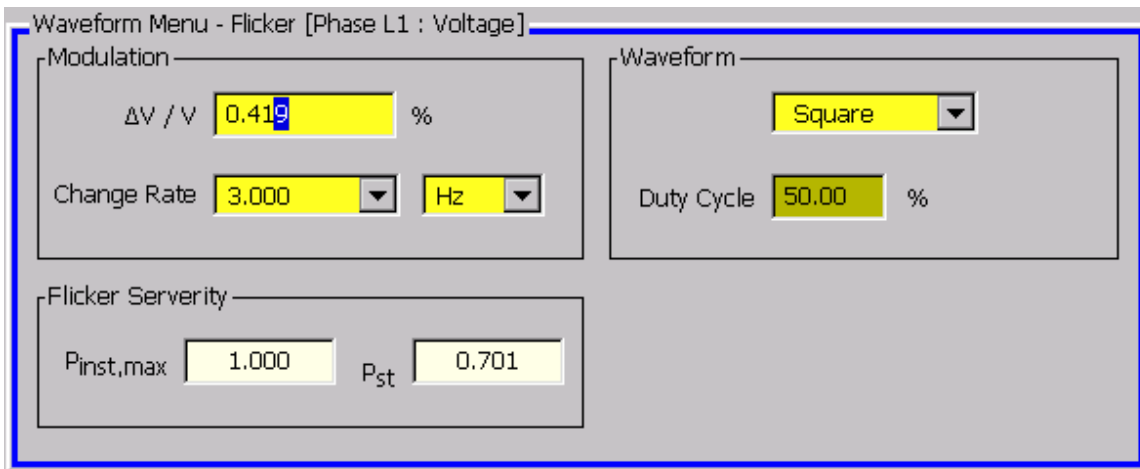
Figure 4-30. Flicker Menu (Frequency)
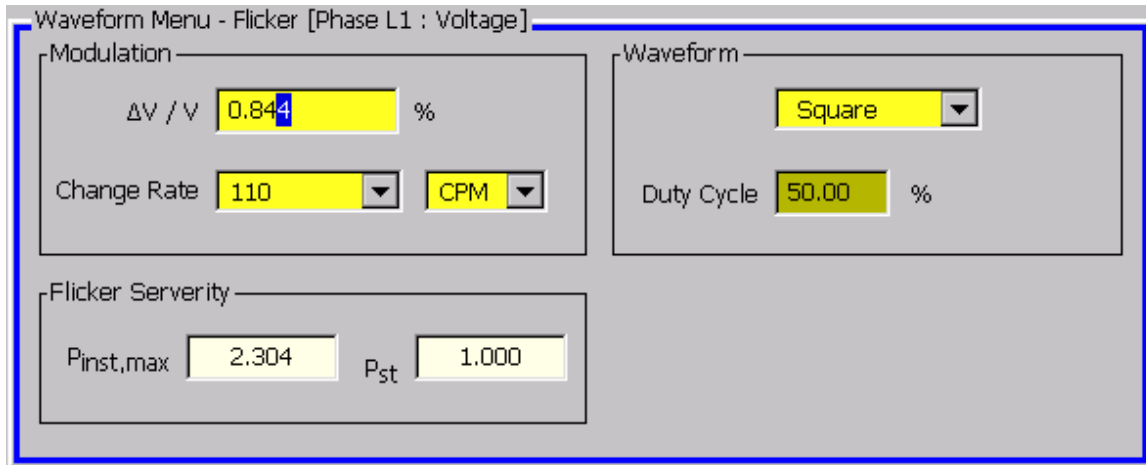
gdw24.bmp

Figure 4-31. Flicker Menu (Changes per Minute)

P_{st} and P_{inst} cannot be directly set. P_{st} can only be set by varying **ΔV/V**, **Change Rate** and **Waveform** parameters, or by changing the channel voltage or frequency settings. **Duty Cycle** setting does not affect P_{st} value.

Note

$P_{inst \cdot max}$ and P_{st} values are grayed out to indicate that the combination of **ΔV/V**, **Change Rate***, and* **Waveform** *parameters are not valid for the channel voltage or frequency settings.*

Use the **Enable/Disable Waveshape** softkey on the top level Flicker softkeys to turn this function on or off from the Waveform Menu. Alternatively use the **Enable/Disable Flicker** softkey in the Output Menu. See Figure 4-28.

4-53. Setting Up Flicker Extended Functions

Note

The extended functions are only available for fundamental frequencies 50 Hz and 60 Hz and Voltage channel settings 120 V or 230 V.

Select the **Extended Functions** softkey from the top level Flicker menu. See Figure 4-28. Select the required **Extended Flicker** function from the softkeys displayed. The Extended Flicker softkeys appear. See Figure 4-32.

gdw26.bmp

Figure 4-32. Extended Flicker Softkeys

The following sections explain the extended functions in detail.

4-54. Periodic Frequency Changes

The Periodic Frequency Changes Flicker function, see Figure 4-33, provides a fixed pattern of changes every 4 seconds. Frequency is stepped ±0.25 Hz either side of the fundamental frequency while voltage steps by up to 1.2 V depending on voltage and fundamental frequency settings. It should be noted that in a multiphase system the ±0.25 Hz frequency changes will occur on every phase. The voltage changes will occur only on the selected voltage channel. See Table 4-3.
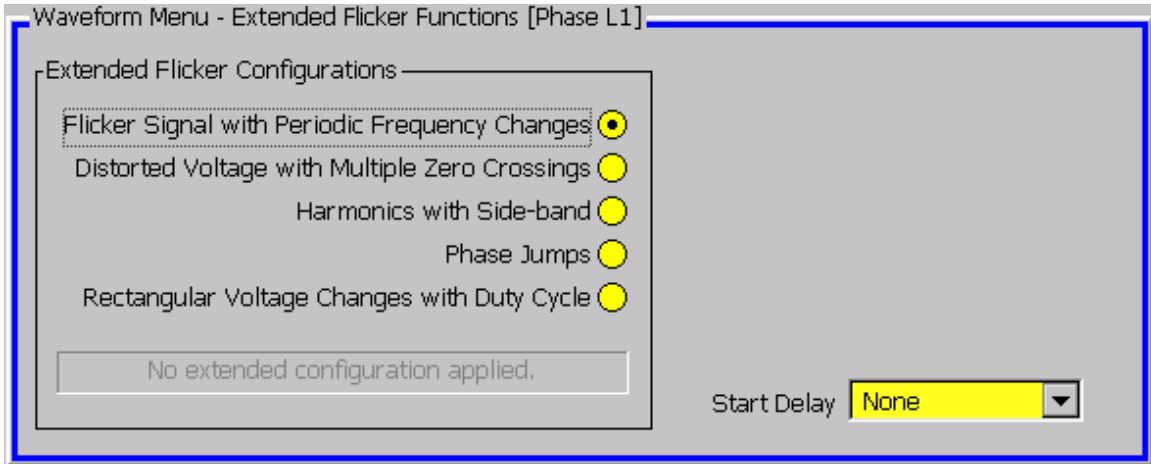
gdw27.bmp

Figure 4-33. Combined Frequency and Voltage Changes

Table 4-3. Periodic Frequency Changes

120 V			230 V		
Fundamental Frequency (Hz)	**Change to Frequency (Hz)**	**Change to Voltage (V)**	**Fundamental Frequency (Hz)**	**Change to Frequency (Hz)**	**Change to Voltage (V)**
60	59.75	120.000	50	49.75	230.000
	60.25	119.266		50.25	228.812
50	49.75	120.000	60	59.75	230.000
	50.25	119.270		60.25	228.805
The observed $P_{inst.max}$ should be 1.00.					

4-55. *Distorted Voltage with Multiple Zero Crossings*

The Distorted Voltage with Multiple Zero Crossings Flicker function, see Figure 4-34, output consists of the fundamental frequency plus 12 "odd" harmonics. The phase angle of the harmonics is 180 °. See Table 4-4 and Table 4-5.
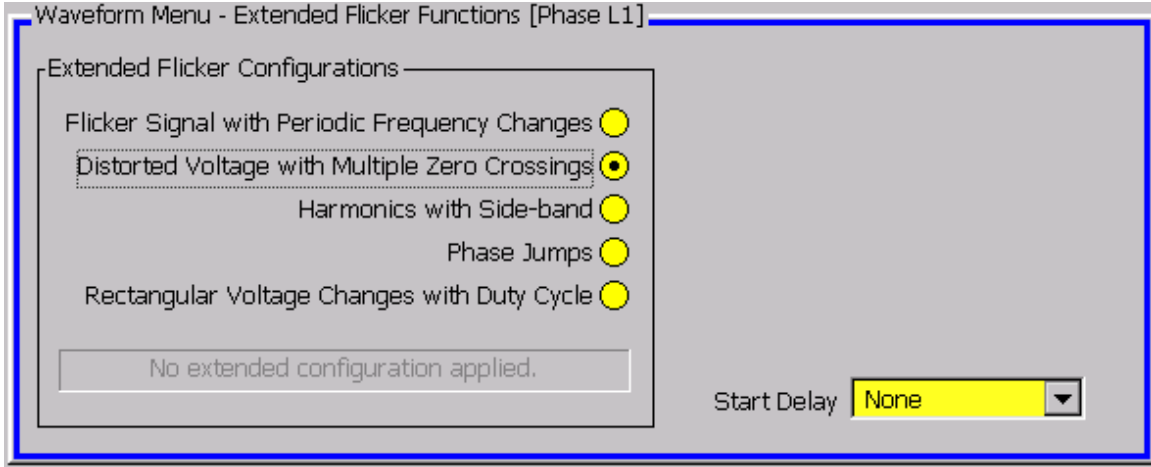
gdw28.bmp

Figure 4-34. Distorted Voltage with Multiple Zero Crossings

Table 4-4. Distorted Voltage with Multiple Zero Crossings Flicker

Harmonic order	3	5	7	9	11	13	17	19	23	25	29	31
Percent of fundamental	5	6	5	1.5	3.5	3.0	2.0	1.76	1.41	1.27	1.06	0.97

The signal is sinusoidally modulated at 8.8 Hz with modulation depth depending on the combination of voltage and fundamental frequency.

Table 4-5. Voltage Fluctuation

230 V		120 V	
Fundamental Frequency (Hz)	**Voltage Fluctuation %**	**Fundamental Frequency (Hz)**	**Voltage Fluctuation %**
50	0.250	60	0.321
60	0.250	50	0.321
The observed $P_{inst \cdot max}$ should be 1.00.			

4-56. Harmonics with Side Bands

The Harmonics with Side Bands Flicker function, see Figure 4-35, allows the input bandwidth of Flickermeters to be explored. The Fundamental frequency voltage waveform is modulated by two frequencies simultaneously. Both frequencies are of the same amplitude.
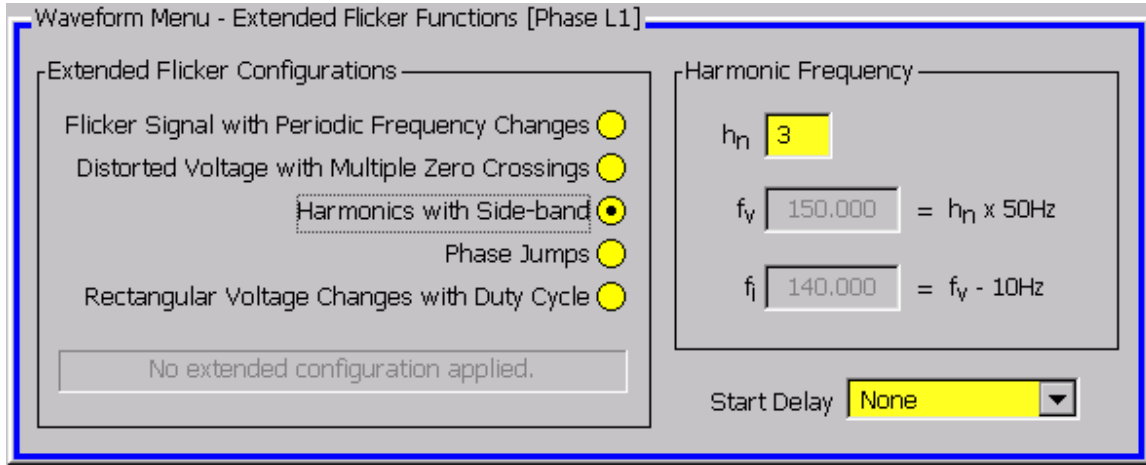
gdw29.bmp

Figure 4-35. Harmonics with Side Bands

Entering a harmonic number (hn) sets the harmonic frequency (fv) as a multiple of the fundamental frequency. See Table 4-6.

An interharmonic modulating frequency fi = fv -10 Hz is also applied.

For example:

fundamental frequency = 50 Hz,
hn = 7, fv = 50 * 7 = 350 Hz,
fi = 350 - 10 = 340 Hz.

Table 4-6. Harmonics with Side Bands

120 V			230 V		
Fundamental frequency (Hz)	**Starting frequencies (Hz)**	**Modulating frequency amplitude (V)**	**Fundamental frequency (Hz)**	**Change to frequency (Hz)**	**Change to voltage (V)**
60	170 & 180	4.126	50	140 & 150	3.611
50	140 & 150	4.126	60	170 & 180	3.611
Flicker meter input bandwidth is the maximum fv frequency at which $P_{inst,max}$ is 1.00.					

4-57. Phase Jumps

The Phase Jumps Flicker function, see Figure 4-36, causes a series of voltage channel phase jumps over a 10-minute period. The phase jumps occur at the positive zero crossing at 1 minute, 3 minutes, 5 minutes, 7 minutes, and 9 minutes after the end of the settling period. The phase jump direction and size is selected by the operator at the start of a sequence. Table 4-7 shows the expected P_{st} for the different combinations of voltage, frequency and phase jump size.
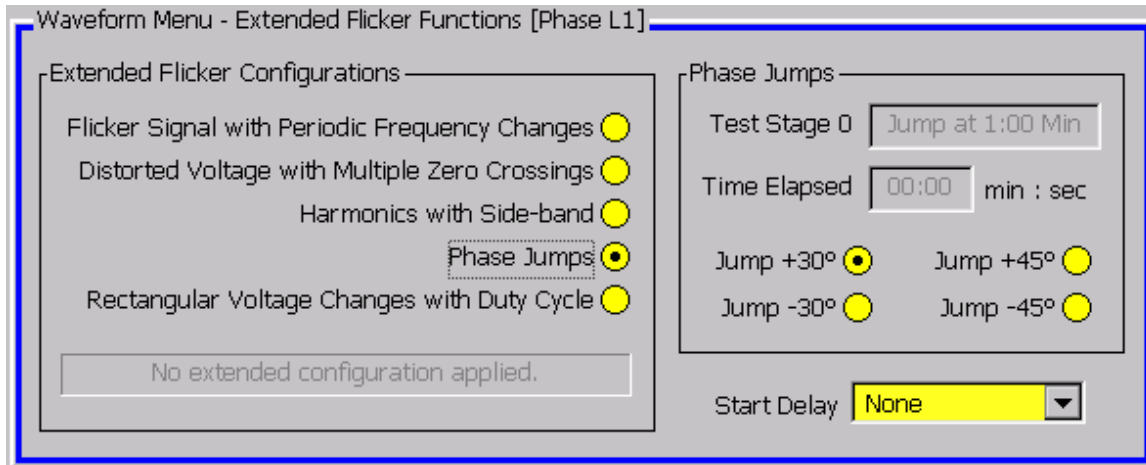
gdw30.bmp

Figure 4-36. Phase Jumps

Table 4-7. Phase Jumps

Phase jump angle Δß	120 V, 60 Hz (P_{st})	230 V, 50 Hz (P_{st})	120 V, 50 Hz (P_{st})	230 V, 60 Hz (P_{st})
±30 º	0.587	0.913	0.706	0.760
±45 º	0.681	1.060	0.819	0.882

4-58. *Rectangular Voltage Changes with 20 % Duty Cycle*

The Rectangular Voltage Changes with 20 % Duty Cycle Flicker function, see Figure 4-37, adds rectangular modulation for 12 seconds every 60 second period. The voltage output is not modulated during the remaining 48 seconds of each period. The depth of modulation is shown in Table 4-8.
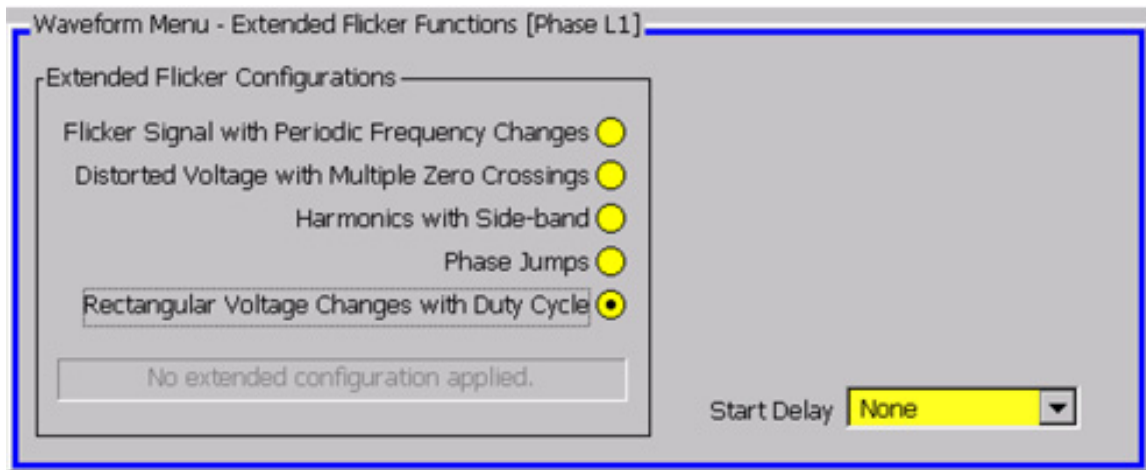
gdw31.bmp

Figure 4-37. Rectangular Voltage Changes with 20 % Duty Cycle

Table 4-8. Rectangular Voltage Changes with 20 % Duty Cycle

230 V		120 V	
Fundamental frequency (Hz)	**Voltage fluctuation %**	**Fundamental frequency (Hz)**	**Voltage fluctuation %**
50	1.418	60	2.126
60	1.480	50	2.017
The observed P_{st} should be 1.00.			

4-59. Copy and Paste

Each of the Waveform Menus has **Copy** and **Paste** softkeys at the top level.

4-60. Copy

Pushing **Copy** puts a copy of the currently active Waveform Menu into the clipboard. The clipboard is overwritten each time **Copy** is pushed. The contents of the clipboard are lost when line power is turned off.

4-61. Paste

Paste allows setups to be copied from the clipboard onto another channel as long as the active Waveform Menu is of the same type. You cannot copy from a Current channel to a Voltage channel.

Pasting erases any existing data in the active Waveform Menu.

The harmonics and fluctuation Waveform Menus share harmonic data, so pasting harmonic data will refresh the data used in the other, i.e., pasting Harmonic data into another channel will also paste the modulation settings.

4-62. The Energy Option

This section describes the 6100B Power Standard Energy Option.

4-63. Overview of Functionality

Meters supply a stream of pulses of a frequency proportional to the power being applied to their voltage and current input terminals. The total pulses represent the total energy delivered. The 6100B has six pulse inputs that can be configured for combinations of Meters Under Test (MUT) and reference meters. The Instrument also provides an output stream of pulses, representing the calculated theoretical output power of the system, to provide an 'ideal' pulse stream reference. A gate signal is available to switch external equipment during a test, or for the user to electronically control the duration of the test. The Energy Pulse Output and Energy Gate In/Out BNC connectors are mounted on the Instrument's rear panel.

4-64. Principle of Operation

One or more MUT are connected to the 6100B voltage and current terminals. A test is conducted which involves counting the number of pulses received within a specified period. The result is compared with the theoretical amount of energy delivered, or against a reference source that was connected in parallel to the MUT. The duration of the test is set by specifying a limit condition, which can be an absolute time, an amount of energy delivered, or as an accumulated energy from any MUT or reference meter channel (expressed as energy or pulse count). Input channels can be combined to allow up to three reference meters to be averaged or summed.

4-65. Limitations

The 6100B is an accurate reference source for independent voltage and current and phantom power. Unlike power supplies, the 6100B has a closed loop feedback system to ensure that the output waveforms are always of the demanded form. Extremely non-linear loads such as the power supply of electronic meters disrupt the 6100B and 6101A ability to maintain the correct output state. Attempting to provide line power to energy meters from the 6100B system may cause the 6100B output to trip or result in inaccurate readings. Always connect the meter's auxiliary power supply to a suitable external power source. The 6100B output capabilities are described in the specifications in Chapter 1.

The 6100B computed theoretical output power is accurate in Sine and Harmonic modes. Adding Flicker, Dips, Fluctuating Harmonics or Interharmonics will reduce the accuracy of the output power calculation and hence calculation of MUT error. If a reference meter is used, measurement accuracy depends on the performance of the reference meter for non-sinusoidal and amplitude modulated signal inputs. Negative power outputs are accumulated as unsigned quantities. The user should apply a context to the displayed magnitude of energy accumulated depending on the application and measurement configuration.

4-66. Preparing to Use the Energy Option

Set the voltage and current output combinations for L1 (and L2 and L3) as required for the test. See Chapters 3 and 4 for front-panel operating instructions. Enable the channels that will be used, but do not turn the outputs on.

To enter the Energy mode, navigate to the Waveform Menu. Press [ESC] until the top-level softkey menu is displayed as shown in Figure 4-38.

gdw35.bmp

Figure 4-38. Waveform Menu Top Level

Press the **Energy Counting** softkey to enter the Energy mode.

Figure 4-39 shows the interface which overlays the Waveform menu.
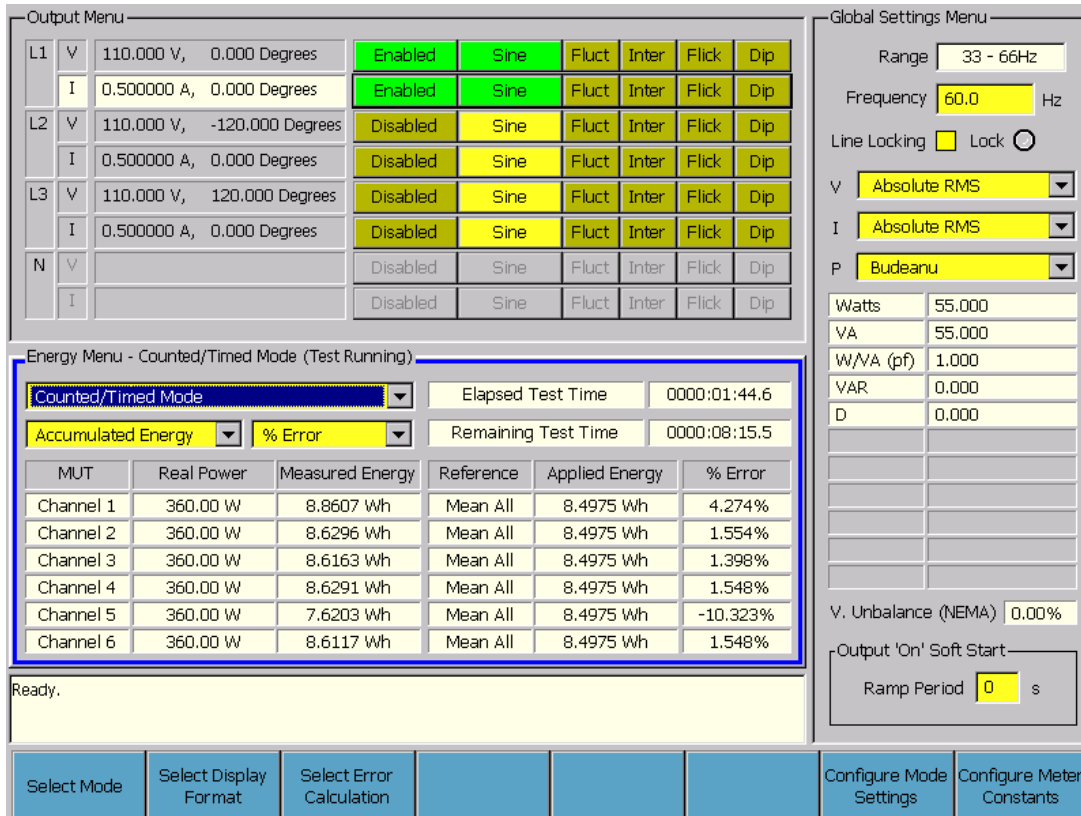
gdw36.bmp

Figure 4-39. Energy Mode

Each row of the display relates to a MUT channel. From left to right, the display shows the channel number, the instantaneous power indicated from that channel, the energy accumulated from that channel since the start of the warm-up or test, the reference source against which the error is calculated, the energy accumulated from that reference source over the MUT measurement period, and the calculated error of the MUT relative to the reference.

4-67. Input Channel Configuration and Meter Constants

The system must first be configured to the required MUT and reference meter set-up. Push the **Configure Meter Constants** softkey to access the configuration options. See Figure 4-40.
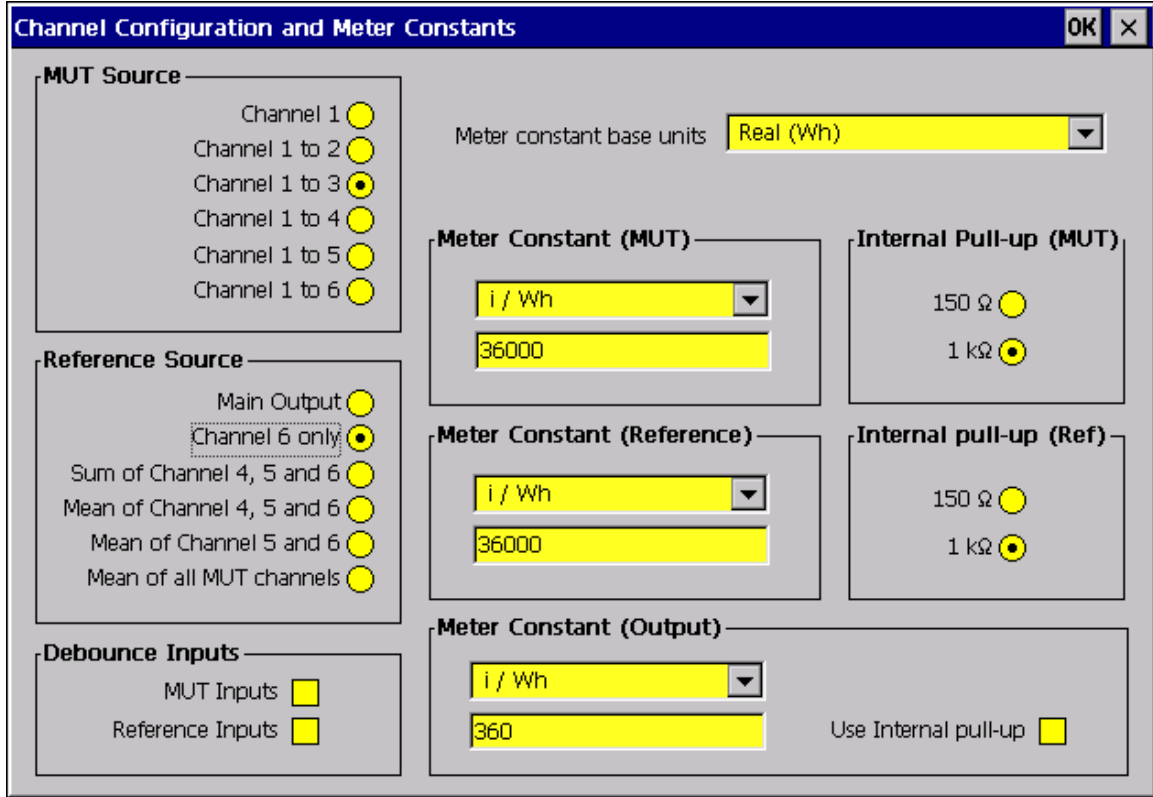
gdw37.bmp

Figure 4-40. Input Channel Configuration and Meter Constants

4-68. Connect MUT and Reference Meters

Connect the MUT to channel(s) starting at the lowest numbered channel and working up. For example, three MUT would connect to channels 1, 2 & 3. If reference meters are used, they should be connected starting at the highest numbered channel and working down. For example, a single reference meter would be on channel 6. Select the combination of MUT and reference meters that you require from the lists on the left of the configuration dialog. If Main Output is selected as the reference, MUT will be compared against the theoretical energy output of the system. Note that if the sum of 4, 5 and 6 is used as the reference source, valid reference inputs should be applied to all three-reference channels. Applying less than three inputs may cause the test duration to be one count too long.

Signal debounce can be applied to inputs to prevent spurious counting. A debounced input will ignore rapid activity in that signal. Debounce should not be applied when input signal pulse rates are expected to be greater than 100 Hz.

4-69. Type of Energy

It is necessary to set the type of energy being measured in the test: Real (Wh), Effective (VAh) or Reactive (VARh). This setting should match the settings on the MUT and reference meter(s). The meter constants then need to be specified. There is one value for all MUT and one for all reference meters.

Note that the Instrument provides various methods of specifying Reactive (VAR) power for non-sinusoidal output waveforms. The 6100B Energy Option always uses the Budeanu method to calculate errors when Main Output is the reference. If the reference source is an external reference meter, then calculation will be dependent upon the method used by the reference meter.

4-70. Internal Pull-ups

Each input group (MUT and Reference) may have either 150 Ω or 1 kΩ pull-ups internal to the 6100B. It is recommended that 150 Ω be selected when using higher frequency pulse rates.

4-71. Energy Pulse Output Meter Constant and Pull up

A value can be set which specifies the effective meter constant of the Pulse Out connector. Whenever an Energy test is active, this output is a pulse stream representing the total power and energy of the active V/I outputs of all 6100B in the system.

A user-selectable internal pull-up is provided for the Energy Pulse Output. The **Use Internal Pull-up** check box selects and deselects this pull-up. The pull-up should remain deselected (not checked) unless the device connected to the Energy Pulse Output does not provide a pull-up.

4-72. Conduct the Test

Push |ᴇɴᴛᴇʀ| to accept the newly defined values, or |ᴇsᴄ| to cancel all changes.

Pushing |ᴏᴘᴇʀ| starts the test. At this point, the voltage and current source main output terminals become active. The user cannot leave (|ᴇsᴄ|) the Energy screen while the test is active. To abort the test, press the |sᴛʙʏ| key.

During the test, the Energy screen will display rows of numbers corresponding to the user channel configuration. Pulse rate and total pulses are displayed, either as power and energy or as frequency and count depending on the Display Units setting. The accumulated total is compared with the specified reference source and an error or registration percentage is displayed. These display parameters can be changed "on the fly" by pressing the corresponding softkey to activate the list box and changing the value with the cursors. Time elapsed and time remaining (where known) for the test is also displayed. Time remaining may be an estimate for some mode combinations.

4-73. Test Modes

Under normal operating conditions, all 6100B main outputs are turned off at the end of a test. If the MUT or reference meters are using the 6100B as a power source, they may lose their configuration if the voltage is removed from them between tests. If **Maintain Voltage Signal On Completion** is selected in **Counted/Timed**, **Gated or Packet** mode, the Current output(s) will turn off, but the Voltage output(s) will not.

⚠⚠ Warning

High voltage will be present on the voltage output terminals after the test has completed if the "Maintain Voltage Signal On Completion" option is selected. Use caution when working under these conditions.

Pushing ⌊STBY⌋ will turn off all outputs regardless of this setting. Push ⌊OPER⌋ to start a new test.

Note

Although the output, global and energy option menu settings can be changed when `maintain voltage' is active, it is not possible to edit a phenomena's settings without pressing ⌊STBY⌋ (standby) first.

There are four test modes available. To change mode, press the **Select Mode** softkey, then cycle through the available modes using the up/down cursor keys. In each case, the parameters for the test can be changed in the configuration dialog for the currently selected mode by pressing the **Configure Mode** softkey.

gdw38.bmp

Figure 4-41. Energy Option Top-Level Softkeys

4-74. Free Run Mode

In Free Run Mode, power is applied to the MUT and a running tally is kept of the pulses received from each. The test will continue until the user aborts the test. This mode is only intended to offer approximate comparisons of performance and might be used, for example, to monitor a MUT during adjustment, or for creep tests.

4-75. Counted/Timed Mode

The purpose of the Counted/Timed Mode is to allow measurements to be made when both the 6100B and MUT are fully stabilized after warm-up and the 6100B output has settled after the output is turned on. The minimum warm-up time is 2 seconds. See Figure 4-42.

In this mode, the activity is divided into two periods, the warm-up and the test. Source power is applied to the MUT immediately when the OPER key is pressed, but the comparison of counts contributing to the result does not start until the specified warm-up period has expired. Both the warm-up and test duration can be specified freely as time or energy or pulse periods on any configured channel.
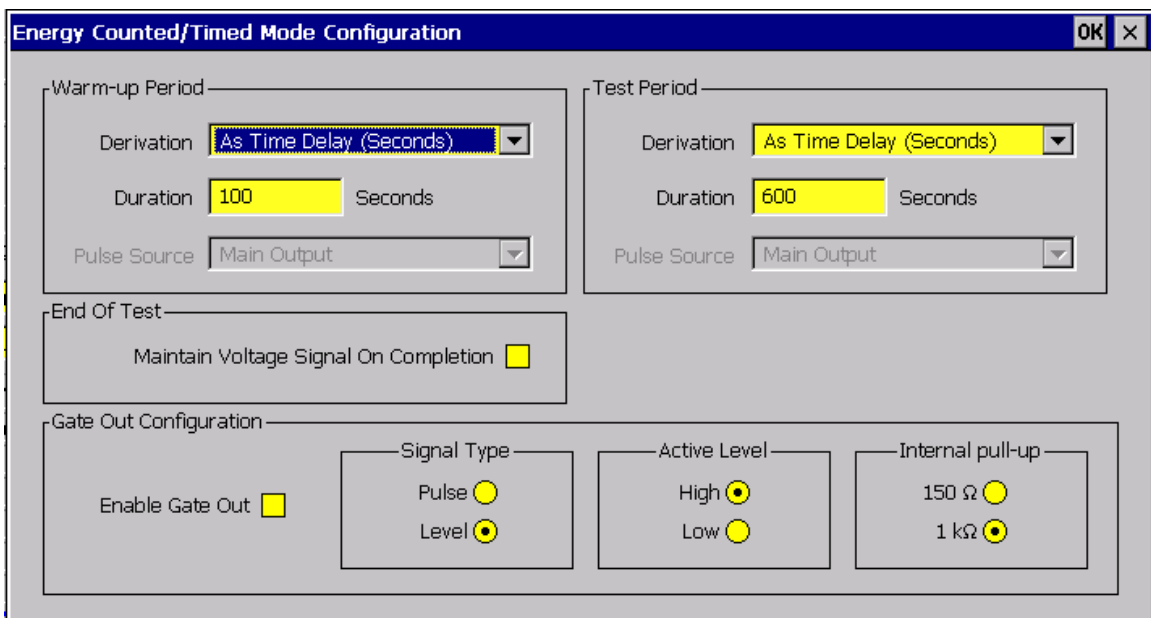
gdw39.bmp

Figure 4-42. Counted/Timed Mode Configuration

If warm up is specified as energy or pulse periods, it is important to ensure the duration specified is equivalent to at least 2 seconds to permit adequate settling of the main output.

If duration is specified as energy from MUT or Reference channels, then the system will accumulate at least this amount of energy on the specified channel(s) to the next whole pulse period. Only whole pulse periods are allowed. One pulse period is the duration between two pulses from a MUT or Reference. If both the warm-up and test duration are specified as pulses from the same source, the last pulse of the warm-up is taken to be the first pulse of the test. If time is used to specify the test duration, then it should be adequate to cover at least one pulse period, otherwise there will be no meaningful measurement.

If desired, a Gate Output signal may be enabled. This will be active for the duration of the actual measured test (not the warm-up and settling period). The gate signal can consist of a level of the required duration, or as a start and end pulse, and may be active high or low.

In the Counted/Timed mode, the MUT and reference meter dials may advance more than the amount measured by the 6100B Energy Option. This is normal, and represents settling and warm-up times included in the test. The actual test duration and count to achieve the displayed result is accurate.

4-76. Gated Mode

In Gated Mode, the Energy Gate connector (on the rear panel) becomes an input. When $\boxed{\text{OPER}}$ is pressed, power is applied to the MUT. Energy counts and error calculations will take place, but until the Gate signal becomes active, it is considered a warm-up period. When the Gate signal activates, the counts reset and the true test starts. The test terminates and the 6100B output is turned off when the gate becomes inactive.

If the period between the first application of power to the MUT and the gate becoming active is more than 2 seconds, the Gated mode accuracy is the same as for the Counted/Timed mode. See Figure 4-43.
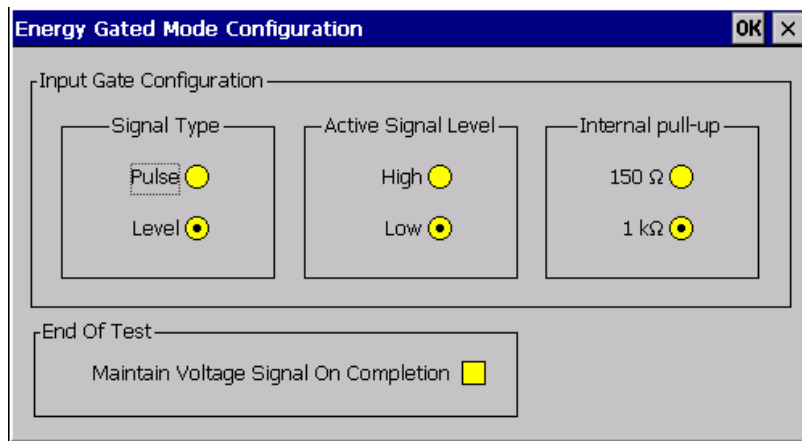
gdw40.bmp

Figure 4-43. Gated Mode Configuration

The gate input signal may a pair of pulses or a change of level. If pulses, the first starts the test, the second ends it. If the gate is a change of level, the test period is set by the time the gate is at the active level. Gate polarity can be set to be active high or low.

In the Gated mode, the MUT and reference meter dials may advance more than the amount measured by the 6100B Energy Option. This is because the dial will advance in the period before the gate signal becomes active. The count displayed by the 6100B accurately reports the pulses received during the time the gate is active.

4-77. Packet Mode

In Packet Mode, the power from the main output terminals is timed to deliver the requested amount of energy. This has the advantage that the dial advance on the MUT will closely match the expected amount, unlike other modes which have settling times and warm-up periods. See Figure 4-44.
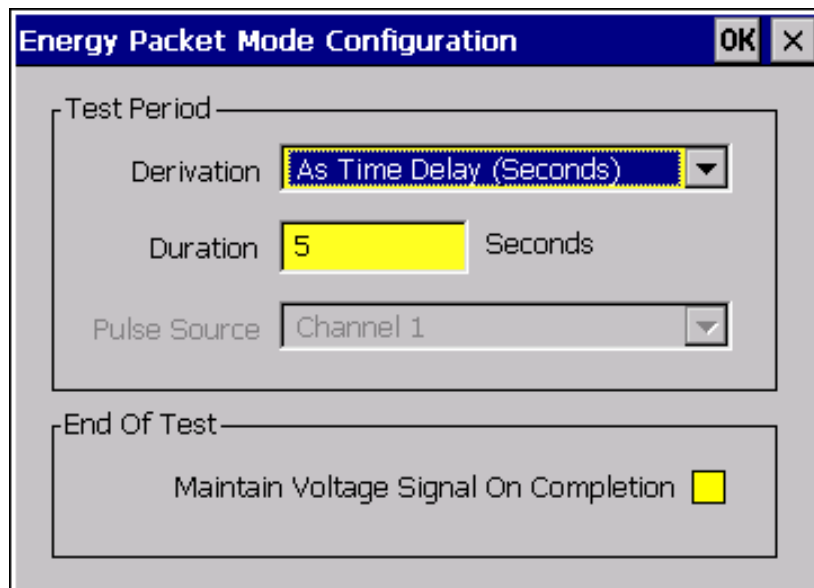
gdw41.bmp

Figure 4-44. Packet Mode Configuration

The size of the "packet" of energy will not be exact due to switching, ramping, and settling times of the main output. If "**Output "On" Soft Start**" is enabled in the Global Settings menu, the timing error may become excessive. The effect of the errors is reduced as the test time increases.

4-78. Remote Operation of the Energy Option

Remote commands are located in Chapter 5.

To start counting using the Energy Option, the energy-option status panel must be displayed on the 6100B, if another wave-shape definition panel is shown, only the power outputs will be activated, not the energy counter/timer. To guarantee correct operation it is recommended that a command from the "ENERgy" tree is the last one sent before ":OUTPut ON"; any command from this sub-system tree will re-display the energy status screen.

Note

Some commands must be sent in a specific order and this is indicated when applicable.

Chapter 5
Remote Operation

5-1. Introduction

Note

Unless otherwise stated, the use of "6100B" in this manual refers to the entire product family of 6100B and 6105A Master units, and 6101B and 6106A Auxiliary units.

The 6100B and 6105A Electrical Power Standards are capable of operating under the remote control of an instrument controller, computer or terminal, as well as under the direct control from the front panel.

The Auxiliary units can also be controlled remotely. But, in this case the remote control connection is still made to the 6100B, which in turn communicates with the Auxiliary units.

⚠⚠Warning

The Instrument is capable of supplying lethal voltages. Do not make or touch connections to the output binding posts while the Instrument is connected to the GPIB to avoid unexpected, dangerous settings.

5-2. Using the IEEE-488 Port for Remote Control

The 6100B is fully programmable for use on the IEEE Standard 488.1 interface bus (IEEE-488 bus). The interface is also designed in compliance with supplemental standard IEEE-488.2. Devices connected to the bus in a system are designated as talkers, listeners, talker/listeners, or controllers. Under the remote control of an instrument controller, the 6100B operates exclusively as a talker/listener on the IEEE-488 bus.

For more detailed information, refer to the standard specification in the publications ANSI/ IEEE Std. 488.1 - 1987 and IEEE Std. 488.2 - 1988.

The Instrument conforms to the Standard Specification IEEE 488.1 - 1987: "IEEE Standard Digital Interface for Programmable Instrumentation", and to IEEE 488.2 - 1988: "Codes, Formats, Protocols and Common Commands".

In IEEE 488.2 terminology the 6100B is a device containing a system interface. It can be connected to a system via its system bus and set into programmed communication with other bus-connected devices under the direction of a system controller.

5-3. Programming Options

The Instrument can be programmed via the IEEE Interface, to:

- Change its operating state (Function, Source, etc).
- Transmit its own status data over the bus.
- Request service from the system controller.

5-4. Capability Codes

- To conform to the IEEE 488.1 standard specification, it is not essential for a device to encompass the full range of bus capabilities.

- For IEEE 488.2, the device must conform exactly to a specific subset of IEEE 488.1, with a minimal choice of optional capabilities.

The IEEE 488.1 document describes and codes the standard bus features, for manufacturers to give brief coded descriptions of their own interfaces' overall capability.

For IEEE 488.2, this description is required to be part of the device documentation. A code string is often printed on the product itself.

The codes that apply to the Instrument are given in the Table 5-1 below, together with short descriptions.

They also appear on the rear of the Instrument next to the interface connector. These codes conform to IEEE 488.2 requirements.

Appendix C of the IEEE 488.1 document contains a fuller description of each code.

Table 5-1. IEEE 488 Compatibility Codes

IEEE 488.1 Subset	Interface Function
SH1	Source Handshake Capability
AH1	Acceptor Handshake Capability
T6	Talker (basic talker, serial poll, unaddressed to talk if addressed to listen)
L4	Listener (basic listener, unaddressed to listen if addressed to talk)
SR1	Service Request Capability
RL1	Remote/Local Capability (including Local Lockout)
PP0	No Parallel Poll Capability
DC1	Device Clear Capability
DT0	No Device Trigger Capability
C0	No Controller Capability
E2	Open-Collector and Three-State Drivers

5-5. Bus Addresses

When an IEEE 488 system comprises several instruments, a unique address is assigned to each to enable the controller to communicate with them individually.

The 6100B has one primary address, which can be set by the user to an exclusive value within the range from 0 to 30 inclusive. It cannot be made to respond to any address outside this range. Secondary addressing is not available. The application program adds data to the active address, to define talk or listen.

Default Bus Address:

The default setting is 18.

5-6. *Limited Access*

The Instrument has three basic operating modes. Some of these modes only give limited support for remote control:

- **Manual Mode -** Remote operation is available for all of manual mode, but for ease of programming, some remote commands do not mirror front panel operations exactly.

- **Calibration Mode -** Remote operation is available.

- **Test Mode -** Remote operation is not available, but the full selftest can be initiated by a SCPI command. The Instrument will give a straight Pass/ Fail response, but to investigate further, it is necessary to re-run Test mode from the front panel.

5-7. *Interconnections*

Instruments fitted with an IEEE 488 interface communicate with each other through a standard set of interconnecting cables, as specified in the IEEE 488.1 Standard document.

The IEEE 488 interface socket is fitted on the rear panel.

5-8. *Operation via the IEEE 488 Interface*

5-9. *General*

The power-up sequence is performed as in local operation. The Instrument can be programmed to generate an SRQ at power-up.

5-10. *Operating Conditions*

When the Instrument is operating under the direction of the application program, there are two main conditions, depending on whether the application program has set the "REN" management line True or False:

1. **REN True** (REN line low).

   The Instrument can be addressed and commanded if in either Manual or Calibration mode. All access to front panel control will be removed, except for the bottom right soft key, labeled **Enable Local Usage**. If LLO (Local Lockout) has been sent with REN true, then the **Enable Local Usage** screen key will be inoperative. If LLO has not been sent, the **Enable Local Usage** screen key will return to local control as if REN were false (see **2** below).

   The Instrument will act in response to valid commands, performing any changes in output, etc. The display presentation will track the changes.

2. **REN False** (REN line high).

   The Instrument will remain in Local Operation, but can be addressed and commanded, while full access to front panel control is also retained.

   The Instrument will act in response to the commands, performing any changes in output, etc. No visible effect will be observed, other than the display presentation tracking the changes.

5-11. *Programmed Transfer to Local Control (GTL or REN False)*

The application program can switch the instrument into Local Control (by sending Command GTL, or by setting the REN line false), permitting a user to take manual control from the front panel.

The application program can regain Remote control by sending the overriding command: Listen Address with REN true (addressing the instrument as a listener with the Remote Enable management line true {Low}). This will re-impose remote control.

5-12. *Device Clear*

Either of the commands DCL or SDC will force the following instrument states:

- All IEEE 488 input and output buffers cleared.

- With IFC (Interface Clear), any device-dependent message bus hold-offs cleared.

- The status byte is changed by clearing the MAV bit.

These commands will not:

- Change any settings or stored data within the device except as listed above.

- Interrupt analog output.

- Interrupt or affect any functions of the device not associated with the IEEE 488 system.

5-13. *Levels of Reset*

Three levels of reset are defined for IEEE 488.2 application programs, a complete system reset being accomplished by resetting at all three levels, in order, to every device. In other circumstances they may be used individually or in combination:

- **IFC** Bus initialization
- **DCL** Message exchange initialization
- *****RST** Device initialization

The effects of the *RST command are described in "Device Settings at Power On".

5-14. Message Exchange

5-15. IEEE 488.2 Model
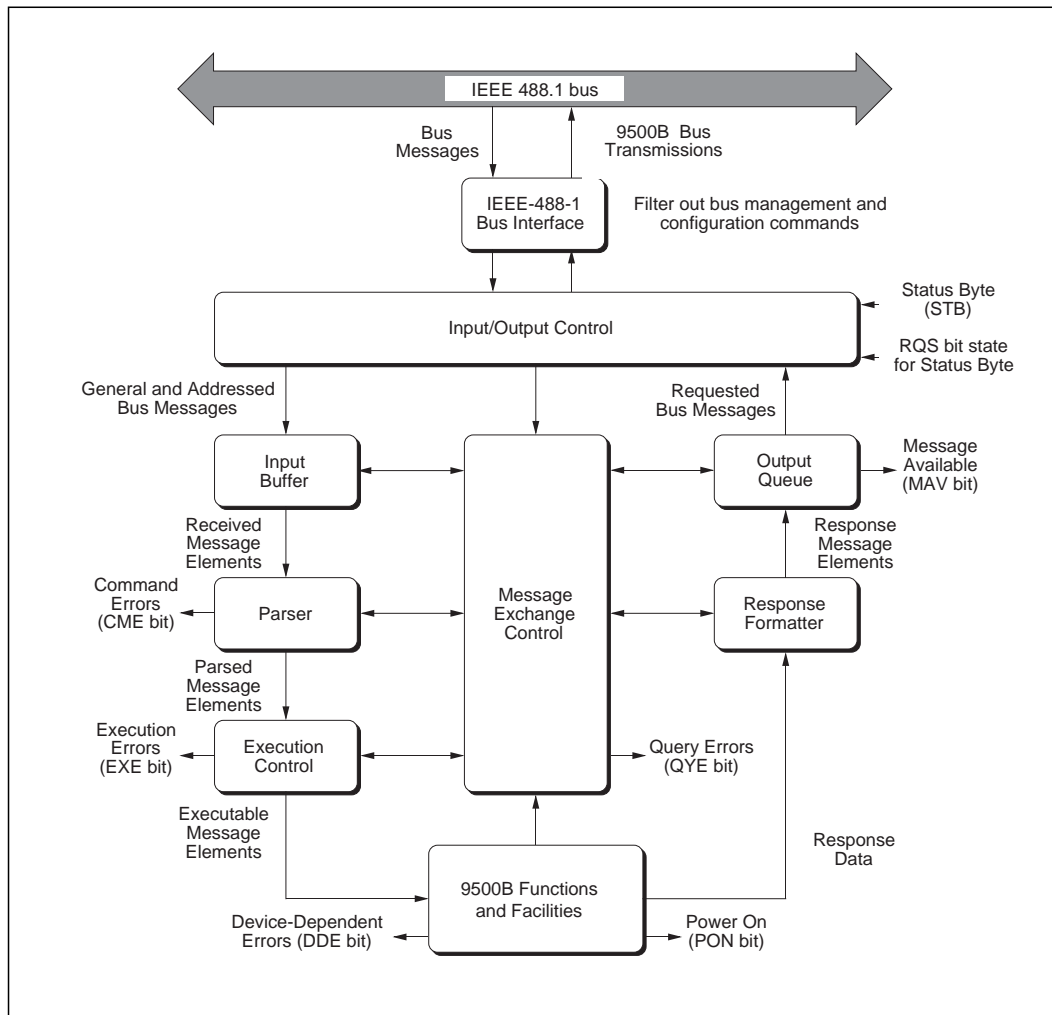
gdw54.eps

Figure 5-1. IEEE 488 Message Exchange Model

The IEEE 488.2 Standard document illustrates its Message Exchange Control Interface model at the detail level required by the device designer. Much of the information at this level of interpretation (such as the details of the internal signal paths etc.) is transparent to the application programmer. However, because each of the types of errors flagged in the Event Status Register is related to a particular stage in the process, a simplified instrument interface model can provide helpful background. This is shown below, together with brief descriptions of the actions of its functional blocks.

5-16. Instrument STATUS Subsystem

Input/ Output Control transfers messages from the Instrument output queue to the system bus; and conversely from the bus to either the input buffer, or other predetermined destinations within the device interface. It receives the Status Byte from the status reporting system, as well as the state of the Request Service bit that it imposes on bit 6 of the Status Byte response. Bit 6 reflects the "Request Service state true" condition of the interface.

5-17.   *Incoming Commands and Queries*

The **Input Buffer** is a first in, first out queue, which has a maximum capacity of 1024 bytes (characters).

Each incoming character in the I/O Control generates an interrupt to the instrument processor, which places it in the Input Buffer for examination by the Parser. The characters are removed from the buffer and translated with appropriate levels of syntax checking. If the rate of programming is too fast for the Parser or Execution Control, the buffer will progressively fill up. When the buffer is full, the handshake is held.

The **Parser** checks each incoming character and its message context for correct Standard-defined generic syntax, and correct device-defined syntax. Offending syntax is reported as a **Command Erro**r, by setting true bit 5 (CME) of the Standard defined Event Status register. Refer to "Retrieval of Device Status Information".

Execution Control receives successfully parsed messages, and assesses whether they can be executed, given the currently programmed state of the instrument functions and facilities. If a message is not viable then an Execution Error is reported, by setting true bit 4 (EXE) of the Standard defined Event Status register. Viable messages are executed in order, altering the instrument functions, facilities etc. Execution does not overlap commands; instead, the Instrument Execution Control processes all commands sequentially (for example, waits for actions resulting from the previous command to complete before executing the next).

5-18.   *Instrument Functions and Facilities*

The Instrument Functions and Facilities block contains all the device-specific functions and features of the instrument, accepting Executable Message Elements from Execution Control and performing the associated operations. It responds to any of the elements which are valid Query Requests (both IEEE 488.2 Common Query Commands and instrument Device-specific Commands) by sending any required Response Data to the Response Formatter (after carrying out the assigned internal operations).

Device-dependent errors are detected in this block. Bit 3 (DDE) of the Standard Event Status register is set true when an internal operating fault is detected. Each reportable error number is appended to the Error Queue as the error occurs.

5-19.   *Outgoing Responses*

The **Response Formatter** derives its information from Response Data (being supplied by the Functions and Facilities block) and valid Query Requests. From these it builds Response Message Elements, which are placed as a Response Message into the Output Queue.

The **Output Queue** acts as a store for outgoing messages, until they are read over the system bus by the application program. For as long as the output queue holds one or more bytes, it reports the fact by setting true bit 4 (Message Available MAV) of the Status Byte register. Bit 4 is set false when the output queue is empty. Refer to "Retrieval of Device Status Information".

5-20.   *Query Error*

Query Error is an indication that the application program is following an inappropriate message exchange protocol, resulting in the Interrupted, Unterminated or Deadlocked condition: Refer to Bit 2 in "Event Status Register".

The Standard document defines the instrument's response, part of which is to set true bit 2 (QYE) of the Standard defined Event Status register.

5-21. *Request Service (RQS)*

5-22. *Reasons for Requesting Service*

There are two main reasons for the application program to request service from the controller:

- When the instrument's message exchange interface is programmed to report a system programming error.

- When the instrument's is programmed to report significant events by RQS.

The significant events vary between types of devices; thus there is a class of events which are known as Device Specific. The device designer determines these.

5-23. *RQS in the IEEE 488.2 Model*

The application programmer can enable or disable the event(s) which are required to originate an RQS at particular stages of the application program. The IEEE 488.2 model is extended to incorporate a flexible SCPI status reporting structure in which the requirements of the device designer and application programmer are both met.

This structure is described in "Retrieval of Device Status Information".

5-24. Retrieval of Device Status Information

For any remotely operated system, the provision of up to date information about the performance of the system is of major importance. In the case of systems, which operate under automatic control, the controller requires the necessary feedback to enable it to progress the task; any break in the continuity of the process can have serious results.

When developing an application program, the programmer needs to test and revise it, knowing its effects. Confidence that the program elements are couched in the correct grammar and syntax (and that the program commands and queries are thus being accepted and acted upon), helps to reduce the number of iterations needed to confirm and develop the viability of the whole program. Such information is given in the following pages.

5-25. IEEE 488 and SCPI Standard Defined Features
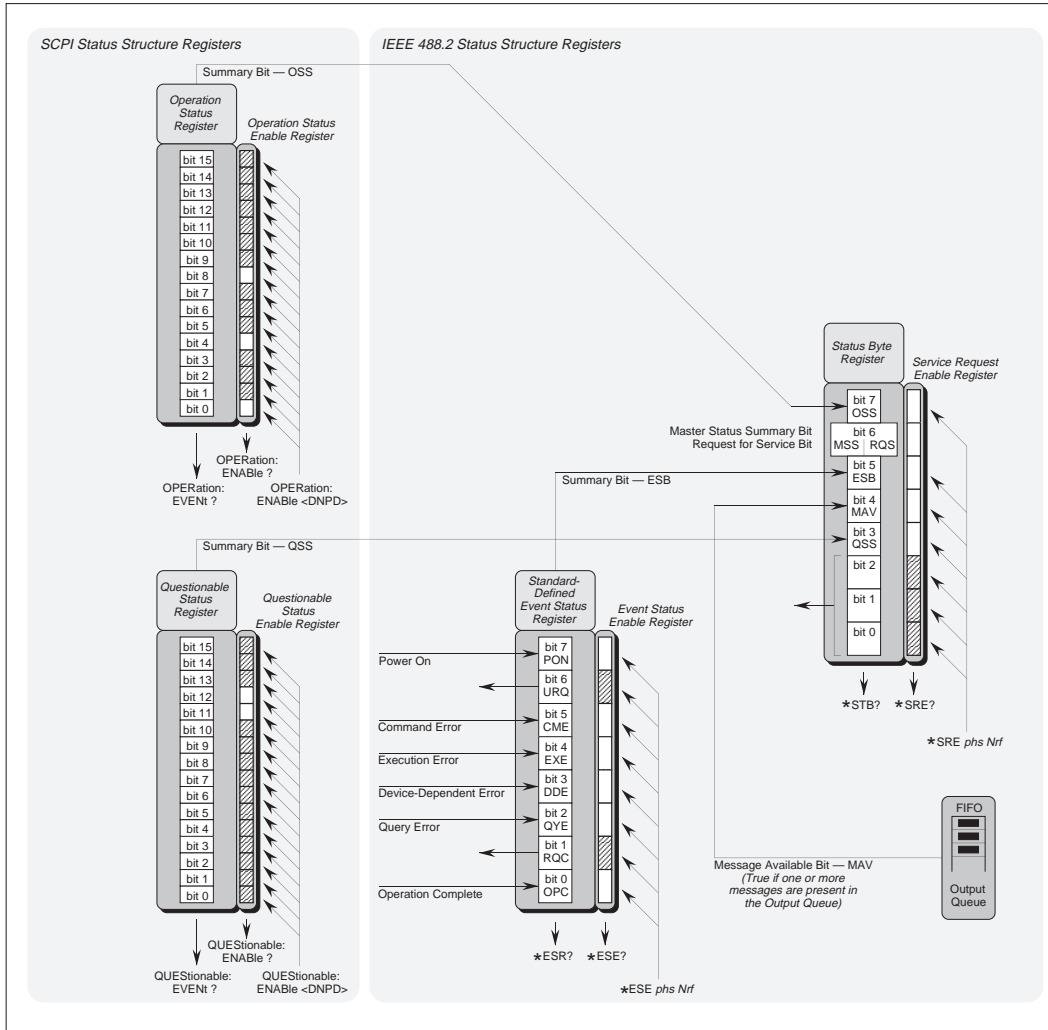
gdw55.eps

Figure 5-2. IEEE 488 and SCPI Standard Defined Features

5-26. Status Summary Information and SRQ

The Status Byte consists of four summary bits which notify events in the 8-bit latched IEEE 488.2 defined Event Status Register (ESB), the two 16-bit latched SCPI defined registers (OSS & QSS), and the Output Queue (MAV). Whenever one of these summary bits is enabled and set true, the Status Byte summary bit (MSS) is also set true. The buffered bit RQS follows true when MSS goes true, and will set the IEEE 488 SRQ line true (Note that in the diagram above no arrow points at bit 6 of the Service Request Enable Register - bit 6 is always enabled).

A subsequent serial poll by the Application Program will discover that the instrument was the requesting device (while resetting RQS false again, MSS remaining true), and which of the summary bits is true. The *STB? command is an equivalent command to serial poll, where serial poll is not available.

5-27. *Event Register Conditions*

The Status Byte summary bits direct the application program down the structure towards causal events.

ESB and MAV are standard IEEE-488 features, described in detail in "Instrument Status Reporting IEEE 488.2 basics", OSS and QSS are features of the SCPI structure, described in "Instrument Status Reporting SCPI Element".

5-28. *Access via the Application Program*

Referring to figure at the beginning of this sub-section take as an example the main Event Status register:

- **Enabling the Events**

  The main Standard-Defined Event Status Register has a second Event Status Enable Register. A program command (*ESE phs Nrf) can be used to set the state of the bits in the Enable register. This enables or disables the events, which will set the main register's summary bit true.

- **Reading the Enable Register**

  A query command (*ESE?) permits the application program to read the state of the Enable register, and hence find out which events are enabled to be reported.

- **Reading the Main Register**

  Another query command (*ESR?) reads the state of the main Standard-Defined register, to discover which event has occurred (for example, has caused the summary bit to be set true). Reading this register clears all its bits.

- **Reporting the Event**

  If an event is to be reported via the SRQ, its corresponding enable bit will have been set true, (using the number Nrf). Each bit in the Standard-Defined register remains in false condition unless its assigned event occurs, when its condition changes to true and remains true until cleared by *ESR? or *CLS. This causes the register's summary bit in the Status Byte also to be set true. If this bit is enabled, then the Status Byte bit 6 (MSS/ RQS) will be set true, and the instrument will set the IEEE-488 bus SRQ line true.

- **SCPI Status Registers**

  The two SCPI Status registers operate in the same way, using the appropriate program commands to set the enable registers, and query commands to discover the condition of the registers (the 6100B does not make use of these registers).

- **Subsequent Action**

  Thus the application programmer can enable any assigned event to cause an SRQ, or not. The controller can be programmed to read the Status Byte, using a serial poll to read the Status Byte register and the true summary bit (ESB or MAV). The application program then investigates the appropriate event structure until the causal event is discovered. The detail for each register is expanded in the following paragraphs, and in the command descriptions.

5-29. Instrument Status Reporting IEEE 488.2 Basics

5-30. *IEEE 488.2 Model*

This develops the IEEE 488.1 model into an extended structure with more definite rules. These rules invoke the use of standard Common messages and provide for device-dependent messages. A feature of the structure is the use of Event registers, each with its own enabling register as shown in "Retrieval of Device Status Information".

5-31. Instrument Model Structure

The IEEE 488.2 Standard provides for an extensive hierarchical structure with the Status Byte at the apex, defining its bits 4, 5 and 6 and their use as summaries of a Standard–defined event structure, which must be included if the device is to claim conformance with the Standard. The instrument employs these bits as defined in the Standard.

Bits 0, 1, 2 and 3 and 7 are available to the device designer; only bits 3 and 7 are used in the instrument, and these are as defined by the SCPI standard. The application programmer must recognize that whenever the application program reads the Status Byte, it can only receive summaries of types of events, and further query messages will be needed to probe the details relating to the events themselves. For example: a further byte is used to expand on the summary at bit 5 of the Status Byte.

5-32. Status Byte Register

In this structure the Status Byte is held in the Status Byte Register; the bits being allocated as follows:

- **Bits: 0** (DIO1), **1** (DIO2) and **2** (DIO3) are not used in the instrument status byte. They are always false.

- **Bit 3** summarizes the state of the Questionable Status data, held in the Questionable Status register (QSR), whose bits represent SCPI-defined and device-dependent conditions in the instrument. The QSS bit is true when the data in the QSR contains one or more enabled bits, which are true, or false, when all the enabled bits in the byte are false. The SCPI Standard defines the QSR and its data, (not used in 6100B).

- **Bit 4** (DIO5) IEEE 488.2 defined Message Available Bit (MAV).

  The MAV bit helps to synchronize information exchange with the controller. It is true when a message is placed in the Output Queue; or false when the Output Queue is empty. The common command *CLS can clear the Output Queue and the MAV bit 4 of the Status Byte Register; providing it is sent immediately following a Program Message Terminator.

- **Bit 5** (DIO6) IEEE 488.2 defined Standard Event Summary Bit (ESB).

  Summarizes the state of the Event Status byte, held in the Event Status Register (ESR), whose bits represent IEEE 488.2-defined conditions in the device. The ESB bit is true when the byte in the ESR contains one or more enabled bits which are true; or false when all the enabled bits in the byte are false.

- **Bit 6** (DIO7) is the Master Status Summary Message (MSS bit), and is set true if one of the bits 0 to 5 or bit 7 is true (bits 0, 1 and 2 are always false in the instrument).

- **Bit 7** (DIO4) SCPI defined Operation Status Summary Bit (QSS).

  Summarizes the state of the Operation Status data, held in the Operation Status register (OSR), whose bits represent processes in progress in the instrument. The OSS bit is true when the data in the OSR contains one or more enabled bits which are true, or false when all the enabled bits in the byte are false. The OSR is not used in the 6100B.

5-33. Reading the Status Byte Register

The common query:*STB? reads the binary number in the Status Byte register. The response is in the form of a decimal number that is the sum of the binary weighted values in the enabled bits of the register. In the instrument, the binary weighted values of bits 0, 1 and 2 are always zero.

5-34. Service Request Enable Register

The SRE register is a means for the application program to select, by enabling individual Status Byte summary bits, those types of events which are to cause the instrument to

originate an RQS. It contains a user modifiable image of the Status Byte, whereby each true bit acts to enable its corresponding bit in the Status Byte.

The common program command:*SRE phs Nrf performs the selection, where Nrf is a decimal numeric, whose binary decode is the required bit pattern in the enabling byte.

For example:

If an RQS is required only when a Standard-defined event occurs and when a message is available in the output queue, then Nrf should be set to 48. The binary decode is 00110000 so bit 4 or bit 5, when true , will generate an RQS; but with this decode, even if bit 3 is true , no RQS will result. The instrument always sets false the Status Byte bits 0, 1 and 2, so they can never originate an RQS whether enabled or not.

5-35. Reading the Service Request Enable Register

The common query: *SRE? reads the binary number in the SRE register. The response is in the form of a decimal number, which is the sum of the binary-weighted values in the register. The binary weighted values of bits 0, 1 and 2 will always be zero.

5-36. IEEE 488.2 defined Event Status Register

The Event Status Register holds the Event Status Byte, consisting of event bits, each of which directs attention to particular information. All bits are "sticky", i.e. once true, cannot return to false until the register is cleared. This occurs automatically when it is read by the query*ESR?. The common command *CLS clears the Event Status Register and associated error queue, but not the Event Status Enable Register.

Note that because the bits are "sticky", it is necessary to read the appropriate subordinate register of the status structure in order to clear its bits and allow a new event from the same source to be reported.

The Event Status Register bits are named in mnemonic form as follows:

- **Bit 0** Operation Complete (OPC).

  This bit is true only if *OPC has been programmed and all selected pending operations are complete. As the instrument operates in serial mode, its usefulness is limited to registering the completion of long operations, such as self test.

- **Bit 1** Request Control (RQC).

  This bit is not used in the instrument. It is always set false.

- **Bit 2** Query Error (QYE).

  QYE true indicates that the application program is following an inappropriate message exchange protocol, resulting in the following situations:

  - **Interrupted Condition.** When the instrument has not finished outputting its Response Message to a Program Query, and is interrupted by a new Program Message.

  - **Unterminated Condition.** When the application program attempts to read a Response Message from the instrument without having first sent the complete Query Message (including the Program Message Terminator) to the instrument.

  - **Deadlocked Condition.** When the input and output buffers are filled, with the parser and the execution control blocked.

- **Bit 3** Device Dependent Error (DDE).

  DDE is set *true* when an internal operating fault is detected, and the appropriate error message is added to the Error Queue. See the "Note about the Error Queue" below:

Note about the ERROR Queue

The Error Queue is a sequential memory stack. Each reportable error has been given a listed number and explanatory message, which are entered into the error queue as the error occurs. The queue is read destructively as a First In/ First Out stack, using the query command SYSTem:ERRor? to obtain a code number and message.

Repeated use of the query SYSTem:ERRor? will read successive Device Dependent, Command and Execution errors until the queue is empty, when the "Empty" message (0,"No error") *will be returned.*

It would be good practice to repeatedly read the Error Queue until the "Empty" message is returned. The common command *CLS clears the queue.

- **Bit 4** Execution Error (EXE).

  An execution error is generated if the received command cannot be executed, owing to the device state or the command parameter being out of bounds. The appropriate error message is added to the ERROR Queue.

  See the "Note about the Error Queue" above.

- **Bit 5** Command Error (CME).

  CME occurs when a received bus command does not satisfy the IEEE 488.2 generic syntax or the device command syntax programmed into the instrument interface's parser, and so is not recognized as a valid command. The appropriate error message is added to the Error Queue. See the "Note about the ERROR Queue" above.

- **Bit 6** User Request (URQ).

  This bit is not used. It is always set false.

- **Bit 7** Instrument Power Supply On (PON).

  This bit is set true only when the Line Power has just been switched on to the instrument.

  Whether or not an SRQ is generated by setting bit 7 true, depends on the previously-programmed Power On Status Clear message *PSC phs Nrf:

  - For an Nrf of 1, the Event Status Enable register would have been cleared at power on, so PON would not generate the ESB bit in the Status Byte register, and no SRQ would occur at power on.

  - If Nrf was 0, and the Event Status Enabling register bit 7 true, and the Service Request Enabling register bit 5 true; a change from Power Off to Power On will generate an SRQ. This is only possible because the enabling register conditions are held in non volatile memory, and restored at power on. This facility is included to allow the application program to set up conditions so that a momentary Power Off followed by reversion to Power On (which could upset the instrument programming) will be reported by SRQ.

  To achieve this, the Event Status register bit 7 must be permanently true (by *ESE phs Nrf , where Nrf ≥128); the Status Byte Enable register bit 5 must be set permanently true (by command *SRE phs Nrf , where Nrf lies in one of the ranges 32 - 63, 96 - 127, 160 - 191, or 224 - 255); Power On Status Clear must be disabled (by *PSC phs Nrf, where Nrf = 0); and the Event Status register must be read destructively immediately following the Power On SRQ (by the common query *ESR?).

5-37. Standard Event Status Enable Register

The ESE register is a means for the application program to select, from the positions of the

bits in the Standard defined Event Status Byte, those events which when true will set the ESB bit true in the Status Byte. It contains a user-modifiable image of the standard Event Status Byte, whereby each true bit acts to enable its corresponding bit in the standard Event Status Byte.

The program command: *ESE phs Nrf performs the selection, where Nrf is a decimal numeric, which when decoded into binary, produces the required bit pattern in the enabling byte.

For example:

If the ESB bit is required to be set true only when an execution or device dependent error occurs, then Nrf should be set to 24. The binary decode is 00011000 so bit 3 or bit 4, when true, will set the ESB bit true; but when bits 0 - 2, or 5 - 7 are true, the ESB bit will remain false.

5-38. Reading the Standard Event Enable Register

The common query: *ESE? reads the binary number in the ESE register. The response is a decimal number, which is the sum of the binary-weighted values in the register.

5-39. The Error Queue

As errors in the instrument are detected, they are placed in a "first in, first out" queue, called the Error Queue. This queue conforms to the format described in the *SCPI Command Reference (Volume 2) Chapter 19, paragraph 19.7*, although only errors are detected. Three kinds of errors are reported in the error queue: command errors, execution errors and device-specific errors.

The queue is read destructively, as described in the SCPI Command Reference, using the query command "SYSTem:ERRor?". This command will return a code number and error message. The query SYSTem:ERRor? can be used to read errors in the queue until it is empty, (when the message "0, No Error" will be returned).

5-40. Instrument Status Reporting - SCPI Elements

5-41. General

In addition to IEEE 488.2 status reporting the instrument implements the Operation and Questionable Status registers with associated Condition, Event and Enable commands.

The extra status deals with current operation of the instrument and the quality of operations.

The structure of these two registers is detailed in the diagram at the beginning of "IEEE-488 and SCPI Standard Defined Features" section, together with the nature of the reported events. Access to the registers is detailed in the STATus subsystem of the "SCPI Commands and Syntax" section.

5-42. SCPI Status Registers

The SCPI states are divided into two groups, reporting from the Operation or Questionable Status event register. Each Status register has its own Enable register, which can be used as a mask to enable bits in the event register itself, in a similar way to that set by the *ESE command for the Standard Event status Register (ESR).

Each Status Register is associated with its own third Condition register, in which the bits are not "sticky", but are set and reset as the internal conditions change.

Each Enable Register can be commanded to set its mask to enable selected bits in the corresponding Event Register. All registers (Event, Enable and Condition) can be interrogated by appropriate Queries to divulge their bits' states.

5-43. Reportable SCPI States

The 6100B does not normally use the Operation Status Event Register, but hardware,such as the energy counter/timer option does.

5-44. SCPI Programming Language.

Standard Commands for Programmable Instruments (SCPI) is an instrument command language which goes beyond IEEE 488.2 to address a wide variety of instrument functions in a standard manner.

IEEE 488.2 defines sets of Mandatory Common Commands and Optional Common Commands along with a method of Standard Status Reporting. The instrument implementation of SCPI language conforms to all IEEE 488.2 mandatory commands but not all optional commands. It conforms to the SCPI approved status reporting method.

Note

Commands in SCPI language, prefaced by an asterisk (e.g.: *CLS), are IEEE-488.2 standard-defined Common commands. Conformance of the instrument remote programming commands to SCPI ensures that the instrument has a high degree of consistency with other conforming instruments.

SCPI commands are easy to learn, self-explanatory and account for a wide variety of usage skills. The full range of instrument commands, with their actions and meanings in the instrument, is detailed in alphabetical order in "SCPI Commands and Syntax". The IEEE 488 Common Commands implemented in the 6100B Electrical Power Standard, together with their operating information are given in "Common Commands and Queries".

5-45. SCPI Commands and Syntax

5-46. SCPI Command Summary

Keyword	Parameter Form	Notes
CALibration		
:SECure		
:PASSword	<spd>	Used to enter calibration mode: Requires calibration password.
:EXIT		Used to exit calibration mode.
:PHASe<x>		<x> is phase (1 to 4): 1 is master phase.
:VOLTage		
:RANGe	<dnpd>, <dnpd>	Calibration range: <dnpd> = Low limit, High limit.
:RANGe?	[<cpd> {LOW | HIGH}]	Calibration range query.
:ACTual	<dnpd>,<dnpd>	<dnpd> = Amplitude, Angle.
		Note: Angle relative to master phase.
:FREQuency?		Query only of Actual frequency.
:TARGet	<dnpd>[,<dnpd>,<dnpd>,<dnpd>,<dnpd>]	<dnpd> = Target point.
		Or,
		<dnpd> =
		Point,
		Fund Freq,
		Harmonic,
		Amplitude,
		Angle.
		Note1: Angle relative to master phase.
		Note2: Second form is only required when changing target point.
:TRIGger?		
:STORe		
:DUMP?		Dump all stores for active range:
		Point,(<target data>,<actual data>)
		<target data> =
		Fund, Harm, Ampl, Angle
		<actual data> =
		Freq, Ampl, Angle

Keyword	Parameter Form	Notes
:CURRent		
:RANGe	<dnpd>, <dnpd>	Calibration range: <dnpd> = Low limit, High limit.
:RANGe?	[<cpd> {LOW | HIGH}]	Calibration range query.
:VOLTage	<dpnd>, <dpnd>	<dnpd> = low limit, high limit.
:VOLTage(?)	[<cpd>{ LOW | HIGH }]	
:UNIT?		Response is VOLT (voltage) or CURR (current). Query only.
:ACTual	<dnpd>,<dnpd>	<dnpd> = Amplitude, Angle. Note: Angle relative to master phase.
:FREQuency?		Query only of Actual frequency.
:TARGet	<dnpd>[,<dnpd>,<dnpd>,<dnpd>,<dnpd>]	<dnpd> = Target point.
		Or,
		<dnpd> =
		Point, Fund Freq, Harmonic, Amplitude, Angle.
		Note1: Angle relative to master phase. Note2: Second form is only required when changing target point.
:TRIGger?		
:STORe		
:DUMP?		Dump all stores for active range:
		Point,(<target data>,<actual data>), …
		<target data> =
		Fund, Harm, Ampl, Angle
		<actual data> =
		Freq, Ampl, Angle
OUTPut		
[:STATe](?)	<bool> {OFF | ON | 0 | 1}	
:ROSCillator		
[:STATe](?)	<bool> {OFF | ON | 0 | 1}	
:SENSe(?)	<bool> {OFF | ON | 0 | 1}	
:DEFer(?)		
[:STATe](?)	<bool> {OFF | ON | 0 | 1}	
:ACTion	[<cpd> {APPLy | UNDO}]	
:RAMP(?)	{FAST | SLOW}	
:TIME(?)	<dnpd>	
:RCLOCk(?)	<dnpd>	
:VOLTage		
:NLIMit(?)	<cpd> {LOW | HIGH}	

Keyword	Parameter Form	Notes
INPut		
:DIP		
:TRIGger		[No query form]
[SOURce]		
:FREQuency(?)	<dnpd>	
:LINE(?)	<bool> {OFF | ON | 0 | 1}	
:LOCKed?		
:POWer		
:UNBalanced?		Query only.
:STANdard(?)	[<cpd> { NEMA | IEC }]	
:BUDeanu?	[<cpd>{DELTa|WYE}, <cpd> { P | S | Q | D |PF}]	
:FLICker		
:STANdard(?)	[<cpd> { STD1 | STD2 }]	
:TERMinal		
[:STATe](?)	<bool> {OFF | ON | 0 | 1}	
:ROUTe(?)	<cpd>{ UPPer | LOWer }	
:PHASe<x>		<x> is phase (1 to 4).
		1 is master phase.
:FITTed(?)		
:SERial?		Serial number of phase.
:MODel?		Model number of phase.
:POWer		
[:WATTs]?		
:VA?		
:PFACtor?		
:BUDeanu?	[<cpd> { P | S | Q | D}]	
:FRYZe?	[<cpd> { P | S | Q}]	
:KUSTers?	[<cpd> { P | S | QC | QCR | QL | QLR}]	
:SHEPherd?	[<cpd> { P | S | SR | SX | SD}]	
:SHARon?	[<cpd> { P | S | SQ | SC}]	
:IEEE?	[<cpd> { P | S | N | SN | P1 | S1 | Q1 | PH | SH | NH}]	
:VOLTage		
[:STATe](?)	<bool> {OFF | ON | 0 | 1}	
:RANGe	<dnpd>, <dnpd>	<dnpd> = Low limit, High limit.
:RANGe?	[<cpd> {LOW | HIGH}]	
:AMPLitude?		Absolute final output amplitude.
		Query only.
:MHARmonics		
[:STATe](?)	<bool> {OFF | ON | 0 | 1}	
:CLEar		
:AMPLitude(?)	<dnpd>	<dnpd> = RMS amplitude.

Keyword	Parameter Form	Notes
:HARMonic\<y>	\<dnpd>,\<dnpd>	\<y> is harmonic number. \<dnpd> = Amplitude, Phase. Note: amplitude absolute or % depending on value of UNIT:MHAR:...
:AMPLitude(?)	\<dnpd>	Absolute or %
:PANGle(?)	\<dnpd>	
:HARMonic\<y>?	[\<cpd> {AMPLitude | PANGle}]	
:ALL?	[\<cpd> {AMPLitude | PANGle}]	Response is in csv format.
:FHARmonics		
[:STATe](?)	\<bool>{OFF|ON|0|1}	
:CLEar		
:FLUCtuate\<y>(?)	\<bool>{OFF|ON|0|1}	\<y> is harmonic number.
:ALL?		Response in csv format.
:MODulation	\<dnpd>,\<dnpd>	\<dnpd> = Depth, Frequency.
:MODulation?	[\<cpd>{ DEPTh | FREQuency }]	
:SHAPe(?)	\<cpd>{ RECTangular | SINusoidal | SQUare}	
:DUTY(?)	\<dnpd>	
:IHARmonics		
[:STATe](?)	\<bool>{OFF|ON|0|1}	
:SIGNal\<y>	\<bool>{OFF|ON|0|1}[,\<dnpd>,\<dnpd>]	\<y> = signal (1 or 2). \<dnpd> = Amplitude, Frequency.
:SIGNal\<y>?	[\<cpd>{ STATe | AMPLitude | FREQuency }]	
:DIP		
[:STATe](?)	\<bool>{OFF|ON|0|1}	
:ENVelope	\<dnpd>,\<dnpd>,\<dnpd>,\<dnpd>,\<dnpd>	\<dnpd> = Change to, Ramp in, Duration, Ramp out, End Delay
:ENVelope?	[\<cpd>{CHANge | RIN | DURation | ROUT | EDELay}]	
:TRIGger		
:INPut(?)	\<cpd>{ FREE | EONE | EREPeat}	
:ODELay(?)	\<dnpd>	
:HOLDoff(?)	\<cpd>{ PHASe | DELay },\<dnpd>	\<dnpd> units depends on the \<cpd>.
:REPeat (?)	\<dnpd>	
:FLICker		
[:STATe](?)	\<bool> { OFF | ON | 0 | 1 }	
:FREQuency(?)	\<dnpd>	
:UNIT(?)	\<cpd> { HZ | CPM }	
:DEPTh(?)	\<dnpd>	
:PINSt?		
:PST?		

Keyword	Parameter Form	Notes
:SHAPe(?)	<cpd> { RECTangular | SINusoidal | SQUare }	
:DUTY(?)	<dnpd>	
:EFLicker		
[:STATe](?)	<bool> { OFF | ON | 0 | 1 }	
:CONFigure(?)	<cpd> { PF | MZ | HS | PJ | RV }	
:SPERiod(?)	<cpd> { OFF | S5 | S10 | M1 | M5 | M10 }	
:HSIDeband		
:HARMonic(?)	<dnpd>	
:PJUMp		
:ANGLe(?)	<dnpd>	Only +/- 30.0 and +/- 45.0 accepted.
:STAGe?		
:ELAPsed?		Query Only command <dnpd>,<dnpd> = minute, second
:CURRent		
[:STATe](?)	<bool>{OFF|ON|0|1}	
:RANGe	<dpnd>, <dpnd>	<dnpd> = low limit, high limit
:RANGe?	[<cpd>{ LOW | HIGH }]	
:VOLTage	<dpnd>, <dpnd>	<dnpd> = low limit, high limit
:VOLTage(?)	[<cpd>{ LOW | HIGH }]	
:UNIT?		Response is VOLT (voltage) or CURR (current). Query only.
:EQUivalence		
[:STATe](?)	<bool>{OFF|ON|0|1}	
:FACTor(?)	<dnpd>	
:TERMinal		
:ROUTe(?)	<cpd>{ UPPer | LOWer }	Only applicable when the 50A option is fitted
:AMPLitude?		Absolute final output amplitude. Query only.
:BANDwidth(?)	[<cpd>{NORMAL | LOW}]	
:MHARmonics		
[:STATe](?)	<bool>{OFF|ON|0|1}	
:CLEar		
:AMPLitude(?)	<dnpd>	<dnpd> = RMS amplitude.
:HARMonic<y>	<dnpd>,<dnpd>	<y> is harmonic number. <dnpd> = Amplitude, Phase. Note: amplitude absolute or % depending on value of

Keyword	Parameter Form	Notes
		UNIT:MHAR:...
:AMPLitude(?)	<dnpd>	
:PANGle(?)	<dnpd>	
:HARMonic<y>?	[<cpd>{ AMPLitude | PANGle }]	
:ALL?	[<cpd>{ AMPLitude | PANGle }]	Response is in CSV format.
:FHARmonics		
[:STATe](?)	<bool>{OFF|ON|0|1}	
:CLEar		
:FLUCtuate<y>(?)	<bool>{OFF|ON|0|1}	<y> is harmonic number.
:ALL?		Response in CSV format.
:MODulation	<dnpd>,<dnpd>	<dnpd> = Depth, Frequency.
:MODulation?	[<cpd>{ DEPTh | FREQuency }]	
:SHAPe(?)	<cpd>{ RECTangular | SINusoidal | SQUare}	
:DUTY(?)	<dnpd>	
:IHARmonics		
[:STATe](?)	<bool>{OFF|ON|0|1}	
:SIGNal<y>	<bool>{OFF|ON|0|1}[,<dnpd>,<dnpd>]	<y> = Signal (1 or 2).
		<dnpd> = Amplitude, Frequency.
:SIGNal<y>?		
:DIP		
[:STATe](?)	<bool>{OFF|ON|0|1}	
:ENVelope	<dnpd>,<dnpd>,<dnpd>,<dnpd>,<dnpd>	<dnpd> =
		Change to,
		Ramp in,
		Duration,
		Ramp out,
		End Delay
:ENVelope?	[<cpd>{CHANge | RIN | DURation | ROUT | EDELay}]	
:TRIGger		
:INPut(?)	<cpd>{ FREE | EONE | EREPeat}	
:ODELay(?)	<dnpd>	
:HOLDoff(?)	<cpd>{ PHASe | DELay },<dnpd>	<dnpd> units depends on the <cpd>.
:REPeat (?)	<dnpd>	

Keyword	Parameter Form	Notes
RESults?	<cpd>	{ CH1 | CH2 | CH3 | CH4 | CH5 | CH6 }
		Response =
		<dnpd>, power or frequency.
		<dnpd>, MUT Energy or counts.
		<dnpd>, Ref. Energy or counts.
		<dnpd> % Error or % Registration.
		Note: Interpretation of above depends on setting of ENERgy:PRESentation.
PRESentation(?)	<cpd>,	{ COUNts | ENERgy }
	<cpd>	{ PERRor | PREGistration }
:FLICker		
[:STATe](?)	<bool>{ OFF|ON|0|1 }	
:FREQuency(?)	<dnpd>	
:UNIT(?)	<cpd> [HZ | CPM]	
:DEPTh(?)	<dnpd>	
:UNIT(?)	<cpd> [HZ | CPM]	
:PST?		Deprecated
:SHAPe(?)	<cpd>{ RECTangular | SINusoidal | SQUare}	
:DUTY(?)	<dnpd>	
STATus		
:OPERation		
[:EVENt]?		Query only.
:ENABle(?)	<dnpd>	
:CONDition?		Query only.
:QUEStionable		
[:EVENt]?		Query only.
:ENABle(?)	<dnpd>	
:CONDition?		Query only.
:PRESet		
SYSTem		
:ERRor?		Query only.
:DATE(?)	<dpnd>,<dpnd>,<dpnd>	<dnpd> = Year, Month, Day.
TIME(?)	<dpnd>,<dpnd>,<dpnd>	<dnpd> = Hour, Minute, Second.
:VERSion?		Query only.
:UNIT		
:ANGLe(?)	<cpd> {DEGrees|RADians}	Selection affects all phase angle entries.
:MHARmonics		
:CURRent(?)	<cpd> {PRMS | PFUNdamental | DBFundamental | ABSolute}	
:VOLTage(?)	<cpd> {PRMS | PFUNdamental | DBFundamental | ABSolute}	

Keyword	Parameter Form	Notes
:DIP		
:TIME(?)	<cpd> {SEConds|CYCLes}	
:FLICker		
:CURRent(?)	<cpd> {HZ | CPM}	
:VOLTage(?)	<cpd> {HZ | CPM}	

5-47. Energy Command Summary

Keyword	Parameter Form	Notes
[:SOURce]		
:ENERgy		
MODE(?)	<cpd>{ TCOUnt | PACKet | GATE | FRUN }	
:WUP:DURation(?)	<cpd>{ SEConds | PPERiods | ENERgy },<dnpd>	The <dnpd> is the duration in the selected units
:WUP:PSOUrce(?)	<cpd>{CH1 | CH2 | CH3 | CH4 | CH5 | CH6 | SUM456 | MEAN456 | MEAN56 | EMUT | MAIN}	
:TEST:DURation(?)	<cpd>{ SEConds | PPERiods | ENERgy },<dnpd>	The <dnpd> is the duration in the selected units
:TEST:PSOUrce(?)	<cpd>{CH1 | CH2 | CH3 | CH4 | CH5 | CH6 | SUM456 | MEAN456 | MEAN56 | EMUT | MAIN}	
:OGATe(?)	<bool>{ OFF | ON | 0 | 1 },<cpd>{ PULSe | LEVel }, <cpd>{ HIGH | LOW },<cpd>{ R150 | R1000 }	
:IGATe(?)	<cpd>{ PULSe | LEVel },<cpd>{ HIGH | LOW }, <cpd>{ R150 | R1000 }	
:MVOLtage(?)	<cpd>{TCOUnt | PACKet | GATE}[,<bool> {OFF | ON | 0 | 1}]	<cpd> also required parameter in query form of command (specifies mode to query)
:UNIT(?)	<cpd>{ REAL | APParent | REACtive }	
:MUT:SOURce(?)	<cpd>{ CH1 | CH1TO2 | CH1TO3 | CH1TO4 | CH1TO5 | CH1TO6 }	
:MUT:DEBounce:[STATe](?)	<bool>{ OFF | ON | 0 | 1 }	
:MUT:CONStant(?)	<dnpd>	in 'impulses per unit'
:MUT:PULLup(?)	<cpd>{ R150 | R1000 }	
:REFerence:SOURce(?)	<cpd>{ CH6 |SUM456 | MEAN456 | MEAN56 | MMUT | MAIN }	
:MUT:DEBounce:[STATe](?)	<bool>{ OFF | ON | 0 | 1 }	
:REFerence:CONStant(?)	<dnpd>	in 'impulses per unit'
:REFerence:PULLup(?)	<cpd>{ R150 | R1000 }	
:OUTput:CONStant(?)	<dnpd>	in 'impulses per unit'
:OUTput:PULLup:[STATe](?)	<bool>{ OFF | ON | 0 | 1}	
RESults?	<cpd>{ CH1 | CH2 | CH3 | CH4 | CH5 | CH6 }	Response = <dnpd>, power or frequency. <dnpd>, MUT Energy or counts. <dnpd>, Ref. Energy or counts. <dnpd> % Error or % Registration. Note: Interpretation of above depends on setting of ENERgy:PRESentation.
PRESentation(?)	<cpd>{ COUNts | ENERgy },<cpd>{ PERRor | PREGistration }	

5-48. *Calibration Subsystem Command Details*

This subsystem is used to calibrate the functions and hardware ranges of the 6100B. This will correct for any system errors due to drift or ageing effects.

Before any adjustments can take place, access to calibration must be enabled.

There is a switch (on the rear panel of the 6100B, marked CALIBRATION) that must be set to ENABLE. Having done this, the calibration password command must be sent. Once entered into calibration mode, only calibration commands are accepted; these can then be used to adjust the instrument.

CALibration:SECure:PASSword <spd>

This command is used to gain access to calibration mode. The `<spd>` must be the correct calibration password registered in the 6100B software. The calibration password can be changed only in calibration mode, (from the 6100B front panel).

CALibration:SECure:EXIT

This command is used to exit calibration mode, and return to normal operation, any pending adjustment operations will be cancelled.

CALibration:PHASe<x>:VOLTage:RANGe <dnpd>,<dnpd>

This command sets the specified phase's voltage channel hardware range:

*   The first parameter is the lower limit that the range must cover.
*   The second parameter is the upper limit that the range must cover.

The instrument determines the narrowest amplitude range that encompasses the limits.

CALibration:PHASe<x>:VOLTage:RANGe? [<cpd>{ LOW | HIGH }]

The default version will return the low and high limits of the presently selected range, (comma separated). Add the appropriate optional parameter to query just one of these values.

CALibration:PHASe<x>: VOLTage:ACTual <dnpd>,<dnpd>

This command is used to change the actual values that the calibration will take place at:

*   The first parameter is the amplitude (interpreted as an absolute voltage).
*   The second parameter is the phase angle (interpreted according to the active setting of the **UNIT:ANGLE** command, i.e. Degrees or Radians).

CALibration:PHASe<x>: VOLTage:ACTual:FREQuency?

This command is used to query the frequency the adjustment will take place at.

Note: The frequency itself is not adjustable.

CALibration:PHASe<x>:VOLTage:TARGet<dnpd>[,<dnpd>,<dnpd>,<dnpd>,<dnpd>]

For each calibration operation, the required calibration point (factor) must be targeted. This command is used to select this point, and also permits the user to define parameters associated with the calibration point in the current operation:

*   The first `<dnpd>` is an integer (from 0 to 2) that indicates the target point to adjust.

    Note: This corresponds to the list of target entries on the adjust instrument screen, (in the target field), for the corresponding function and hardware range.

*   The subsequent (and optional) `<dnpd>'s` correspond to the fundamental frequency, harmonic number, absolute amplitude and phase angle of this point. These parameters allow the target point itself to be moved. In practice, the factory set target defaults

should not require modification, so the non-optional form of the command should be all that is required.

Once a target has been set, the 6100B adjustment is restricted to values within the selected hardware voltage span, and frequency band. In order to release this restriction, one of the following commands must be sent:

TRIG?, EXIT or a new TARG command.

CALibration:PHASe<x>:VOLTage:TRIGer?

After the parameters are set for calibration at a single calibration point, this command initiates the internal calibration process. This command applies to the TARGet settings.

The response returns a 0 for success, and a 1 for failure. In this latter case an error message is put in the error queue.

Note

The current channel calibration commands are the same as voltage above, but replace "VOLT" with "CURR".

The exceptions to this rule are as follows:

CALibration:PHASe<x>:CURRent:RANGe:VOLTage <dpnd>,<dpnd>

This command sets the specified phase's current channel hardware range to output a voltage instead of a current. The first parameter is the lower limit that the range must cover. The second parameter is the upper limit that the range must cover. The instrument determines the narrowest amplitude range that encompasses the limits.

For reference purposes, note that the following ranges are presently defined:

Range	Lower Limit	Upper Limit
0.5 V range	0.05 V	0.25 V
1 V range	0.15 V	1.5 V
10 V range	1 V	10 V

CALibration:PHASe<x>:CURRent:RANGe:VOLTage? [<cpd>{ LOW | HIGH }]

The default version will return the low and high limits of the presently selected range, comma separated. Use the parameters to query just one of these values.

CALibration:PHASe<x>:CURRent:RANGe:UNIT?

This query only command can be used to check whether the voltage out of current ranges are in use.

The response is:

> CURRent   An ordinary current range is active.
> VOLTage   A voltage out of current range is active.

5-49.   *Output Subsystem Command Details*

OUTPut[:STATe](?) <bool>{OFF|ON|0|1}

This command turns the instrument's output on or off, dependent upon the individual Voltage and Current channel output settings of each phase.

- ON or 1 will set the output on.
- OFF or 0 will set the output off.

The query command returns 1 if the output is on, or 0 if the output is off.

OUTPut:ROSCillator[:STATe](?) <bool>{OFF|ON|0|1}

This command turns the instrument's reference oscillator signal on or off.

- ON or 1 will enable the generation of a sample reference signal.
- OFF or 0 will disable the generation of a sample reference signal.

The query command returns 1 if reference oscillator is on, or 0 if reference oscillator is off.

OUTPut:SENSe(?) <bool>{OFF|ON|0|1}

This command turns the instrument's 2-wire or 4-wire sense capability on or off.

- ON or 1 will select 4-wire sensing.
- OFF or 0 will select 2-wire sensing.

The query command returns 1 if 4-wire sensing is on, or 0 if 2-wire sensing is on.

OUTPut:DEFer[:STATe](?) <bool>{OFF|ON|0|1}

This command sets the deferred or direct operating mode.

When deferred mode is active, all commands that effect the output signal of the master instrument and phases, are buffered until the instrument receives an apply or undo operation. At this point, the actual output signal on all phases is updated to reflect the buffered state, or the buffered state is undone.

- ON or 1 will enable deferred mode.
- OFF or 0 will disable deferred mode, and return the instrument to direct operation.

The query command returns 1 if deferred mode is on, or 0 if deferred mode is off.

Note

The Instrument will default to direct mode.

OUTPut:DEFer:ACTion <cpd>{APPLy | UNDO}

This command will apply or undo any pending (buffered) command that have been received when in deferred mode.

- APPLy will act upon those commands last received since the last apply/undo.
- UNDO will discard any commands received since the last apply.

The command has no query form. Note that it will report a settings conflict if DEFer mode is not ON.

Note

Operations which are invalid when the output is ON are also invalid when Deferred mode is active, even if the output is OFF. For example you cannot change range in Deferred mode even if the output is OFF.

[SOURce]:OUTPut:RCLOCk(?) <dnpd>

This command allows a signal derived from the internal master oscillator to be routed to the rear panel.

The following values are accepted:

0.0   - disable reference out signal.

10e6   - set reference out to 10 MHz.

20e6   - set reference out to 20 MHz.

The default value is 0.0 (i.e. reference out signal is off).

SOURce]:OUTPut:RAMP(?) <CPD>{ FAST | SLOW }

When the output is enabled, the output level is not instantaneously applied at its full amplitude; instead it ramps up to this value over a short period of time. This normally takes 10 ms; it is possible to set this time to 2 s to provide a "soft start" for systems which might trip the internal over-voltage/current detectors, if the default rate of change is too fast.

Select whether the output ramp up time is 10 ms or 2 s.

- FAST - Ramp up within 10 ms,

SLOW   - Ramp up within 2 s.

The default value is FAST.

Note: This command is depreciated in favour of OUTPut:RAMP:TIME

[SOURce]:OUTPut:RAMP:TIME(?) <dnpd>

When the output is enabled, the output level is not instantaneously applied at its full amplitude; instead it ramps up to this value over a short period of time. This normally takes 10 ms. This command allows the setting of this time between 0 and 10 seconds to provide a soft start for systems which might trip the internal over-voltage/current detectors, if the default rate of change is too fast.

The default value is 0.

[SOURce]:OUTPut:VOLTage:NLIMit <CPD>{ LOW | HIGH }

This command allows the neutral phases' voltage channel range limits to be extended from 33 V to 1008 V.

The parameters are:

- LOW - Maximum amplitude is 33 V

HIGH - Maximum amplitude is 1008 V.

The default value is LOW.

Note: The HIGH setting is intended for use when the instrument's neutral phase is being used as an independent supply – i.e. not connected in a star or delta configuration. Damage to the instrument can result if the N-phase voltage Hi is connected to any 6140A Lo terminal when an amplitude greater than 33 V is selected.

5-50. *Input Subsystem Command Details*

INPut:DIP:TRIGger

This command triggers all dip/swell phenomena that have external trigger selected. It has the same effect as supplying a trigger signal to the rear input External Trigger BNC.

5-51. *Source Subsystem Command Details*

5-52. *General Commands*

[SOURce]:FREQuency(?) <dnpd>

This command is used to set the fundamental frequency for all voltage and current channels on all phases. The <dnpd> is a number, which sets the required fundamental frequency, expressed in Hz. It will automatically choose the best hardware range for the defined frequency of output.

The query version will return the present output frequency value. The returned number will be in standard scientific format (300 Hz would be returned as 3.0E2).

[SOURce]:FREQuency:LINE(?) <bool>{OFF|ON|0|1}

This command is used to set the line locking of the frequency for all voltage and current channels on all phases.

- ON or 1 will select line locking.
- OFF or 0 will select line locking

The query command will return 1 if line locking is enabled, or 0 if line locking is disabled.

[SOURce]:FREQuency:LOCK?

This query only command returns line lock state:

- 1 indicates that line-lock has been achieved.
- 0 indicates that line lock has not been achieved.

[SOURce]:POWer:UNBalanced?

This query only command returns the current three-phase unbalanced percentage value. It is calculated using either the IEC or NEMA methods. Note that if the system is not configured as a three-phase system, then this this query returns a value of zero.

[SOURce]:POWer:UNBalanced:STANdard(?) <CPD>{ NEMA | IEC }

This command selects the method for calculating the three-phase unbalanced value.

[SOURce]:POWer:BUDeanu? <cpd>{DELTa|WYE}[, <cpd> { P | S | Q | D |PF}]

This command is a query only. It returns the Budeanu power values for a three phase system calculated for the system connected in a delta or Wye (star) configuration.

If the optional second <cpd> parameter is not present, then all values in comma separated format, in the order P, S, Q, D, PF will be returned. If the second <cpd> parameter is present, then just that value will be returned. The returned numbers will be in standard scientific format.

[SOURce]:FLICker:STANdard(?) <cpd>{ STD1 | STD2 }

Flicker can be produced to two different standards and this command selects which one is used:

STD1	IEC 61000-4-15 (2003-2) Ed 1.1.
STD2	IEC 61000-4-15. Ed 2.0

[SOURce]:TERMinal[:STATe](?) <bool>{OFF|ON|0|1}

The Current Binding posts selections apply only when the 50 A option is fitted. Currents up to 21A can be routed through the normal 4 mm binding posts or if preferred through the same terminals that provide the 50A output (lower terminals). The individual phases can be configured individually or all together.

This command will allow the current channel of a phase to be routed via the 50 A option.

- ON or 1 will apply the same routing to all phases.
- OFF or 0 will allow different routings for each phase.

The query command returns 1 if routings are common or 0 if routings are individual.

This command is used inconjunction with the PHASe<x>:CURRent:TERMinal command

[SOURce]:TERMinal:ROUTe(?) <cpd>{ UPPer | LOWer }

This command selectes where the up-to-21A sigal is routed

- UPPer will select the normal 4 mm terminals
- LOWer will select the lower 50 A terminals

SOURce:PHASe<x>:FITTed?

This command is a query only and is used to return whether or not a phase is present.

The query version returns 1 if the phase is present and 0 otherwise.

SOURce:PHASe<x>:SERial?

This command is used to get the serial number of an instrument.

The query response is a <spd>, for example "12345"

SOURce:PHASe<x>:MODel?

This command is used to return the model number of the phase.

The query response is a <spd>, for example "6105A"

5-53. *Power Values*

SOURce:PHASe<x>:POWer:WATT?

This command is a query only and is used to return a Phase's Power value in units of Watts (this is always the same irrespective of the reactive power calculation method).

The instrument will return the specified Phase's output power value. The returned number will be in standard scientific format (24.3 kW would be returned as 2.43E4).

SOURce:PHASe<x>:POWer:VA?

This command is a query only and is used to return a Phase's Power value in units of VA (this is always the same irrespective of the power calculation).

The instrument will return the specified Phase's output power value. The returned number will be in standard scientific format (453.6 VA would be returned as 4.536E2).

SOURce:PHASe<x>:POWer:PFACtor?

This command is a query only and is used to return a Phase's Power Factor value (this is always the same irrespective of the power calculation).

SOURce:PHASe<x>:POWer:BUDeanu? [<cpd>{ P | S | Q | D }]

This command is a query only. The default (no parameter) version will return all of the components from a calculation of the Phase's Power according to Budeanu in comma separated format, in the order P, S, Q, D. The parameters select a specific component to

return. The returned numbers will be in standard scientific format.

Example:
```
1.0E1,1.141E1,0.0E0,0.0E0
```

Note:
> P is identical to WATT.
> S is identical to VA.

SOURce:PHASe<x>:POWer:FRYZe? [<cpd>{ P | S | Q }]

This command is a query only. The default (no parameter) version will return all of the components from a calculation of the Phase's Power according to Fryze in comma separated format, in the order P, S, Q. The parameters select a specific component to return. The returned numbers will be in standard scientific format.

Example:

```
1.0E1,1.141E1,0.0E0
```

Note:
> P is identical to WATT.
> S is identical to VA.

SOURce:PHASe<x>:POWer:KUSTers? [<cpd>{ P | S | QC | QCR | QL | QLR }]

This command is a query only. The default (no parameter) version will return all of the components from a calculation of the Phase's Power according to Kusters & Moore in comma separated format, in the order P, S, Qc, Qcr, Ql, Qlr. The parameters select a specific component to return. The returned numbers will be in standard scientific format.

Example:

```
1.0E1,1.414E1,0.314E0,0.1E0,0.207E0,0.207E0
```

Note:
> P is identical to WATT.
> S is identical to VA.

SOURce:PHASe<x>:POWer:SHEPherd? [<cpd>{ P | S | SR | SX | SD }]

This command is a query only. The default (no parameter) version will return all of the components from a calculation of the Phase's Power according to Shepherd & Zakikhani in comma separated format, in the order P, S, Sr, Sx, Sd. The parameters select a specific component to return. The returned numbers will be in standard scientific format.

Example:
```
1.0E1,1.414E1,1.314E0,0.1E0,0.0E0
```

Note:
> P is identical to WATT.
> S is identical to VA.

SOURce:PHASe<x>:POWer:SHARon? [<cpd>{ P | S | SQ | SC }]

This command is a query only. The default (no parameter) version will return all of the components from a calculation of the Phase's Power according to Sharon & Czarnecki in comma separated format, in the order P, S, Sq, Sc. The parameters select a specific component to return. The returned numbers will be in standard scientific format.

Example:

```
1.0E1,1.414E1,1.314E0,0.1E0
```

Note:
> `P` is identical to `WATT`.
> `S` is identical to `VA`.

SOURce:PHASe<x>:POWer:IEEE? [<cpd>{ P | S | N | SN | P1 | S1 | Q1 | PH | SH | NH }]

This command is a query only. The default (no parameter) version will return all of the components from a calculation of the Phase's Power according to the IEEE Working Group on Harmonics in comma separated format, in the order P, S, N, SN, P1, S1, Q1, PH, SH, NH. The parameters select a specific component to return. The returned numbers will be in standard scientific format.

Example:

```
1.0E1,1.414E1,1.314E0,0.1E0,0.0E0,0.7E1,0.8E1,0.1E1,0.3E1,0.6
14E1,1.2E-3
```

Note:
> `P` is identical to `WATT`.
> `S` is identical to `VA`.

5-54.   Voltage Setup

SOURce:PHAeS<x>:VOLTage:STATe(?) <bool>{OFF|ON|0|1}

This command will make the specified Phase's Voltage channel enabled or disabled.

- `ON` or `1` will enable the channel.
- `OFF` or `0` will disable the channel.

The query command returns `1` if channel enabled, or `0` if channel is disabled.

SOURce:PHASe<x>:VOLTage:RANGe <dpnd>,<dpnd>

This command sets the specified Phase's Voltage channel hardware range. The first parameter is the lower limit that the range must cover. The second parameter is the upper limit that the range must cover. The instrument determines the narrowest amplitude range that encompasses the limits.

For reference purposes, note that the following ranges are presently defined for the 6100A/6101A:

Range	Lower Limit	Upper Limit
11 V range	1.0 V	16 V
23 V range	2.3 V	33 V
56 V range	5.6 V	78 V
120 V range	11 V	168 V
230 V range	23 V	336 V
560 V range	56 V	1008 V

For reference purposes, note that the following ranges are presently defined for the 6100B/6101B:

Range	Lower Limit	Upper Limit
15 V range	0.0 V	23 V
30 V range	0.0 V	45 V
60 V range	0.0 V	90 V
120 V range	0.0 V	180 V
230 V range	0.0 V	360 V
560 V range	0.0 V	1008 V

For reference purposes, note that the following ranges are presently defined for the 6105A/6106A:

Range	Lower Limit	Upper Limit
15 V range	0.0 V	23 V
30 V range	0.0 V	45 V
60 V range	0.0 V	90 V
120 V range	0.0 V	180 V
230 V range	0.0 V	360 V
480 V range	0.0 V	650 V
560 V range	0.0 V	1008 V

SOURce:PHASe<x>:VOLTage:RANGe? [<cpd>{ LOW | HIGH }]

The default version will return the low and high limits of the presently selected range, comma separated. Add the appropriate optional parameter to query just one of these values.

SOURce:PHASe<x>:VOLTage:AMPLitude?

This query only command is used to find out the specified phase's output amplitude, in RMS Volts.

The instrument will return the present voltage value. The returned number will be in standard scientific format (550 V would be returned as 5.5E2).

5-55. *DC and Harmonics Phenomenon*

SOURce:PHASe<x>:VOLTage:MHARmonics:STATe(?) <bool>{OFF|ON|0|1}

This command turns the specified phase's voltage channel harmonics phenomena on and off, toggling it with the sine mode:

- ON or 1 will enable Harmonics mode, disabling sine mode.
- OFF or 0 will disable Harmonics mode, enabling sine mode.

The query command will return 1 if the harmonics are applied, or 0 if the harmonics are inactive.

SOURce:PHASe<x>:VOLTage:MHARmonics:CLEar

This command clears all harmonics, except the fundamental associated with this phase's voltage. It does not have a query form.

SOURce:PHASe<x>:VOLTage:MHARmonics:AMPLitude(?) <dnpd>

This command sets the RMS value of the harmonic waveshape. Any harmonics will be scaled appropriately to keep the waveshape of the composite waveform the same. The query form returns the RMS value.

SOURce:PHASe<x>:VOLTage: MHARmonics: HARMonic<y> <dnpd>,<dnpd>

This command sets the specified phase's voltage channel harmonics for harmonic number **y** (0 to 100). DC is represented by harmonic number zero. The parameters specify amplitude (in the presently selected voltage amplitude units), and phase angle (in the presently selected phase angle units), respectively. The phase angle for the 0th harmonic (DC) must be zero.

SOURce:PHASe<x>:VOLTage:MHARmonics:HARMonic<y>? [<cpd>{ AMPLitude | PANGle }]

This query returns the amplitude (in the presently selected voltage amplitude units), and phase angle (in the presently selected phase angle units) of the specified harmonic on the specified phase. Add the appropriate optional parameter to query just one of these values.

SOURce:PHASe<x>:VOLTage:MHARmonics:HARMonic<y>:AMPLitude?

This query returns the amplitude (in the presently selected Voltage amplitude Units of the specified harmonic on the specified phase.

SOURce:PHASe<x>:VOLTage:MHARmonics:HARMonic<y>:PANGle?

This query returns the phase angle (in the presently selected phase angle units) of the specified harmonic on the specified phase.

SOURce:PHASe<x>:VOLTage:MHARmonics:ALL? [<cpd>{ AMPLitude | PANGle }]

This query returns the amplitude (in the presently selected voltage amplitude units), and phase angle (in the presently selected phase angle units) of all harmonics on the specified phase as a comma separated list. Add the appropriate optional parameter to query just one of these values.

Example:

Suppose we have the following:

Harmonic	Amplitude	Phase
1	25.0 V	90.0 deg
2	0.0 V	0.0 deg
3	10.9 V	0.0 deg
4	0.0 V	0.0 deg
5	2.5 V	165.0 deg

Expected responses:

```
:SOUR:PHAS:VOLT:HARM:ALL?    "2.5E1,9.0E1,0.0E0,0.0E0,1.09E1,0
                             .0E0,0.0E0,0.0E0,2.5E0,1.65E2"
:SOUR:PHAS:VOLT:HARM:ALL?    "2.5E1,0.0E0,1.09E1,0.0E0,0.0E0,2
AMPL                         .5E0"
:SOUR:PHAS:VOLT:HARM:ALL?    "9.0E1,0.0E0,0.0E0,0.0E0,1.65E2"
PANG
```

5-56.   *Fluctuating Harmonics Phenomenon*

SOURce:PHASe<x>:VOLTage:FHARmonics:STATe(?) <bool>{OFF|ON|0|1}

This command turns the specified phase's voltage channel fluctuating harmonics phenomena on and off. If no harmonics are currently selected for the specified phase, a suitable error message will be reported indicating that some harmonics need to be activated before fluctuation can be applied.

- ON or 1 will enable fluctuation of the phase's voltage harmonics.
- OFF or 0 will disable fluctuation of the phase's voltage harmonics.

The query command will return 1 if the specified fluctuation is being applied, or 0 if the specified fluctuation is inactive.

SOURce:PHASe<x>:VOLTage:FHARmonics:CLEar

This command clears the modulation of harmonics associated with this phase's voltage. It does not have a query form.

SOURce:PHASe<x>:VOLTage:FHARmonics:FLUCtuate<y>(?)<bool>{OFF|ON|0|1}

This command turns on/off the fluctuation of harmonic **y** on the Voltage channel of Phase **x**.

The query command will return 1 if the specified harmonic is being fluctuated, or 0 if the specified harmonic is not being fluctuated.

SOURce:PHASe<x>:VOLTage:FHARmonics:ALL?

This query allows all the active harmonics to return their fluctuation state as a comma delimited string. The comma separated string will contain a value for each harmonic. Inactive harmonics will always cause 0 to be returned.

SOURce:PHASe<x>:VOLTage:FHARmonics:MODulation <dnpd>,<dnpd>

This command sets the specified phase's voltage channel fluctuating harmonics modulation parameters. The first parameter is the modulation depth (expressed as a percentage of the voltage waveform RMS amplitude). The second parameter is the required modulation frequency (expressed in Hertz).

SOURce:PHASe<x>:VOLTage:FHARmonics:MODulation? [<cpd>{DEPTh | FREQuency}]

This query returns the modulation depth and frequency for the Voltage channel of the specified phase. Add the appropriate optional parameter to query just one of these values.

**SOURce:PHASe<x>:VOLTage:FHARmonics:SHAPe(?)
<cpd>{RECTangular|SINusoidal|SQUare}**

This command selects the specified phase's voltage channel fluctuating harmonics modulation shape:

- `RECT` will set the modulation waveform to be rectangular.
- `SIN` will set the modulation waveform to be sinusoidal.
- `SQU` will set the modulation waveform to be square.

The query command will return `SIN` if the modulation shape is sinusoidal etc.

SOURce:PHASe<x>:VOLTage:FHARmonics:DUTY(?) <dnpd>

This command sets the specified phase's voltage channel fluctuating harmonics duty cycle value for rectangular modulation.

The query command will return the present duty cycle value. The returned number will be in standard scientific format (10.55 would be returned as `1.055E1`).

5-57. Interharmonics Phenomenon

SOURce:PHASe<x>:VOLTage:IHARmonics:STATe(?) <bool>{OFF|ON|0|1}

This command turns the specified phase's voltage channel interharmonics phenomena on and off.

- `ON` or `1` will enable interharmonics on this phase's voltage channel.
- `OFF` or `0` will disable interharmonics on this phase's voltage channel.

The query command will return `1` if the interharmonics are enabled, or `0` if the inter-harmonics are disabled.

**SOURce:PHASe<x>:VOLTage:IHARmonics:SIGNal<y> <bool>
{OFF|ON|0|1}[,<dnpd>,<dnpd>]**

This command sets the specified inter-harmonics parameters. The <bool> parameter controls whether the inter-harmonic is active or not. The two optional <dnpd> parameters are numbers, which set the required amplitude (expressed in volts), and the required frequency (expressed in Hertz). <y> specifies the inter-harmonic to be set since the instrument is capable of producing 2 inter-harmonics simultaneously.

**SOURce:PHASe<x>:VOLTage:IHARmonics:SIGNal<y>? [<cpd>{STATe |
AMPLitude | FREQuency}]**

The default version of this query returns all of the settings of the specified Inter Harmonic, comma separated. Add the appropriate optional parameter to query just one of these values.

5-58. Dip Phenomenon

SOURce:PHASe<x>:VOLTage:DIP:STATe(?) <bool>{OFF|ON|0|1}

This command turns the specified Phase's Voltage channel Dip phenomena on and off.

- `ON` or `1` will set the specified Dip to be applied.
- `OFF` or `0` will set the specified Dip to be removed.

The query command will return `1` if Dip is applied, or `0` if Dip is inactive.

SOURce:PHASe<x>:VOLTage:DIP:ENVelope <dnpd>,<dnpd>,<dnpd>,<dnpd>,<dnpd>

This command sets the specified phase's voltage channel dip parameters:

- 1st dnpd - Change To value (expressed as a percentage of total RMS voltage).
- 2nd dnpd - Ramp In period (expressed in Seconds or Cycles).
- 3rd dnpd - Duration (expressed in Seconds or Cycles).
- 4th dnpd - Ramp Out period (expressed in Seconds or Cycles).
- 5th dnpd - End Delay period (expressed in Seconds or Cycles).

SOURce:PHASe<x>:VOLTage:DIP:ENVelope? [<cpd>{CHANe | RIN | DURation | ROUT | EDELay}]

The default version of this query returns the dip envelope settings for the specified phase's voltage channel. Add the appropriate optional parameter to return a single value:

CHANge   Change To value, expressed as a percentage of the total RMS Voltage

RIN   the Ramp In period, expressed in Seconds or Cycles depending on the Dip Units setting

DURation   the Duration, expressed in Seconds or Cycles depending on the Dip Units setting

ROUT   the Ramp Out period, expressed in Seconds or Cycles depending on the Dip Units setting

EDELay   the "End Delay period (expressed in Seconds or Cycles).

SOURce:PHASe<x>:VOLTage:DIP:TRIGger:INPut(?) <cpd>{ FREE | EONE | EREPeat}

This command sets and queries the trigger mode used to determine the event that starts the dip or swell:

- FREE is used for free running dips/swells.
- EONE is used to produce one dips/swell triggered from an external source.
- EREPeat is used to produce continuous dips/swells triggered from an external source.

SOURce:PHASe<x>:VOLTage:DIP:TRIGger:HOLDoff(?) <cpd>{PHASe|DELay},<dnpd>

This command selects sets and queries the hold-off before the dip/swell starts following a trigger.

PHASe   The hold-off is an angle following the trigger point. In this case the delay, <dnpd>, has units of degrees or radians.

DELay   The hold-off is a time. In this case the delay ,<dnpd>, has units of seconds or cycles

SOURce:PHASe<x>:VOLTage:DIP:TRIGger:ODELay(?)<dnpd>

This sets and queries the delay (in seconds or cycles) before the output trigger is generated, following the completion of a dip or swell.

SOURce:PHASe<x>:VOLTage:DIP:TRIGger:REPeat(?)<dnpd>

This sets and queries the number of times a dip will repeat when in the external trigger mode.

5-59. Flicker Phenomenon

SOURce:PHASe<x>:VOLTage:FLICker:STATe(?) <bool>{OFF|ON|0|1}

This command turns the specified Phase's Voltage channel flicker phenomena on and off.

- ON or 1 will enable flicker on this phase's voltage channel.
- OFF or 0 will disable flicker on this phase's voltage channel.

The query command will return 1 if flicker is applied, or 0 if flicker is inactive.

SOURce:PHASe<x>:VOLTage:FLICker:DEPTh(?) <dnpd>

This command sets the specified phase's voltage channel flicker modulation depth.

The <dnpd> is a number, which sets the required modulation depth, expressed as a

percentage of the total RMS voltage signal.

The query version of this command will return the present modulation depth value. The returned number will be in standard scientific format (15.1 % would be returned as `1.51E1`).

SOURce:PHASe<x>:VOLTage:FLICker:FREQuency(?) <dnpd>

This command sets the specified phase's voltage channel flicker modulation frequency.

The <dnpd> is a number, which sets the required modulation frequency, expressed in Hertz.

The query command will return the present modulation frequency value. The returned number will be in standard scientific format (440.0Hz would be returned as `4.40E2`).

[SOURce]:PHASe<x>:VOLTage:FLICker:FREQuency:UNIT(?) <cpd> { HZ | CPM }

This command selects the units for change rate:

- **Hz** - will set the change rate to Hertz.

CPM - set the change rate to Changes per Minute.

The query command will return HZ or CPM.

Note

On changing the units, the change rate will return to its default value of 1 CPM or 0.5 Hz depending on the unit selected.

Note

The "UNIT:FLICker:VOLTAge:FREQuency(?) <cpd> {HZ|CPM}" command is now depreciated as it only affects Channel 1.

SOURce:PHASe<x>:VOLTage:FLICker:PST?

This query only command will return the present PST value. The returned number will be in standard scientific format (1.82 would be returned as `1.82E0`).

SOURce:PHASe<x>.:VOLTage:FLICKer:SHAPe(?)<cpd>{RECTangular| SINusoidal|SQUare}

This command selects the specified phase's voltage channel flicker modulation shape.

- `RECT` will set the modulation waveform to be rectangular.
- `SIN` will set the modulation waveform to be sinusoidal.
- `SQU` will set the modulation waveform to be square.

The query command will return `SIN` if the modulation shape is sinusoidal etc.

SOURce:PHASe<x>:VOLTage:FLICker:DUTY(?) <dnpd>

This command sets the specified phase's voltage channel flicker duty cycle value for rectangular modulation.

The query command will return the present duty cycle value. The returned number will be in standard scientific format (10.55 would be returned as `1.055E1`).

5-60. *Extended Flicker Sub-System*

The extended flicker sub-system allows the generation of signals conforming to the flicker-meter test scenarios described in IEC 60000-4 section 4.3.3 to 4.3.7.

When one of the extended functions is active, it will over-ride the existing behaviour of the phenomena selected for the voltage channel of the passed phase (the current channel will be unaffected), the original settings will be restored on disabling the extended function.

5-61. *Extended Flicker State*

[SOURce]:PHASe<x>:VOLTage:EFLicker:[STATe](?) <bool> { ON | OFF | 0 | 1 }

Enable or disable the currently selected extended flicker signal configuration (for the passed phase x). If the output is on, the new configuration will be applied immediately to the output.

5-62. *Configure Signal*

[SOURce]:PHASe<x>:VOLTage:EFLicker:CONFigure(?) <cpd> { PF | MZ | HS | PJ | RV }

Select the extended flicker signal function (for the passed phase x).

Note

The instruments state will not change until :EFLicker:STATe is set to ON (or 1). If the extended flicker function is changed, :EFLicker:STATe will automatically be set back to OFF or (0).

The extended functions are:

- PF - Flicker signal with periodic frequency changes (section 4.3.3 of IEC 601000-4).

- MZ - Distorted voltage with multiple zero crossings (section 4.3.43 of IEC 601000-4).

- HS - Harmonics with sideband (section 4.3.5 of IEC 601000-4).

- PJ   - Phase jumps (section 4.3.6 of IEC 601000-4).

- RV - Rectangular voltage changes with duty cycle (section 4.3.7 of IEC 601000-4).

The default value is PF (periodic frequency changes).

5-63. *Select Sideband Harmonic*

[SOURce]:PHASe<x>:VOLTage:EFLicker:HSIDeband:HARMonic(?) <dnpd>

Select the distorting harmonic to use when generating the harmonics with side-band test signal.

Value range: 3-99.

Value default: 3.

Note

This value is only applied when HSIDeband is selected using the :EFLicker:CONFigure command.

5-64. *Select Phase Jump Angle*

[SOURce]:PHASe<x>:VOLTage:EFLicker:PJUMp:ANGLe(?) < dnpd >

Select the phase angle to use with the phase jump sequence test: only values of +/- 30.0 degrees or +/- 45.0 degrees will be accepted.

The default value is +30.0.

Note

This value is only applied when PJUMp is selected using the :EFLicker:CONFigure command.

5-65. *Select Phase Jump Settle Period*

[SOURce]:PHASe<x>:VOLTage:EFLicker:PJUMp:SPERiod(?) <cpd> { OFF | S5 | S10 | M1 | M5 | M10 }

Select the settle period to use before starting the phase jump sequence. The output is on

during this period:

- OFF- Apply no delay.

- S5 - Delay by 5 Seconds.

- S10- Delay by 10 Seconds.

- M1 - Delay by 1 Minute.

- M5 - Delay by 5 Minutes.

- M10 - Delay by 10 Minutes.

The default value is OFF.

Note

This value is only applied when PJUMp is selected using the :EFLicker:CONFigure command.

5-66.   *Report Phase Jump Stage*

[SOURce]:PHASe<x>:VOLTage:EFLicker:PJUMp:STAGe?

Report the progress of the phase jump sequence:

- Stage 0 – Settle period.

- Stage 1 – Perform phase jump at 1 minute elapsed.

- Stage 2 – Perform phase jump at 3 minutes elapsed.

- Stage 3 – Perform phase jump at 5 minutes elapsed.

- Stage 4 – Perform phase jump at 7 minutes elapsed.

- Stage 5 – Perform phase jump at 9 minutes elapsed.

- Stage 6 – End sequence at 10 minutes elapsed.

Note: query only.

5-67.   *Report Phase Jump Elapsed Time*

[SOURce]:PHASe<x>:VOLTage:EFLicker:PJUMp:ELAPsed?

Report the elapsed time since the phase jump sequence started as: Minutes, Seconds.

Note: query only.

5-68.   *Current Setup*

SOURce:PHASe<x>:CURRent:STATe(?) <bool>{OFF|ON|0|1}

This command turns the specified phase's current channel enabled or disabled.

- ON or 1 will enable the channel.
- OFF or 0 will disable the channel.

The query command will return 1 if output is on, or 0 if output is off.

SOURce:PHASe<x>:CURRent:RANGe <dpnd>,<dpnd>

This command sets the specified phase's current channel hardware range. The first parameter is the lower limit that the range must cover. The second parameter is the upper limit that the range must cover. The instrument determines the narrowest amplitude range that encompasses the limits.

For reference purposes, note that the following ranges are presently defined:

Range	Lower Limit	Upper Limit
0.25 A range	0.05 A	0.25 A
0.5 A range	0. 05 A	0.5 A
1 A range	0.1 A	1 A
2 A range	0.2 A	2 A
5 A range	0.5 A	5 A
10 A range	1 A	10 A
21 A range	2 A	21 A
50 A range	5 A	50 A
80 A range	8 A	80 A

SOURce:PHASe<x>:CURRent:RANGe? [<cpd>{ LOW | HIGH }]

The default version will return the low and high limits of the presently selected range, comma separated. Add the appropriate optional parameter to query just one of these values.

SOURce:PHASe<x>:CURRent:RANGe:VOLTage <dpnd>,<dpnd>

This command sets the specified phase's current channel hardware range to output a voltage instead of a current. The first parameter is the lower limit that the range must cover. The second parameter is the upper limit that the range must cover. The instrument determines the narrowest amplitude range that encompasses the limits.

For reference purposes, note that the following ranges are presently defined:

Range	Lower Limit	Upper Limit
0.5 V range	0.05 V	0.25 V
1 V range	0.15 V	1.5 V
10 V range	1 V	10 V

SOURce:PHASe<x>:CURRent:RANGe:VOLTage? [<cpd>{ LOW | HIGH }]

The default version will return the low and high limits of the presently selected range, comma separated. Add the appropriate optional parameter to query just one of these values.

SOURce:PHASe<x>:CURRent:RANGe:UNIT?

This query only command can be used to check whether the voltage out of current ranges are in use.

The response is:

- CURRent An ordinary current range is active.
- VOLTage A voltage out of current range is active.

SOURce:PHASe<x>:CURRent:AMPLitude?

This query only command is used to find out the specified phase's output amplitude, in RMS amps (or volts, if this mode is active.

The query command will return the present current value. The returned number will be in standard scientific format (14.4 A would be returned as 1.44E1).

SOURce:PHASe<x>:CURRent:EQUivalence[:STATe](?) <bool>{OFF|ON|0|1}

This selects whether the voltage out of current equivalence factor is applied.

- `ON` or `1` will enable equivalence factor.
- `OFF` or `0` will disable equivalence factor

SOURce:PHASe\<x>:CURRent:EQUivalence:FACTor(?) \<dnpd>

This command sets the value, in units of Volts per Amp, of the voltage to current equivalence factor

SOURce:PHASe\<x>:CURRent:TERMinal:ROUTe(?) \<cpd>{ UPPer | LOWer }

This command selectes where the up-to-21A signal is routed for this phase. Used in conjunction with the the :TERMinal:STATe and :TERMinal:ROUTe commands.

- `UPPer` will select the normal 4 mm terminals
- `LOWer` will select the lower 50 A terminals

Note

This command will return a settings conflict if the 50 A option is not fitted.

SOURce:PHASe\<x>:CURRent:BANDwidth(?) [\<cpd>{ NORMal | LOW }]

This command is used to select the current channel bandwidth limit.

- NORMAL   a 6 kHz limit is applied.
- LOW   a 1.5 kHz limit is applied.

The query command will return the active setting.

Note: the *OPT? command reports whether bandwidth selection is available.

5-69.   *Harmonics Phenomenon*

SOURce:PHASe\<x>:CURRent:MHARmonic[:STATe](?) \<bool>{OFF|ON|0|1}

This command turns the specified phase's current channel harmonics phenomena on and off, toggling it with the Sine mode

- `ON` or `1` will enable harmonics mode, disabling Sine mode.
- `OFF` or `0` will disable harmonics mode, enabling Sine mode.

The query form returns the current state.

SOURce:PHASe\<x>:CURRent:MHARmonics:CLEar

This command clears all harmonics, except the fundamental associated with this phase's Current. It does not have a query form.

SOURce:PHASe\<x>:CURRent:MHARmonics:AMPLitude(?) \<dnpd>

This command sets the RMS value of the harmonic waveshape. Any harmonics will be scaled appropriately to keep the waveshape of the composite waveform the same. The query form returns the RMS value.

SOURce:PHASe\<x>:CURRent: MHARmonic:HARMonic\<y> \<dnpd>,\<dnpd>

This command sets the specified phase's current channel harmonics for harmonic number **y** (1 to 100). The parameters specify amplitude (in the presently selected current amplitude units), and phase angle (in the presently selected phase angle units), respectively.

SOURce:PHASe\<x>:CURRent:MHARmonic:HARMonic\<y>? [\<cpd>{ AMPLitude | PANGle }]

This query returns the amplitude (in the presently selected current amplitude units), and phase angle (in the presently selected phase angle units) of the specified harmonic on the specified phase. Add the appropriate optional parameter to query just one of these values.

SOURce:PHASe<x>:CURRent:MHARmonics:HARMonic<y>:AMPLitude?

This query returns the amplitude (in the presently selected Current amplitude Units of the specified harmonic on the specified phase.

SOURce:PHASe<x>:CURRent:MHARmonics:HARMonic<y>:PANGle?

This query returns the phase angle (in the presently selected phase angle units) of the specified harmonic on the specified phase.

SOURce:PHASe<x>:CURRent:MHARmonic:ALL? [<cpd>{ AMPLitude |

PANGle }]

This query returns the amplitude (in the presently selected current amplitude units), and phase angle (in the presently selected phase angle units) of all harmonics on the specified phase as a comma separated list. Add the appropriate optional parameter to query just one of these values.

Example, suppose we have the following:

Harmonic	Amplitude	Phase
1	2.5 A	90.0 deg
2	0.0 V	0.0 deg
3	1.09 A	0.0 deg
4	0.0 V	0.0 deg
5	0.25 A	165.0 deg

Expected responses:

```
:SOUR:PHAS:CURR:HARM:ALL?   "2.5E0,9.0E1,0.0E0,0.0E0,1.09E0,0.0
                            E0,0.0E0,0.0E0,2.5E-1,1.65E2"
:SOUR:PHAS:CURR:HARM:ALL?   "2.5E0,0.0E0,1.09E0,0.0E0,0.0E0,2.5
AMPL                        E-1"
:SOUR:PHAS:CURR:HARM:ALL?   "9.0E1,0.0E0,0.0E0,0.0E0,1.65E2"
PANG
```

5-70. *Fluctuating Harmonics Phenomenon*

SOURce:PHASe<x>:CURRent:FHARmonics:STATe(?) <bool>{OFF|ON|0|1}

This command turns the specified phase's current channel fluctuating harmonics phenomena on and off. If no harmonics are currently selected for the specified Phase, a suitable error message will be reported indicating that some harmonics need to be activated before fluctuation can be applied.

- ON or 1 will enable fluctuation of this phase's current harmonics.
- OFF or 0 will disable fluctuation of this phase's current harmonics.

The query command will return 1 if the specified fluctuation is being applied, or 0 if the specified fluctuation is inactive.

SOURce:PHASe<x>:CURRent:FHARmonics:CLEar

This command clears the modulation of harmonics associated with this phase's current. It does not have a query form.

SOURce:PHASe<x>:CURRent:FHARmonics:FLUCtuate<y>(?)<bool>{OFF|ON|0|1}

This command turns on/off the fluctuation of harmonic **y** on the Current channel of Phase **x**.

The query command will return `1` if the specified harmonic is being fluctuated, or `0` if the specified harmonic is not being fluctuated.

SOURce:PHASe<x>:CURRent: FHARmonics:ALL?

This query allows all the active harmonics to return their Fluctuation State as a comma delimited string. The comma separated string will contain a value for each harmonic. Inactive harmonics will always cause 0 to be returned.

SOURce:PHASe<x>:CURRent: FHARmonics:MODulation <dnpd>,<dnpd>

This command sets the specified phase's current channel fluctuating harmonics modulation parameters. The first parameter is the modulation depth (expressed as a percentage of the current waveform RMS amplitude). The second parameter is the required modulation frequency (expressed in Hertz).

SOURce:PHASe<x>:CURRent:FHARmonics:MODulation? [<cpd>{DEPTh | FREQuency}]

This query returns the modulation depth and frequency for the current channel of the specified phase. Add the appropriate optional parameter to query just one of these values.

SOURce:PHASe<x>:CURRent:FHARmonics:SHAPe(?) <cpd>{RECTangular|SINusoidal|SQUare}

This command selects the specified Phase's Current channel fluctuating harmonics modulation shape.

- `RECT` will set the modulation waveform to be rectangular.
- `SIN` will set the modulation waveform to be sinusoidal.
- `SQU` will set the modulation waveform to be square.

The query command will return `SIN` if the modulation shape is sinusoidal etc.

SOURce:PHASe<x>:CURRent:FHARmonics:DUTY(?) <dnpd>

This command sets the specified Phase's Current channel fluctuating harmonics duty cycle value for rectangular modulation.

The query command will return the present duty cycle value. The returned number will be in standard scientific format (10.55 would be returned as `1.055E1`).

5-71. *Interharmonics Phenomenon*

SOURce:PHASe<x>:CURRent:IHARmonics:STATe(?) <bool>{OFF|ON|0|1}

This command turns the specified phase's current channel interharmonics phenomena on and off.

- `ON` or `1` will enable interharmonics on this phase's current channel.
- `OFF` or `0` will disable interharmonics on this phase's current channel.

The query command will return `1` if the inter-harmonics are applied, or `0` if the inter-harmonics are inactive.

SOURce:PHASe<x>:CURRent:IHARmonics:SIGNal<y> <bool>{OFF|ON|0|1}[,<dnpd>,<dnpd>]

This command sets the specified interharmonics parameters. The <bool> parameter controls whether the inter-harmonic is active or not. The two optional <dnpd> parameters are numbers, which set the required amplitude (expressed in amps), and the required frequency (expressed in Hertz). <y> specifies the interharmonic to be set since the instrument is capable of producing 2 interharmonics simultaneously.

SOURce:PHASe<x>:CURRent:IHARmonic:SIGNal<y>? [<cpd>{STATe |

AMPLitude | FREQuency}]

The default version of this query returns all of the settings of the specified inter-harmonic, comma separated. Add the appropriate optional parameter to query just one of these values.

SOURce:PHASe<x>:CURRent:DIP:STATe(?) <bool>{OFF|ON|0|1}

This command turns the specified Phase's Current channel Dip phenomena on and off.

- ON or 1 will set the specified Dip to be applied.
- OFF or 0 will set the specified Dip to be removed.

The query command will return 1 if Dip is applied, or 0 if Dip is inactive.

SOURce:PHASe<x>:CURRent:DIP:ENVelope <dnpd>,<dnpd>,<dnpd>,<dnpd>,<dnpd>

This command sets the specified Phase's current channel Dip parameters:

- 1st dnpd - Change To value (expressed as a percentage of total RMS voltage).
- 2nd dnpd - Ramp In period (expressed in Seconds or Cycles).
- 3rd dnpd - Duration (expressed in Seconds or Cycles).
- 4th dnpd - Ramp Out period (expressed in Seconds or Cycles).
- 5th dnpd - End Delay period (expressed in Seconds or Cycles).

SOURce:PHASe<x>:CURRent:DIP:ENVelope? [<cpd>{CHANge | RIN | DURation | ROUT | EDELay}]

The default version of this query returns the Dip Envelope settings for the specified phase's current channel. Add the appropriate optional parameter to query just one of these values:

CHANge	Change To value, expressed as a percentage of the total RMS Voltage
RIN	Ramp In period, expressed in Seconds or Cycles depending on the Dip Units setting
DURation	Duration, expressed in Seconds or Cycles depending on the Dip Units setting
ROUT	Ramp Out period, expressed in Seconds or Cycles depending on Dip Units setting
EDELay	End Delay period, expressed in Seconds or Cycles

SOURce:PHASe<x>:CURRent:DIP:TRIGger:INPut(?) <cpd>{ FREE | EONE | EREPeat}

This command sets and queries the trigger mode used to determine the event that starts the dip or swell.

- FREE is used for free running dips/swells.
- EONE is used to produce one dips/swell triggered from an external source.
- EREPeat is used to produce continuous dips/swells triggered from an external source.

SOURce:PHASe<x>:CURRent:DIP:TRIGger:HOLDoff (?) <cpd>{PHASe|DELay},<dnpd>

This command selects sets and queries the hold-off before the dip/swell starts following a trigger:

PHASe	The hold-off is an angle following the trigger point. In this case the delay ,<dnpd>, has units of degrees or radians.
DELay	The hold-off is a time. In this case the delay ,<dnpd>, has units of seconds or cycles.

SOURce:PHASe<x>:CURRent:DIP:TRIGger:ODELay(?)<dnpd>

This sets and queries the delay (in seconds or cycles) before the output trigger is generated, following the completion of a dip or swell.

SOURce:PHASe<x>:CURRent:DIP:TRIGger:REPeat(?)<dnpd>

This sets and queries the number of times a dip will repeat when in the external trigger mode.

5-73. *Flicker Phenomenon*

SOURce:PHASe<x>:CURRent:FLICker:STATe(?) <bool>{OFF|ON|0|1}

This command turns the specified phase's current channel flicker phenomena on and off.

- `ON or 1` will enable flicker on this phase's current channel.
- `OFF or 0` will disable flicker on this phase's current channel.

The query command will return `1` if flicker is applied, or `0` if flicker is inactive.

SOURce:PHASe<x>:CURRent:FLICker:DEPTh(?) <dnpd>

This command sets the specified phase's current channel flicker modulation depth.

The <dnpd> is a number, which sets the required modulation depth, expressed as a percentage of the total RMS current signal.

The query command will return the present modulation depth value. The returned number will be in standard scientific format (15.1 % would be returned as `1.51E1`).

SOURce:PHASe<x>:CURRent:FLICker:FREQuency(?) <dnpd>

This command sets the specified phase's current channel flicker modulation frequency.

The <dnpd> is a number, which sets the required modulation frequency, expressed in Hz.

The query command will return the present modulation frequency value. The returned number will be in standard scientific format (440.0Hz would be returned as `4.40E2`).

[SOURce]:PHASe<x>:CURRent:FLICKer:FREQuency:UNIT(?) <cpd> { HZ | CPM }

This command selects the units for change rate:

- **Hz** - will set the change rate to Hertz.

CPM - set the change rate to Changes per Minute.

The query command will return HZ or CPM.

Note

On changing the units, the change rate will return to its default value of 1 CPM or 0.5 Hz depending on the unit selected.

Note

The "UNIT:FLICker:CURRent:FREQuency(?) <cpd> {HZ|CPM}" command is now depreciated as it only affects Channel 1.

SOURce:PHASe\<x>:CURRent:FLICker:PST?

This query only command will return the present PST value. The returned number will be in standard scientific format (1.82 would be returned as `1.82E0`).

SOURce:PHASe\<x>:CURRent:FLICker:SHAPe(?) \<cpd>{RECTangular|SINusoidal|SQUare}

This command selects the specified phase's current channel flicker modulation shape.

- `RECT` will set the modulation waveform to be rectangular.
- `SIN` will set the modulation waveform to be sinusoidal.
- `SQU` will set the modulation waveform to be square.

The query command will return `SIN` if the modulation shape is sinusoidal etc.

SOURce:PHASe\<x>:CURRent:FLICker:DUTY(?) \<dnpd>

This command sets the specified Phase's Current channel Flicker duty cycle value for rectangular modulation.

The query command will return the present duty cycle value. The returned number will be in standard scientific format (10.55 would be returned as `1.055E1`).

SOURce:PHASe\<x>:CURRent:TERMinal:ROUTe(?) \<cpd> {UPPer | LOWer}

The Current Binding posts selections apply only when the 50 A option is fitted. Currents up to 21 A can be routed through the normal 4 mm binding posts or if preferred through the same terminals that provide the 50 A output (lower terminals).

This command is used inconjunction with the [SOURce]:TERMinal[:STATe](?) \<bool>{OFF|ON|0|1} command

5-74. Status Subsystem Command Details

This subsystem is used to enable bits in the Operation and Questionable Event registers. The Operation and Questionable: Event, Enable and Condition registers can be interrogated to determine their state.

STATus:OPERational [:EVENt]?

This command returns the contents of the Operation Event register, clearing the register.

This register is only used if the Energy Option is fitted.

Bit	Condition Event	Comment
8	Warm-Up Active	Set 1 during the warm-up period. Set back to 0 when the period ends.
9	Test Active	Set 1 during the test period. Set back to 0 when the period ends.
10	Gate Trigger Pending	Set to 1 when waiting for the trigger. Set back to 0 when trigger is received.
11	Energy Active	Set 1 at the start of the Energy test. Set back to 0 at the end of the test.

STATus:OPERational:ENABle(?) \<dnpd>

This command sets or returns the mask which enables those Operation Event register bits which are required to be summarized at bit 7 of the IEEE 488.2 Status Byte register.

Note: Only the energy timer/counter option affects these bits:

Bit	Enable Condition
8	Warm-Up Active.
9	Test Active.
10	Gate Trigger Pending.
11	Energy Active.

STATus:OPERational:CONDition?

This query only command returns the contents of the Operation Condition register, which is not cleared by the command. N. B. This register contains transient states, in that its bits are not "sticky", but are set and reset by the referred operations. The response to the query therefore represents an instantaneous "Snapshot" of the register state, at the time that the query was accepted.

This register is only used if the Energy Option is fitted.

Bit	Condition	Comment
8	Warm-Up Active	Set 1 during the warm-up period. Set back to 0 when the period ends.
9	Test Active	Set 1 during the test period. Set back to 0 when the period ends.
10	Gate Trigger Pending	Set to 1 when waiting for the trigger. Set back to 0 when trigger is received.
11	Energy Active	Set 1 at the start of the Energy test. Set back to 0 at the end of the test.

STATus:QUEStionable [:EVENt]?

Note

The 6100B does not set any bits in this register.

This command returns the contents of the Questionable Event register, clearing the register.

STATus:QUEStionable:ENABle(?) <dnpd>

This command sets the mask which enables those Questionable Event register bits which are required to be summarized at bit 3 of the IEEE 488.2 Status Byte register.

STATus:QUEStionable:CONDition?

Note

The 6100B does not set any bits in this register.

This query only command returns the contents of the Questionable Condition register which is not cleared by the command. N. B. This register contains transient states, in that its bits are not "sticky", but are set and reset by the referred conditions. The response to the query therefore represents an instantaneous "Snapshot" of the register state, at the time that the query was accepted.

STATus:PRESet

This is a SCPI mandated command. The intention behind mandating the STAT:PRES command is to enable all bits in the SCPI defined device-dependent and transition registers in order to provide a "device-independent structure for determining the gross status of a device".

In the 6100B, the functions of the "transition" registers are not required, so no access is given. The PRES command therefore affects only the two device-dependent enabling registers:

- The Operation Event Enable register.
- The Questionable Event Enable register.

Sending STAT:PRES will set true all bits in both Enable registers. This will enable all bits in the two Event registers, so that all reportable device-dependent events, reported in the two registers, will be capable of generating an SRQ; providing only that bits 3 and 7 in the IEEE 488.2 Status Byte Register are also enabled.

The use of STAT:PRES in the 6100B allows the status-reporting structure to be set to a known state, not only for the intention of the SCPI mandate, but also to provide a known starting point for application programmers.

5-75. *System Subsystem Command Details*
SYSTem:ERRor?

As errors in the 6100B are detected, they are placed in a "first in, first out" queue, called the Error Queue. This queue conforms to the format described in the SCPI Command Reference (Volume 2), although errors only are detected. Three kinds of errors are reported in the Error Queue, in the sequence that they are detected:

Command errors, execution errors and device-dependent errors.

Queue Overflow

Any time the Error Queue overflows, the earliest errors remain in the queue, and the most recent error is discarded. The latest error in the queue is replaced by the error:

-350,"Queue overflow".

Purpose of **SYST:ERR?** — Reading the Error Queue

This query is used to return any error that has reached the head of the Error Queue, and delete the error from the queue. The Error Queue is first in / first out, so the returned string will represent the earliest error in the queue.

The queue is read destructively as described in the SCPI Command Reference to obtain a code number and error message. The query can be used successively to read errors in the queue until it is empty, when the message 0,No Error will be returned.

The response is in the form of String Program Data, and consists of two elements: a code number and error message.

SYSTem:DATE(?) <dnpd>,<dnpd>,<dnpd>

This command is used to change the date of the clock within the 6100B. The date format is YYYY, MM, DD

The Query will return the presently programmed date YYYY, MM, DD.

SYSTem:TIME(?)<dnpd>,<dnpd>

This command changes the present time as recorded by the 6100B. Any new time will be updated from a non-volatile real-time internal 24-hour clock.

A 24-hour clock format is used to set the time: HH, MM.

The Query will return the updated time at the moment the query was accepted as HH,MM,SS.

SYSTem:VERSion?

The query only command returns an <Nr2> formatted numeric value corresponding to the SCPI version number for which the 6100B complies. At the time of writing, this will be 1999.0.

5-76. *Unit Subsystem Command Details*

UNIT:ANGLe(?) <cpd>{DEGrees|RADians}

This command sets the units to be used to express all instances of Phase Angle.

- DEG will set the phase angle units to be Degrees.
- RAD will set the phase angle units to be Radians.

The query command will return DEG if the units are set to Degrees, or RAD if the units are set to Radians.

UNIT:MHARmonics:CURRurrent(?) <cpd>{PRMS|PFUN|DBF|ABS }

This command selects the specified harmonics amplitude units for current.

- PRMS will set the units to be Percentage of RMS Current amplitude.
- PFUN will set the units to be Percentage of Fundamental amplitude.
- DBF will set the units to be dB down from Fundamental amplitude.
- ABS will set the units to be Absolute value.

The query command will return PRMS if the units are set to "Percentage of RMS Current", etc.

UNIT:MHARmonics:VOLTage(?) <cpd>{PRMS|PFUN|DBF|ABS}

This command selects the specified harmonics amplitude units for voltage.

- PRMS will set the units to be Percentage of RMS Voltage amplitude.
- PFUN will set the units to be Percentage of Fundamental amplitude.
- DBF will set the units to be dB down from Fundamental amplitude.
- ABS will set the units to be Absolute value.

The query command will return PRMS if the units are set to percentage of RMS voltage, etc.

UNIT:DIP:TIME(?) <cpd>{SEConds|CYCLes}

This command selects the units used for time, when specifying dip parameters.

- SEC will set the Dip time units to be seconds.
- CYCL will set the Dip time units to be cycles.

The query command will return SEC if the Dip time units are set to seconds etc.

UNIT:FLICker:CURRent:FREQuency(?) <cpd> {HZ|CPM}

This command selects the units for change rate when specifying flicker parameters for current:

- HZ will set the change rate to Hertz.
- CPM will set the change rate to Changes Per Minute

The query command will return HZ or CPM.

UNIT:FLICker:VOLTage:FREQuency(?) <cpd> {HZ|CPM}

This command selects the units for change rate when specifying flicker parameters for voltage:

- HZ will set the change rate to Hertz.
- CPM will set the change rate to Changes per Minute.

The query command will return HZ or CPM.

5-77. Remote Operation of the Energy option

To start counting using the energy option, the energy-option status panel must be displayed on the 6100B, if another wave-shape definition panel is shown, only the power outputs will be activated, not the energy counter/timer. To guarantee correct operation it is recommended that a command from the "ENERgy" tree is the last one sent before ":OUTPut ON"; any command from this sub-system tree will re-display the energy status screen.

Note: Some commands must be sent in a specific order and this is indicated when applicable.

5-78. SCPI Command Set

The "[SOURce]:ENERgy" SCPI subsystem is used to remotely control the energy timer/counter hardware option. The SCPI status mechanism has also been expanded to support the energy option (see Figure 5-3 in chapter 5 and the STATus:OPERation tree commands and query commands at paragraph 8-52 to 8-55).

5-79. Operating mode

ENERgy:MODE(?) <cpd> { TCOUnt|PACKet|GATE|FRUN }

This command selects the operating mode for the energy counter/timer option.

On receiving an "operate" request (":OUTPut ON"), the selected operating mode will count or time the pulse streams seen on the selected inputs.

- TCOUnt   Counted/Timed mode.

The power outputs are activated, and allowed to stabilize. The selected energy pulse inputs are counted for a defined period. Then the outputs are automatically returned to standby when the completion criteria are met. This is the default mode of operation.

- PACKet   Energy packet delivery mode.

The power outputs are activated for the time it takes the 6100B to deliver a specific "packet" of energy and then deactivated again.

- GATE   Gated input mode.

The power outputs are activated. An externally generated signal can then be used to gate the counting of the selected energy pulse inputs, and deactivate the power outputs.

- FRUN   Free-run mode.

The free run mode is mainly provided for manual use but remote control can be used.

5-80. Energy Maintain Voltage

ENERgy:MVOLtage(?) <cpd> { TCOUnt | PACKet | GATE}[,<bool> {OFF | ON | 0 | 1}]

This command allows the timed/counted, packet or gated operating modes to maintain the presence of the voltage channel test signal on test completion, instead of automatically shutting off all the enabled current and voltage channels.

The first parameter specifies the operating mode:

- TCOUnt   Timed/counted mode.
- PACKet   Energy packet mode.

- GATE Gated input mode.

The second parameter specifies whether all the enabled voltage channels should remain on after test completion.

The default action is to turn off all enabled channels on test completion.

The query form of the command also requires the mode parameter (i.e. MVOLtage? <cpd>). It will return whether the specified mode has "maintain voltage" enabled.

Note

The energy "free-running" mode is not supported by this operation.

When "maintain voltage" is activated, and a test completes, a query using :OUTPut? will report "1" or "ON" until a :OUTPut 0 is sent.

5-81. *Energy units*

ENERgy:UNIT(?) <cpd> { REAL|APPParent|REACtive }

This command selects the base units used in energy counter/timer calculations.

- REAL Real power (Wh).
- APPParent Apparent power (VAh).
- REACtive Reactive power (VARh).

5-82. *Result presentation*

ENERgy:PRESentation(?) <cpd> { COUNts|ENERgy }, <cpd> { PERRor|PREGistration }

This command configures the presentation of displayed results. It also defines the meaning the result fields returned by using the ":ENERgy:RESults?" command.

The first parameter defines the meaning of the MUT accumulated energy field:

- COUNts As raw counts.
- ENERgy As accumulated energy (using the base units defined by the "ENERgy:UNIT" command).

The second parameter defines the meaning of the measured error field:

- PERRor As percentage error = ((MUT counts - ref. counts) / ref. counts) * 100.0.
- PREGistration As percentage registration = (MUT counts / ref. counts) * 100.0.

5-83. *Results*

ENERgy: RESults? <cpd> { CH1|CH2|CH3|CH4|CH5|CH6 }

This query only command returns the result data for the selected channel:

- 1st <dnpd> Power or Frequency [1] (the power field's units are implied by the active "ENERgy:UNITS" definition).
- 2nd <dnpd> MUT accumulated Energy or Counts [1].
- 3rd <dnpd> Reference accumulated Energy or Counts [1].
- 4th <dnpd> Percentage Error or Registration [2].

    [1] Second meaning applies when "PRESentation" is set to "COUNts".

    [2] Second meaning applies when "PRESentation" is set to "PREGistration".

If the selected channel is inactive, a comma-delimited list of zero value <dnpd>s will be returned. A "ENERgy: RESults?" query can be made at any time.

This command would typically be used in conjunction with the "STATus:OPERation" commands, so data can be read a key stages in a test sequence.

The following conditions can be monitored using the "STATus" system (see paragraph 51):

- Warm up active.
- Test active.
- Input gate trigger pending.
- Energy timer/counter active.

Notes:

The power field's units are implied by the active "ENERgy:UNITS" definition.

- 1 Second meaning applies when "PRESentation" is set to "COUNts".
- 2 Second meaning applies when "PRESentation" is set to "PREGistration".

5-84. Output Gating

ENERgy: OGATE(?) <bool> { OFF|ON|0|1 }, <cpd> { PULSe|LEVel }, <cpd> { HIGH|LOW }, <cpd> { R150|R1000 }

This command configures the output-gating signal. The OGATE settings have no effect when the operating mode is set to "GATED"

The first parameter enables the generation of a gating signal. This is active while the power outputs are on.

The second parameter specifies the gating signal type:

- PULSe   Indicate start/stop with pulse.
- LEVel   Indicate start/stop with level change.

The third parameter specifies the gating signal level:

- HIGH   Go to high level to indicate start/stop.
- LOW   Go to low level to indicate start/stop.

The fourth parameter specifies which internal pull-up resistance value to use:

- R150   150 Ohm.
- R1000   1 k Ohm.

5-85. Input Gating

ENERgy: IGATE(?) <cpd> { PULSe|LEVel }, <cpd> { HIGH|LOW }, <cpd> { R150|R1000 }

This command configures the input gating line. The settings only apply when the operating mode is set to "GATED".

The first parameter specifies the gating signal type:

- PULSe   Indicate start/stop with pulse.
- LEVel   Indicate start/stop with level change.

The second parameter specifies the gating signal level:

- HIGH   Go to high level to indicate start/stop.
- LOW   Go to low level to indicate start/stop.

The third parameter specifies which internal pull-up resistance value to use:

- R150   150 Ohm.
- R1000   1 k Ohm.

5-86. *Warm-up Sequence Tree*

The warm-up test sequence can be used to allow the MUT and reference sources to settle.

A warm-up sequence can be configured in any operating mode, but will only have an effect when the operating mode is "TCOUnt". The warm-up test-sequence parameters specify the initial actions that will occur on sending "OUTPut ON". The test sequence will then be executed (see 5-89).

The source of pulses to count can be specified, as well as whether to count for a specific time period or counter value. The option to let the 6100 calculate the period (from energy) is also available.

It should also be noted (when "TCOUnt" is selected) that there is always a settling period of approximately 1 Second, whether or not a warm-up period has been defined.

5-87. *Warm-up Duration*

ENERgy:WUP:DURation(?) {SEConds|PPERiods|ENERgy},<dnpd>

This command specifies the duration of the warm-up sequence as a period of time, a counter value (in terms of pulse periods), or a period defined in terms of energy.

SEConds   As a time delay in Seconds.

PPERiods   As pulse periods.

COUNts   As pulse counts.

(Depreciated on release of version II of the energy option.)

ENERgy   As accumulated energy.

Note: When energy is used (ENER), the actual limits applied will be determined by the meter constant selected for the pulse source.

5-88. *Warm-up Pulse Source*

**ENERgy:WUP:PSOUrce(?) { CH1|CH2|CH3|CH4|CH5|CH6|
SUM456|MEAN456|MEAN56|EMUT|MAIN }**

This command specifies the pulse source to use when determining the warm-up sequence-completion criteria.

The actual sources available will be determined by the active MUT source and reference source selection.

Note: If one of the source parameters has been changed after using this command a valid default will be set (typically "CH1" or "MAIN"); so it is recommend that the "MUT:WUP:PSOUrce" command is sent AFTER any "MUT:SOURce" or "REFerence:SOURce" commands, to prevent unexpected side effects.

The source can be:

- CH1 to CH6   Raw pulse streams from individual channels.
- SUM456   Sum of channels 4 through 5.
- MEAN456   Arithmetic mean of channels 4 through 6.
- MEAN56   Arithmetic mean of channels 5 and 6.
- EMUT   On Every MUT channel. For example, on selecting a warm up duration of 100 pulses, at least 100 pulses would have to be counted

on all selected MUTs before the warm-up sequence was considered complete.

- MAIN   Equivalent pulse count of the power outputs (value calculated from the "OUTPut:CONStant" meter constant value and active power settings).

5-89. Test Sequence Tree

The test sequence commands specify the actions that will occur on sending "OUTPut ON". These parameters are applied in all operating modes except "FRUN".

The source of pulses to count can be specified, as well as whether to count for a specific period of time or counter value. The option to let the 6100 calculate the period (from energy) is also available.

5-90. Test Duration

ENERgy:TEST:DURation(?) { SEConds|PPERiods|ENERgy }, <dnpd>

This command specifies the duration of the test sequence as either a time period, a counter value, or a period defined in terms of energy. When energy is used, the actual limits applied will be determined by the meter constant selected for the pulse source.

SEConds   As a time delay in Seconds.

PPERiods   As pulse periods.

COUNts   As pulse counts.(Depreciated on release of version II of the energy option.)

ENERgy   As accumulated energy.

Note: When energy is used (ENER), the actual limits applied will be determined by the meter constant selected for the pulse source.

5-91. Test Pulse Source

ENERgy:TEST:PSOUrce(?) { CH1|CH2|CH3|CH4|CH5|CH6|SUM456|MEAN456|MEAN56|EMUT|MAIN}

This command specifies the pulse source to use when determining the test completion criteria.

The actual sources available will be determined by the active MUT source and reference source selection.

Note: If one of the source parameters has been changed after using this command a valid default will be set (typically "MAIN"); so it is recommend that the "MUT:TEST:PSOUrce" command is sent after any "MUT:SOURce" or "REFerence:SOURce" commands, to prevent unexpected side effects.

The source can be:

- CH1 to CH6   Raw pulse streams from individual channels.
- SUM456   Sum of channels 4 through 5.
- MEAN456   Arithmetic mean of channels 4 through 6.
- MEAN56   Arithmetic mean of channels 5 and 6.
- EMUT   On Every MUT channel. For example, on selecting a test duration of 100 pulses, at least 100 pulses would have to be counted on all selected MUTs before the test sequence was considered complete.

- MAIN   Equivalent pulse count of the power outputs (value calculated from the "OUTPut:CONStant" meter constant value and active power settings).

5-92. MUT Tree

The MUT commands configure a MUT source. A MUT source is typically made up from pulse streams from channels 1 to 3, though channels 4 to 6 can also be used when treated as independent sources (i.e. for "drift monitoring").

5-93. MUT Meter Constant

ENERgy:MUT:CONStant(?) <dnpd>

This command specifies the meter constant (as impulses per unit energy) used by channels considered to be MUT sources.

5-94. Input Debounce

ENERgy:MUT:DEBounce[:STATe](?) <bool> { ON|OFF|0|1 }

The energy counter MUT inputs can be filtered to reduce switch contact bounce. The maximum usable pulse rate is 100 Hz when debounce is enabled. "

5-95. MUT Source

ENERgy:MUT:SOURce(?) { CH1|CH1TO2|CH1TO3|CH1TO4|CH1TO5|CH1TO6}

This command specifies the pulse source(s) used to define the MUT.

The source(s) can be:

- CH1, CH1TO2 to CH1TO6   Pulse streams from (independent) channels.
- SUM123   Sum of channels 1 through 3.

If the requested source channel is already in use as part of a reference source definition, the reference source definition will default to a value that does not clash with the MUT source (typically "MAIN"). Because of this, it is recommended that the MUT source be defined before the reference source.

5-96. MUT Pull-up

ENERgy:MUT:PULLup <cpd> { R150|R1000 }

This command specifies which internal pull-up resistance value to select for the reference source:

- R150   150 Ohm.
- R1000   1 k Ohm.

5-97. Reference Tree

The Reference commands configure a reference source. The reference source can be made up from pulse streams on channels 4 to 6.

5-98. Input Debounce

ENERgy:REFerence:DEBounce[:STATe](?) <bool> { ON|OFF|0|1 }

The energy-counter reference inputs can be filtered to reduce switch contact bounce. The maximum usable pulse rate is 100 Hz when debounce is enabled.

5-99. Reference Meter Constant

ENERgy:REFerence:CONStant(?) <dnpd>

This command specifies the meter constant (as impulses per unit energy) used by channels considered to be reference sources.

5-100. Reference Source

ENERgy:REFerence:SOURce(?) { CH6|SUM456|MEAN456|MEAN56|MMUT|MAIN }

This command specifies the pulse source(s) used to define the reference source.

The source(s) can be:

- CH6   Pulse stream from (independent) channel 6.
- SUM456   Sum of channels 4 through 6.
- MEAN456   Arithmetic mean of channels 4 through 6.
- MEAN56   Arithmetic mean of channels 5 and 6.
- MMUT   Mean of the active MUT sources (typically used in "drift monitor" scenarios).
- MAIN   Equivalent pulse count of the power outputs (value calculated from the "OUTPut:CONStant" meter constant value and active power settings).

Note

If the requested source channel is already in use as part of a MUT source definition, an error will be reported.

5-101. Reference Pull-up

ENERgy:REFerence:PULLup <cpd> { R150|R1000 }

This command specifies which internal pull-up resistance value to select for the reference source:

- R150   150 Ohm.
- R1000   1 k Ohm.

5-102. Output Tree

The output commands configure the pulse out channel. This channel generates a pulse stream that is proportional to the active power outputs.

Pulses will be generated whenever the energy timer/counter option has been selected, and the output is on.

5-103. Output Meter Constant

ENERgy:OUTPut:CONStant(?) <dnpd>

This command specifies the meter constant (as impulses per unit energy) used by the output channel.

5-104. Output Pull-up

ENERgy:OUTPut:PULLup[:STATe] <bool> { ON|OFF|0|1 }

This command specifies whether the output channel should switch in an internal pulled up resistor.

5-105. Common Commands and Queries

5-106. Clear Status

This measurement event status data structure conforms to the IEEE 488.2 standard requirements for this structure.

Figure 5-3. Clear Status

***CLS** clears all the event registers and queues except the output queue.

The output queue and MAV bit will be cleared if *CLS immediately follows a "Program Message Terminator"; refer to the IEEE 488.2 standard document.

Execution Errors:

None.

Power On and Reset Conditions

Not applicable.

5-107. Event Status Enable

This event status data structure conforms to the IEEE 488.2 standard requirements for this structure.
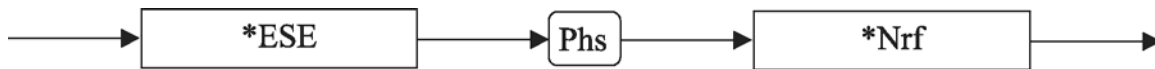
Figure 5-4. Event Status Enable

***ESE** enables the standard defined event bits, which will generate a summary message in the status byte.

Nrf is a Decimal Numeric Data Element representing an integer decimal value equivalent to the Hex value required to enable the appropriate bits in this 8 bit register. The detailed definition is contained in the IEEE 488.2 standard document. Note that numbers **will** be rounded to an integer.

Execution Errors:

None.

Power On and Reset Conditions

Not applicable.

5-108. *Recall Event Status Enable*

This event status data structure conforms to the IEEE 488.2 standard requirements for this structure.

Figure 5-5. Event Status Enable Query

Execution Errors:

None

Power On and Reset Conditions

The Power On condition depends on the condition stored by the common *PSC command if 0 then it is not cleared; if 1 then the register is cleared. Reset has no effect.

*ESE? recalls the enable mask for the standard defined events.

Response Decode:

The value returned, when converted to base 2 (binary), identifies the enabled bits which will generate a summary message in the service request byte, for this data structure. The detailed definition is contained in the IEEE 488.2 document.

5-109. *Read Event Status Register*

This event status data structure conforms to the IEEE 488.2 standard requirements for this structure.

Figure 5-6. Event Status Register Query

*ESR? recalls the standard defined events.

Response Decode:

The value returned, when converted to base 2 (binary), identifies the bits as defined in the IEEE 488.2 standard.

Execution Errors:

None

5-110. *IDN? (Instrument Identification)

This command conforms to the IEEE 488.2 standard requirements.

Figure 5-7. Instrument Identification

***IDN?** will recall the instrument's manufacturer, model number, serial number and firmware level.

Response Format:

Character position

```
Fluke,6100B,XXXXXXXXXXXX,X.XX or Fluke,6105A,XXXXXXXXXXXX,X.XX
```

Where:

The data contained in the response consists of four comma-separated fields, the last two of which are instrument-dependent. The data element type is defined in the IEEE 488.2 standard specification.

Response Decode:

The data contained in the four fields is organized as follows:

- First field - manufacturer.
- Second field - model.
- Third field - serial number.
- Fourth field - firmware level (will possibly vary from one instrument to another).

Execution Errors:

None.

Power On and Reset Conditions

Not applicable.

5-111. Operation Complete

This command conforms to the IEEE 488.2 standard requirements.

Figure 5-8. Operation Complete

Execution Errors:

None.

Power On and Reset Conditions

Not applicable.

*OPC is a synchronization command which will generate an operation complete message in the standard Event Status Register when all pending operations are complete.

5-112. *Operation Complete?*

This query conforms to the IEEE 488.2 standard requirements.
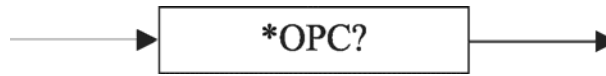
Figure **5-9. Operation Complete Query**

Response Decode:

The value returned is always 1, which is placed in the output queue when all pending operations are complete.

5-113. *Recall the instrument Hardware Fitment*

This command conforms to the IEEE 488.2 standard requirements.

Figure 5-10. Option Query

*OPT? recalls the instrument's hardware configuration.

Response Format:

The data in the response consists of eight comma-separated values, one for each channel. These values are a binary weighted to indicate which options are fitted.

Response Decode:

The data element type is Nr1 as defined in the IEEE 488.2 standard specification.

A list of comma delimited Nr1 values represent the installed options per channel. This list is terminated by a newline with EOI character:

Phase1 V, Phase 1 I, Phase 2 V, Phase 2 I, Phase 3 V, Phase 3 I, Neutral V, Neutral I

A bit weighted number represents the (optional) hardware included with a channel.

- Bit 0   80 A current option has been fitted.
- Bit 1   The bandwidth current option has been fitted.
- Bit 2   The energy timer/counter option has been fitted.
- Bit 3   The 50 mR shunt upgrade has been fitted.
- Bit 4   The version II energy timer/counter option has been fitted.
- Bit 5   The 20 MHz reference clock out option has been fitted.
- Bit 6   50 A current option has been fitted.
- Bit 7   Unused

For example, a 6100B and a 6101B, the latter having 80A and bandwidth option would report " 0,0,0,3,0,0,0,0".

Execution Errors:

None.

Power On and Reset Conditions

Not applicable.

5-114. *Power-On Status Clear*

This common command conforms to the IEEE 488.2 standard requirements.

```
──────────▶   *PSC   ──▶ Phs ──▶   *Nrf   ──────▶
```
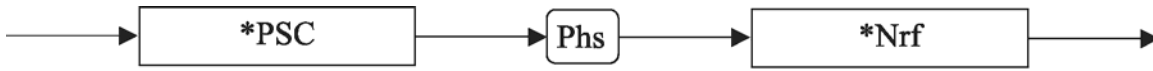
Figure 5-11. Power On Status Clear

***PSC** sets the flag controlling the clearing of defined registers at Power On.

Nrf is a decimal numeric value which, when rounded to an integer value of zero, sets the *power on clear flag* false. This allows the instrument to assert SRQ at power on, providing that the PON bit in the ESR is enabled at the time of power down, by the corresponding bit in its Enable register (ESE).

When the value rounds to an integer value other than zero it sets the *power on clear flag* **tru**e, which clears the standard *event status enable* and *service request enable* registers so that the instrument will not assert an SRQ on power up.

Examples:

*PSC 0 or *PSC 0.173 sets the instrument to **assert** an SRQ at Power On.
*PSC 1 or *PSC 0.773 sets the instrument to **not assert** an SRQ on Power On.

Execution Errors:

None.

Power On and Reset Conditions

Not applicable.

5-115. *Recall Power On Status Clear Flag*

This common query conforms to the IEEE 488.2 standard requirements. The existing flag condition will have been determined by the *PSC command.

```
──────────▶   *PSC?   ──────▶
```

Figure 5-12. Power On Status Clear Query

***PSC?** will recall the Power On Status condition.

Response Format:

A single ASCII character is returned.

Response Decode:

The value returned identifies the state of the saved flag:

Zero indicates **false**. The instrument is not programmed to clear the Standard Event Status Enable Register and Service Request Enable Register at power PO, so the instrument will generate a "power on" SRQ, providing that the PON bit in the ESR is enabled at the time of power-down, by the corresponding bit in its Enable register (ESE).

One indicates **tru**e. The instrument **is** programmed to clear the Standard Event Status Enable Register and Service Request Enable Register at power on, so the instrument cannot generate any SRQ at power on.

Execution Errors:

None

Power On and Reset Conditions

No change. This data is saved in non-volatile memory at power off, for use at power on.

5-116. Reset

Figure 5-13. Reset

*RST will reset the instrument to a defined condition, stated for each applicable command with the command's description, and listed in "Device Settings at Power On".

The reset condition is not dependent on past use history of the instrument except as noted below:

*RST does not affect the following:

- The selected address of the instrument.
- Calibration data that affect specifications.
- SRQ mask conditions.
- The state of the IEEE 488.1 interface.

Execution Errors:

None.

Power On and Reset Conditions

Not applicable.

5-117. Service Request Enable

This Status Byte data structure conforms to the IEEE 488.2 standard requirements for this structure.
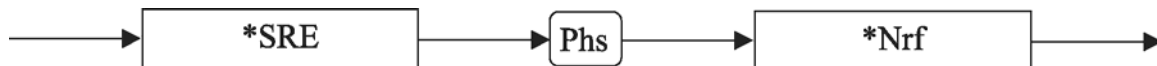
Figure 5-14. Service Request Enable

*SRE enables the standard and user defined summary bits in the service request byte, which will generate a service request.

Nrf is a Decimal Numeric Data Element representing an integer decimal value equivalent to the Hex value required to enable the appropriate bits in this 8 bit register. The detail definition is contained in the IEEE 488.2 document.

Note that numbers **will** be rounded to an integer.

Execution Errors:

None.

Power On and Reset Conditions

Not applicable.

5-118. Recall Service Request Enable

This Status Byte data structure conforms to the IEEE 488.2 standard requirements for this structure.

$$\longrightarrow \boxed{\text{*SRE?}} \longrightarrow$$

Figure 5-15. Service Request Enable Query

*SRE? recalls the enable mask for the standard defined events.

Response Decode:

The value returned, when converted to base 2 (binary), identifies the enabled bits that will generate a service request. The detail is contained in the IEEE 488.2 standard document.

Execution Errors:

None.

Power On and Reset Conditions

The Power On condition depends on the condition stored by the common *PSC command if 0 then it is not cleared. If 1 then the register is cleared. Reset has no effect.

5-119. Read Service Request Register

This Status Byte data structure conforms to the IEEE 488.2 standard requirements for this structure.

*STB? recalls the service request register for summary bits.

$$\longrightarrow \boxed{\text{*STB?}} \longrightarrow$$

Figure 5-16. Status Byte Query

Response Decode:

The value returned, when converted to base 2 (binary), identifies the summary bits for the current status of the data structures involved. For the detail definition see the IEEE 488.2 standard document. There is no method of clearing this byte directly. Its condition relies on the clearing of the overlying status data structure.

Execution Errors:

None.

Power On and Reset Conditions

Not applicable.

5-120. Test Operations — Full Selftest

This query conforms to the IEEE 488.2 standard requirements.

```
──────────▶  ┌──────────────┐  ──────────▶
             │    *TST?      │
             └──────────────┘
```

Figure 5-17. Test Query

*TST? executes a Full selftest. A response is generated after the test is completed.

N. B. Operational selftest is valid only at temperatures: 23 °C ±10 °C.

Response Decode:

The value returned identifies pass or failure of the operational selftest:

- **ZERO** indicates operational selftest complete with no errors detected.

- **Non zero** indicates operational selftest has failed. The number itself represents the number of test failures.

The failure codes can be found only by re-running the self-test manually.

Execution Errors:

Operational selftest is not permitted when calibration is successfully enabled.

Power On and Reset Conditions

Not applicable.

5-121. Wait

This command conforms to the IEEE 488.2 standard requirements.

```
──────────▶  ┌──────────────┐  ──────────▶
             │    *WAI       │
             └──────────────┘
```

Figure 5-18. Wait

*WAI prevents the instrument from executing any further commands or queries until the *No Pending Operations Flag* is set true. This is a mandatory command for IEEE-488.2 but has little relevance to this instrument as there are no parallel processes requiring Pending Operation Flags.

Execution Errors:

None.

Power On and Reset Conditions

Not applicable.

5-122. Device Settings After *RST

*RST will reset the instrument to a defined condition, stated for each applicable command.

The reset condition is not dependent on past use history of the instrument except as noted below:

*RST does not affect the following:

- The selected address of the instrument.

- Calibration data that affect specifications.

- SRQ mask conditions.

- The state of the IEEE 488.1 interface.

- The Error Queue.

- The Power on Status Clear flag setting.

- The contents of:

  - The Status Byte Register.

  - The Status Byte Enable Register.

  - The Standard Event Status Register.

  - The Standard Event Status Enable Register.

  - The SCPI Operation Status Register.

  - The SCPI Operation Status Enable Register.

  - The SCPI Questionable Status Register.

  - The SCPI Questionable Status Enable Register.

*RST enforces the following states:

- The instrument is returned to "Operation Complete Command Idle State" (OCIS).
- The instrument is returned to "Operation Complete Query Idle State" (OQIS.

Settings Related to Common IEEE 488.2 Commands are as detailed in "Common Commands and Queries":

- The "Enable Macro Command" (*EMC) is not used in the instrument.
- The "Define Device Trigger Command" (*DDT) is not used in the instrument.
- Parallel Poll is not implemented in the instrument.

5-123. Device Settings at POWER ON

5-124. General

Active Mode: The instrument powers up in "manual" mode.

Device I/D (Serial Number).   Factory serial number preserved.

Status Reporting Conditions:

Status Byte Register.	Depends on state of *PSC.
Status Byte Enable Register.	Depends on state of *PSC.
Event Status Register.	Depends on state of *PSC.
Event Status Enable Register.	Depends on state of *PSC.
Operation Status Event Register.	Depends on state of *PSC.
Operation Status Enable Register.	Depends on state of *PSC.
Questionable Status Event Register.	Depends on state of *PSC.
Questionable Status Enable Register.	Depends on state of *PSC.
Error Queue.	Empty until first error is detected.

5-125. Power-On Settings Related to Common IEEE 488.2 Commands

Program Coding	Condition
*CLS	Not applicable
*ESE Nrf	Not applicable
*ESE?	Response depends on state of *PSC
*ESR?	Response depends on state of *PSC
*IDN?	Not applicable
*OPC	Not applicable
*OPC?	Not applicable
*PSC	0/ 1 Not applicable
*PSC?	No change. This data is saved at power off for use at power on.
*PUD	Data area remains unchanged
*PUD?	Data area remains unchanged
*RST	Not applicable
*SRE Nrf	Not applicable
*SRE?	Response depends on state of *PSC
*STB?	Response depends on state of *PSC
*TST?	Not applicable
*WAI	Not applicable

5-126. *RST Settings Related to Common IEEE 488.2 Commands

Program Coding	Condition
*CLS	Not applicable
*ESE Nrf	Not applicable
*ESE?	Previous state preserved
*ESR?	Previous state preserved
*IDN?	No Change
*OPC	OPIC state forced
*OPC?	OPIQ state forced
*OPT?	Not applicable
*PSC	0/ 1 Not applicable
*PSC?	No change.
*PUD	Data area remains unchanged
*PUD?	Data area remains unchanged
*SRE Nrf	Not applicable
*SRE?	Previous state preserved
*STB?	Previous state preserved
*TST?	Not applicable
*WAI	Not applicable

5-127. *RST Settings Related to SCPI Commands

Setting	Value Following *RST
OUTPut	
:STATe	OFF
ROSCillator	
:STATe	OFF
:SENSe	Last set manually
:DEFer	
:STATe	OFF
:OUTPut	
:RAMP	Unchanged
:TIME	Unchanged
:RCLock	0.0
:VOLTage	0.0
:NLIMit	Unchanged
SOURce	
:FREQuency	Last set manually
:LINE	OFF
:UNBalanced	
:STANdard	Unchanged
:FLICker	
:STANdard	Unchanged
:TERMinal	Unchanged
:STATe	Unchanged
:ROUTe	Unchanged
:PHASe<x>	
:VOLTage	
:STATe	OFF
:RANGe	11,168
:AMPLitude	110
:MHARmonics	
:STATe	OFF
:HARMonic<y>	Harmonic 1 100%
	Harmonic 2 – 100 0%

Setting	Value Following *RST		
:FHARmonics			
:STATe	OFF		
:FLUCtuate\<y>	Harmonic 1 – 100 OFF		
:MODulation	Depth	0.0%	
	Frequency		10.0 Hz
:SHAPe	SINusoidal		
:IHARmonics			
:STATe	OFF		
:SIGNal\<y>	State	OFF	
	Amplitude	0.0%	
	Frequency	33 Hz	
:DIP			
:STATe	OFF		
:ENVelope	Change to	10.0%	
	Ramp In	0.0001 seconds	
	Period	0.001 seconds	
	Ramp Out	0.0001 seconds	
	End Delay	0.0 seconds	
TRIGger:			
INPut:	FREE		
HOLDoff:	DEL, 0.0		
ODELay:	0.0		
:FLICker			
:STATe	OFF		
:FREQuency	13.5 Hz		
:DEPTh	0.402		
:SHAPe	SQUare		
:EFLicker			
[:STATe](?)	0 or "OFF"		
:CONFiguration(?)	"PF"		
:HSIDeband			
:HARMonic(?)	3		

Setting	Value Following *RST		
:PJUMp			
:SPERiod(?)	"OFF"		
:ANGLe(?)	30.0		
:CURRent			
:STATe	OFF		
:RANGe	0.1 1		
:VOLTage			
:EQUivalence			
: STATe	Unchanged		
: FACTor	Unchanged		
:AMPLitude	0.5		
:UNIT?	CURR		
:MHARmonics			
[:STATe](?)	OFF		
:HARMonic\<y\>	Harmonic 1	100%	
	Harmonic 2 – 100 0%		
:FHARmonics			
:STATe	OFF		
:FLUCtuate\<y\>	Harmonic 1 – 100 OFF		
:MODulation	Depth	0.0%	
	Frequency		10.0 Hz
:SHAPe	SINusoidal		
:IHARmonics			
:STATe	OFF		
:SIGNal\<y\>	State		OFF
	Amplitude		0.0%
	Frequency		33 Hz
:DIP			
:STATe	OFF		
:ENVelope	Change to		10.0%
	Ramp In		0.0001 seconds

Setting	Value Following *RST
	Period 0.001 seconds
	Ramp Out 0.0001 seconds
	End Delay 0.0 seconds
TRIGger:	
INPut:	FREE
HOLDoff:	DEL, 0.0
ODELay:	0.0
:FLICker	
:STATe	OFF
:FREQuency	13.5 Hz
:DEPTh	0.402
:SHAPe	SQUare
:TERMinal	Unchanged
:UNIT	
:ANGLe	Last set manually
:MHARmonics	
:CURRent	Last set manually
:VOLTage	Last set manually
:DIP	
:TIME	Last set manually.
:FLICker	
:CURRent	Last set manually.
:VOLTage	Last set manually.

5-128. Energy Option Action on Receiving *RST

The following default settings are used on receiving a *RST command.

Setting	Value Following *RST
[:SOURce]	
:ENERgy	
:MODE(?)	Timed/counted mode.
:UNIT(?)	Real (Wh).
:OGATe(?)	Output gate Off.
	Gate type level.
	Gate active low.
	Internal pull-up 1k Ohm.
:IGATe(?)	Gate type level.
	Gate active low.
	Internal pull-up 1k Ohm.
:MVOLtage(?)	0 (all modes)
:PRESentation(?)	Accumulated Energy, % Error.
:RESults(?)	n/a
:WUP	
:DURation(?)	Time delay, 100 Seconds.
:PSOUrce(?)	Channel 1.
:TEST	
:DURation(?)	Time delay, 100 Seconds.
:PSOUrce(?)	Channel 1.
:MUT	
:DEBounce	
[:STATe](?)	0
:CONSTant(?)	1.0e5 i/Wh
:SOURce(?)	Channel 1.
:PULLup(?)	1 k Ohm.
:REFerence	
:DEBounce	
[:STATe](?)	0
:CONSTant(?)	1.0e5 i/Wh
:SOURce(?)	Channel 1.
:PULLup(?)	1 k Ohm.
:OUTPut	
:CONSTant(?)	1.0e5 i/Wh

5-129. Worked Examples

Examples summary:

- Example 1   Create a pure ac voltage signal.
- Example 2   Create an ac voltage signal with 2nd harmonic destortion.
- Example 3   Create an ac voltage signal with fluctuating 2nd harmonic destortion.
- Example 4   Create an ac current signal with flicker.
- Example 5   Create an ac voltage signal with multiple harmonic distortion and phase shifts.
- Example 6   Clear harmonics.
- Example 7   Create an ac multichannel signal.
- Example 8   Create an ac multiphase signal.
- Example 9   Create a pure dc voltage signal.
- Example 10   Create an ac voltage signal with a dc offset.
- Example 11   Create a pure dc voltage signal using SCPI tree-walked method.

Example 1.

Configure a master unit to output a sinusoidal signal of 60 Hz, 115 V RMS, containing no sub-harmonics or aberrations, and no phase shifts.

Setting UNIT:MHAR:VOLT (main harmonics units) to ABS (absolute) will allow the amplitude value to be entered directly in volts:

Reset all parameters to a known state.	*RST
Use abs units for voltage harmonics.	UNIT:MHAR:VOLT ABS
Setup Phase 1 (master) voltage range.	SOUR:PHAS1:VOLT:RANG 0,180
Fundamental amplitude and angle.	SOUR:PHAS1:VOLT:MHAR:HARM1 115,0
Setup the fundamental frequency.	SOUR:FREQ 60
Enable voltage output on this phase.	SOUR:PHAS1:VOLT:STAT ON
Set output to on (all phases).	OUTP:STAT ON

Example 2.

Configure a master unit to output a sinusoidal signal of 60 Hz, 115 V RMS, containing no aberrations, and no phase shifts.

Add a 2ND Harmonic component of 10 V RMS, 0 ° Phase angle to the waveform.

Reset all parameters to a known state.	*RST
Use abs units for voltage harmonics.	UNIT:MHAR:VOLT ABS
Setup Phase 1 (master) voltage range.	SOUR:PHAS1:VOLT:RANG 0,180
Fundamental amplitude and angle.	SOUR:PHAS1:VOLT:MHAR:HARM1 115,0

Set amplitude (in absolute units).	SOUR:PHAS1:VOLT:MHAR:HARM2 10,0
Setup the fundamental frequency.	SOUR:FREQ 60
Enable voltage output on this phase.	SOUR:PHAS1:VOLT:STAT ON
Set output to on (all phases).	OUTP:STAT ON

Example 3.

Fluctuate the 2nd Harmonic with a 25 Hz, sine wave at 30 % amplitude.

Ensure output is off.	OUTP:STAT OFF
Clear any modulation in progress.	SOUR:PHAS1:VOLT:FHAR:CLE
Select the harmonic to fluctuate.	SOUR:PHAS1:VOLT:FHAR:FLUC2 ON
Set fluctuation wave shape to sine.	SOUR:PHAS1:VOLT:FHAR:SHAP SIN
Set fluctuation.	SOUR:PHAS1:VOLT:FHAR:MOD 30,25
Enable fluctuating harmonics.	SOUR:PHAS1:VOLT:FHAR:STAT ON
Set output to on (all phases).	OUTP:STAT ON

Example 4.

In a similar way, a 1 A, 60 Hz Current Output with 20 %, 25 Hz sine wave Flicker can be produced:

Reset all parameters to a known state.	*RST
Set units to absolute.	UNIT:MHAR:CURR ABS
Setup phase 1 (master) current range.	SOUR:PHAS1:CURR:RANG 0.2,2
Set amplitude (in absolute units).	SOUR:PHAS1:CURR:MHAR:HARM1 1,0
Setup frequency.	SOUR:FREQ 60
Set flicker wave shape to sine.	SOUR:PHAS1:CURR:FLIC:SHAP SIN
Set flicker frequency.	SOUR:PHAS1:CURR:FLIC:FREQ 25
Set flicker depth.	SOUR:PHAS1:CURR:FLIC:DEPT 20
Enable flicker.	SOUR:PHAS1:CURR:FLIC:STAT ON
Enable current output (phase 1).	SOUR:PHAS1:CURR:STAT ON
Set output to on (all phases).	OUTP:STAT ON

Example 5.

This example shows how to setup a fundamental and the 3rd and 5th harmonics.

The fundamental is set to 110 V, 60 Hz, the 3rd harmonic to 10 V with 0 ° phase angle, and the 5th harmonic to 5 V with a 90 ° phase angle.

Reset all parameters to a known state.	*RST
Ensure output is off.	OUTP:STAT OFF
Set units to absolute.	UNIT:MHAR:VOLT ABS

Setup frequency.	SOUR:FREQ 60
Setup phase 1 (master) voltage range.	SOUR:PHAS1:VOLT:RANG 0,180
Set amplitude (in absolute units).	SOUR:PHAS1:VOLT:MHAR:HARM1 110,0
Set amplitudes and phases of harm 3.	SOUR:PHAS1:VOLT:MHAR:HARM3 10,0
Set amplitudes and phases of harm 5.	SOUR:PHAS1:VOLT:MHAR:HARM5 5,90
Enable main harmonics.	SOUR:PHAS1:VOLT:MHAR:STAT ON
Enable voltage output (phase 1).	SOUR:PHAS1:VOLT:STAT ON
Set output to on (all phases).	OUTP:STAT ON

Example 6.

The harmonics in the previous example can be cleared before setting up new parameters so that they do not interfere with any new setup. This can be a useful approach, if a full *RST is not convenient.

Note: This will also clear the fundamental.

Clear all the harmonics.	SOUR:PHAS1:VOLT:MHAR:CLE

Example 7.

This example shows how to setup a 110 VRMS 60 Hz voltage output from the voltage terminals and a 1 A, 60 Hz current output from the current terminals. The current output lags the voltage output by 90 °.

Reset all parameters to a known state.	*RST
Ensure Output is off.	OUTP:STAT OFF
Set voltage units to absolute.	UNIT:MHAR:VOLT ABS
Set current units to absolute.	UNIT:MHAR:CURR ABS
Setup frequency.	SOUR:FREQ 60
Setup phase 1 (master) voltage range.	SOUR:PHAS1:VOLT:RANG 0,180
Set Amplitude (in absolute units).	SOUR:PHAS1:VOLT:MHAR:HARM1 110,0
Setup phase 1 (master) current range.	SOUR:PHAS1:CURR:RANG 0.2,2
Set amplitude and phase.	SOUR:PHAS1:CURR:MHAR:HARM1 1,-90
Enable voltage output.	SOUR:PHAS1:VOLT:STAT ON
Enable current output.	SOUR:PHAS1:CURR:STAT ON
Set output to on (all phases).	OUTP:STAT ON

Example 8.

The previous example can be duplicated using a master unit to produce the voltage and an auxiliary unit to produce the current.

Reset all parameters to a known state.	*RST
Ensure output is off.	OUTP:STAT OFF
Disable voltage output (master).	SOUR:PHAS1:VOLT:STAT OFF
Disable current output (auxiliary).	SOUR:PHAS2:CURR:STAT OFF
Setup Frequency.	SOUR:FREQ 100
Setup phase 1 (master) voltage range.	SOUR:PHAS1:VOLT:RANG 0,180
Set amplitude (in absolute units).	SOUR:PHAS1:VOLT:MHAR:HARM1 110,0
Setup phase 2 (aux) current range.	SOUR:PHAS2:CURR:RANG 0.2,2
Set amplitude and phase.	SOUR:PHAS2:CURR:MHAR:HARM1 1,-90
Enable voltage output.	SOUR:PHAS1:VOLT:STAT ON
Enable current output.	SOUR:PHAS2:CURR:STAT ON
Set output to on (all phases).	OUTP:STAT ON

Example 9.

Configure a master unit to output a pure 5V dc signal. Note that as dc is treated by the 6100B as the 0th harmonic of a fundamental frequency, that frequency must be defined even when as in this case, the fundamental has zero amplitude.

Also note that previously enabled phenomena e.g., dip or interharmonic etc. would remain enabled if the *RST was not commanded.

Reset all parameters to a known state.	*RST
Use abs units for voltage harmonics.	UNIT:MHAR:VOLT ABS
Setup Phase 1 (master) voltage range.	SOUR:PHAS1:VOLT:RANG 1.1,16
Enable main harmonics (needed for DC).	SOUR:PHAS1:VOLT:MHAR:STAT ON
RMS amplitude (to remove fundemetal).	SOUR:PHAS1:VOLT:MHAR:AMPL 0
DC amplitude (will calculate new RMS).	SOUR:PHAS1:VOLT:MHAR:HARM0 5,0
Setup the fundamental frequency.	SOUR:FREQ 60
Enable voltage output on this phase.	SOUR:PHAS1:VOLT:STAT ON
Set output to on (all phases).	OUTP:STAT ON

Example 10.

Configure a master unit to output an AC signal of 60 Hz, 10 V RMS, with a 5 V dc offset, containing no aberrations.

Reset all parameters to a known state.	*RST
Use % rms mode to easily calculate offset.	UNIT:MHAR:VOLT PRMS
Setup Phase 1 (master) voltage range.	SOUR:PHAS1:VOLT:RANG 1.1,16
Enable main harmonics (needed for DC).	SOUR:PHAS1:VOLT:MHAR:STAT ON
RMS amplitude (to remove fundemetal).	SOUR:PHAS1:VOLT:MHAR:AMPL 10
DC amplitude (will calculate new RMS).	SOUR:PHAS1:VOLT:MHAR:HARM0 50,0
Setup the fundamental frequency.	SOUR:FREQ 60
Enable voltage output on this phase.	SOUR:PHAS1:VOLT:STAT ON
Set output to on (all phases).	OUTP:STAT ON

Example 11.

This example creates the same output as example 9 (a pure 5 V dc signal), but using SCPI tree walking, and avoiding *RST.

:FREQ 60;:UNIT:MHAR:VOLT ABS;:PHAS1:VOLT:RANG 0,23;STATE ON;MHAR:STAT ON;AMPL 0;CLE;HARM0 5,0;:OUTP ON

Chapter 6
Operator Maintenance

6-1. Introduction

This chapter explains how to perform the routine user maintenance required to you're your Instrument in optimal operating condition. The topics covered in this chapter include:

- Changing the User Password

- Running the Confidence Test

- Replacing the Fuse

- Cleaning the Air Filter and External Surfaces

Calibration is explained in Chapter 7.

6-2. Confidence Test

The Confidence Test provides an indication that instrument performance has not deteriorated significantly. The test for connected Auxiliary units is run from the 6100B Master instrument. The test is not designed to be used to determine service intervals as the measurements made are relatively crude compared with those that would be made at routine calibration and adjustment.

Note

Some temperature (Pic) tests may report percentage error of 100 % but this is normal and should not be of concern.

6-3. Setting Up and Running the Confidence Test

Navigate to the Waveform Menu with ⌨. If necessary, push ⌨ until the top-level softkey menu is displayed. See Figure 6-1.

Select **Support Functions**, **Diagnostic tools**, and enter the user password. Push the **Run Self Tests** softkey.

The softkeys associated with the Self Test pop up menu allow you to:

- Under the Select Test Channels softkey, select which channels to test i.e., L1 Voltage, L1 Current ... N Current

- Choose which channel sub-components to test, i.e., all boards, the DSP board, the control board or the first or second slave boards

- Start the self test

- Save the test results to external media via USB ports

Once the test required regimen has been set up, push **Start Self Test** to initiate the test.

Note

Remember, when navigating the various menus, the ⌨ key takes you up through the softkey hierarchy.

When the test is complete a summary report is presented in the Self Test menu.

The Test Pathway menu allows more detailed diagnosis of test results but this is essentially a tool provided for service centers. Although the Test Pathway facilities are available, a detailed description is not provided here as the technical content is beyond the scope of this manual.

6-4. Changing the User Password

Navigate to the Waveform Menu using [SELECT MENU]. If necessary push [ESC] until the top-level softkey menu is displayed. See Figure 6-1.

gdw32.bmp

Figure 6-1. Waveform Menu Top Level Softkeys

Select **Support Functions**, **Diagnostic Tools**, and enter the user password. The default password when the 6100B is first shipped is "12321".

Select **Change Password** to display the "change the calibration password..." pop-up menu. Enter the existing password, the new password and the new password again. Push [ENTER] to change the password (or [ESC] to cancel the operation).

6-5. Accessing the Fuse

The power fuse is accessible from the rear panel. See Figure 6-2.

⚠⚠Warning

To avoid electrical shock or personal injury, ensure that the Instrument is switched off at the rear-mounted on/off switch and disconnected by removing the line power cord from the power input socket before attempting to access the power fuse,

To access the fuse, proceed as follows:

1. Disconnect line power.

2. Using a standard screwdriver, turn the fuse holder counterclockwise until the cap and fuse are disengaged.

Always replace with the approved fuse shown in Table 6-1.

Table 6-1. Approved Replacement Fuses

Description	Part Number	Rating
Fluke part number and description:	1998159	T15AH 250 V 32 mm
Fuse manufacturer and part number:	Bussmann	MDA-15

POWER SWITCH

POWER FUSE
T15AH 250V
DISCONNECT POWER
BEFORE ACCESSING FUSE

POWER INPUT
100V - 240V
47 - 63Hz 1250VA MAX
(1000VA FOR 115V NOMINAL)

AUX PROTECTIVE
EARTH (GROUND)

FLUKE CORPORATION
www.fluke.com
MADE IN UK
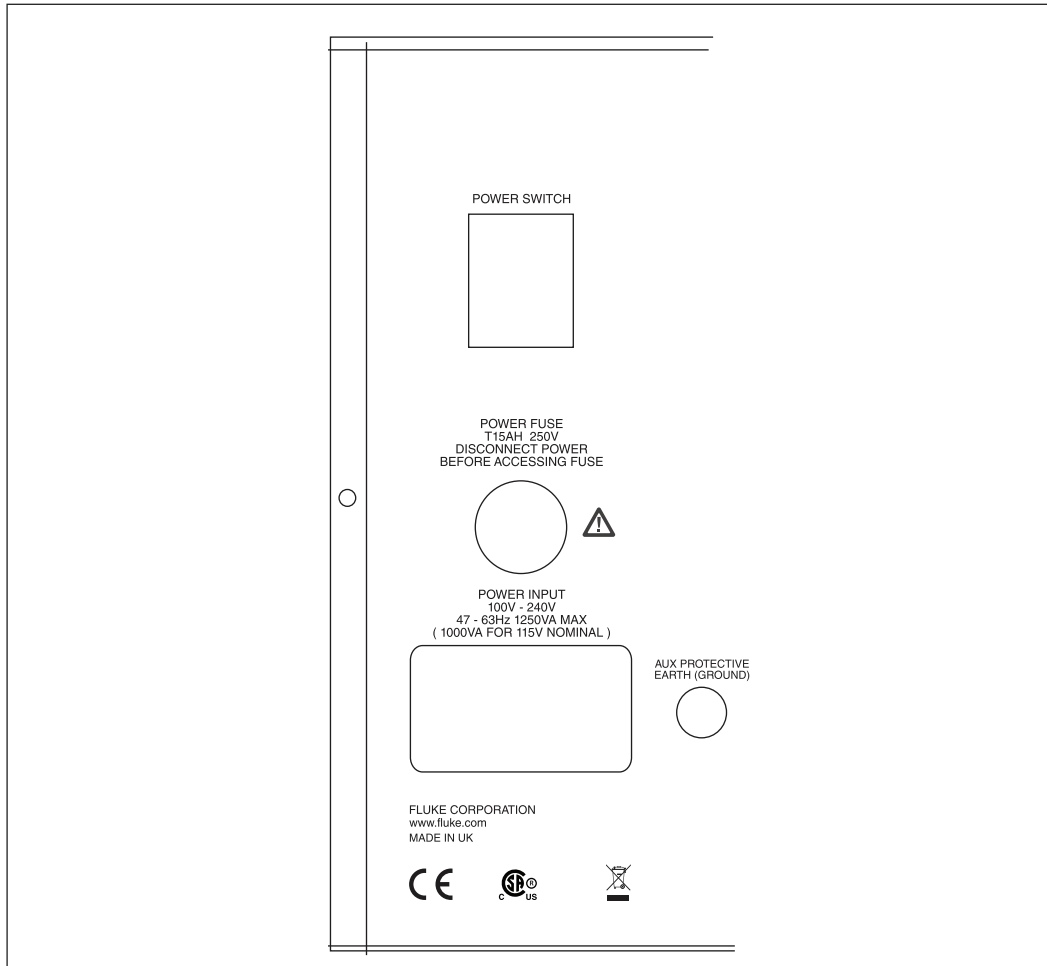
gdw033.eps

Figure 6-2. Rear Panel Showing Fuse

6-6. How to Clean the Instrument

Clean the exterior of the instrument using a soft cloth slightly dampened with either water or a non-abrasive mild cleaning solution that is not harmful to plastics.

⚠ Caution

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

6-7. How to Clean the Air Filter

⚠Caution

Damage caused by overheating may occur if the area around the fan is restricted, the intake air is too warm, or the air filter becomes clogged.

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

To clean the air filter proceed as follows. See Figure 6-3:

1. Disconnect line power.

2. The air filter is accessible from the rear of the unit. If the unit is sited on a bench, ensure that there is 24-inch clearance at the rear of the unit to allow you to withdraw the filter.

3. Remove the filter by unscrewing the two knurled screws at the top and the bottom of the vertical panel that secure the air filter. Pull the filter out of the unit.

4. Clean the filter by washing it in soapy water. Rinse and dry it thoroughly before reinstalling.

5. Reinstall the filter and tighten the knurled screws.

TO CLEAN THE FILTER :
DISCONNECT POWER
REMOVE FILTER
FLUSH WITH SOAPY WATER
DRY BEFORE REINSTALLATION
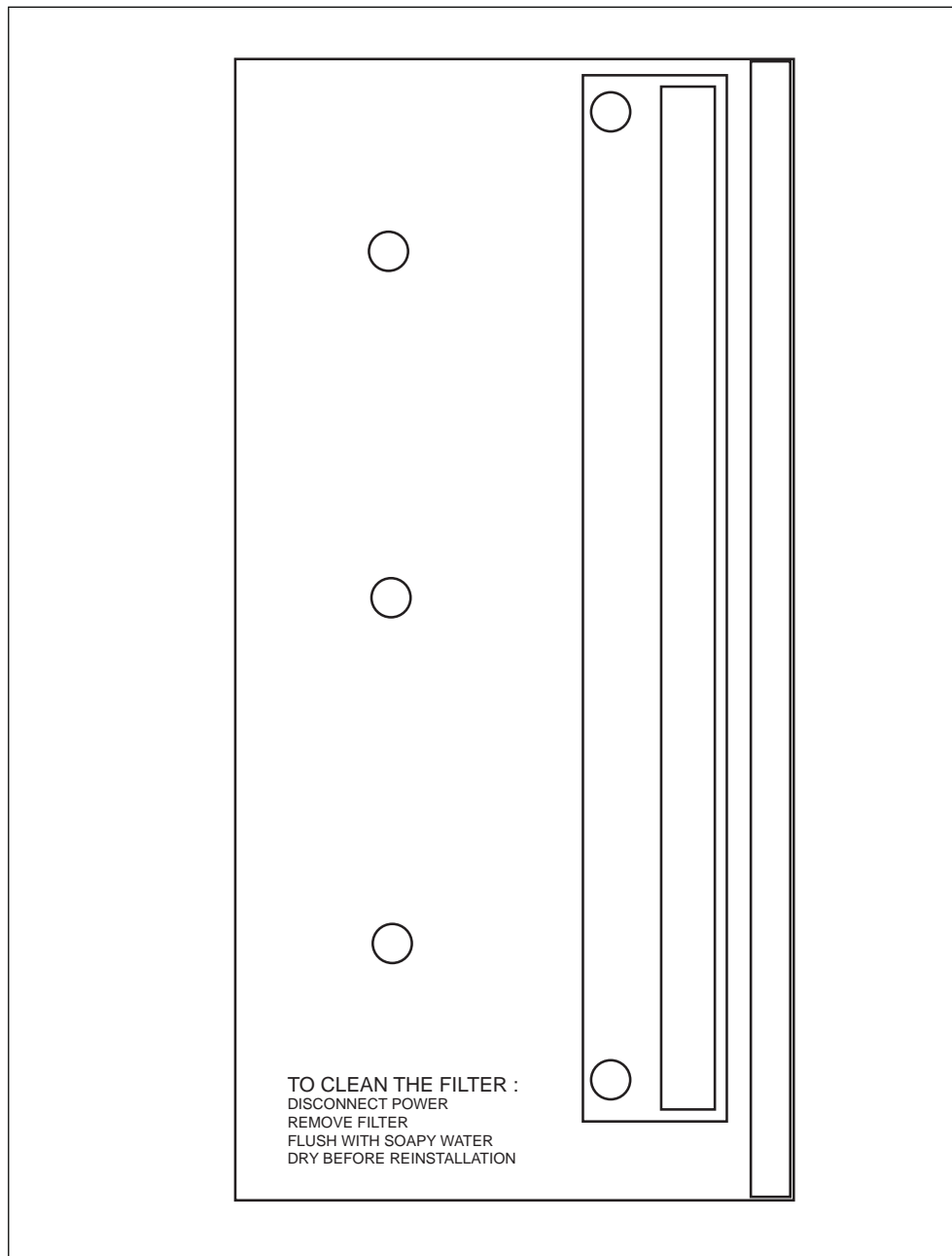
gdw53.eps

Figure 6-3. Air Filter Access

6-8. Lithium Battery Replacement

The PC within this instrument is fitted with a lithium battery (3V, 180mAH, CR2023 coin cell). Battery life should exceed 10 years. After this the PC setup and date information may be lost. The battery should be replaced with a UL approved equivalent by Fluke authorized technical personnel.

Note

This instrument contains a Lithium battery.

Do not mix with the solid waste stream. Spent batteries should be disposed of by a qualified recycler or hazardous materials handler.

Contact your authorized Fluke Service Center for recycling information.

⚠ Caution

Do not leave batteries unused for extended periods of time, either in the product or in storage. When a battery has not been used for six months, check the charge status and charge or dispose of the battery as appropriate.

Chapter 7
Calibration

7-1. Introduction

This chapter explains the Calibration procedures for the Instrument and the Energy Option.

7-2. Calibration Methods

7-3. Full Calibration Verification and Adjustment

Annual calibration verification and adjustment is recommended to maintain 6100B too full specifications. If adjustment is required all points in the adjustment point tables below should be adjusted to nominal.

7-4. Confidence Check

If the Instrument is used mainly at power line frequencies there are a number of commercially-available measuring power reference standards with accuracies comparable to that of the 6100B and 6105A. These can be used to perform a confidence check of 6100B accuracy. A single-phase device is sufficient to check both single and poly-phase 6100B systems. Example products are Radian Research RD-22, ZERA COM 1003 or MTE K2006. Be aware that the results of such measurements have uncertainties far in excess of those required to check 6100B and 6105A to full specification.

As an example, consider a power measurement made with a RD-22 meter at 120 V, 5 A, 60 Hz with power factor of 0.5. The reported error is 0.006 %.

The RD-22 specification is 0.01 %. Therefore, the uncertainty of the measurement of the 6105A is no better than 0.01 %. The specification of 6105A when calibrated at a Fluke service center is also 0.01 %; but with a calibration uncertainty of 0.01 % a relaxation of 6105A specification is clearly necessary. A reasonable method is to take the root-sum-of-squares of the result and the measurement uncertainty (Uncert) to set the new 6105A specification limit.

In the case of this example: $New\_spec = \sqrt{0.01^2 + 0.006^2} = 0.012$ %

Notice there is no separate measurement of voltage, current or phase angle. This method relies on the three parameters being independent in the 6105A. It is very unlikely that all would drift together such that the power value measured was correct.

7-5. Partial Adjustment

The confidence check described above does not provide sufficient information to decide what parameter should be adjusted if that were deemed necessary. Phase angle is the least likely parameter to shift unless a fault has occurred. Phase angle is also the hardest to measure with the accuracy required. The ZERA COM 1003 has the capability to report voltage and current measurements; so it should be easy to decide what needs to be adjusted. Follow the process for adjustment described below as required then verify the adjustment by making a confidence power measurement as described above.

7-6. Confidence Check of a Poly-phase System

A modified version of confidence checking can be used to check a poly-phase system. It is recommended that all phases are checked before any adjustment is made. Checking a 6135A with a three phase measuring device is clearly the easiest method to follow but using a single phase device may yield the best results depending on measurement accuracy. Consider checking a three phase 6135A system with a single phase measurement device. This method has the advantage that four devices are inter-compared. There is no reason why different phases in a poly-phase system should drift

significantly at the same rate or direction. High confidence can be taken from checking three phases with the same measurement device. If the result from one phase appears different to the others it is highly probable this item is the furthest from specification. If, however, all results are similar, the accuracy of the measurement device should be considered.

If an adjustment is necessary, a cross check can be made to get more information about the individual voltage and current channels. Though time consuming, this will give more confidence with selection of any adjustments to be made:

1. Set the L1 channel voltage and current channels to the required levels.

2. Set L1 current phase angle to zero.

3. Set L2 voltage phase angle to zero.

4. Set L2 current amplitude to the required amplitude.

5. Set the L2 current phase angle to zero.

Now the L1 voltage and the L2 current are in phase. Measure power and record the result. Repeat the process until all the current outputs have been measured with all voltage outputs (six measurements). A simple analysis of the results will reveal which of the voltage or currents is furthest from specification and which, if any, need to be adjusted.

7-7. Best Calibration Accuracy

7-8. Amplitude Measurements

Rigorous type testing of the 6100B has shown that when the phase and gain of each voltage or current channel are correctly adjusted, all other specifications will be met. Consequently, calibration of 6100B/6105A can be achieved with sinusoidal signals. Users should be aware, however, that the Instrument is optimized for use with sampling measurement instruments. Some rms-sensing meters have ac input bandwidths of many MHz and cannot reject non-harmonic components. As a result, this type of instrument may report amplitude values different from those obtained by sampling techniques. Sampling systems using Fourier analysis have the advantage of extracting the signal of interest from noise and yield accurate phase information.

7-9. Phase Measurement

Potentially, there are many ways of measuring amplitude and phase between Electrical Power Standard output channels. The amplitude of voltage and current can be determined independently but measurement of phase angle requires some form of comparison to be made. Comparing the current and voltage outputs of a 6100B with a zero crossing detection phase meter would provide phase information for that unit. But there are two disadvantages to this method.

*   Comparison of the zero crossing of two signals is subject to noise at the zero crossing points; whereas sampling techniques get information from at least two points on the waveform.

*   Measuring only the phase angle between voltage and current of a single unit does not allow independence of 6100B and 6105A calibration. Each 6101B auxiliary unit would need to be calibrated with its Master 6100B unit for voltage to voltage information.

If these disadvantages are acceptable for the calibration of a 6100B then phase uncertainties in the order of 0.050 degrees are possible with zero-detection phase meters.

Note

Zero-detection phase meters may give erroneous results in the presence of even harmonics because even harmonics can cause the zero crossing of a composite waveform to differ from the notional fundamental frequency zero crossing. Sampling techniques, on the other hand, can give phase uncertainties as low as 0.0008 degrees and are not susceptible to other harmonics affecting the measurement.

7-10. The Effect of Phase Uncertainty on Power Accuracy

As power = V.I.Cos(A), the contribution from phase angle accuracy can be shown with the following example:

If phase accuracy is ±0.05 degrees, at nominal PF = 0.5, Cos(A) could vary between Cos(59.95) and Cos(60.05) i.e., 0.5008 to 0.4992. This represents a range of

$$\frac{0.5008 - 0.4992}{0.5} *100\% = 0.3\ \%$$

If Φ is the set phase angle and $u(\phi)$ is the phase accuracy, the general case of phase accuracy contribution to power accuracy u(P) is given by:

$$u(P) = (1 - \frac{\cos(\Phi\ + u(\phi))}{\cos(\Phi)}) \times 100\ \%$$

Table 7-1 shows how phase uncertainty affects power accuracy at different power factors.

Table 7-1. The Contribution of Phase Uncertainty to Power Accuracy

Phase Uncertainty	PF = 1.0	PF = 0.75	PF = 0.5	PF = 0.25
0.0008 °	±0.000 %	±0.001 %	±0.002 %	±0.005 %
0.050 °	±0.000 %	±0.077 %	±0.151 %	±0.338 %

7-11. Calibration Uncertainties for Full Accuracy

The uncertainties of measurement required to achieve the full specification of the 6105A are below. Lower accuracy equipment can be used but at the expense of 6105A accuracy. The calibration uncertainties stated are at 95 % confidence probability. See Tables 7-2, 7-3, and 7-4.

Table 7-2. Voltage Amplitude Calibration Uncertainty Required

	ppm of Range
1 V to 1008 V, 16 Hz to 450 Hz	<26
1 V to 1008 V, 450 Hz to 6 kHz	<30
1 V to 1008 V, 6 kHz to 9kHz	<1 %

Table 7-3. Current Amplitude Calibration Uncertainty Required

	ppm of Range
0.25 A to 10 A, 16 Hz to 450 Hz	<27
10 A to 50 A , 16 Hz to 450 Hz	<42
0.25 A to 10 A, 450 Hz to 6 kHz	<36
10 A to 50 A , 450 Hz to 6 kHz	<58
0.25 A to 50 A, 6 kHz to 9 kHz	<1 %

Table 7-4. Phase Calibration Uncertainty Required

	Phase measurement uncertainty	
Frequency	**Current to voltage**	**Voltage to voltage**
16 Hz to 69 Hz	0.0008 °	0.002 °
69 Hz to 180 Hz	0.0013 °	0.005 °
180 Hz to 450 Hz	0.0038 °	0.014 °
450 Hz to 3 kHz	0.0375 °	0.098 °
3 kHz to 6 kHz	0.0750 °	0.195 °

7-12. Required Equipment

Two lists of equipment are provided for two different methods of calibrating the 6100B. Fluke's method is used within the Fluke Service Centers and has measurement uncertainties which support the full specifications of the 6100B.

The alternative, non-Fluke Service Center method will not achieve full 6100B specified accuracy, particularly for phase and power accuracy. You should perform your own uncertainty analysis if using alternative methods. See Table 7-5.

Table 7-5. Calibration Methods

Measurement	Fluke Method	Alternative Method
System control	Custom Microsoft Windows application	Manual control or custom automation
Sampling	Fluke HP3458A/HFL with memory extension option in DC sampling mode.	Sampling measurement device with appropriate analysis software
Voltage amplitude transducers	AC voltage divider set with small, known phase displacement errors	AC voltage dividers as required
Current amplitude transducers	A40B ac current shunts with small, known phase displacement errors	A40B ac current shunts as required
Voltage to phase reference signal phase angle	Derived from voltage amplitude measurements	Custom design or use voltage to current phase measurement
Current to phase reference signal phase angle	Derived from current amplitude measurements	Custom design or use voltage to current phase measurement
Voltage to current phase angle	Derived from angles with respect to phase reference	Clarke-hess model 6000 phase meter or similar plus suitable shunts

7-13. Overview of 6100B Signal Generation

An overview of the 6100B signal generation system will aid further discussion of the Fluke method of calibration.

An Electrical Power Standard system consists of a 6100B to provide a single phase of voltage and current, plus up to three 6101B auxiliaries. The voltage and current channels are independent of each other for amplitude but are linked by a common internal "Phase Reference" signal. Calibration adjustment of 6100B phase at manufacture is implemented independently on voltage and current channels by referring them to the Phase Reference.

An understanding of the way the 6100B generates its output signals will aid discussion of calibration methods.

7-14. Independence of 6100B and 6101B

Adding up to three 6101B Auxiliary units provides additional phases. Each 6101B Auxiliary stores its own calibration constants but is configured and calibrated via a 6100B. The 6100B Master unit provides its Phase Reference signal to its 6101B Auxiliaries thus linking the phase of all output channels.

Because the phase of all signals is derived from the same, common Phase Reference, the calibration of a 6101B Auxiliary unit is independent of the 6100B Master unit controlling it.

The following describes the 6100B (L1) voltage channel. Unlike all other channels, the phase angle on the L1 voltage channel cannot be altered from zero except in calibration mode.

A digital representation of the requested output waveform is sampled, converted to an analog signal and amplified. The D to A conversion process and subsequent amplification introduces a phase shift and the output at the binding posts lags the digitally generated waveform. Figure 7-1 is a stylized representation of the relationship between the Phase Reference, the digitally sampled waveform and the analog output signal.
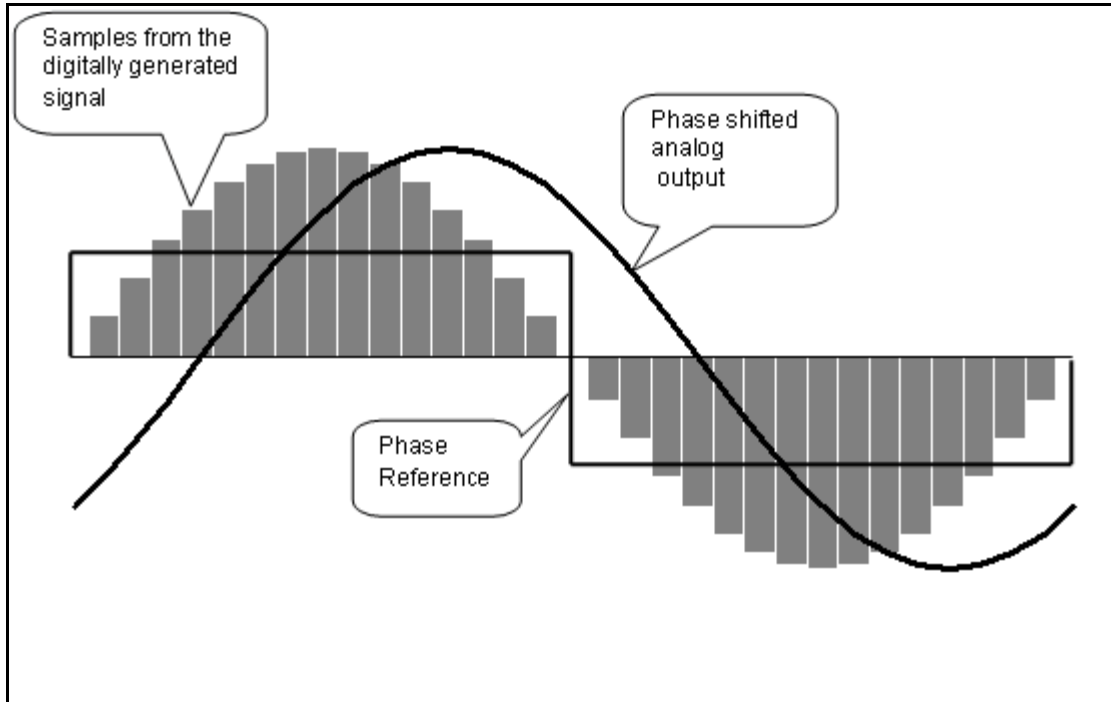
gdw47.bmp

Figure 7-1. Signal Generation

The objective of phase calibration adjustment is to remove the phase offset between the Phase Reference and the analog output signal. Figure 7-2 shows the digitally sampled waveform phase shifted to align the analog output to the Phase Reference. In practice there will be a small residual phase error determined by the accuracy of measurement.
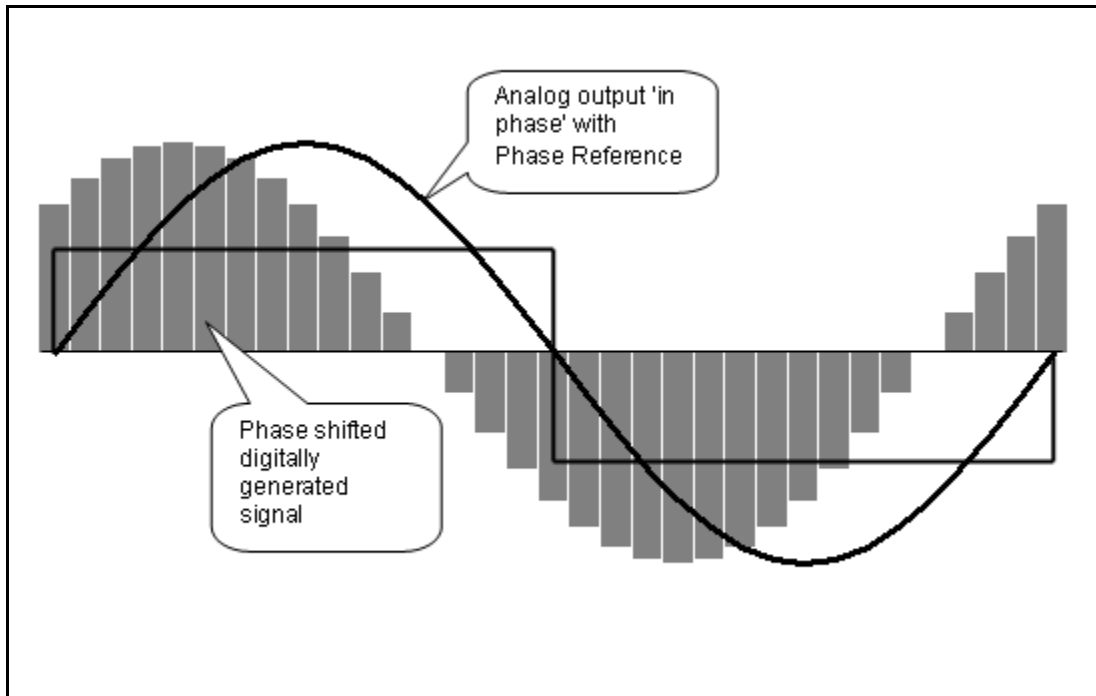
gdw48.bmp

Figure 7-2. After Phase Adjustment

With the analog signal of both voltage and current channels in phase with the common Phase Reference, the phase relationship between voltage and current is known with an uncertainty, which is the sum of the residual error from the voltage and current calibration adjustment.

The phase angles relative to the Phase reference of voltage channels other than L1 are nonzero by default. Nevertheless, the same principle applies but with the phase angle between the analog signal and the Phase Reference set to an appropriate nonzero value.

7-15. The Fluke Service Center Calibration System

As described above, the Fluke calibration system independently compares a voltage or current channel to the system phase reference. Fourier analysis of sampled analog signals yield amplitude and phase information which is used for calibration and adjustment. The digitizing DMM is triggered externally by a signal from the 6100B. The trigger signal, the Sample Reference, has a fixed phase relationship with the system Master Phase and controls that start of the sample period. Thus the phase relationship of the analog signals is fixed to the phase reference and is known.
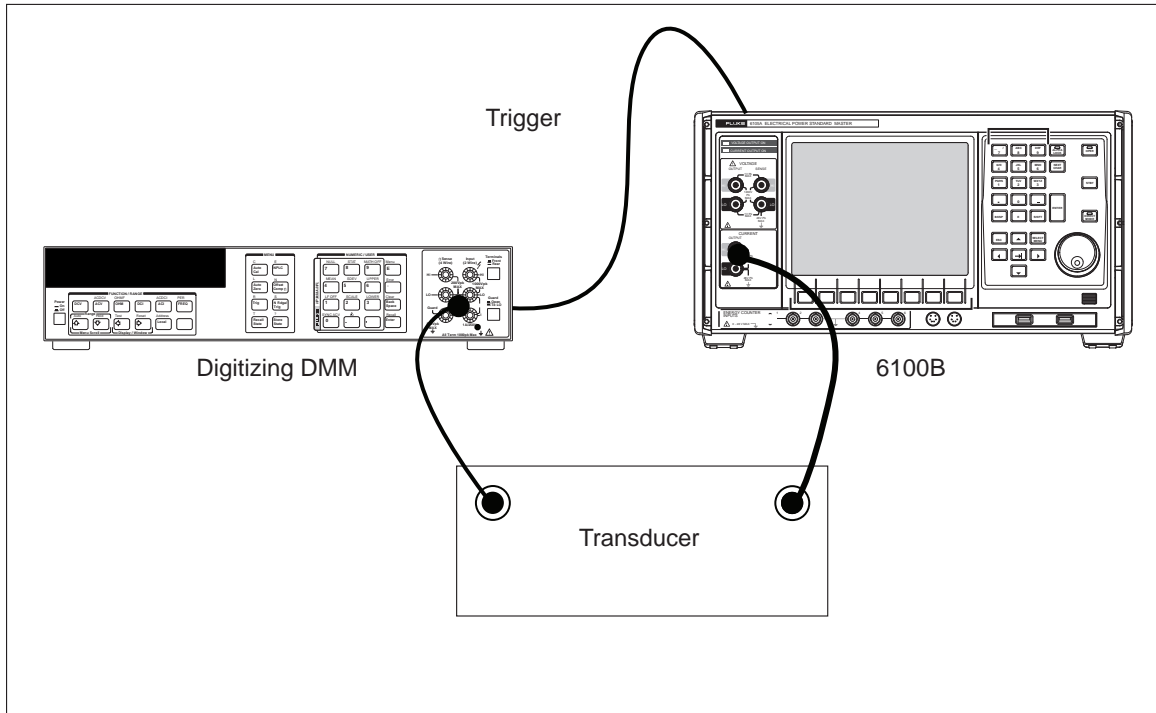
gdw56.eps

Figure 7-3. Phase Measurement Connections

Figure 7-3 shows how the 6100B, a digitizing DMM and transducer are connected. Note that voltage dividers and shunts are used to scale the input to the DMM for optimum performance. The same DMM is used to calibrate voltage and current.

The Sample Reference and the Phase Reference signals are provided on the 6100B rear panel. Figure 7-4 shows the relationship between reference signals and the analog output. The Sample reference is turned OFF and ON with GPIB commands. Sample Reference pulses do not appear after an ON command until the positive zero crossing of the Phase Reference occurs. Then the first falling edge is simultaneous with the Phase Reference rising edge. The DMM samples the analog signal at each falling edge of the "trigger" thereby phase-locking the sample to the analog output.
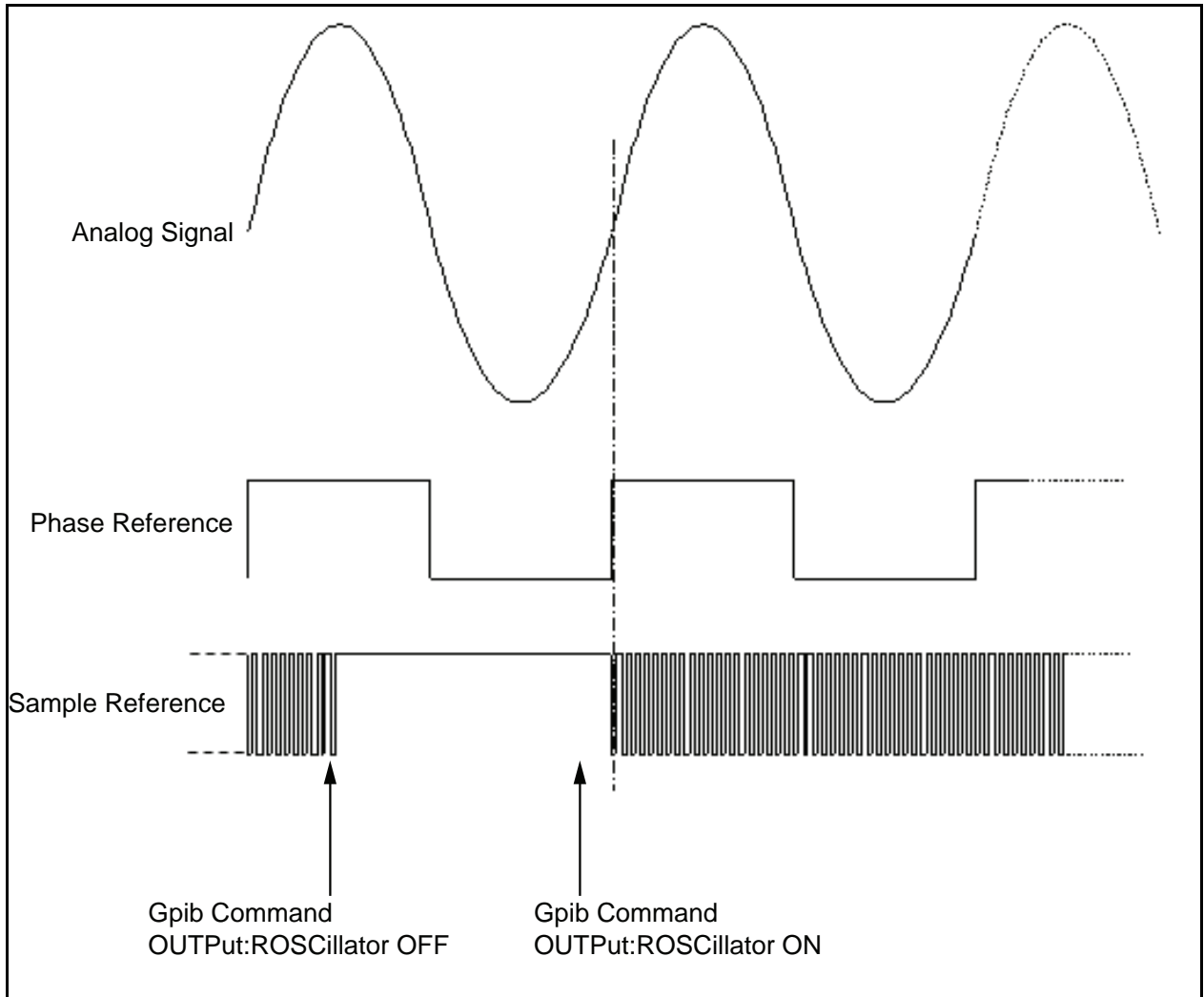
gdw49.eps

Figure 7-4. Waveforms

The system software programs the DMM to take the required number of samples so as long as the minimum required time is allowed to elapse, the timing of the sample reference off command is not critical. The sample reference frequency is always a binary multiple of the analog fundamental frequency thereby simplifying the task of analyzing the sampled data.

7-16. *Characteristics of the Calibration System*

Transducers are used to convert the different 6100B output voltage and current levels to nominally 800 mV. The DMM, a Fluke HP3458A/HFL with extended memory option, is used on its 1.2 V dc range for all measurements to reduce the relative phase uncertainty contribution from the DMM, i.e., errors in the DMM are the same for voltage and current. For each measurement, the DMM is programmed to take 65,536 samples with an aperture of 6 µs giving 18-bit resolution. Table 7-6 below shows samples per fundamental cycle and the minimum samples at the highest settable harmonic frequency.

Table 7-6. Samples Per Cycle

6100B Fundamental Frequency (Hz)	Sample Reference Pulses per Fundamental Cycle	Minimum Samples per Cycle at Maximum Harmonic Frequency
16 to 32	2048	20
32 to 69	1024	10
69 to 128	512	5
128 to 256	256	5
256 to 512	128	5
512 to 850	64	5

7-17. *Transducers*

The output from all transducers is 800 mV rms at full range. The switchable range voltage transducer is built into a system switching control unit to provide full automation. There are 6 voltage ranges each compensated by a parallel capacitive divider to compensate for stray capacitance and the input capacitance of the system DMM. Voltage divider phase uncertainty is typically 0.0002 ° at 60 Hz, 0.002 ° at 1500 Hz. Five special co-axial shunts are used with values of 0.5 A, 2 A 10 A, 20 A and 80 A.

The shunts are designed to exhibit mutual inductance of 0.5 nH ± 0.5 nH. Shunts typically have phase displacement error uncertainty of 0.0003 ° at 60 Hz and 0.013 ° at 1500 Hz. With the calibration system in a temperature-controlled environment the transducers contribute less than 1 ppm to measurement uncertainty.

7-18. *DMM Amplitude Error Contributions*

DMM gain and bandwidth contribute to amplitude error. These errors are calculated and combined with those of the transducers to provide amplitude corrections.

7-19. *DMM Amplitude Phase Contributions*

The various phase error contributions of the DMM considerably exceed that of the transducers. Some of these contributions cancel for current to voltage phase measurements but not in voltage to voltage measurements for multiphase systems. The main systematic contributions to phase error from the DMM are bandwidth, aperture and trigger delay. Table 7-7 shows the phase displacement uncertainties achieved in the Fluke system once DMM phase errors are compensated.

Table 7-7. DMM Phase Error Uncertainty (Degrees)

Frequency	Bandwidth Uncertainty	Trigger Uncertainty	Aperture Uncertainty	Combined uncertainty	Expanded Uncertainty (k = 2)
60 Hz	0.0004	0.0008	0.0000	0.0009	0.0018
6 kHz	0.0441	0.0786	0.0001	0.0901	0.1802

7-20. *Voltage to Voltage Phase Uncertainty*

In Fluke service center systems errors are compensated by the application of corrections. The uncertainty due to the short-term stability of the DMM and measurement noise, plus the uncertainty due to voltage and current transducers must be combined with these values but these at typically 0.00023 ° are negligible. Thus the voltage to voltage phase calibration uncertainty for a 6100B and 6101B calibrated at different service centers will fall within the uncertainties estimated in Table 7-7 above.

7-21. *Current to Voltage Phase Uncertainty*

The phase of the current output of a 6100B or 6101B is specified relative to the voltage channel of the same instrument. By using the same DMM to measure both voltage and current against the common Sample Reference signal means all DMM related uncertainties other than short-term stability and measurement noise cancel. The remaining contributions (typically 0.00023 °) are combined with transducer contributions giving a total expanded system uncertainty of 0.0008 ° for current to voltage phase.

7-22. Overview of Adjustment

The steps required to calibrate at an adjustment point are enter the calibration mode then, for each calibration point:

- Select the instrument configuration required

- Determine the 6100B error by measurement

- Initiate the adjustment

The 95th harmonic amplitudes are outside the normal range for harmonics and can only be set in the calibration adjustment mode. The final step is to check the residual error is within acceptable limits and report the value to the calibration certificate.

7-23. Calibration Adjustment Process

The Instrument can be adjusted in the software configuration. Select Support Functions/Adjust Instrument. See Figure 7-5.

gdw34.bmp

Figure 7-5. Waveform Top Level

7-24. Entering Calibration Mode

To make calibration adjustments, the 6100B (or 6101B) calibration switch must be in the Enable position. See Figure 3-9 and Table 3-2. Use the Password Prompt to enter your password. See Figure 7-6.

gdw50.bmp
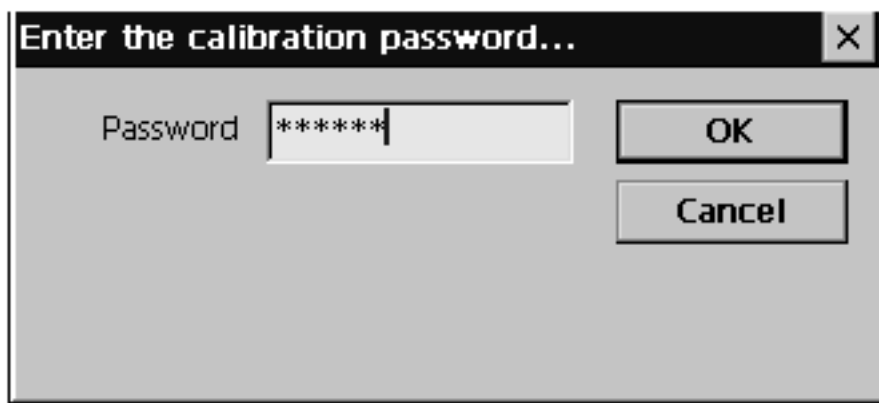
Figure 7-6. Password Prompt

The default password is "12321". The password may be changed via the Change Password softkey. See Chapter 6. Any alpha numeric character available via the 6100B front panel can be used in passwords.

7-25. Select Instrument Configuration

To select instrument configuration, see Figure 7-7 and do the following:

1. Select the instrument (L1, L2 etc.) and channel to be adjusted via the Output Menu

2. Select the required range

3. Select the required *Target*

4. For voltage calibration, ensure 4-wire is selected.

Note

Line locking is disabled when calibration mode is entered. The previous state is reinstated on exit from calibration mode.
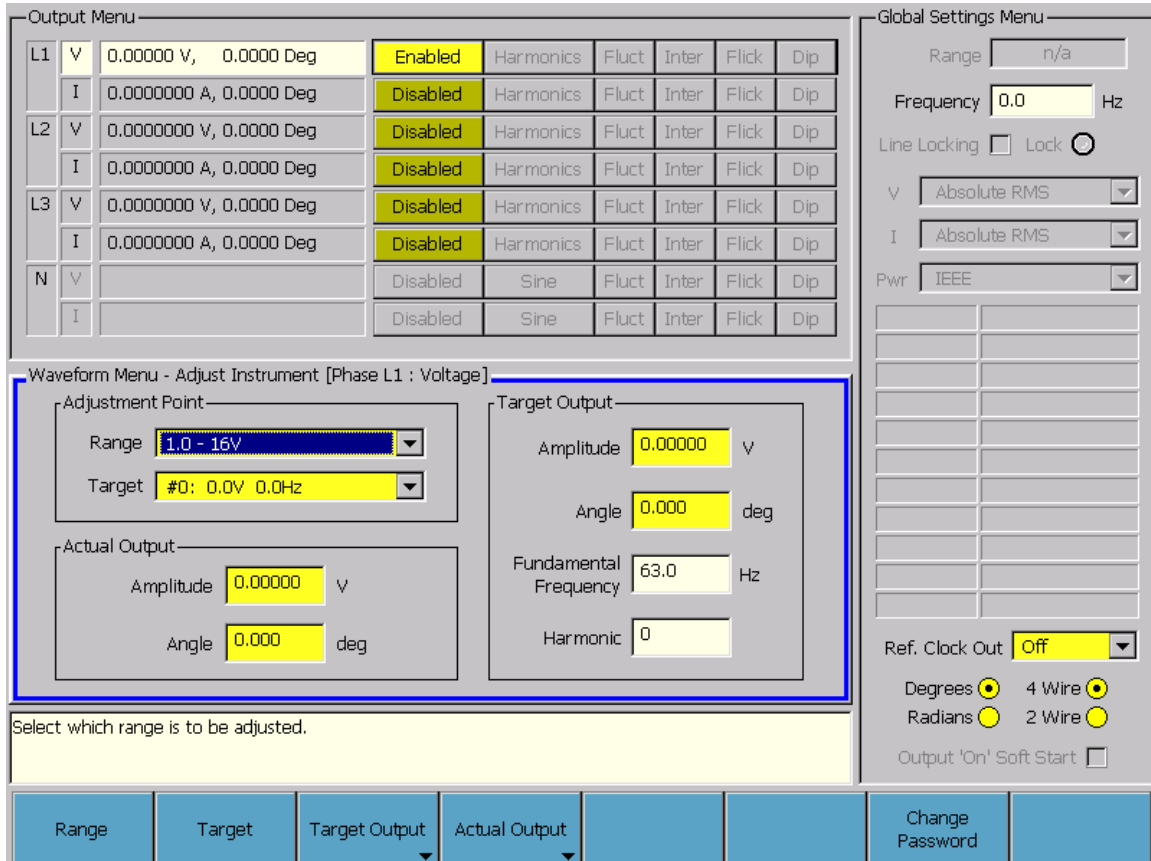
gdw51.bmp

Figure 7-7. Adjust Instrument Screen

7-26. *Determine the 6100B Error*

Ensure the measurement equipment is correctly configured; connections are correctly made and turn the 6100B/6101B output on. After allowing the 6100B/6101B and measurement equipment time to settle, for each of the components to be adjusted:

1. Note the difference (D) between Target (T) and measured value (M): D=T–M

2. Calculate the required Actual value = T+D (which is the same as 2T–M)

3. Enter the Actual value in the Actual field

7-27. *Initiate the Adjustment*

Press Accept adjustment.

The 6100B instrument stores the amplitude and phase calibration constants.

Allow the 6100B and measurement equipment time to settle.

If the residual errors are within limits, report the amplitude and phase values to the calibration certificate.

Otherwise, repeat the calibration adjustment process until the verification measurement results are within the required tolerance.

7-28. *Return Calibration Switch to Normal*

Once calibration adjustment is complete, return the calibration enable switch to the Normal position.

7-29.   Verification

Verify adjustments using the same equipment against the product specification in Chapter 1.

7-30. Calibration Adjustment Points

The following tables list the calibration adjustment points.

Table 7-8. Voltage Adjustment Points

Range (Volts)	Fundamental Frequency (Hz)	Harmonic Number	Frequency (Hz)	Point	Output Level Setting (Volts)	Output Phase Angle Setting (Degrees)
23	57	0	0	DC offset	0.000	0
		1	57	Gain	16.000	0
		15	855	Gain	16.000	0
	63	95	5985	Gain	16.000	0
45	57	0	0	DC offset	0.000	0
		1	57	Gain	30.000	0
		15	855	Gain	30.000	0
	63	95	5985	Gain	30.000	0
90	57	0	0	DC offset	0.000	0
		1	57	Gain	60.000	0
		15	855	Gain	60.000	0
	63	95	5985	Gain	60.000	0
180	57	0	0	DC offset	0.000	0
		1	57	Gain	120.000	0
		15	855	Gain	120.000	0
	63	95	5985	Gain	120.000	0
360	57	0	0	DC offset	0.000	0
		1	57	Gain	240.000	0
		15	855	Gain	240.000	0
	63	95	5985	Gain	240.000	0
650 (6105A and 6106A only)	57	0	0	DC offset	0.000	0
		1	57	Gain	460.000	0
		15	855	Gain	460.000	0
	63	95	5985	Gain	400.000	0
1008	57	0	0	DC offset	0.000	0
		1	57	Gain	800.000	0
		15	855	Gain	800.000	0
	63	95	5985	Gain	400.000	0

Table 7-9. Current Adjustment Points

Range (Amps)	Fundamental Frequency (Hz)	Harmonic Number	Frequency (Hz)	Point	Output Level Setting (Amps)	Output Phase Angle Setting (Degrees)
0.25	57	0	0	DC offset	0.000	0
		1	57	Gain	0.225	0
		15	855	Gain	0.225	0
	63	48	3024	Gain	0.200	0
		95	5985	Gain	0.125	0
0.5	57	0	0	DC offset	0.000	0
		1	57	Gain	0.450	0
		15	855	Gain	0.450	0
	63	48	3024	Gain	0.400	0
		95	5985	Gain	0.250	0
1	57	0	0	DC offset	0.000	0
		1	57	Gain	0.900	0
		15	855	Gain	0.900	0
	63	48	3024	Gain	0.800	0
		95	5985	Gain	0.500	0
2	57	0	0	DC offset	0.000	0
		1	57	Gain	1.800	0
		15	855	Gain	1.800	0
	63	48	3024	Gain	1.600	0
		95	5985	Gain	1.000	0
5	57	0	0	DC offset	0.000	0
		1	57	Gain	4.500	0
		8	456	Gain	4.500	0
		15	855	Gain	4.500	0
	63	48	3024	Gain	4.000	0
		95	5985	Gain	2.500	0
10	57	0	0	DC offset	0.000	0
		1	57	Gain	9.000	0
		8	456	Gain	9.000	0
		15	855	Gain	9.000	0
		27	1539	Gain	8.000	0
	63	48	3024	Gain	8.000	0
		69	4347	Gain	5.000	0
		80	5040	Gain	5.000	0
		95	5985	Gain	5.000	0

Range (Amps)	Fundamental Frequency (Hz)	Harmonic Number	Frequency (Hz)	Point	Output Level Setting (Amps)	Output Phase Angle Setting (Degrees)
21	57	0	0	DC offset	0.000	0
		1	57	Gain	18.000	0
		8	456	Gain	18.000	0
		15	855	Gain	18.000	0
		27	1539	Gain	16.000	0
	63	48	3024	Gain	16.000	0
		69	4347	Gain	10.000	0
		80	5040	Gain	10.000	0
		95	5985	Gain	10.000	0
50	57	1	57	Gain	45.000	0
		6	342	Gain	45.000	0
		15	855	Gain	45.000	0
	63	48	3024	Gain	20.000	0
		95	5985	Gain	20.000	0
80	57	1	57	Gain	64.000	0
		6	342	Gain	64.000	0
		15	855	Gain	64.000	0
	63	48	3024	Gain	20.000	0
		95	5985	Gain	20.000	0

Table 7-10. Current Adjustment Points for 80 A Option (if fitted)

Range (Amps)	Frequency (Hz)	Harmonic Number		Setting	6100B Contribution	Measurement Std. Deviation	Combined Verification Tolerance (High)	Combined Verification Tolerance (Low)	Result
8 – 0.80	57	1	Amplitude	64 A	±8 mA				
			Phase	0°	±0.0005°				
	2961	47	Amplitude	64 A	±11 mA				
			Phase	0°	±0.002°				

Table 7-11. Voltage from Current Terminals Adjustment Points

Range (Volts)	Fundamental Frequency (Hz)	Harmonic Number	Frequency (Hz)	Point	Output Level Setting (Volts)	Output Phase Angle Setting (degrees)
0.25	57	0	0	DC offset	0.000	0
		1	57	Gain	0.225	0
		15	855	Gain	0.225	0
	63	48	3024	Gain	0.200	0
		95	5985	Gain	0.125	0
1.5	57	0	0	DC offset	0.000	0
		1	57	Gain	1.350	0
		15	855	Gain	1.350	0
	63	48	3024	Gain	1.200	0
		95	5985	Gain	0.750	0
10	57	0	0	DC offset	0.000	0
		1	57	Gain	8.000	0
		15	855	Gain	8.000	0
	63	48	3024	Gain	7.100	0
		95	5985	Gain	4.500	0

7-31. Energy Option Calibration

The Energy option is not adjustable. The performance of the option depends on the accuracy of the internal crystal oscillator. This may be measured and verified in two ways:

7-32. Using Direct Measurement with a Frequency Meter

Equipment required: a frequency meter with accuracy 2.5 ppm or better at the frequency to be measured.

1. Connect the frequency meter to the Energy Pulse Out connector.

2. Use the Channel Configuration options (see "Preparing to Use the Energy Option") to set a meter constant for the Pulse Output that will result in a known output frequency for the total system power. The Use Internal Pull-up check box should be enabled (checked) for most frequency meters. For example, Enable and set the 6100B Voltage and Current to Sine 10 V rms and 1 A rms, phase angle zero, providing 10 W rms of real power. Set the Output meter constant to 360,000 i/Wh to give an output frequency of 1 kHz.

3. Short Current Output terminals together, and ensure nothing is connected to the Voltage Output terminals. Select Free Run test mode, then press OPER.

4. Verify that the frequency meter reads the expected frequency ±(10 ppm - frequency meter accuracy in ppm).

5. Terminate the test by pressing ⌑STBY.

7-33. *Using an External Reference Frequency*

Equipment required: a pulse source with frequency accuracy 2.5 ppm or better.

1. Connect any Pulse Input channel to an accurate frequency reference source between 10 Hz and 5 MHz. The source must be suitable to drive the Pulse Inputs. See Chapter 1 for input driving specifications.

2. Enable a voltage channel. For safety reasons, ensure nothing is connected to the voltage terminals.

3. Use the Channel Configuration options (see "Preparing to Use the Energy Option") to select MUT Source to be "Channel 1 to 6 independent".

4. Press Enter to accept the Channel Configuration and select the Display Units to be Counts.

5. Begin a Free Run test by pressing the OPER key.

6. Verify that the frequency displayed for the chosen Pulse Input channel is within $\pm$(10 ppm - pulse source frequency accuracy in ppm) of the applied frequency.

7. Terminate the test by pressing [STBY].

Appendix A
Glossary

A-1. Introduction

Glossary of terms and abbreviations found in this manual or referenced documents.

Adjustment	The operation that aligns or modifies the calibrator output (or UUT indication) such that its error in relation to its published specification is minimized.
Calibration	Measurement of the calibrator (or UUT) against a defined and traceable standard using an established, documented and verifiable process with the object of determining the calibrator (or UUT) error. Implicit in this process is the ability to report the uncertainty of the measurement process in accordance with the ISO Guide to the Expression of Uncertainty in Measurement
Channel	Each output (voltage or current) is a channel. A voltage channel and a current channel together form a Phase
Dip	See Voltage Dip.
Distortion	In a waveform, any steady state deviation from the demanded shape.
EUT	Equipment Under Test
First harmonic	The first harmonic of a waveform is its fundamental frequency. Note that for the 6100B, the 1st harmonic of a waveform may have zero amplitude.
Flicker	Repetitive (voltage) level variation in the range to cause the physiological phenomenon of flicker.
Fluctuation	A change in the amplitude of a waveform which does not alter the harmonic content or phase relationships within the waveform
Harmonics	Multiples of the fundamental supply frequency

IEC 61868	Evaluation of Flicker severity
IEC 61000-3-2	Limits for harmonic current emissions (equipment input current <= 16A per phase
IEC 61000-3-3	Limits of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems (for equipment <= 16A per phase)
IEC 61000-4-7	Harmonics and interharmonics measurements
IEC 61000-4-11	Voltage dips, short interruptions and voltage variations
IEC 61000-4-14	Voltage fluctuation immunity test
IEC 61000-4-15	Flicker meter functional design specification
IEC 61000-4-30 (draft)	
Interharmonic	A frequency component of a periodic quantity (ac waveform) that is not an integer multiple of the frequency at which the system is operating.
Interruption	For a single-phase voltage, there is an interruption if the RMS(1/2) value is below 10% of the reference voltage. In a three-phase system, an interruption is when all three phases are below 10% simultaneously.
Measurement uncertainty	Where used in this document, Measurement Uncertainty is the contribution to uncertainty because of resolution of the measuring device and the randomness of the indication due to 'noise'.
MUT	Meter Under Test (used in the Energy option chapter).
Nominal voltage	The nominal voltage is the reference voltage.
Phase	A phase is the combination of a voltage channel and a current channel. The phases are identified as L1, L2 and L3. L1 is the master phase in a multi-phase system. Neutral phase is identified as N.
Phase angle	Phase angle is the angular difference between two corresponding points on two ac waveforms of the same frequency or which have frequencies which are integer multiples of each other.
Pst	Short term flicker indicator, Pst = 1 is the conventional threshold of irritability.
Reference channel	The reference channel is L1,Voltage

Reference voltage	The reference voltage is the voltage that is used for determining the depth of a dip and the height of a swell.
RMS voltage shape	The time function of the RMS voltage change evaluated as a single value for each successive half period between zero-crossings of the source voltage.
RMS(1/2)	Actual instantaneous RMS voltage: the sliding value of the RMS voltage measured over an exact period and refreshed each half period.
Sag	See Voltage Dip.
Short interruption	The disappearance of the supply voltage for a period of time typically not exceeding 1 minute.
Swell	see Voltage swell
THD	Total Harmonic Distortion
Total harmonic current	Total RMS value of the harmonic current components.
Voltage dip	A sudden reduction of the voltage at a point in the electrical system, followed by voltage recovery after a short period of time, from half a cycle to a few seconds.
Voltage fluctuation	Series of changes of RMS voltage evaluated as a single value for each successive half-period between zero-crossings of the source voltage.
Voltage swell	A sudden increase of the voltage at a point in the electrical system, followed by voltage recovery after a short period of time, from half a cycle to a few seconds.