

**HGA  
TABLE OF CONTENTS**

<b>SECTION</b>	<b>DESCRIPTION</b>	<b>PAGE</b>
1	INTRODUCTION AND SPECIFICATION .....	1
1.0	INTRODUCTION .....	1
1.1	GENERAL DESCRIPTION .....	1
2	INSTALLATION AND ACCEPTANCE .....	7
2.0	UNPACKING .....	7
2.1	POWER REQUIREMENTS.....	7
2.2	MECHANICAL INSTALLATION .....	7
2.3	CONNECTIONS.....	7
	2.3.1 INPUT WIRING .....	7
	2.3.2 CURRENT SENSE TERMINAL BLOCK.....	10
	2.3.3 EXTERNAL SENSE.....	10
	2.3.4 IEEE-488.....	10
	2.3.5 RS232.....	10
	2.3.6 SYSTEM INTERFACE .....	21
2.4	FUNCTION TEST .....	24
3	LOCAL CONTROL .....	27
3.0	GENERAL .....	27
3.1	KEY DESCRIPTION .....	27
3.2	STACKED PROGRAMMING.....	29
3.3	IMMEDIATE PROGRAMMING.....	29
3.4	MEASUREMENT .....	30
3-5	UTILITY .....	32
	3.5.1 LCD.....	33
	3.5.2 GPIB LISTEN ADDRESS .....	33
	3.5.3 RS232 CONFIGURATION.....	33
	3.5.4 SETUPS.....	35
4	REMOTE PROGRAMMING.....	36
4.0	GENERAL .....	36
4.1	STEADY STATE PROGRAMMING.....	36
	4.1.1 VOLTAGE PROGRAMMING.....	36
	4.1.2 FREQUENCY PROGRAMMING.....	37
	4.1.3 CURRENT LIMIT PROGRAMMING.....	37
	4.1.4 PHASE ANGLE PROGRAMMING.....	38
	4.1.5 WAVEFORM SHAPE.....	38
	4.1.6 EXTERNAL SYNCHRONIZATION.....	38
	4.1.7 VOLTAGE SLEW .....	39
	4.1.8 FREQUENCY SLEW.....	39

SECTION	DESCRIPTION	PAGE
4.2	TRANSIENT PROGRAMMING.....	39
	4.2.1 STEP PROGRAMMING.....	40
	4.2.2 PULSE PROGRAMMING.....	41
	4.2.3 LIST PROGRAMMING.....	42
4.3	TRIGGER CONTROL.....	43
4.4	MEASUREMENT.....	43
	4.4.1 RMS VOLTAGE, CURRENT AND POWER MEASUREMENTS.....	44
	4.4.2 PEAK CURRENT MEASUREMENT.....	44
	4.4.3 APPARENT POWER, POWER FACTOR AND CREST FACTOR MEASUREMENT.....	45
	4.4.4 HARMONIC MEASUREMENTS AND HARMONIC DISTORTION.....	45
4.5	CALIBRATION.....	46
5	HGA SCPI COMMAND REFERENCE.....	47
	5.0 GENERAL.....	47
	5.1 NOTATION.....	47
	5.1.1 PARAMETER ABBREVIATIONS.....	47
	5.1.2 RESPONSE FORMAT ABBREVIATION.....	47
	5.2 SYSTEM.....	48
	5.3 OUTPUT SUBSYSTEM.....	49
	5.4 SOURCE SUBSYSTEM.....	50
	5.5 LIMIT SUBSYSTEM.....	64
	5.6 INITIAL SUBSYSTEM.....	66
	5.7 TRACE SUBSYSTEM.....	68
	5.8 LIST SUBSYSTEM.....	71
	5.9 PULSE SUBSYSTEM.....	78
	5.10 TRIGGER SUBSYSTEM.....	80
	5.11 MEASUREMENT SUBSYSTEM.....	84
	5.12 CALIBRATION SUBSYSTEM.....	89
	5.13 SCPI COMMON COMMANDS.....	94
6	CALIBRATION AND ADJUSTMENT.....	98
	6.0 GENERAL.....	98
	6.1 TEST EQUIPMENT.....	98
	6.2 OUTPUT VOLTAGE CALIBRATION.....	98
	6.3 CURRENT BURDEN ADJUSTMENT.....	101
	6.4 MEASUREMENT CALIBRATION.....	102
	6.4.1 VOLTAGE CALIBRATION.....	102
	6.4.2 CURRENT CALIBRATION.....	102
	6.4.3 PEAK CURRENT CALIBRATION.....	103
	6.4.4 POWER CALIBRATION.....	103

SECTION	DESCRIPTION	PAGE
	6.4.5 HARMONIC FILTER TUNE UP AND GAIN ADJUSTMENT.....	104
	6.4.6 VOLTAGE HARMONIC CALIBRATION.....	104
	6.4.7 CURRENT HARMONIC CALIBRATION.....	105
6.5	CURRENT LIMIT CALIBRATION .....	105
6.6	LOAD BALANCE ADJUSTMENT .....	105
6.7	80/160 AMPS CURRENT RANGES .....	105
7	THEORY OF OPERATION .....	107
7.0	GENERAL .....	107
7.1	OVERALL DESCRIPTION.....	107
7.2	DIGITAL BOARD .....	109
7.3	ANALOG BOARD.....	109
7.4	BASIC MEASUREMENT BOARD .....	109
7.5	HARMONIC MEASUREMENT BOARD.....	109
7.6	CONTROL BOARD.....	109
7.7	CURRENT SENSE BOARD.....	109
8	GRAPHICAL USER INTERFACE.....	110
8.0	INTRODUCTION .....	110
8.1	SYSTEM REQUIREMENT .....	110
8.2	GUI INSTALLATION.....	110
8.3	RS232 INTERFACE .....	110
8.4	GPIB INTERFACE.....	111
8.5	INTERFACE CONFIGURATION .....	115
8.6	GUI OPERATION.....	116

**LIST OF ILLUSTRATIONS**

<b>FIGURE</b>	<b>DESCRIPTION</b>	<b>PAGE</b>
2-1	Overall View of HGA .....	8
2-2	Rear Panel of HGA .....	9
2-3-1	System Interconnect 751L/1501L.....	11
2-3	System Interconnect 751L/1501L with Output Switch .....	12
2-3-3	System Interconnect 2750L/4500L .....	13
2-3-4	System Interconnect 2750L/4500L with Output Switch.....	14
2-3-5	System Interconnect FCS18 .....	15
2-3-6	System Interconnect FCS18 with Output Switch.....	16
2-3-7	System Interconnect 3001TCA Single Phase .....	17
2-3-8	System Interconnect 3001TCA Single Phase with Output Switch .....	18
2-3-9	System Interconnect 3001TCA Three Phase .....	19
2-3-10	System Interconnect 3001TCA Three Phase with Output Switch .....	20
2-4	Function Sync Connections .....	24
2-5	Function Setup.....	26
3-1	Front Panel Controls and Indicators.....	28
6-1	Adjustment Potentiometers and Test Points .....	99
6-2	Output Function Test Connections .....	100
7-1	Block Diagram of HGA .....	108

**LIST OF TABLES**

<b>TABLE</b>	<b>DESCRIPTION</b>	<b>PAGE</b>
2-1	Connection between HGA and Personal Computer .....	21
2-2	Connection between HGA and Personal Computer .....	21
2-3	System Interface (J3).....	22
6-1	Current Burden Adjustments .....	101
6-2	80/160 Amps Current Ranges Test Points and Adjustment Pots	105

## SECTION 1

### INTRODUCTION AND SPECIFICATION

#### 1.0 INTRODUCTION

This instruction manual contains information on the installation, operation, calibration, and maintenance of the HGA with an AC source system. The AC source instruction manual should be used only when the HGA manual refers to the AC source manual.

#### 1.1 GENERAL DESCRIPTION

The HGA is a waveform, harmonic and transient generator producing with a complete measurement subsystem. The HGA will interface with many AC power sources to produce a programmable power system with harmonic generator and harmonic analyzer.

The HGA gives an AC power source the following capabilities

- Programmable AC voltage, Frequency, Phase Angle (3-phase system) and Current Limit.
- Sine, Clipped sine, user defined waveforms and square waves (if capable by the AC source).
- Voltage and Frequency slew control.
- Synthesized waveform generation with high resolution, accuracy and low distortion.
- Step and Pulse output transients for generating surge, sag, dropout and other line disturbance simulation.
- Programmable lists for generation of complex output transients or test sequences
- Extensive measurement capabilities of:

AC rms Voltage and Current

Peak Current

Real and Apparent Power

Harmonic analysis of voltage and current up to the 49th harmonic

Total harmonic distortion calculation

## **California Instruments**

- Trigger transient on phase angle or external bus command.
- External source synchronization.
- External Voltage Amplitude Modulation
- Nonvolatile state and waveform storage
- IEEE488 and RS232 Interface with SCPI command language.
- Over and under voltage, overcurrent and overtemperature shutdown.
- Remote shut down signal input
- Software Calibration.

## ARBITRARY WAVEFORM GENERATOR/CONTROLLER SPECIFICATION

### ELECTRICAL

**Input** (Nominal line voltage, 50 or 60 Hz, unless specified otherwise)

Line Voltage	103 - 127 VAC, 207 - 253 VAC user selectable
Line Current	0.5A/0.25A (1 amp fuse)
Line Frequency	47 - 63 Hz
Isolation Voltage (input-chassis)	1350 VAC

Refer to the AC source specification for its input specification.

**Output** (when used with external amplifier)

Number of Phases	1 or 3
Voltage Range	0 to 312V
Total Harmonic Distortion	Refer to AC source Output specification
Line Regulation (10% change)	2%
Load Regulation (100% load change)	0.5 %
Voltage Accuracy	0.4 %
Voltage stability	±0.25% over 24 hrs, constant line, load and temperature.
Fundamental Frequency Range	45 - 66 Hz
Frequency Temperature Coefficient	±5 ppm
Frequency Stability	±15 ppm of value per year

### **Protection**

Refer to AC source protection specification

### **Measurements (23° C ±5° C)**

	Range	Resolution	Accuracy
Voltage	0 - 312V	0.1V	0.5V
Current	0 - 16A	0.01A	0.05A
	0 - 160A (Opt)	0.1A	0.5A
Peak Current	80A	0.02A	2.4A
	800A (Opt)	0.2A	24A
Power	0 - 4kW	0.001kW	0.005kW
	0 - 40kW (Opt)	0.01kW	0.05kW
Apparent Power	0 - 4kVA	0.001kVA	Not specified
	0 - 40kVA (Opt)	0.01kVA	Not specified
Power Factor	0 - 1	0.001	Not specified
Frequency	45 - 66Hz	0.01Hz	0.02Hz
Phase Angle (at V>20)	0 to 359°	0.1°	2°
Individual Harmonic Voltage	0 to 312V	0.1V	1.0V



Measurements (23° C ±5° C) Accuracy	Range	Resolution	
Individual Harmonic Current	0 to 16A	0.005A	48mA
	0 to 8A	0.003A	
	0 to 4A	0.002A	
	0 to 2A	0.001A	
Total Harmonic Distortion (Voltage and Current)	0 to 80A (Opt)	0.03A	240mA
	0 to 160A (Opt)	0.05A	480mA
Harmonic Bandwidth	0 - 100%	0.1%	1%
Harmonic Measurement Time	2nd to the 49 <sup>th</sup> harmonic for a fundamental frequency of 45 to 66 Hz		
	8 seconds (to measure all harmonics)		

### Control

#### Front Panel Control

Voltage, Frequency, Current Limit, Listen Address and single-phase/three-phase. All phases are programmed simultaneously. Measurement of voltage, current, power, and frequency.

Function Selection Keys	Set, measure, voltage, freq, current, power, utility, execute, cursor control and numerical control knob.
Display Indicators	2 x 16 Backlit LCD, 4.8mm x 9.6mm character size Power On, Remote

#### Computer Control

##### I. IEEE-488.1 (GPIB)

Subset:

SH1, AHI, T6, L3, SR1, RL1, DC1, DT1

Code and Format:

Conform and Support Common Commands defined by IEEE-488.2

##### II. RS232

1. Data Format  
Same as GPIB
2. Baud Rate  
Up to 9600 bauds

##### III. Language

SCPI (Standard Command for Programmable Instruments)

#### IV. Functions (with L Series Power System)

	Range	Resolution	Accuracy	Initialization
Voltage	0 to 312 Vrms	0.1V	0.4%	00
Frequency	45 to 66 Hz	0.01Hz	.005%	60 Hz
Phase Angle	0 to 360°	1°	2°	0 to 360
Harmonic Distortion				
(Flat Top)	0 to 20%	1%	2%	0%

Single/Multiple Harmonic Voltage Generation 2-49<sup>th</sup> (for a fundamental frequency of 45 to 66 Hz). Any harmonic may be programmed from 0 to 100%.

Transient: Use the List, pulse or step subsystem for voltage, frequency, current limit and phase angle transient with slew capabilities for both voltage and frequency.

Waveform files down loaded:

Ability to store up to 18 downloaded waveforms 4096 points each.

Programmable transient start point.

Calibration Measured voltage, current, power, harmonic voltage, harmonic current and output phase angle.

Diagnostics (Self Test) Ram Test, ROM sum check

Storage Store up to 4 steady state setups

Status Byte IEEE488.2 Status Subsystem

#### External Control

Modulation 0 to 10Vrms = 10% amplitude modulation, DC to 550 Hz, simultaneous on 3ø system

Shutdown Logic low

Sync Input TTL waveform to sync phase A output. Output frequency locks to the input sync from 45 Hz to 66 Hz.

Output Signals: Sync output, TTL output active high for 500 usec, 1.5 mA sink to indicate the beginning or end of transient.

#### Features

- Remote Sense
- Calibration of measurement and output phase offset - from Computer Bus
- Output Relay control - from Computer Bus
- Current Limit/Current Limit Delay

## Options

High Current range - 160A  
Single/Three-phase Programmable  
Drop out switch (Independent output dropout for each phase)

## Systems

Compatible with California Instruments Models 4500L, 2750L, 1501L, 751L, 3001TCA and FCS series. Consult factory for other compatible manufacturers' AC power sources.

### **MECHANICAL** (HGA controller only)

Dimensions	3 1/2"(88.9mm)H x 17"(431.8mm)W x 22"(558.8mm)D
Weight	35 lbs.(15.9Kgm)
Material	Steel
Finish	Zinc Plate, Front Panel Gray paint
Air Intake/Exhaust	Sides/Rear
Connectors	
- Input	IEC320-C14 AC Receptacle
- Sense	1-480705-0 AMP
- AC Power Source	
Interface	3M3367-1000
- IEEE/488	3M3549-1000
- RS232	9 Pins DB9 male
Chassis Slides	Zero P/N C300-S-18

Refer to AC power source user manual for AC source Mechanical specification.

### **ENVIRONMENTAL**

Operating Temperature	0 to 50°C
Storage Temperature	-40 to +85°C
Operating Altitude	7500 ft.
Vibration	Commercial transportation levels
Shock	Commercial transportation levels
Acoustic Noise	65 dBA, 3 ft.

Refer to AC power source user manual for AC source Environment specification.

## **SECTION 2**

### **INSTALLATION AND ACCEPTANCE**

#### **2.0 UNPACKING**

Inspect the unit for any possible shipping damage immediately upon receipt. If damage is evident, notify the carrier. DO NOT return an instrument to the factory without prior approval. Do not destroy the packing container until the unit has been inspected for damage in shipment.

#### **2.1 POWER REQUIREMENTS**

The HGA has been designed to operate for single-phase AC line voltage. The HGA can operate from input voltage line from 103 volts to 127 volts in the 115 voltage range or from 207 volts to 242 volts on the 230 volt range. The input line frequency may be between 47 Hz and 66 Hz.

**Refer to AC source manual Section 2 for power requirements for the AC source.**

#### **2.2 MECHANICAL INSTALLATION**

The HGA is designed for rack mounting in a standard 19 inch rack. The unit should be supported from the sides with optional rack slides. Refer to Section 1, under Mechanical specifications for the proper chassis slides. The cooling fan at the rear of the unit must be free of any obstructions which would interfere with the flow of air. A 2.5 inch clearance should be maintained between the rear of the unit and the rear panel of the mounting cabinet. The air intake holes on the sides of the HGA must not be obstructed. See Figure 2.1

#### **2.3 CONNECTIONS**

##### **2.3.1 INPUT WIRING**

Refer to Figure 2-2 for the HGA rear panel connections.

The HGA Input connector uses a standard IEC320-C14 AC Receptacle. The HGA operates from nominal 115 volts AC or 230 Volts AC. To change the input voltage range, locate F1 power input selector on the rear panel. Pull out the printed circuit board located under the fuse. Rotate the printed circuit board and insert it so that the desired voltage range is shown when the board is in its place. Do not use other voltage range positions except the 120 and 240 volts selections.

**Refer to AC source manual Section 2 for input wiring for the AC source.**

Figure 2-1 Overall view of HGA

Figure 2-2 Rear Panel

### **2.3.2 CURRENT SENSE TERMINAL BLOCK**

Figure 2-1 shows the overall view of the HGA.

The output of the AC source is routed through the HGA to sense the current. TB1 terminal block connects to the output of the power source in use, and terminal block TB2 is the output terminal that connects to the load. Refer to the AC power source manual in use with the HGA for the correct wire size and length. Refer to Figures 2-3-1 through 2-3-10 for the proper connections with various power sources.

### **2.3.3 EXTERNAL SENSE**

To ensure correct voltage regulation, the sense input must be connected to either the load or the output of the AC source.

J1 is the external sense input connector. The external sense input must be connected to the output of the AC source or to TB2 of the current sense terminal block. If the sense inputs are not connected to the output of the AC source or the load, the output voltage will fault.

The following table identifies the pins of J1 connector and the proper connection.

1-phase A sense HI	phase A output HI
2-phase B sense HI	phase B output HI
3-phase C sense HI	phase B output HI
4 Neutral sense	Neutral output
(Low output for single phase power source)	

### **2.3.4 IEEE-488**

J2 is the IEEE-488 (GPIB) connector for the HGA.

### **2.3.5 RS232**

J4 is the RS232 connector for the HGA.

Refer to the Tables 2-1 and 2-2 for the proper connection between the HGA and the personal computer.

Figure 2-3 Connections between HGA and Power Sources



Figure 2-3 Connections between HGA and Power Sources

Figure 2-3 Connections between HGA and Power Sources

Figure 2-3 Connections between HGA and Power Sources

Figure 2-3 Connections between HGA and Power Sources

Figure 2-3 Connections between HGA and Power Sources

Figure 2-3 Connections between HGA and Power Sources

Figure 2-3 Connections between HGA and Power Sources

Figure 2-3 Connections between HGA and Power Sources



Figure 2-3 Connections between HGA and Power Sources

SIGNAL	IBM PC DB-25 FEMALE	HGA DP9 FEMALE
RXD	2	2
TXD	3	3
DTR	5	4
RTS	6,8	7
GND	7	5
CTS	20	8

TABLE 2-1

SIGNAL	IBM PC DB-9 FEMALE	HGA DP9
RXD	3	2
TXD	2	3
DTR	8	4
RTS	6,1	7
GND	5	5
CTS	4	8

TABLE 2-2

### 2.3.6 SYSTEM INTERFACE

J3 is the System Interface connector. Table 2-3 identifies the pins of the System Interface connector.

TABLE 2-3

## SYSTEM INTERFACE CONNECTOR (J3)

- J3-1 ANALOG COMMON: This is the common for all analog signals on the connector.
- J3-2 MR B: This is the input signal to the phase B amplifier from the internal oscillator drive signal. Make no connection to this pin except for troubleshooting.
- J3-3 ANALOG COMMON: See J3-1.
- J3-4 CS B: Current sum for the phase B output. Make no connections to the pin.
- J3-5 CT COMMON:
- J3-6 OS B: This is the output from the internal phase B oscillator. Use this pin as an input if an oscillator is not installed. A 5.0 Vrms signal will generate a full- scale output voltage.
- J3-7 ANALOG COMMON: See J3-1.
- J3-8 CL B: A DC level from the oscillator used to set the current limit for phase B. Make no connection to the pin.
- J3-9 External modulation input. A 10 Vrms signal input will amplitude modulate the output 10% of the programmed output voltage. Use J3-1 for common.
- J3-10 A logic low output to indicate an over temperature condition. Make no connection to the pin.
- J3-11 Output relay control indication. This is an output logic line that indicates the state of the output relay. A logic low indicates the output relay is open. Make no connection to the pin.
- J3-12 FLT C: Make no connections.
- J3-13 FLT A: Make no connections.
- J3-14 F STB LO: Function Sync Low signal. This is the emitter lead of an optically isolated NPN transistor. The internal power controller turns this transistor on to indicate a change of programmed values.
- J3-15 EX SYNC LO: External Sync Low signal. This is the ground return for the TTL external sync input. It connects to the cathode of an LED at the input of an optocoupler. Refer to J3-32.

- J3-16 Solid State control of phase B. Make no connection.
- J3-17 Single phase and three phase control. No connection.
- J3-18 No connection.
- J3-19 MR C: This is the input signal to the phase C amplifier from the internal oscillator drive signal. Do not make any connection to this pin except for troubleshooting.
- J3-20 MR A: This is the input signal to the phase A amplifier from the internal oscillator drive signal. Do not make any connection to this pin except for troubleshooting.
- J3-21 CS C: Current sum for the phase C output. Make no connection to this pin. Not used for standard configuration.
- J3-22 CS A: Current sum for the phase A output. Make no connection to this pin. Not used for standard configuration.
- J3-23 OS C: This is the output from the internal phase C oscillator reference. Make no connection except for Troubleshooting.
- J3-24 OS A: This is the output from the internal phase A oscillator reference. Make no connection except for Troubleshooting.
- J3-25 CL C: A DC level from the oscillator used to set the current limit for phase C. Make no connection to the pin.
- J3-26 CL A: A DC level from the oscillator used to set the current limit for phase A. Make no connection to the pin.
- J3-27 D COM: Digital common.
- J3-28 A logic output from the internal oscillator to control the range relays. A logic low on this pin indicates the high voltage range. If the power system is used without an oscillator, this pin is a logic input.
- J3-29 Make no connection.
- J3-30 FLT B: Make no connection.
- J3-31 F STB HI: Function Sync High signal. This is the collector lead of an optically isolated NON transistor. The internal power controller turns this transistor on to indicate a change of programmed values. This output will sink more than 2 milliamps to a TTL low logic output level (<.4 volts). The output is an open, collector optocoupler output. A pullup resistor to a + VDC

must be connected to J3, pin 31. J3, pin 14, is the common output. Refer to Figure 2-4.

- J3-32 EX SYNC HI: External Sync HI signal. This is an input that can be used to synchronize the outputs of the AC Power System. This input requires a logic high level of at least +4.5 VDC at 5 Ma. The input should have a duty cycle  $50 \pm 30\%$ . J3-15 is the common input. The External Sync input is optically isolated. It must also be enabled from the SNC screen.
- J3-33 Solid state control for phase A, make no connection.
- J3-34 Solid state control for phase C, make no connection.
- J3-36 Remove shutdown. Control this pin to digital ground. J3-27 will cause the output voltage to go to zero voltage.

Figure 2-4

## FUNCTION SYNC CONNECTIONS

### 2.4 FUNCTION TEST

Refer to Figure 2-5 for the test setup.

Perform the following test sequence.

1. Apply Input power to both the HGA and the power source. Refer to Figure 2-3 for proper connections between the HGA and the power source.
2. Verify that the power-on lamps are lit for both the HGA and the Power source.
3. From the front panel program the output voltage to full scale volts. Use the Voltage key and the left or right arrow with the knob to reach the program value. Verify the output voltage is about full scale volts.
4. Skip step 5 and 6 if the power source is not equipped with a voltage range change.
5. From the front panel keypad, select UTILITY key and rotate the knob to select SETUP. Press

the right arrow twice and rotate the knob to select the High voltage. Notice the power source high range LED is lit.

6. From the front panel program the output voltage to full scale volts at the high voltage range. Use the voltage key and the left or right arrow with the knob to reach the program value. Verify the output voltage is at full scale volts.
7. Observe each of the outputs with oscilloscope or distortion analyzer. The output should be clean sine wave with less the 1% distortion.
8. Apply full scale voltage to each phase for a three phase system or on phase A only for a single-phase system. Apply a full load and verify that the output voltage remains within 0.5% of full scale voltage at the no load condition.
9. Program the current limit to 80% of the full scale current and notice the output fault to 0 volts.

Figure 2-5 Function Setup

## **SECTION 3**

### **LOCAL CONTROL**

#### **3.0 GENERAL**

The front panel consists of a 2 line LCD with a backlit display, 8 function keys, 2 keys for cursor control, rotary encoder and a remote LED. For 3Ø models, all phases are programmed to the selected values. Measured parameters are performed for all three phases. The rotary control allows individual phase measurements to be selected. See Figure 3-1 for front panel layout.

#### **3.1 KEY DESCRIPTIONS:**

- SET** This key is used to allow stacking of programmable parameters. These parameters are Voltage, Frequency and Current. The entered values are not executed until the EXECUTE key is activated.
- MEASURE** This key is used to activate the measured parameter. These parameters are Voltage, Frequency, Current and Power. The measurement is activated when the EXECUTE key is activated after a parameter selection.
- VOLTAGE** This key is used to program the output voltage or measure the sensed voltage. The MEASURE key defines its function. All three phases are measured. The knob is used to view phase B and Phase C measurement.
- FREQ** This key is used to program the output frequency or measure the sensed frequency. The MEASURE key defines its function.
- CURRENT** This key is used to program the current limit or measure the rms load current. The MEASURE key defines its function. All three phases are measured. The knob is used to view phase B and Phase C measurement.
- POWER** This key is used to measure the rms power if preceded with the MEASURE key. All three phases are measured. The knob is used to view phase B and Phase C measurement.
- UTILITY** This Utility key will access the control of LCD View angle, GPIB listen address, RS232 configuration and the setup for voltage range and single or three phase configuration. The left and right arrow key pads and the knob are used to establish the selection.



Figure 3-1 Front Panel

## **3.2 STACKED PROGRAMMING:**

The **SET** key allows stacking of the programmable parameters before execution. After power is on press the SET key. The following message will appear on the screen:

Set  
Voltage

To program the output voltage press the VOLTAGE key. The following message will appear on the screen as follows:

Set  
Volt = 0.0 V

To set the desired output value rotate the knob clockwise to increase the value and counterclockwise to decrease the value. To increase or decrease the incremental size of the steps use the left arrow or the right arrow respectively. The output voltage does not change at this point.

To program the output frequency press the **FREQ** key after the **SET** key. The following message will appear on the screen:

Set  
Freq = 50.00 Hz

To set the desired frequency use the knob and the left and right arrows as the voltage programming.

To program the current limit value press the **CURRENT** key after the **SET** key. The following message will appear on the screen

Set  
Curr = 12.1 A

To change the current limit setting use the knob and the left and right arrows.

To execute all the stacked parameters, press the **EXECUTE** key. All output parameters will change to the program setting values.

## **3.3 IMMEDIATE PROGRAMMING**

Immediate programming is accomplished by selecting the desired function key and dialing the program value using the knob and the left and right arrow keys.

To program the output voltage select the **VOLTAGE** key. The following message will appear on the

display:

Immediate  
Volt = 100.0 V

To change the output voltage use the right and left arrow to control the size of the steps and rotate the knob to the right or to the left to increase or decrease the output voltage. The output voltage will change immediately with the change in the displayed value.

To program the output frequency select the **FREQ** key. The following message will appear on the screen.

Immediate  
Freq = 60.00 Hz

To change the output frequency use the knob and the right and left arrow. The output frequency will change immediately with the change in the displayed value.

To program the current limit select the **CURRENT** key. The following message will appear on the screen.

Immediate  
Curr = 11.2 A

To change the current limit setting use the knob and the left and right arrows.

### **3.4 MEASUREMENT**

Measurement are accomplished by selecting the **MEASURE** key followed by one of the measurement functions key and the **EXECUTE** key. When the measurement are completed use the knob to view the measurement for each phase.

Press the **MEASURE** key. The following message will appear on the screen.

Measure  
Volt = OFF

To measure the voltage, press the **VOLTAGE** key. The following message will appear on the screen.

Measure  
Volt = ON

To start the measurement press the **EXECUTE** key. The following message will appear on the screen

Measuring . . .

The message will remain until the measurements are completed and the display will show phase A measurement in the following format:

Measured  
Volt A = 115.0

To view the measured value for phase B and phase C, rotate the knob clockwise once or twice.

To measure the frequency, press the MEASURE key followed by the FREQ key and the following message will appear on the screen.

Measure  
Freq = ON

To start the measurement press the EXECUTE key. The message Measuring... will appear on the screen until the measurement is completed. The display will show the measured frequency value as follows:

Measured  
Freq = 50.0 Hz

To measure current, press the MEASURE key followed by the CURRENT key. The following message will appear on the screen.

Measure  
Curr = ON

To start the measurement press the EXECUTE key. The message Measuring... will appear on the screen until the measurement are completed. The display will show the measured current value as follows:

Measured  
Curr A = 11.5 A

To view the measured value for phase B and phase C current, rotate the knob clockwise.



To measure power, press the MEASURE key followed by the POWER key. The following message will appear on the screen.

Measure  
Power = ON

To start the measurement, press the EXECUTE key. The message Measuring ... will appear on the screen until the measurement are completed. The display will view the measured value as follows:

Measured  
Power A = 1.20 Kw

To view phase B and phase C measurements, rotate the knob clockwise.

### 3.5 UTILITY

The utility key will control the following functions:

- |    |   |              |
|----|---|--------------|
| 1. | LCD viewing angle control               | LCD          |
| 2. | GPIB listen address                     | GPIB         |
| 3. | Serial communication configuration      | RS232        |
| 4. | Voltage Range and single or three-phase | SETUP        |
|    | Range change                            | SETUP: RANGE |
|    | Single or three-phase configuration     | SETUP: Mode  |

To select the utility, press the UTILITY key. The following message will appear on the display.

Utility  
LCD

To select any of the functions listed above, rotate the knob clockwise until the desired function appears on the screen.

#### 3.5.1 LCD

This function will control the view angle of the LCD display. Press the right arrow. The display will appear in the following format:

Util:LCD  
Cont = 5.0

The value that appears on the screen is a value between 0 and 10. Changing this value will affect the viewing angle. To change the value use the left or right arrow and the knob. Note a value less than 4 will cause the display characters to disappear from the screen.

### 3.5.2 GPIB LISTEN ADDRESS

If the display does not show the main utility menu, press the left arrow to go to the main menu. Rotate the knob until the display shows as follows:

```
Utility
GPIB
```

Press the right arrow. The display will show the following:

```
Util:GPIB
Address
```

Press the right arrow one more time to display the GPIB listen address

```
Util:GPIB
Adr = 16
```

Rotate the knob to change the listen address to the desired address.

Press the left arrow once and rotate the knob clockwise to select the listen only mode and the display will show as follows:

```
Util:GPIB
ListenOnly
```

### 3.5.3 RS232 CONFIGURATION

If the display does not show the main utility selection, press the left arrow. Rotate the knob until the following menu is shown:

```
Utility
RS232
```



Press the right arrow to view the various RS232 parameter selections. Rotate the knob to select the desired parameter. The display will show the following screen each time the knob advances.

Util:RS232  
Baud Rate

Util:RS232  
Parity Bit

Util:RS232  
Bits

Util:RS232  
Handshake

Pressing the right arrow for any one of the above screens will display their parameters as follows:

Util:RS232  
Baud = 9600

Rotate the knob to select 1200, 2400 or 9600 baud.

Util:RS232  
Parity = None

Rotate the knob to select between None, Odd or Even.

Util:RS232  
Bits = 8D1S

Rotate the knob to select between 8D1S, 8D2S, 7D1S or 7D2S. Where the D is the number of bits and S number of stop bits. **Selecting 7 data bits could cause problems. Some of the data require 8 data bits.**

Util:RS232  
HandShk = HW

Rotate the knob to select HW or SW. **HandShake must always be HW.**

### 3.5.4 SETUPS

If the display does not show the main utility selection, press the left arrow. Rotate the knob until the following menu is shown:

Utility  
SETUP

Use the right arrow to enter the SETUP menu. Rotating the knob will display the following selection:

Util:SETUP  
Range

Util:SETUP  
Mode

Press the right arrow key when any of the above is visible to select one of its parameters.

Util:SETUP  
Range = Low

Rotate the knob to select Low or High Voltage range. This selection is only allowed if the option is enabled. This option is power source dependent.

Util:SETUP  
Mode = 1 Phase

Rotate the knob to select 1-Phase or 3-Phase configuration. This selection is only allowed if the option is enabled. This option is power source dependent.



## SECTION 4

### REMOTE PROGRAMMING

#### 4.0 GENERAL

Remote programming can be achieved from the GPIB or from the RS232. The Listen Address must be set properly from the Local Control. Refer to Section 3.5.2 under Utility for Listen Address setting.

RS232 setup must be set for the proper baud rate and data format. Data should be set to 8 bits to ensure proper download of waveforms. Refer to Section 3.5.3 for RS232 setup. Refer to Section 8.6.1 for RS232 and GPIB setup examples. <sp> will be used throughout the programming examples. This symbol means a space is required.

#### 4.1 STEADY STATE PROGRAMMING

For AC sources with Output Relay, closing the relay is required with the following command:

```
OUTPUT <sp> ON.
```

##### 4.1.1 VOLTAGE PROGRAMMING

The output voltage of the power source is controlled with the voltage command. To set the output Voltage for phase A to 115 volt, use the following command:

```
VOLT1<sp>115   or  
VOLT<sp> 115
```

To program all three outputs to the same voltage simultaneously, the coupling is set to all with the following command.

```
COUP<sp>ALL
```

To find the maximum output voltage the HGA will accept, use the following command.

```
VOLT1?<sp>MAX
```

To change the output voltage range to the high range use the following command:

```
VOLT1:RANG<sp>HIGH
```

### 4.1.2 FREQUENCY PROGRAMMING

The output frequency of the HGA is controlled by the **FREQ** command. To change the output frequency to 60 Hz use the following command.

```
FREQ<sp>60
```

To find the maximum frequency program value, query the HGA with the following command

```
FREQ?<sp>MAX
```

To find the minimum frequency program value, query the HGA with the following command.

```
FREQ?<sp>MIN
```

### 4.1.3 CURRENT LIMIT PROGRAMMING

The Current Limit for the power source is controlled by the **CURR** command. To change the current limit of phase A to 5 amps use the following command:

```
CURR1<sp> 5 or  
CURR<sp> 5
```

To find the maximum current the power source could provide, use the following command.

```
CURR?<sp>MAX
```

To change the current for all three phases simultaneously, set the coupling to **ALL** with the following command:

```
COUP<sp>ALL
```

To change the current limit for all three phases to 4 amps use the following command after the coupling is set to all.

```
CURR<sp>4
```

To change the current for individual phase, change the coupling to **NON** with the following command:

```
COUP<sp>NON
```

#### 4.1.4 PHASE ANGLE PROGRAMMING

The Output Phase Angle of the HGA can be controlled with the PHASE command. To change the phase angle of phase B to 90°, use the following command:

```
PHAS2<sp>90
```

#### 4.1.5 WAVEFORM SHAPE

The waveform shape could be a sine wave, a clipped sine wave or one of the 18 waveforms stored in the HGA memory. The clip level is defined by the percentage distortion.

The following command will program the output waveform to a sine wave with a clip level that produces a 5% distortion.

```
FUNC:CSD<sp>5
```

To program the output to sine wave use the following command:

```
FUNC<sp>SIN
```

The following command will program the output waveform with a waveform that is stored in the HGA memory:

```
FUNC "WAVE1"
```

Where WAVE1 is a custom waveform loaded previously.

#### 4.1.6 EXTERNAL SYNCHRONIZATION

The output frequency can be locked to external frequency source in value and phase. The external frequency source must be a TTL level and a frequency within the frequency range of the HGA.

The following command will lock the internal frequency to the external source.

```
FREQ:MODE<sp>SENS
```

To change the frequency to internal, use the following command:

```
FREQ:MODE<SP>FIX
```

#### 4.1.7 VOLTAGE SLEW

The interface has the ability to control the voltage slew rate of the HGA. This could be used to generate a voltage ramp. The voltage slew rate is set for maximum at the power up. To change the slew rate of phase A voltage to 100 volts per second, the following command is used.

```
VOLT1:SLEW<sp>100
```

To set the slew rate to a maximum the following command is used:

```
VOLT1:SLEW<sp>MAX
```

The slew rate applies to all voltage program changes in FIXed, STEP or PULSe subsystems.

#### 4.1.8 FREQUENCY SLEW

The interface has the ability to control the frequency slew rate of the HGA. This could be used to generate frequency ramps. The frequency slew rate is set for maximum at the power up. To change the frequency slew rate to 10 Hz per second, the following command is used.

```
FREQ:SLEW<sp>10
```

To set the frequency slew rate to a maximum the following command is used:

```
FREQ:SLEW<sp>MAX
```

The slew rate applies to all frequency program changes in FIXed, STEP or PULSe subsystem.

### 4.2 TRANSIENT PROGRAMMING

The interface has three modes to generate output transient:

- Fixed: Does not respond to the trigger command.
- Step: A single triggered output change from the Fixed value to the Step value.
- Pulse: A transient change will return to its original fixed value after some time period.
- List: A sequence of amplitude data, each with an associated dwell time or paced by triggers.

The output transients are useful to generate a complex of output changes with precise timing. The transient could be triggered with an internal or external command and at a specific phase angle of the waveform.

The following parameters can be used in transient definitions.

Voltage, Frequency, Current Limit, Phase Angle, Voltage slew and Frequency slew.

#### 4.2.1 STEP PROGRAMMING

The following example will set the output voltage for phase A to 115 volts and the start angle of 90°.

If you are not sure of the states of the transient parameter, use the reset command to initialize the system to the initial condition.

```
*RST
```

Close the output relay if the power source is equipped with an output relay.

```
OUTPUT<sp>ON
```

Set the voltage mode to STEP.

```
VOLT1:MODE<sp>STEP
```

Set the voltage trigger level to 115 Volts.

```
VOLT1:TRIG<sp>115
```

Set the trigger arm source to immediate

```
TRIG:ARM:SOUR<sp>IMM
```

Set the trigger source to internal, the transient will start at specific phase angle.

```
TRIG:TRIG:SOUR<sp>INT
```

Set the triggered phase angle to 90°.

```
TRIG:TRIG:PHAS<sp>90°
```

To initiate the transient with the following command:

```
TRIG:INIT
```

To step the output voltage from 0 volts to 115 voltage with a slew rate of 1000 volts per

second and the sequence initiated with the trigger command, use the following sequence:

```
VOLT1:MODE<sp>STEP
VOLT1:TRIG<sp>115
VOLT1:SLEW:MODE<sp>STEP
VOLT1:SLEW:TRIG<sp>1000
TRIG:TRIG:SOUR<sp>IMM (Default setting)
TRIG:INIT
```

Frequency steps can be achieved in the same way as the voltage steps example above. **No slew rate commands are associated with the phase and current step.**

#### 4.2.2 PULSE PROGRAMMING

The following example will show how to step the output voltage for all three phases from 115 volts to 135 volts for one cycle and return to 115 volts.

Set the output voltage and frequency to 115 volts and 50 Hz.

```
COUP<sp>ALL
FREQ<sp>50
VOLT<sp>115
```

Set the voltage mode to pulse and the voltage trigger value to 135.

```
VOLT:MODE<sp>PULSe
VOLT:TRIG<sp>135
```

Set the pulse width to 20 msec.

```
PULS:PER<sp>0.04
```

NOTE: Pulse width is set for 50% duty cycle at power up.

Initiate the internal trigger with the following command:

```
TRIG:TRIG:SOUR<sp>IMM
TRIG:INIT
```

#### 4.2.3 LIST PROGRAMMING

The list programming mode allows the generation of complex sequences of output changes with rapid precise timing control by the dwell delay associated with each step or controlled by the trigger received.

The following example is given for a simple list of voltage and frequency. This example will set both voltages and frequency for 115 volts and 60 Hz for 20 msec. Voltage and frequency will change simultaneously to 125 volts and 55 Hz for 20 msec. Then both the voltages and frequency will return to 115 volts and 60 Hz.

Set the mode to LIST for both voltage and frequency as follows:

```
VOLT:MODE LIST
FREQ:MODE LIST
```

Set the voltage and frequency list data points as follows:

```
LIST:VOLT<sp>115,125,115
LIST:FREQ<sp> 60,55,60
```

Set the dwell time between the above data points. If the dwell time is the same between these data points, one data point could describe them all.

```
LIST:DWEL1 0.020.
```

If dwell time is different between data points, the dwell list must have the same number of data points.

```
LIST:DWEL1<sp>0.020,0.002,0.020.
```

The shortest dwell time must be 0.002 second in 0.001 second increments to a maximum of 300 seconds per data point.

Initiate the above program with the following command:

```
TRIG:INIT
```

### 4.3 TRIGGER CONTROL

The HGA Trigger subsystem can be Armed Immediate or wait for a bus Group Execute Trigger command as follows:

```
TRIG:ARM:SOUR<sp>IMM or
TRIG:ARM:SOUR<sp>BUS
```

The trigger initiation could be in continuous mode or single trigger depending on the continuous status as follows:

```
TRIG:INIT:CONT<sp>ON. or
TRIG:INIT:CONT<sp>OFF
```

The HGA Trigger source could be Immediate or Internal. The internal trigger is synchronized by the phase angle relative to phase A. The trigger phase should be set to the desired phase angle.

TRIG:TRIG:SOUR<sp>IMMediate no internal condition is required  
or TRIG:TRIG:SOUR<sp>INTernal the trigger phase angle must be specified or the trigger subsystem will use the default trigger phase angle. To specify the phase angle the following command must be used.

```
TRIG:TRIG:PHAS<sp>90 will set the phase angle for 90°
```

The trigger could be delayed by certain amounts of time from the trigger command with the following command:

```
TRIG:TRIG:DELAy<sp>0.02 20 msec delay.
```

The following command will activate the trigger:

```
TRIG:INITiate
```

To abort the transient at any time the following command is used:

```
TRIG:ABORT
```



## 4.4 MEASUREMENT

The HGA has the capability to return the rms voltage, rms current, rms power, peak current, harmonic current, harmonic voltage, phase angle and frequency measurement. The responses to all measurements are in NR2 format.

Current measurement has 4 ranges for the standard configuration. These ranges are 2 amps, 4 amps, 8 amps and 16 amps. The measurement subsystem auto ranges between the 2 amp and the 4 amp ranges. It also auto ranges between the 8 amp and the 16 amp ranges. User must select the proper range for the current measurement for currents less than 4 amps and currents above 4 amps for optimum results. The load must be removed to change range from any value below 4 amps to a value above 4 amps and vice versa. The following command is used to range change the current.

MEAS:RANGE<sp>4 will set the measurement to 4 amps range.

Power measurement, peak current measurement and harmonic current measurement require range selections for accurate results.

### 4.4.1 RMS VOLTAGE, CURRENT AND POWER MEASUREMENTS

To measure the rms Voltage for phase A, use the following command:

MEAS:VOLT1?

To measure the rms Current for phase B, use the following command:

MEAS:CURR2?

To measure the rms Power for Phase A, use the following command:

MEAS:POW? Note the absence of the channel number designate phase A.

### 4.4.2 PEAK CURRENT MEASUREMENT

The peak current measurement is activated with the following command:

MEAS:CURR1:AMPL:MAX?

This command will return the peak current value for phase A measurement. After the peak current for this channel is selected, peak current measurement will track the peak value. Subsequent peak current measurement for the same channel will return the highest value.

To measure the peak current for other channels requires resetting the peak current measurement circuit. Peak current measurement reset is also required whenever the user needs to find the peak current value at the time of measurement. The following command is used to reset the peak current measurement and should proceed the peak current measurement.

MEAS:CURR:AMPL:CLEAR

#### 4.4.3 APPARENT POWER, POWER FACTOR AND CREST FACTOR MEASUREMENT

The Measurement subsystem will return Apparent Power, Power factor and Crest factor by measuring the appropriate component and returning the computed values.

The following command will return the apparent power in kVA for phase A.

MEAS:POW1:APP?

The following command will return the power factor between 0 and 1 for phase B

MEAS:POW2:PFACT?

The following command will return the crest factor of load current for phase C.

MEAS:CURR3:CREStfactor?

#### 4.4.4 HARMONIC MEASUREMENTS AND HARMONIC DISTORTION

The Measurement subsystem is able to measure both voltage and current harmonics. The subsystem will measure either a single harmonic or an array of harmonics up to the 49<sup>th</sup> harmonic. The subsystem will compute the total harmonic distortion up to the 49<sup>th</sup> harmonic. Current range should be selected prior to measurement to obtain accurate results.

The following command will measure the 3<sup>d</sup> harmonic of phase A current for a fundamental frequency of 50 Hz.

MEAS:CURR1:HARM?<sp>50,3

The following command will measure the array of current harmonics of phase A up to the 39<sup>th</sup> harmonic for a fundamental frequency of 50 Hz.

MEAS:ARRAY:CURR1:HARM?<sp>50,39

The following command will measure the array of current harmonics of phase A to the 49<sup>th</sup> harmonic for a fundamental frequency of 50 Hz and will compute and return the Total harmonic distortion as a percentage of the fundamental.

MEAS:CURRE1:HARM:THD?<sp>50

Voltage harmonic could be measured in the same fashion as above.

## **4.5 CALIBRATION**

Refer to Section 6, Adjustment and Calibration procedure section in this Manual.

## SECTION 5

### HGA SCPI COMMAND REFERENCE

#### 5.0 GENERAL

This section provides detailed description of the HGA SCPI Command.

#### 5.1 NOTATION

The following notations are used

- o Command headers are shown in mixed case. The upper case portions indicate the short form of the command. Case is not significant in programming the interface.
- o Items contained within square brackets [ ] are optional.
- o Items separated by a vertical bar indicate alternative.
- o Items within angle brackets < > are parameter abbreviations.

##### 5.1.1 PARAMETER ABBREVIATIONS

NRf	Device listening flexible numeric format, which is flexible in accepting optional signs, number of digits before or after an optional decimal point, and optional 10 multiplier.
bool	Boolean parameter notation.
CRD	character response data
sp	space 20 hex

##### 5.1.2 RESPONSE FORMAT ABBREVIATION

NR1	Integer with optional sign.
NR2	Real number with decimal points.
NR3	Real number in exponential notation.

All commands that accept numeric parameters will accept a MINimum or MAXimum instead of the numeric format. Use the query command followed by the MINimum or MAXimum as a parameter to find the range of numeric data the command will accept.

## 5.2 SYSTEM

### SYSTEM:VERSion?

The query System Version command returns the SCPI revision number.

Example:

```
SYST:VERS?
```

Response:

```
1991.0
```

### SYSTEM:ERRor?

This query command will respond with the generic error number and error string.

Example:

```
SYST:ERR?
```

Response:

The following are all possible responses:

- 0, "No error" response when there are no errors.
- 100, "Command error" generic response for syntax error.
- 200, "Execution error" response to data errors, string errors, hardware errors and trigger errors.
- 300, "Device specific error" system error, memory error and overflow error.
- 400, "Query error" The output queue has a problem.

### SYSTEM:LOCal

This command will set the HGA in local and allow Keypad operation. This command is only active in RS232 operation.

Example:

```
SYST:LOC
```

### SYSTEM:REMote

This command will set the HGA in remote and will lock any keypad operation. This command is only active in RS232 operation.

Example:

```
SYST:REM
```

## 5.3 OUTPUT SUBSYSTEM

### **OUTPut[:STATe]<sp>ON|OFF**

This command will close or open the output relay

Initial  
OFF

Example:  
OUTP ON  
output OFF

### **OUTPut[:STATe]?**

This query command will return the status of the output relay

Example:  
OUTP?

Response:  
1 | 0

### **OUTPut:TTLTrg[:STATe]<sp>ON|OFF**

This command will enable or disable the output sync

Initial:  
OFF

Example:  
OUTP:TTLT ON

### **OUTPut:TTLTrg[:STATe]?**

This query command will return the status of the output trigger

Example:  
OUTPut:TTLTrg?

Response:  
0 | 1

### **OUTPut:TTLTrg:SOURce<sp>BOT|EOT|LIST**

This command will define the source of the output trigger, begin of transient, end of transient and begin of a list.

Initial:  
BOT

Example:  
OUTP:TTLT:SOUR EOT

### **OUTPut:TTLTrg:SOURce?**

This query command will return the status of the trigger source.

Example:  
OUTP:TTLT:SOUR?

Response:  
BOT|EOT|LIST

## **5.4 SOURCE SUBSYSTEM**

### **[SOURce:]MODE<sp>ONEPhase|THReephase**

This command will configure the HGA and the power source to a single-phase or three-phase configuration.

Initial:  
Depend on the configuration switches in the control board.

Examples:  
MODE ONEPHASE  
SOURCE:MODE THREEPHASE

### **[SOURce:]MODE?**

This query command will return the status of the mode configuration. The response will be ONE or THR

Examples:

```
MODE?  
SOUR:MODE?
```

Responses:

```
ONE | THR
```

### **[SOURce:]VRANge<sp>LOW|HIGH**

This command will select the High or Low voltage range if the HGA is configured as a dual voltage range.

Initial:

Defined by the INITial:VRANge in the initial subsystem.

Examples:

```
SOUR:VRAN LOW  
vrange LOW  
vran LOW
```

### **[SOURce:]VRANge?**

This query command will return the status of the voltage range. The response will be HIGH or LOW.

Examples:

```
VRANge?
```

Responses:

```
HIGH | LOW
```

### **[SOURce:]COUPlE<sp>NONE|ALL**

This command will allow the voltage and current programming for all three phases simultaneously. At power-up the coupling is set to none.

Initial:

```
NONE
```

Examples:

```
source:couple none  
coup ALL
```

### **[SOURce:]COUPlE?**



This query command will return the status of the coupling.

Examples:

SOUR:COUP?

Responses:

ALL | NONE

**[SOURce:]FREQUency[:IMMediate]<sp><NRf>**

This command will program the immediate output frequency to a value specified by the NRf. At power up the immediate value is equal to the initial value.

Initial:

Defined by the initial frequency in the initial subsystem.

Examples:

FREQ 60.0

SOUR:FREQ 6e1

**[SOURce:]FREQUency[:IMMediate] ?**

This query command will return the immediate output frequency value.

Example:

FREQUENCY?

source:freq?

Responses:

<NR2>

**[SOURce:]FREQuency:MODE<sp>FIXed|STEP|PULSe|LIST|SENSe**

This command will control the source of the programmed frequency as follows:

- FIXed            Frequency is updated upon receiving the immediate value.
- STEP            Frequency is updated from the triggered value upon receiving a trigger.
- PULSe          Frequency is updated from the triggered value upon receiving a trigger and for a duration defined by the PULSe
- LIST            Frequency is updated from the values defined by the LIST upon receiving a trigger command.
- SENSe          Frequency will lock to the external Sync frequency.

Initial:

FIXed

Examples:

FREQ:MODE FIX

FREQ:MODE SENS

**[SOURce:]FREQuency:MODE?**

This query command will return the status of the frequency mode FIX, STEP, PULSe, LIST or SENSe

Example:

FREQ:MODE?

Responses:

FIX | SENS

**[SOURce:]FREQuency:TRIGgered<sp><Nrf>**

This command sets the triggered frequency value. The output frequency is programmed with the triggered value when the MODE is set for STEP or PULSe and the trigger is initiated.

Initial:

0

Example:

FREQUENCY:TRIG 55        The frequency will change to 55 Hz if the MODE is set for STEP or PULSe and a Trigger is initiated.

**[SOURce:]FREQuency:TRIGgered?**

This query command will return the triggered frequency value.

Example

```
SOUR:FREQ:TRIG?
```

Responses:

```
<NR2>
```

### **[SOURce:]FREQuency:SLEW[:IMMediate]<sp><NRf>|MINimum|MAXimum**

This command will set the frequency slew rate in Hz per second when the frequency source mode is FIXed.

initial:

```
MAXimum
```

Example:

```
FREQ:SLEW 20 The slew rate is 20 Hz per second.
```

### **[SOURce:]FREQuency:SLEW[:IMMediate]?**

This query command will return the frequency slew rate for fixed mode frequency programming.

Example:

```
FREQ:SLEW?
```

Response:

```
<NRf>
```

### **[SOURce:]FREQuency:SLEW:MODE<sp>FIXed|STEP|PULSe|LIST**

This command will define the source of the Frequency slew rate as follows

FIXed	Frequency is slew using the immediate slew rate value
STEP	Frequency is slew using the triggered slew value upon receiving a trigger.
PULSe	Frequency is slew using the triggered slew value upon receiving a trigger and for a duration defined by the PULSe.
LIST	Frequency is slew using the values defined by the LIST slew rate upon receiving a trigger command.

Initial:

```
FIXed
```

Example:

```
FREQ:SLEW:MODE LIST
```

### **[SOURce:]FREQuency:SLEW:MODE?**

This query command will return the source of the frequency slew value.

Example:

```
FREQ:SLEW:MODE?
```

Response:

```
FIX | STEP | PULSe | LIST
```

**[SOURce:]FREQuency:SLEW:TRIGgered<sp><NRf>**

This command will define the frequency slew rate when the mode is set for PULSe or STEP.

Initial:

```
MAXimum
```

Example:

```
FREQ:SLEW:TRIG 10
```

**[SOURce:]FREQuency:SLEW:TRIGgered?**

This query command will return the frequency slew rate.

Example

```
FREQ:SLEW:TRIG?
```

Response:

```
<NRf>
```

**[SOURce:]PHASe<n>[:IMMEDIATE]<sp><NRf>**

This command will program the phase angle of n with the numeric value specified by the NRf value. n is the phase number of 1, 2 or 3.

Initial:

Defined by the initial phase in the initial subsystem.

Examples:

```
PHASE2 240.0 set phase 2 angle to 240°
```

```
SOUR:PHAS3:IMM 120 set phase 3 angle to 120°
```

**[SOURCE:]PHASe<n>[:IMMediate]?**

This query command will return the numeric value of phase n.

Examples:

```
PHASE2?  
source:phase3?
```

Responses:

```
<NR2>
```

**[SOURCE:]PHASe<n>:MODE<sp>FIXed|STEP|PULSe|LIST**

This command will control the source of the programmed phase as follows.

FIXed	Phase is updated immediately.
STEP	Phase is updated from the triggered value upon receiving a trigger.
PULSe	Phase is updated from the triggered value upon receiving a trigger and for a duration defined by the PULSe.
LIST	Phase is updated from the values defined by the LIST upon receiving a trigger command.

Initial:

```
FIXed
```

Example:

```
PHAS2:MODE FIXED
```

**[SOURCE:]PHASe<n>:MODE?**

This query command will return the status of the phase mode FIX, STEP, PULSe or LIST.

Example:

```
PHASe1:MODE?
```

Responses:

```
FIX | STEP | PULS | LIST
```

**[SOURCE:]PHASe<n>:TRIGgered<sp><NRf>**

This command sets the triggered phase value. The output phase will change to the triggered value when the mode is set to a STEP or PULSE upon receiving the trigger command.

Initial:

```
MINimum
```

Example:

```
PHAS1:TRIG 20
```

**[SOURce:]PHASe<n>:TRIGgered?**

This query command will return the phase n triggered value.

Example:

PHASe2:TRIG?

Response:

<NR2>

**[SOURce:]FUNCtion<n>[:SHAPe][:IMMEDIATE]<sp>SINusoid|SQUare|<trace>**

This command will program the shape of the waveform of phase n to SIN, SQU or CSIN or trace. The trace functions will output a waveform shape that is described by the user-defined TRACe table.

Initial:

SIN

Examples:

FUNC:SHAP1 SIN

Set output waveform of phase 1 to sine wave.

SOUR:FUNC1:SHAPe `WAVE1'

Set output waveform of phase 1 to a shape defined by user-defined trace WAVE1.

**[SOURce:]FUNCtion<n>[:SHAPe][:IMMEDIATE]?**

This query command will return the shape of the waveform SIN, SQU, CSIN.

Examples:

FUNC1:SHAP?

Responses

SIN | SQU | <CRD>

**[SOURCE:]FUNCTION<n>[:SHAPE]:CSDISTORTION<sp><NRf>**

This command will program phase n waveform to a clipped sine wave with a percentage distortion specified by the NRf value. Both positive and negative peak amplitudes are clipped to a certain level to obtain the specified distortion level. Distortion level is 0 to 20% in 1% increments.

Initial

0 % distortion

Example:

FUNC1:SHAP:CSDI 10 10% distortion with a clipped sine wave

**[SOURCE:]FUNCTION<n>[:SHAPE]:CSDISTORTION?**

This query command will return the percentage distortion of clipped sine wave of phase n waveform.

Examples:

FUNC:CSDI?

Responses:

<NR2>

**[SOURCE:]VOLTAGE:RANGE<sp>LOW | HIGH**

This command will set the output voltage range to the low or high range. The maximum value of the high and low voltage range is determined from the value of the voltage limit set by the limit vrange in the limit subsystem.

Initial:

Defined by the INIT:VOLT in the initial subsystem.

Example:

SOUR:VOLT:RANG LOW

**[SOURCE:]VOLTAGE<n>:RANGE?**

This query command will return the value of the voltage range?

Example:

VOLT1:RANGE?

Response:

HIGH | LOW

**[SOURCE:]VOLTAGE<n>[:LEVEL][:IMMEDIATE][:AMPLITUDE]<sp><NRf>**

This command will program the output voltage of phase n with the numeric value defined by the NRf.

Initial:  
Defined by the initial volt in the initial subsystem.

Example:  
VOLTage1 100

**[SOURce:]VOLTage<n>[:LEVel][:IMMediate][:AMPLitude] ?**

This query command will return the value of the programmed output voltage of phase n.

Example:  
VOLT1?

Response:  
<NR2>

**[SOURce:]VOLTage<n>[:LEVel]:MODE<sp>FIXed|STEP|PULSe|LIST**

This command will control the source of the programmed voltage as follows.

FIXed	Voltage is updated from the immediate value.
STEP	Voltage is updated from the triggered value upon receiving a trigger.
PULSe	Voltage is updated from the triggered value upon receiving a trigger and for a duration defined by the PULSe
LIST	Voltage is updated from the values defined by the LIST upon receiving a trigger command.

Initial:  
FIXed

Examples:  
VOLT1:MODE FIX  
VOLT2:MODE LIST



**[SOURce:]VOLTage<n>[:LEVel]:MODE?**

This query command will return the mode status of phase n voltage as FIX,STEP,PULSe or LIST.

Example:

VOLT2:MODE?

Responses:

FIX | STEP | PULS : LIST

**[SOURce:]VOLTage<n>[:LEVel]:TRIGgered[:AMPLitude]<sp><NRf>**

This command sets the triggered voltage value of phase n. The output voltage is programmed with the triggered value when the MODE is set for STEP or PULSe and the trigger is initiated.

Initial:

MINimum

Example:

VOLT1:TRIG 115 the voltage of phase 1 will change to 115 volt if the MODE is set for STEP or PULSe and a Trigger is initiated.

**[SOURce:]VOLTage<n>[:LEVel]:TRIGgered[:AMPLitude]?**

This query command will return the triggered voltage value.

Example

SOUR:VOLT3:TRIG?

Responses:

<NR2>

**[SOURce:]VOLTage<n>:SLEW[:IMMediate]<sp><NRf>**

This command will program the slew rate of the output voltage level of phase n with a value specified by NRf. Instantaneous voltage changes can be obtained by sending MAXimum.

Initial:

MAXimum

Example:

VOLT1:SLEW 10

**[SOURce:]VOLTage<n>:SLEW[:IMMediate]?**

This query command will return the immediate slew rate value of the output voltage.

Example:

VOLT1:SLEW?

Response:

<NRf>

### **[SOURCE:]VOLTage<n>:SLEW:MODE<sp>FIXed|STEP|PULSe|LIST**

This command will define the source of the voltage slew rate of phase n as follows:

FIXed	Voltage is slew using the immediate slew rate value.
STEP	Voltage is slew using the triggered slew value upon receiving a trigger.
PULSe	Voltage is slew using the triggered slew value upon receiving a trigger and for a duration defined by the PULSe.
LIST	Voltage is slew using the values defined by the LIST slew rate upon receiving a trigger command.

Initial:

FIXed

Example:

VOLT2:SLEW:MODE LIST

### **[SOURCE:]VOLTage<n>:SLEW:MODE?**

This query command will return the source of the voltage slew value.

Example:

VOLT1:SLEW:MODE?

Response:

FIX | STEP | PULSe | LIST

### **[SOURCE:]VOLTage<n>:SLEW:TRIGgered<sp><NRf>**

This command will define the voltage slew rate when the mode is set for PULSe or STEP

Initial:

MAXimum

Example:

VOLT2:SLEW:TRIG 10

### **[SOURCE:]VOLTage<n>:SLEW:TRIGgered?**

This query command will return the voltage slew rate.

Example:  
VOLT1:SLEW:TRIG?

Response:  
<NRf>

**[SOURCE:]CURRENT:PROTECTION:DELAY<sp><NRf>**

This command will inhibit the current limit protection for an amount of time defined by the NRf value.

Initial:  
0.010 seconds

Example:  
CURR:PROT:DEL 0.1     Set the current limit delay to 100 msec.

**[SOURCE:]CURRENT:PROTECTION:DELAY?**

This query command will return the value of the current limit protection delay in seconds.

Example  
CURR:PROT:DEL?

Response:  
<NR2>

**[SOURCE:]CURRENT<n>[:LEVEL][:IMMEDIATE][:AMPLITUDE]<sp><NRf>**

This command will program the current limit of phase n with a value specified with the NRf value.

Initial:  
Defined by the INITIAL:CURRENT in the INITIAL subsystem.

Example:  
CURR1 11     Set current limit of phase 1 to 11 amps.

**[SOURCE:]CURRENT<n>[:LEVEL][:IMMEDIATE][:AMPLITUDE]?**

This query command will return the current limit value of phase n.

Example:  
CURR1?

Response:  
<NR2>

**[SOURce:]CURRent<n>[:LEVel]:MODE<sp>FIXed|STEP|PULSe|LIST**

This command will control the source of the programmed current limit as follows.

FIXed	Current is updated immediately.
STEP	Current is updated from the triggered value upon receiving a trigger.
PULSe	Current is updated from the triggered value upon receiving a trigger and for a duration defined by the PULSe.
LIST	Current is updated from the values defined by the LIST upon receiving a trigger command.

Initial:  
FIXed

Examples:  
CURR1:MODE FIX  
CURR2:MODE LIST

**[SOURce:]CURRent<n>[:LEVel]:MODE?**

This query command will return the mode status of phase n current limit as FIX, STEP, PULSe or LIST.

Example:  
CURR2:MODE?

Responses:  
FIX | STEP | PULS | LIST

**[SOURce:]CURRent<n>[:LEVel]:TRIGgered[:AMPLitude]<sp><NRf>**

This command sets the triggered current limit value of phase n. The output current limit is programmed with the triggered value when the MODE is set for STEP or PULSe and the trigger is initiated.

Initial:

MINimum

Example:

CURR1:TRIG 115      The current of phase 1 will change to 115 volt if the MODE is set for STEP or PULSe and a Trigger is initiated.

**[SOURce:]CURRent<n>[:LEVel]:TRIGgered[:AMPLitude]?**

This query command will return the triggered current limit value.

Example

SOUR:CURR3:TRIG?

Responses:

<NR2>

## **5.5 LIMIT SUBSYSTEM**

**LIMit:PASSword<sp><CRD>**

This command is used to set the password to access the LIMIT configuration. This configuration is dependent on the power source rating and capabilities and must not be modified. The query command does not require the password.

Example:

LIM:PASS "23457CD"

**LIMit:SAVe**

This command is used to save the limit parameter in nonvolatile RAM.

Example:

LIMIT:SAVE

**LIMit:FREQuency<sp><NRf, NRf>**

This command is used to set the upper and lower frequency limit.

Example:

LIM:FREQ 44,66      Set lower limit to 44 Hz and high limit to 66 Hz.

### **LIMit:FREQuency?**

This query command will return the upper and lower frequency limits.

Example:

LIM:FREQ?

Response:

<NR2>,<NR2>

### **LIMit:VOLTage<sp><NRf>**

This command is used to set the upper voltage limit.

Example:

LIM:VOLT 270      Set voltage limit to 270 volt.

### **LIMit:VOLTage?**

This query command will return the upper limit for voltage.

Example:

LIM:VOLT?

Response

<NR2>

### **LIMit:CURREnt<sp><NRf>**

This command is used to set the maximum current limit. This current is the sum of three-phase current at the low voltage range.

Example:

LIM:CURR 33      Set maximum current limit to 33 amps.

### **LIMit:CURREnt?**



This query command will return the current limit value.

Example:  
LIM:CURR?

Response:  
<NR2>

## 5.6 INITIAL SUBSYSTEM

### INITial:SAVE

This command saves the initialization value in nonvolatile RAM.

Example:  
INIT:SAVE

### INITial:FREQuency<sp><NRf>

This command sets the initial frequency value. This value must be within the frequency limits set by the limits subsystem.

Example:  
INIT:FREQ 60           Set the output frequency at power up for 60 Hz.

### INITial:FREQuency?

This query command will return the initial frequency value.

Example:  
INIT:FREQ?

Response:  
<NR2>

### INITial:VOLTag<sp><NRf>

This command will set the initial voltage value.

Example  
INIT:VOLT 5           Set the output voltage at power up to 5 volts.

### INITial:VOLTag?

This query command will return the initial voltage value.

Example:

INIT:VOLT?

Response:

<NR2>

**INITial:PHASe<n>[:ANGLE]<sp><NRf>**

This command will set the initial phase angle for phase n.

Examples:

INIT:PHAS2 240      Set phase 2 to 240° at power up.

INIT:PHAS3 120      Set phase 3 to 120° at power up.

**INITial:PHASe<n>[:ANGLE]?**

This query command will return the initial phase angle value.

Example:

INIT:PHAS2?

Response:

<NR2>

**INITial:VRANge<sp>LOW|HIGH**

This command will set the initial voltage range to a high or low voltage range. The high voltage range will equal the maximum voltage range set by the voltage limit value. The lower voltage range is equal to half the voltage set by the voltage limit value.

Example:

INIT:VRAN LOW

**INITial:VRANge?**

This query command will return the initial voltage range:

Example:

INIT:VRAN?

Response:

HIGH | LOW

**INITial:CURREnt<sp><NRf>**



This command sets the initial current limit value which must not exceed the maximum current limit at the initial voltage range and initial mode.

Example:

```
INIT:CURR 11.2
```

### **INITial:CURRent?**

This query command will return the initial current limit value.

Example:

```
INIT:CURR?
```

Response:

```
<NR2>
```

### **INITial:MODE?**

This query command will return the initial configuration of the power source as a single-phase or as a parallel-phase. The initial configuration is controlled by the hardware.

Example:

```
INIT:MODE?
```

Response:

```
ONE | THR
```

## 5.7 TRACE SUBSYSTEM

### TRACe:CATalog?

This query command will return a comma-separated list of strings which contains the names of all traces.

Example:

```
Trace:cat?
```

Response:

```
<CRD>[,<CRD>] .....[,<CRD>]
```

### TRACe:FREE?

This query command will return the amount of used memory space and available memory space for traces, in the following format <byte available>, <bytes in use>, where the return data for both shall be in <NR1> format.

Example:

```
TRACe:FREE?
```

Response:

```
<NR1>,<NR1>
```

### TRACe:DEFine<sp><trace\_name>[(numeric\_value) | <trace\_name>]

This command allocates and initializes a new trace. The first parameter is <character data>, and it specifies the new <trace name>. If the second parameter is a <numeric value>, a new trace is allocated with specified number of elements. If the second parameter is a name of existing trace, the new trace becomes a copy of the existing trace in all respects, include size and content. The number of elements must be 4096.

Example:

```
TRAC:DEF "Wave1", "Wave2"
```

Defines Wave1 as a new trace that is identical to the trace wave2.

```
TRAC:DEF "waves"
```

This command will define waves Trace and will allocate a 4096 data point (8192 bytes)

### TRACe:DEFine?<sp><trace\_name>

This query command will return the number of data points for the trace name.

Example:

```
TRAC:DEF? "wave1"
```

Response:  
<NR1>

**TRACe[:DATA]<sp><trace\_name>,<trace\_name>|<block>|<numeric\_value>  
[,<numeric\_value>]**

This command will set the data values in the destination trace. If the data source is a trace name, the data is copied into the destination trace. If the data source is a block of data, then the block is directly loaded into the destination trace. If the data is a simple <numeric value>, every element of the destination trace is set to the constant value represented by the evaluation of <numeric value>. The number of data elements must be 4096. The amplitude of each data element is a value within the range of -2048 to +2047. The waveform is normalized so that the peak of the waveform will equal the peak of the sine wave program value.

Example:  
TRAC "wave1", "wave2"  
TRAC "wave2", 1234,127,.....,1256

**TRACe[:DATA]? <trace\_name>**

This query command will return the data values for the trace name.

Example:  
TRAC? "wave4" will return the data value for the trace wave4.

**TRACe:DELeTe[:NAME] <trace\_name>**

This command will delete the trace defined by the trace name.

Example:  
TRAC:DEL "wave3"

**TRACe:DELeTe:ALL**

This command will delete all traces from the trace buffers.

Example  
TRACE:DEL:ALL

## 5.8 LIST SUBSYSTEM

**LIST:COUNT**<sp> <NRf>

This command will define the number of times the list will be executed.

Initial:

1

Example:

LIST:COUNT 2

**LIST:COUNT?**

This query command will return the number of times the list will repeat itself.

Example:

LIST:COUN?

Response:

<NR1>

**LIST:STEP**<sp>**ONCE|AUTO**

This command will set the list step mode to step once with every trigger or it will advance automatically after the first trigger paced by the Dwell time between the list points.

Initial:

AUTO

Example:

LIST:STEP AUTO

**LIST:CURREnt**<n>[:**AMPLitude**] <NRf>[,<NRf>][,<NRf>] ....[,<NRf>]

This command will set the list amplitude data points for the current limit of phase n.

Example:

LIST:CURR1 2,3,4,5 Set the current limit data points for phase 1 to 2,3,4 and 5 Amps.

**LIST:CURRENT<n>[:AMPLitude]?**

This query command will return the list data points for phase n current limit.

Example:

```
LIST:CURR1?
```

Response:

```
<NR2>[,<NR2>] .....[,<NR2>]
```

**LIST:CURRENT<n>:POINTs?**

This query command will return the number of data points the current list has.

Example:

```
LIST:CURR1:POINT?
```

Response:

```
<NR1>
```

Example:

```
LIST:CURR1:POIN? MAX
```

Response:

```
16 This is the maximum data points in a list.
```

**LIST:DWELl[:TIME] <NRf>[,<NRf>][,<NRf>] ....[,<NRf>]**

This command will set the dwell time between data points in a list when the step mode is set for auto.

Example:

```
LIST:DWEL 2,3,2,4 Set the time between data points to 2,3,2 and 4 seconds.
```

**LIST:DWELl:POINTs?**

This query command will return the number of dwell data points in a list.

Example:

```
LIST:DWEL:POIN?
```

Response:

```
<NR1>
```

**LIST:FREQuency[:LEVel][:AMPLitude]<sp><NRf>[,<NRf>][,<NRf>] ....[,<NRf>]**

This command will set the data point sequence for the frequency list.

Example:

```
LIST:FREQ 47,50,60,66
```

### **LIST:FREQuency[:LEVel][:AMPLitude]?**

This query command will return the list data points for frequency.

Example:

```
LIST:FREQ?
```

Response:

```
<NR2>[,<NR2>] .....[,<NR2>]
```

### **LIST:FREQuency[:LEVel]:POINts?**

This query command will return the data points in a frequency list.

Example:

```
LIST:FREQ:POIN?
```

Response:

```
<NR1>
```

Example:

```
LIST:FREQ:POIN? MAX
```

Response:

```
16
```

### **LIST:FREQuency:SLEW[:RATE]<sp><NRf>[,<NRf>]...[,<NRf>]**

This command will set the frequency slew rate sequence data points.

Units:

```
Hz/Sec
```

Example:

```
LIST:FREQ:SLEW 2 Set the frequency slew rate between data points in a list to 2 Hz/Sec.
```

### **LIST:FREQuency:SLEW[:RATE]?**

This query command will return the frequency slew rate sequence data points in a list.

Example:

LIST:FREQ:SLEW?

Response:

<NRf>[,<NRf>]...[,<NRf>]

**LIST:FREQuency:SLEW:POINts?**

This query command will return the number of frequency slew points in a list.

Example:

LIST:FREQ:SLEW:POIN?

Response:

<NR1>

**LIST:PHASe<n>[:ANGLE] <sp><NRf>[,<NRf>][,<NRf>] ...[,<NRf>]**

This command will set the data points sequence of phase n angle of a list.

Example:

LIST:PHAS2 117,120,123     Set phase2 angle data points to 117°, 120° and 123°

**LIST:PHASe<n>[:ANGLE]?**

This command will return the phase n angle data points sequence in a list.

Example:

LIST:PHAS2?

Response:

<NR2>[,<NR2>] .....[,<NR2>]

**LIST:PHASe<n>:POINts?**

This query command will return the phase n number of data points in the list.

Example:

LIST:PHAS2:POINts?

Response:

<NR1>

**LIST:VOLTage<n>[:LEVel][:AMPLitude]<sp><NRf>[,<NRf>][,<NRf>] ...[,<NRf>]**

This command will set the data point for the voltage list.

Example:

LIST:VOLT1 108,115,122

**LIST:VOLTage<n>[:LEVel][:AMPLitude]?**

This query command will return the list data points sequence for voltage for phase n.

Example:

LIST:VOLT1?

Response:

<NR2>[,<NR2>] .....[,<NR2>]

**LIST:VOLTage<n>[:LEVel]:POINts?**

This query command will return the number of data points in phase n voltage list.

Example:

LIST:VOLT2:POIN?

Response:

<NR1>

Example:

LIST:VOLT1:POIN? MAX

Response:

16

**LIST:VOLT<n>:SLEW[:RATE]<sp><NRf>[,<NRf>]...[,<NRf>]**

This command will set phase n voltage slew rate between data points.

Units:

Volts/Sec

Example:

LIST:VOLT1:SLEW 2 Set the frequency slew rate between data points in a list to 2Volt/Sec.



### **LIST:VOLTage<n>:SLEW[:RATE]?**

This query command will return phase n slew rate between data points in a list.

Example:

```
LIST:VOLT1:SLEW?
```

Response:

```
<NRf>[,<NRf>]...[,<NRf>]
```

### **LIST:VOLTage<n>:SLEW:POINts?**

This query command will return the number of phase n voltage slew points in a list.

Example:

```
LIST:VOLT1:SLEW:POIN?
```

Response:

```
<NR1>
```

### **LIST:TTLTrg[:SWITCh]<sp>OFF|ON**

This command will enable or disable the output trigger for each of the data points in the List.

Initial:

On for one data point

Example:

```
LIST : TTLT ON, OFF, ON
```

### **LIST:TTLTrg[:SWITCh]?**

This query command will respond with the status of output trigger for each data point in the list.

Example:

```
LIST:TTLT?
```

Response:

```
<bool>[,<bool>]...[,<bool>]
```

### **LIST:TTLTrg:POINts:**

This query command will respond with a number of points of output trigger in the list.

Example:

LIST:TTLT:POIN?

Response:

<NR1>

## 5.9 PULSE SUBSYSTEM

**PULSe:COUNT**<sp><NRf>

This command will define the number of times the pulse repeats itself.

Example:

PULSe:COUNT 2

**PULSe:COUNT?**

This query command will return the number of times the pulse will repeated when the trigger occurs.

Example:

PULS:COUN?

Response:

<NR1>

**PULSe:DCYClE**<sp><NRf>

This command will set the time delay between the trigger command and the start of the pulse sequence.

Initial:

0 sec

Example

PULS:DCYC 2      Set the delay to two seconds.

**PULSe:DCYClE?**

This query command will return the delay time between the trigger command and the pulse sequence.

Example:

PULS:DCYC?

Response:

<NR2>

**PULSe:PERiod**<sp><NRf>

This command will set the pulse period.

Initial

1 sec

Example:

PULS:PER 2            Set the pulse period for 2 seconds.

**PULSe:PERiod?**

This command will return the pulse period.

Example:

PULS:PER?

Response:

<NR2>

**PULSe:WIDTh<sp><NRf>**

This command will set the pulse width. The pulse width will track the pulse period to maintain the duty cycle.

Initial

0.5 sec

Example:

PULS:WIDT 1 Set the pulse width to 1 second.

**PULSe:WIDTh?**

Example:

PULS:WIDT?

This command will return the pulse width.

Response:

<NR2>

**FAULT:SOURCE**

In the event the controller detects a fault, the output voltage will go to zero voltage. The above command will be used to find the source of fault. The format of the data returned is a bit filed decimal. The following are the Fault Errors and the corresponding decimal value:

Phase 1(A) Voltage fault	1
Phase 2(B) Voltage fault	2
Phase 3(C) Voltage fault	4
Temperature fault	8
Phase 1(A) Current limit fault	16
Phase 2(B) Current limit fault	32
Phase 3(C) Current limit fault	64

Example:

FAULT:SOURCE?

Response:

6      The response indicates a Voltage fault for both phase 2 and 3.

**5.10      TRIGGER SUBSYSTEM****TRIGger:ABORt**

This command will abort the trigger.

Example:

TRIG:ABOR

**TRIGger:STATe?**

This query command will respond with the state of the trigger. The only possible responses are IDLE, wait for ARM and BUSY.

Example:

TRIG:STAT?

Response:

IDLE | WARM | BUSY

### **TRIGger:INITiate[:IMMEDIATE]**

This command will initiate the trigger command upon execution of the trigger statement.

Example:

```
TRIG:INIT
```

### **TRIGger:INITiate:CONTinuous <sp>ON|OFF**

This command will enable or disable the trigger in continuous mode. If the continuous mode is on, the list execution will continue after the first step and the dwell time will define the time between data points. If the continuous is off, the list will not advance to the next sequence until another trigger is initiated.

Default:

```
ON
```

Example:

```
TRIG:INIT:CONT ON
```

### **TRIGger:INITiate:CONTinuous?**

This query command will return the status of the trigger.

Example:

```
TRIG:INIT:CONT?
```

Response:

```
ON|OFF
```

### **TRIGger:ARM[:IMMEDIATE]**

This command will arm the trigger subsystem.

Example:

```
TRIG:ARM
```

### **TRIGger:ARM:SOURce<sp>BUS|IMMEDIATE**

This command will define the trigger arm source. If the trigger source is Bus a Group Execute Trigger will initiate the trigger

Example:

```
TRIG:ARM:SOUR BUS
```

**TRIGger:ARM:SOURce?**

This query command will return the source of the trigger.

Example:

```
TRIG:ARM:SOUR?
```

Response:

```
BUS | IMM
```

**TRIGger:TRIGger:SOURce<sp>IMMEDIATE|INTERNAL**

This command will define the trigger source. If internal is set, the trigger system will wait for the trigger phase angle. If the trigger is immediate the action is immediate.

Example:

```
TRIG:TRIG:SOUR INT
```

The trigger will initiate at the proper phase angle specified by the trigger phase angle.

**TRIGger:TRIGger:SOURce?**

This query command will return the status of the trigger source.

Example:

```
TRIG:TRIG:SOURCE?
```

Response:

```
IMM | INT
```

**TRIGger:TRIGger:PHASe<sp><NRf>**

This command will set the phase angle to trigger the trigger subsystem if the trigger is set to internal. This phase angle is relative to phase 1. Phase 2 and 3 in three-phase will change at the same time phase 1 changes but not at the same angle.

Example:

```
TRIG:TRIG:PHASE 90
```

### **TRIGger:TRIGger:PHASe?**

This query command will return the phase angle at which phase 1 will trigger when the trigger is set to internal.

Example:

```
TRIG:TRIG:PHASE?
```

Response:

```
<NR2>
```

### **TRIGger:TRIGger:DELay<sp><NRf>**

This command will define the delay time between initiate the trigger and the actual transient trigger.

Units:

seconds

Example:

```
TRIG:TRIG:DEL 2
```

### **TRIGger:TRIGger:DELay?**

This command will return the delay in seconds.

Example

```
TRIG:TRIG:DEL?
```

Response:

```
<NR2>
```

Define the trigger arm source. If the trigger source is Bus a Group Execute Trigger will initiate the trigger.

Example:

```
TRIG:ARM:SOUR BUS
```



## 5.11 MEASUREMENT SUBSYSTEM

### **MEASure|FETCh[:SCALar]:FREQuency?**

This query command will return the measured frequency value.

Units:

Hz

Example:

MEAS:FREQ?

Response:

<NR2>

### **MEASure|FETCh[:SCALar]:PHASe<n>?**

This query command will return the measured phase angle for phase n.

Units:

degrees

Example:

MEAS:PHAS2?

Response:

<NR2>

### **MEASure|FETCh[:SCALar]:CURRent:RANGe<sp><NRf>**

This command will select the current measurement range. These ranges are 2, 4, 8 and 16 amps or 80 and 160 amps if the high current option is installed. The HGA will auto range between the 2 amp and 4 amp ranges. It, also, will auto range between the 8 amp and 16 amp ranges. The range command must be used to change ranges from the 4 amp range to the 8 amp range. All loads must be removed for the HGA to accept the range change command.

Example

MEAS:CURR:RANGE 8

The above command will change the current measurement range to the 8 amp range. The load must be removed if the previous range is the 2 amp or the 4 amp range.

**MEASure|FETCh[:SCALar]:CURRent?**

This query command will return the current range measurement setting.

Example:

MEAS:CURR:RANG?

Response:

<NR1>

**MEASure|FETCh[:SCALar]:CURR<n>[:AC]?**

This query command will return the measured rms current value of phase n.

Units:

amps.

Example:

MEAS:CURR2?

Response:

<NR2>

**MEASure|FETCh[:SCALar]:CURR<n>:AMPLitude:MAX?**

This query command will return the measured peak current value of phase n. Resetting the measurement circuit may be required with the rest command prior to starting the measurement depending on the application.

Units:

amps

Example:

MEAS:CURR2:AMPL:MAX?

Response:

<NR2>

**MEASure|FETCh[:SCALar]:CURR:AMPLitude:CLEAr**

This command will reset and clear the peak measurement circuit.

Example:

MEAS:CURR:AMPL:CLEAr

**MEASure|FETCh[:SCALar]:CURR<n>:CREStfactor?**

This query command will return the ratio of the measured peak current to the measured rms current of phase n.

Units:

ratio

Example:

MEAS:CURR1:CRES?

Response:

<NR2>

**MEASure|FETCh[:SCALar]:CURR<n>:HARMonic[:AMPLitude]?<sp><NRf1>, <NRf2>**

This query command will return a single measured current harmonic number specified by the NRf2 at the fundamental frequency specified by the NRf1.

Units:

amps

Example:

MEAS:CURR2:HARM? 60,3

The above example will measure the third harmonic of phase two current at 60 Hz fundamental frequency

Response:

<NR2>

**MEASure|FETCh[:SCALar]:CURR<n>:HARMonic:THD?<sp><NRf>**

This query command will return the ratio of the root sum square of all current harmonic up to the 49th harmonic to the fundamental in percentage format. The fundamental frequency is specified by the NRf value.

Units:

ratio

Example:

MEAS:CURR1:HARM:THD? 50

The above example will measure phase one total harmonic distortion of 50 Hz fundamental frequency.

Response:

<NR2>

**MEASure|FETCh[:SCALar]:POWer<n>[:AC][:REAL]?**

This query command will return the true power of phase n.

Units:

Kilowatts

Example:

MEAS:POW1?

Response:

<NR2>

**MEASure|FETCh[:SCALar]:POWer<n>[:AC]:APParent?**

This query command will return the product of voltage and current for phase n.

Units:

Kilo Volt-Amp

Example:

MEAS:POW2:APP?

Response:

<NR2>

**MEASure|FETCh[:SCALar]:POWer<n>[:AC]:PFACtor?**

This query command will return the ratio of the true power to the product of current and voltage of phase n.

Unit

ratio

Example:

MEAS:POW1:PFAC?

Response:

<NR2>

**MEASure|FETCh[:SCALar]:VOLTage<n>[:AC]?**

This query command will return the measured rms voltage value of phase n.

Units:

Volts

Example:

MEAS:VOLT1?

Response:

<NR2>

**MEASure|FETCh[:SCALar]:VOLTage<n>HARMonic?<sp><NRf1>,<NRf2**

This query command will return a single measured voltage harmonic number specified by the NRf2 at the fundamental frequency specified by the NRf1.

Units:

volts

Example:

MEAS:VOLT1:HARM? 60,5

This example will measure the fifth harmonic of phase one voltage for a 60 Hz fundamental frequency.

Response:

<NR2>

**MEASure|FETCh:ARRay:CURRent<n>:HARMonic[:AMPLitude]?<sp><NRf1>,<NRf2>**

This query command will return an array of measured current harmonics. The highest harmonic number is specified by the NRf2 value at the fundamental frequency specified by the NRf1.

Units:

amps

Example:

MEAS:ARR:CURR1:HARM? 60,9

The above example will measure the array of phase one current harmonic up to the ninth harmonic and to include the fundamental for a 60 Hz fundamental frequency.

Response:

<NR2>,<NR2>,<NR2>,<NR2>,<NR2>,<NR2>,<NR2>,<NR2>,<NR2>,<NR2>

**MEASure|FETCh:ARRay:VOLTage<n>:HARMonic[:AMPLitude]?<sp><NRf1>,<NRf2>**

This query command will return an array of measured voltage harmonics. The highest harmonic number is specified by the NRf2 value at the fundamental frequency specified by the NRf1.

Units:  
volts

Example:  
MEAS:ARR:VOLT1:HARM? 60,9

This example will measure the array of phase one voltage harmonic up to the ninth harmonic and to include the fundamental for a 60 Hz fundamental frequency.

Response:  
<NR2>,<NR2>.....<NR2>

## 5.12 CALIBRATION SUBSYSTEM

### **CALibrate:SAVE**

This command will save the calibration value for the output parameters only.

Example:  
CAL:SAV

### **CALibrate:PHASe<n><sp><NRf>**

This command will add a value specified by NRf to the phase n angle value.

Initial:  
0°

Example  
CAL:PHAS2 +2

### **CALibrate:PHASe<n>?**

This query command will return the value of phase n calibration angle.

Example:  
CAL:PHASe<n>?

Response:  
<NR2>

### **CALibrate:STATe<sp>ON|OFF**

This command will enable or disable the calibration.

Example:  
CAL:STATE ON

**CALibrate:STATe?**

This query command returns the state of the calibration.

Example

```
CAL:STAT?
```

Response

```
ON|OFF
```

**CALibrate[:MEASure]:CURRent<n>[:AC][:DATA]<sp><NRf>**

This command will Auto calibrate the rms current of phase n. The calibration will be completed when the measured value is equal to the NRf value.

Example:

```
CAL:CURR1 3.76
```

**CALibrate[:MEASure]:CURRent<n>[:AC]:CONStant<sp><NRf>**

This command will update the calibration constant of the rms current to a value specified by the NRF value. This value is a constant range 0 to 255.

Example:

```
CAL:CURR2:CONStant 127
```

**CALibrate[:MEASure]:CURRent<n>[:AC]:CONStant?**

This query command will return the calibration constant for phase n current.

Example:

```
CAL:CURR3:CONS?
```

Response:

```
<NR1>
```

**CALibrate[:MEASure]:CURRent<n>:AMPLitude:MAXampl[:DATA]<sp><NRf>**

This command will Auto calibrate the peak current of phase n. The calibration will be completed when the measured value is equal to the NRf value.

Example:

```
CAL:CURR1:AMPL:MAX 3.7
```

**CALibrate[:MEASure]:CURRent<n>:AMPLitude:MAXampl:CONStant<sp><NRf>**

This command will update the calibration constant of the peak current of phase n to a value specified by the NRf value.

Example:

```
CAL:CURR2:AMPL:MAX:CONS 120
```

**CALibrate[:MEASure]:CURRent<n>:AMPLitude:MAXampl:CONStant?**

This query command will return the calibration constant for phase n peak current.

Example:

```
CAL:CURR1:AMPL:MAX:CONS?
```

Response:

```
<NR1>
```

**CALibrate[:MEASure]:CURRent<n>:HARMonic[:DATA]<sp><NRf1>,<NRf2>**

This command will Auto calibrate the harmonic current of phase n. The harmonic frequency is specified by the NRf1 value. The calibration will be completed when the measured value is equal to the NRf2 value.

Example:

```
CAL:CURR2:HARM 60, 3
```

This command will calibrate the current harmonic at 60 Hz for 3 amps at that frequency.

**CALibrate[:MEASure]:CURRent<n>:HARMonic:CONStant<sp><NRf>,<NRf>**

This command will update the calibration constant of the harmonic current of phase n to a value specified by the NRf value.

Example:

```
CAL:MEAS:CURR1:HARM:CONS 127,0
```

Currently the second value is not in use but required.





### **CALibrate[:MEASure]:CURRent<n>:HARMonic:CONStant?**

This query command will return the calibration constant for phase n harmonic current.

Example:

```
CAL:CURR3:HARM:CONS?
```

Response:

```
<NR1>
```

### **CALibrate[:MEASure]:POWER<n>[:AC][:DATA]<sp><NRf>**

This command will Auto calibrate the true power of phase n. The calibration will be completed when the measured value is equal to the NRf value.

Example

```
CAL:POW1 2.6 units in Kw
```

### **CALibrate[:MEASure]:POWER<n>[:AC]:CONStant<sp><NRf>**

This command will update the calibration constant of the true power to a value specified by the NRf value.

Example:

```
CAL:POW2:CONS 110
```

### **CALibrate[:MEASure]:POWER<n>[:AC]:CONStant?**

This query command will return the calibration constant for phase n power.

Example:

```
CAL:POW:CONS?
```

Response:

```
<NR1>
```

### **CALibrate[:MEASure]:VOLTage<n>[:AC][:DATA]<sp><NRf>**

This command will Auto calibrate the rms voltage of phase n. The calibration will be completed when the measured value is equal to the NRf value.

Example:

```
CAL:VOLT1 135
```

**CALibrate[:MEASure]:VOLTage<n>[:AC]:CONStant<sp><NRf>**

This command will update the calibration constant of the rms voltage to a value specified by the NRf value.

Example:

```
CAL:VOLT2:CONS 100
```

**CALibrate[:MEASure]:VOLTage<n>[:AC]:CONStant?**

This query command will return the calibration constant for phase n voltage.

Example:

```
CAL:VOLT:CONS?
```

Response:

```
<NR1>
```

**CALibrate[:MEASure]:VOLTage<n>:HARMonic[:DATA]<sp><NRf1>,<NRf2>**

This command will Auto calibrate the harmonic voltage of phase n. The harmonic frequency is specified by the NRf1 value. The calibration will be completed when the measured value is equal to the NRf2 value.

Example:

```
CAL:VOLT1:HARM 50, 135
```

Calibrate Harmonic voltage for phase 1 for 135 volt at 50 Hz.

**CALibrate[:MEASure]:VOLTage<n>:HARMonic:CONStant<sp><NRf>,<NRf>**

This command will update the calibration constant of the harmonic voltage of phase n to a value specified by the NRf value.

Example:

```
CAL:VOLT2:HARM:CONS 100,0
```

The second constant is not used but required.

**CALibrate[:MEASure]:VOLTage<n>:HARMonic:CONStant?**

This query command will return the calibration constant for phase n harmonic voltage.

Example:

```
CAL:VOLT2:HARM:CONS?
```

Response:

```
<NR1>
```

## 5.13 SCPI COMMON COMMANDS

### \*CLS

No query format.

This command clears all event registers and the Status Byte register.

### \*ESE<NRf>

Query Format NR1

This command programs the standard Event Status Enable register bits. The register determines which events in the standard Event Status Register cause the event summary bit (esb) in the status register to become set. All enable event bits are o'rd to form the summary bit.

The definition of the individual bits within the standard event status structure is shown below:

b7	b6	b5	b4	b3	b2	b1	b0
PON	0	CMD	EXEC	DDE	QRY	0	OPC

### \*IDN?

Query format.

Arbitrary ASCII Response Data

Description

This query returns an ASCII string which identifies the HGA. The string contains four comma-separated fields.

- Field 1: California Instruments
- Field 2: <model number>
- Field 3: <serial number>
- Field 4: <firmware revision level>

**\*OPT?**

Query format

Arbitrary ASCII Response Data

This query returns information about options installed in the HGA. It returns an ASCII string containing five comma-separated fields for options installed. A zero in the field indicates the option is not installed. The following are the options.

3-PHASE  
SEL\_1/3\_PH  
OUTP\_RELAY  
DROP\_SWITCH  
DUAL\_VRANGE

**\*RST**

Query format

No query form

This command resets all programmable functions to a fixed initial state.

**\*RST** command does not clear any of the status registers. It also sets the trigger system to idle state by sending an implied ABORT command.

**\*SAV**

Query format: none

This command saves an instrument's state so that it can later be retrieved using **\*RCL** command. The argument to **\*SAV** is the state number. There are 4 states in the interface numbered 1 through 4. All states are saved in nonvolatile memory.

**\*RCL**

Query format: none

This command recalls an instrument state that was previously saved with the **\*SAV** command. The argument to **\*RCL** is the state number. There are 4 states numbered through 4.

**Note:** When using the **\*SAV** or **\*RCL** commands, the voltage range setting of the HGA may be recalled incorrectly. This is due to a firmware bug. This may prevent certain transients that require voltage values higher than the low range to generate a -200 Execution error, despite the fact that the high range is selected. This condition may be verified by querying the VOLT:MAX? value. If the VOLT:MAX? query result is equal to the low voltage range yet the selected voltage range is the HIGH range, this condition has occurred. To recover from this condition, issue a **\*RST** command. Avoid the use of the **\*SAV** and **\*RCL** commands if this condition affects your test programs.

**\*OPC**

Query format: <NR1>

This command causes the interface to set the **OPC** bit of the Standard Event Status register when all pending operations have been completed.

The query form of **\*OPC?** causes the interface to return the number "1" when all pending operation has been completed.

**\*ESR**

Query format: <NR1>

This query command returns the Standard Event Status register and clears the register to 0.

The definition of the individual bits within the Standard Event Status structure is shown below:

b7	b6	b5	b4	b3	b2	b1	b0
PON	0	CMD	EXEC	DDE	QRY	0	OPC

PON - Power on

CMD - Command Error

EXEC - Execution Error

DDE - Instrument Dependent

QRY - Query Error

OPC - Operation Complete

**\*SRE<NRf>**

Query format: <NR1>

This command sets or returns the value of the Service Request Enable register. This register determines what bits in the Status Byte will be summed into the MSS/RQS summary bits. RQS is the service request bit which is cleared by a Serial Poll, while MSS is the Master Status Summary bit which is not cleared away when read. The Status Byte definitions are shown below:

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
-	mss/rqs	esb	mav	-	-	-	-

**\*STB?**

Query format: NR1

This query returns the value of the Status Byte register. This register contains summary bits of all the status structures in the interface. The bit definitions are shown below:

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
-	mss/rqs	esb	mav	-	-	-	-

NOTE: The serial poll also returns the Status Byte register but with the Request Service bit (RQS) at bit 6. Performing a serial poll clears the RQS bit but does not clear the MSS bit.

### **\*TRG**

Query format: None

This command generates an Event Signal to any subsystem that has BUSS selection. It has the same effect as a Group Execute Trigger <GET>.

### **\*TST?**

Query format: <NR1>

This query command causes the HGA to perform a self-test and report any errors. A zero return value indicates that all tests passed without error.

## **SECTION 6**

### **CALIBRATION and ADJUSTMENT**

#### **6.0 GENERAL**

This section details the adjustment and calibration procedure for the HGA to meet its specified electrical performance level with a specific power source. The calibration and adjustment are required periodically every 1 year unless otherwise specified.

The procedures used in this section to adjust and calibrate the GUI require the GUI software. All calibration commands are accessible from the SCPI command and do not require the GUI software. However, harmonic generation for gain adjustment requires the GUI software.

For details on how to use the GUI software refer to Section 8 of this manual.

#### **6.1 TEST EQUIPMENT**

The following equipment or their equivalents are required to calibrate the HGA.

- 6.1.1 Digital voltmeter(DVM), Fluke 8840A.
- 6.1.2 100m $\bar{V}$  current shunt.
- 6.1.3 Resistive load
- 6.1.4 Function generator Wavetek 182A
- 6.1.5 Phase angle meter Krohn-Hite 6500A
- 6.1.6 Distortion meter Hewlett Packard 339A
- 6.1.7 Oscilloscope Kikusui COS6100
- 6.1.8 PC 386 or 486 with Serial interface or GPIB interface.
- 6.1.9 Graphical User Interface (GUI)

Refer to Figure 6-2 for System Connection and instrument hookup.

#### **6.2 OUTPUT VOLTAGE CALIBRATION**

This adjustment must be done with the power supply connected to the HGA. Refer to the HGA and Power Source manual Installation sections.

The top cover of the HGA must be removed to access to the adjustment pot.

**Refer to Figure 6-1 for location of test points on the A4 board.**

- 6.2.1 Program all three phases for full scale voltage at the low voltage range (135 Volts for standard configuration). Program the output frequency for 50 Hz.

Figure 6-1 Adjustment potentiometers and test points on A4, A5, A7.



Figure 6-2 System Connection and Instrument hookups

- 6.2.2 Select the customer waveform screen from the GUI. Enter 100% in the 10th harmonic. All other harmonics must be at zero (include the fundamental). Select compute. When computation is completed, select WV10 and select send. When send is completed, return to the steady state screen.
- 6.2.3 From the Transient screen, select custom waveform and waveform 10. The output frequency will change to 500 Hz. Adjust R39, R67 and R111 for phase A, B and C respectively for full scale volts  $\pm 0.05$  volts.
- 6.2.4 Select Sine wave. The output frequency will change to 50 Hz. Adjust R20, R75 and R117 for phase A, B and C respectively for full scale volts  $\pm 0.05$  volts.
- 6.2.5 Repeat steps 6.2.3 and 6.2.4 if necessary.

### **6.3 CURRENT BURDEN ADJUSTMENT**

**Note: This adjustment is not required unless Current or Harmonic Current calibration is not successful.**

**For 80/160 Amp Current Ranges, follow Section 6.7 instead of this section.**

**Refer to Figure 6-1 for location of test points on the A7 board.**

- 6.3.1 From the GUI Interface Command Line select the 2 amp range with the following command:  
  
CAL:CURREN1:RANGE 2 and select the SEND key.
- 6.3.2 Program the output voltage to 100 volts.
- 6.3.3 Apply resistive load on phase A to produce a 2 amp load current. To reach the exact value, increase or decrease the program voltage value. Connect the low input of the AC voltmeter to TP1.
- 6.3.4 Reference to Table 6-1. Connect the high end of the voltmeter to the test point for the proper phase. Adjust the resistor value for that range and for that phase so that the voltage at the test point measures 0.4 volts  $\pm 0.2$  mv rms.
- 6.3.5 Repeat steps 6.3.3 and 6.3.4 for phase B and C.
- 6.3.6 Remove the load and change the current range to the 4 amps range with following command:  
  
CAL:CURREN4:RANGE 4
- 6.3.7 Repeat steps 6.3.3 and 6.3.4 for phase A, B and C with 4 amps load current.

	Phase A	Phase B	Phase C
Ref. TP1	TP2	TP3	TP4
2 Amps.	R7	R15	R23
4 Amps	R8	R16	R24

Table 6-1

## 6.4 MEASUREMENT CALIBRATION

To access the Calibration screen from the Main Menu, select the Configuration screen then select the Measurement calibration.

### 6.4.1 VOLTAGE CALIBRATION

6.4.1.1 Program the output voltage to 135 volts and close the output relay.

6.4.1.2 Measure the output voltage for phase A with an external voltmeter.

6.4.1.3 Enter the above value in the value window for phase A voltage and select Accept to start the calibration.

6.4.1.4 When calibration is completed, the GUI will return the value of the calibration coefficient in the coefficient window.

6.4.1.5 Repeat steps 6.4.1.2 through 6.4.1.4 for phase B and phase C.

### 6.4.2 CURRENT CALIBRATION

6.4.2.1 From the Interface screen verify that the current range is set for the 2 amps range with the following query: `MEAS:CURR:RANGE?`

6.4.2.2 Change the current range to 2 amps if necessary with the following command.

`MEAS:CURR:RANGE 2`

**NOTE: Range change may not take effect if unit is under load.**

6.4.2.3 Select the measurement calibration screen from the configuration screen.

- 6.4.2.4 Apply resistive load about 1.8 amps on phase A. With the external voltmeter, measure the voltage across the shunt and compute the actual current for phase A.
- 6.4.2.5 Enter the computed value in the value window for phase A rms current and select Accept to start the calibration.
- 6.4.2.6 When calibration is completed the GUI will return the value of the calibration coefficient in the coefficient window.
- 6.4.2.7 Repeat steps 6.4.2.4 through 6.4.2.6 for phase B and phase C

### **6.4.3 PEAK CURRENT CALIBRATION**

- 6.4.3.1 From step 6.4.2.4 compute the peak current value by multiplying the value by 1.4142 ( $\sqrt{2}$ ).
- 6.4.3.2 Enter the computed value above in the value window for phase A peak current and select Accept to start the calibration.
- 6.4.3.3 When calibration is completed the GUI will return the value of the calibration coefficient in the coefficient window.
- 6.4.3.4 Repeat steps 6.4.3.1 through 6.4.3.3 for phase B and phase C.

### **6.4.4 POWER CALIBRATION**

- 6.4.4.1 For the same program voltage and load current in step 6.4.1 and 6.4.2, calculate the output power of phase A by multiply the external voltmeter reading of voltage and current. The calculated value must be in Kwatts.
- 6.4.4.2 Enter the computed value above in the value window for phase A power and select Accept to start the calibration.
- 6.4.4.3 When calibration is completed the GUI will return the value of the calibration coefficient in the coefficient window.
- 6.4.4.4 Repeat steps 6.4.4.1 through 6.4.4.3 for phase B and phase C.

## 6.4.5 HARMONIC FILTER TUNE UP and GAIN ADJUSTMENT

**Note: This adjustment is not required unless harmonic calibration was unsuccessful.**

**Refer to Figure 6-1 for location of test points on the A5 board.**

6.4.5.1 Filter Clock frequency must be adjusted first. This adjustment should be done once. Do not repeat this adjustment for phase B or C.

6.4.5.2 Program the output voltage for 135 volts and the output frequency for 60 Hz. From the calibration screen enter 60 in the frequency window at the harmonic calibration screen.

6.4.5.3 Enter 0 volts in the value window for phase A voltage harmonic and select Accept to start the filter calibration. Wait until calibration is completed. The GUI will return the value for the calibration coefficient. Disregard the value.

6.4.5.4 Select the Interface screen. From the immediate command line set the calibration coefficient for phase A voltage to 127 with the following command followed by the SEND key.

```
CAL:VOLT1:HARM:CONSTant<sp>127
```

6.4.5.5 Enter the following command to measure the fundamental followed by the SEND key.

```
MEAS:VOLT1:HARM?<sp>60,1
```

6.4.5.6 Adjust R14 on 4007-713 Harmonic-Interface board.

6.4.5.7 Repeat steps 6.4.5.5 and 6.4.5.6 until the response reads 135 volts  $\pm 0.2$  volts.

## 6.4.6 VOLTAGE HARMONIC CALIBRATION

6.4.6.1 Select the Measurement Calibration screen from the Configuration screen. Enter 135 volts in the value window for phase A voltage harmonic ; enter 60 Hz in the frequency window. Select Accept to start the calibration of phase A.

6.4.6.2 When calibration is completed the GUI will return the value of the calibration coefficient in the coefficient window.

6.4.6.3 Repeat steps 6.4.6.1 for phase B and C.

### **6.4.7 CURRENT HARMONIC CALIBRATION**

- 6.4.7.1 Remove all loads and select the 2 amps range by typing the following command from the interface screen :MEAS:CURR:RANGE 2.0 and select the SEND key
- 6.4.7.2 Apply a resistive load for 1.8 amps on phase A. Adjust the output voltage to produce the proper load current.
- 6.4.7.3 From the Measurement Calibration screen, enter 60 Hz in the frequency window. Enter the value of the measured current with the external voltmeter into the value window for phase A current harmonic. Select Accept to start current harmonic calibration of phase A.
- 6.4.7.4 When the calibration is completed the GUI will return the value of the calibration coefficient in the coefficient window.
- 6.4.7.5 Repeat steps 6.4.7.2 and 6.4.7.3 for phase B and C.

### **6.5 CURRENT LIMIT CALIBRATION**

Refer to the manual for the AC source Calibration section for this adjustment if it is required.

### **6.6 LOAD BALANCE ADJUSTMENT**

This adjustment is only required when the HGA is installed with the 4500L with single and three phase configuration. This adjustment is not required unless the amplifier has been repaired. Refer to the Calibration section of the AC power source manual if this calibration is required.

### **6.7 80/160 AMPS CURRENT RANGES (Option)**

**Refer to Figure 6-1 for location of test points on the A7 board.**

- 6.7.1 If the option is installed, select the Interface screen and from the command line enter the following command.  

MEAS:CURR:RANGE 80      and select SEND
- 6.7.2 Program the output voltage for 100 volts.
- 6.7.3 Apply resistive load on phase A to produce 30 Amps. To reach the exact value increase or decrease the program value. Connect the low input of the AC voltmeter to TP1.
- 6.7.4 Refer to Table 6-2. Connect the high end of the voltmeter to the test point for the proper phase. Adjust the resistor value for that range and for that phase so that the voltage at the test point measures 0.15 volts rms  $\pm 0.5\text{mV}$ .

6.7.5 Repeat steps 6.7.3 and 6.7.4 for phase B and phase C.

6.7.6 Remove the load and change the range to the 160 amps range with the following command from the command line.

MEAS:CURR:RANG 160

6.7.7 Repeat steps 6.7.2 through 6.7.5 for a load current of 60 amps and adjust voltage at test points for 0.15 volts rms  $\pm 0.5$  mV. Use Table 6-2 for proper test points and adjustment pots.

	Phase A	Phase B	Phase C
Ref. TP1	TP2	TP3	TP4
80 Amps	R7	R15	R23
160 Amps	R8	R16	R24

Table 6-2

## SECTION 7

### THEORY OF OPERATION

#### 7.0 GENERAL

An explanation of the circuit within the HGA is given in this section. Refer to Figure 7-1 for a block diagram of the HGA.

#### 7.1 OVERALL DESCRIPTION

Input power from the rear panel is routed through the power on switch and into an EMI filter and voltage selection to an A8 regulated power supply and an A6 unregulated power supply.

The two power supplies provide DC voltages to all the printed circuit boards of the HGA.

The following is a summary of the basic components of the HGA:

- Digital board and the Main processor, A10.
- Analog board has a three-waveform generator, A9.
- Auxiliary processor board for measurement, A3.
- Harmonic board for harmonic measurement, A5.
- Control board to control the output voltage regulation and accuracy, A4.
- Keypad board, A11.
- Display board, A12.
- Current Sense board, A9.
- Interconnect board provides connection between boards and interface connection to power sources.
- Regulated DC supply, A8, to supply power to the A9, A10 and A12 boards.
- Unregulated supply, A6, to supply power to A3, A4, A5 and A7 boards. It also supplies 5 volts to provide isolation for GPIB and RS232 located on the A9 board.

\*



Figure 7-1 Block Diagram of HGA

## **7.2 DIGITAL BOARD**

The digital board contains the main processor. The main processor board receives SCPI commands from the IEEE488 interface or RS232 interface. It will process these commands and generate the appropriate response. It also scans the keypad and updates the display in local operation.

The digital board also will generate the frequency and the phase angle for the AC output signal.

## **7.3 ANALOG BOARD**

This board has the optocoupler isolation for the IEEE488 and RS232 interface. The basic function is to generate the voltage programming reference and generate a waveform for all three phases. It will accept data from the digital board. This data has information about the voltage level, frequency value and phase angle for all three phases.

## **7.4 BASIC MEASUREMENT BOARD**

This board has a microcontroller that will accept measurement and calibration commands from the main processor. It will translate this command and perform the measurement or calibration and report the result to the main processor.

## **7.5 HARMONIC MEASUREMENT BOARD**

This board is an extension of the measurement board. It contains the hardware required to measure the harmonics and the peak current. This board utilizes a 4-stage programmable switch capacitor filter to measure the harmonic of a known fundamental.

## **7.6 CONTROL BOARD**

This board has the parallel interface circuits that will allow the communication between the measurement processor and the main processor. It also has a control circuit for voltage accuracy and voltage regulation. It also has the logic to detect a fault condition if the output voltage does not agree with the program value.

## **7.7 CURRENT SENSE BOARD**

This board contains the current transformers that sense the load current and generates a voltage signal proportionate to the load current. It has several ranges to select the proper signal level for accurate current and harmonic current measurements.

Refer to the theory of operation in the AC source user manual for the appropriate power source. Disregard any reference to the oscillator Theory of Operation in the AC source manual.

## **SECTION 8**

## GRAPHICAL USER INTERFACE

### 8.0 INTRODUCTION

Graphical User Interface is a software program operating under Microsoft "Windows"<sup>TM</sup> on the PC platform. The Graphical User Interface will be referred to as GUI. The GUI is a set of screens that allows the user to control the HGA functions such as harmonic analysis, waveform generation and transient generation of output voltage and frequency.

### 8.1 SYSTEM REQUIREMENT

GUI requires the following configuration.

- An IBM personal computer or 100% compatible running MS-DOS version 5 or later.
- An 80386 or higher processor.
- Four megabytes of memory.
- 2 Megabytes of available hard disk.
- Microsoft "Windows"<sup>TM</sup> graphical environment.
- RS232 port or GPIB Interface Adapter with appropriate drivers.

### 8.2 GUI INSTALLATION

1. Insert the distribution disk in drive A or drive B.
2. From the "Windows"<sup>TM</sup> Program Manager select RUN.
3. Type A:\SETUP if the distribution disk is in drive A or B:\SETUP if the distribution disk is in drive B.

### 8.3 RS232 INTERFACE

The RS232 Interface is a standard Interface in the PC. Use COM1 or COM2 port. Refer to Section 2.3.5 for cable connections between the HGA and the PC.

### 8.4 GPIB INTERFACE

The GPIB Interface requires a GPIB Interface adapter and appropriate driver to operate in the "Windows"<sup>TM</sup> environment. It is recommended using National Instrument AT-GPIB. Follow the manufacture's installation procedure.

## **8.5 INTERFACE CONFIGURATION**

The following steps describe how to set the Listen Address for the GPIB and the RS232 configuration.

### **8.5.1 HGA SETUP**

#### **GPIB Address selection:**

1. Turn power on for the HGA.
2. Press the UTILITY key and rotate the knob clockwise until the Utility:GPIB appears on the screen.
3. Press the right arrow twice. The GPIB address will appear on the screen.
4. Rotate the knob to select the desired GPIB address.

#### **RS232 Configuration:**

1. Turn power on for the HGA.
2. Press the UTILITY key and rotate the knob clockwise until the Utility:RS232 appears on the screen.
3. Press the right arrow twice. The baud rate will appear on the screen. Rotate the knob to select the desired baud rate.
4. Press the left arrow and rotate the knob clockwise once. The parity bit will appear on the screen. Press the right arrow once and verify that the parity is none. If not rotate the knob until the parity is none.
5. Press the left arrow once and rotate the knob clockwise once. The No. of Bits screen will appear on the screen. Press the right arrow once to review the number of bits. Rotate the knob left or right if the Bits does not equal 8D1S (8 data bits and 1 stop bits)
6. Press the left arrow once and rotate the knob clockwise once. The Handshake message will appear. Press the right arrow once. Rotate the knob in either direction until Handshake is HW. Press the UTILITY key and the VOLT key.

## 8.5.2 GUI SETUP

1. Double click on the HGA Icon. When the program is loaded click on the START button. Select the Interface screen from the menu.

### **For RS232 configuration:**

2. Select COM port number and baud rate that matches the baud rate selected for the HGA.

### **For GPIB Address selection:**

3. Click on the down arrow for the GPIB address and select the Listen Address for the GPIB. This address must match the address selected for the HGA control panel.
4. Click on CLOSE to go to the main menu selection

## 8.6 GUI OPERATION

Refer to the CIGUI or CIGUI32 User Manual for information on using the Windows Graphical User Interface.