Chroma

Programmable AC Source

61511/61512

User's Manual

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61511/61512
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Material Contents Declaration

The recycling label shown on the product indicates the Hazardous Substances contained in the product as the table listed below.

: See **<Table 1>**.

: See **<Table 2>**.

<Table 1>

Part Name	Hazardous Substances					
	Lead	Mercury	Cadmium	Hexavalent Chromium	Polybrominated Biphenyls	Polybromodiphenyl Ethers
	Pb	Hg	Cd	Cr^{6+}	PBB	PBDE
PCBA	O	O	O	O	O	O
CHASSIS	O	O	O	O	O	O
ACCESSORY	O	O	O	O	O	O
PACKAGE	O	O	O	O	O	O

“O” indicates that the level of the specified chemical substance is less than the threshold level specified in the standards of SJ/T-11363-2006 and EU 2005/618/EC.

“×” indicates that the level of the specified chemical substance exceeds the threshold level specified in the standards of SJ/T-11363-2006 and EU 2005/618/EC.

Disposal

Do not dispose of electrical appliances as unsorted municipal waste; use separate collection facilities. Contact your local government for information regarding the collection systems available. If electrical appliances are disposed of in landfills or dumps, hazardous substances can leak into the groundwater and get into the food chain, damaging your health and well-being. When replacing old appliances with a new one, the retailer is legally obligated to take back your old appliances for disposal free of charge.

<Table 2>

Part Name	Hazardous Substances					
	Lead	Mercury	Cadmium	Hexavalent Chromium	Polybrominated Biphenyls	Polybromodiphenyl Ethers
	Pb	Hg	Cd	Cr^{6+}	PBB	PBDE
PCBA	×	O	O	O	O	O
CHASSIS	×	O	O	O	O	O
ACCESSORY	×	O	O	O	O	O
PACKAGE	O	O	O	O	O	O

"O" indicates that the level of the specified chemical substance is less than the threshold level specified in the standards of SJ/T-11363-2006 and EU 2005/618/EC.

"×" indicates that the level of the specified chemical substance exceeds the threshold level specified in the standards of SJ/T-11363-2006 and EU 2005/618/EC.

1. Chroma is not fully transitioned to lead-free solder assembly at this moment; however, most of the components used are RoHS compliant.
2. The environment-friendly usage period of the product is assumed under the operating environment specified in each product's specification.

Disposal

Do not dispose of electrical appliances as unsorted municipal waste; use separate collection facilities. Contact your local government for information regarding the collection systems available. If electrical appliances are disposed of in landfills or dumps, hazardous substances can leak into the groundwater and get into the food chain, damaging your health and well-being. When replacing old appliances with a new one, the retailer is legally obligated to take back your old appliances for disposal free of charge.

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Declaration of Conformity

For the following equipment :

Programmable AC Source

(Product Name/ Trade Name)

61512, 61511, 61612, 61611, A615103

(Model Designation)

CHROMA ATE INC.

(Manufacturer Name)

66, Hwaya 1st Rd., Kueishan Hwaya Technology Park, Taoyuan County 33383, Taiwan

(Manufacturer Address)

Is herewith confirmed to comply with the requirements set out in the Council Directive on the Approximation of the Laws of the Member States relating to Electromagnetic Compatibility (2004/108/EC) and Low Voltage Directive (2006/95/EC). For the evaluation regarding the Directives, the following standards were applied :

EN 61326-1:2006 Class A

EN 61326-1:2006 (industrial locations)

IEC 61000-4-2:1995+A1:1998+A2:2000, IEC 61000-4-3:2002,

IEC 61000-4-4:2004, IEC 61000-4-5:1995+A1:2000, IEC 61000-4-6:2003,

IEC 61000-4-8:1993+A1:2000, IEC 61000-4-11:2004

EN 61010-1:2010

The following importer/manufacturer or authorized representative established within the EUT is responsible for this declaration :

CHROMA ATE INC.

(Company Name)

66, Hwaya 1st Rd., Kueishan Hwaya Technology Park, Taoyuan County 33383, Taiwan

(Company Address)

Person responsible for this declaration:

Mr. Benjamin Huang

(Name, Surname)

Division Vice President

(Position/Title)

Taiwan	**2013.02.27**	Benjamin Huang
(Place)	(Date)	(Legal Signature)

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EN 61326-1:2006 Class A

EN 61326-1:2006 (industrial locations)

IEC 61000-4-2:1995+A1:1998+A2:2000, IEC 61000-4-3:2006,

IEC 61000-4-4:2004, IEC 61000-4-6:2006, IEC 61000-4-8:2001

EN 61010-1:2010

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(Company Address)

Person responsible for this declaration:

Mr. Benjamin Huang

(Name, Surname)

Division Vice President

(Position/Title)

Taiwan	**2013.02.27**	Benjamin Huang
(Place)	(Date)	(Legal Signature)

Safety Summary

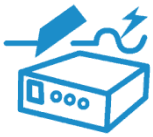
The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or specific WARNINGS given elsewhere in this manual will violate safety standards of design, manufacture, and intended use of the instrument. *Chroma* assumes no liability for the customer's failure to comply with these requirements.

BEFORE APPLYING POWER

Verify that the power is set to match the rated input of this power supply.

PROTECTIVE GROUNDING

Make sure to connect the protective grounding to prevent an electric shock before turning on the power.



NECESSITY OF PROTECTIVE GROUNDING

Never cut off the internal or external protective grounding wire, or disconnect the wiring of protective grounding terminal. Doing so will cause a potential shock hazard that may bring injury to a person.

FUSES

Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired fuses or short-circuited fuse holders. To do so could cause a shock or fire hazard.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. The instrument should be used in an environment of good ventilation.

DO NOT REMOVE THE COVER OF THE INSTRUMENT

Operating personnel must not remove the cover of the instrument. Component replacement and internal adjustment can be done only by qualified service personnel.

⚠WARNING

1. Lethal voltage. AC source may output 426 V peak voltage.
2. Touching the connected circuit or output terminal on the front or rear panel when power is on may result in death.
3. Before placing the device, be sure the floor is smooth and can withstand the maximum weight. The installation should close to the main structure (beam) of the building
4. Be noted that the L1/L2/L3 and NEU may generate maximum current when the configuration is Y connection. Thus, the wire diameter should meet the maximum current requirement.

Safety Symbols

	DANGER – High voltage.
	Explanation: To avoid injury, death of personnel, or damage to the instrument, the operator must refer to the explanation in the instruction manual.
	High temperature: This symbol indicates the temperature is hazardous to human beings. Do not touch it to avoid any personal injury.
	Protective grounding terminal: This symbol indicates that the terminal must be connected to ground before operation of the equipment to protect against electrical shock in case of a fault.
	Functional grounding: To identify an earth (ground) terminal in cases where the protective ground is not explicitly stated. This symbol indicates the power connector does not provide grounding.
	Frame or chassis: To identify a frame or chassis terminal.
	Alternating Current (AC)
	Direct Current (DC) / Alternating Current (AC)
	Direct Current (DC)
	Push-on/Push-off power switch
	The **WARNING** sign highlights an essential operating or maintenance procedure, practice, condition, statement, etc., which if not strictly observed, could result in injury to, or death of, personnel or long term health hazards.
	The **CAUTION** sign highlights an essential operating or maintenance procedure, practice, condition, statement, etc., which if not strictly observed, could result in damage to, or destruction of, equipment.
	The **Notice** sign highlights an essential operating or maintenance procedure, condition, or statement.

Revision History

The following lists the additions, deletions and modifications in this manual at each revision.

Date	Version	Revised Sections
Aug. 2009	1.0	Complete this manual.
Jan. 2012	1.1	Reformat the manual layout and add "*Verification of Compliance*" Add 3-phase voltage input 440Vac /480Vac(Y: L-L) support
May 2013	1.2	Replace the "*CE Declaration of Conformity*"
Jun. 2014	1.3	Update the following: – Icons of keys described in the section of "*Front Panel.*" – Pin description in the appendix of "*TTL Signal Pin Assignments*."
Apr. 2015	1.4	Add warning items in Safety Summary. Modify the following section: – "*Key Features*", "*Specifications*", "*Front Panel*" and "*Rear Panel*" in the chapter of "*General Information*." – "*Preparation for Use*" and "*Input Connection*" in the chapter of "*Installation*." – "*External Vref*" and "*Protection*" in the chapter of "*Local Operation*." – "*List Mode*" in the chapter of "*Application*."

Table of Contents

1. General Information 1-1
1.1 Introduction 1-1
1.2 Key Features 1-1
1.3 Specifications 1-1
1.4 Names of Parts 1-4
1.4.1 Front Panel 1-4
1.4.2 Rear Panel 1-6
2. Installation 2-1
2.1 Initial Inspection 2-1
2.2 Preparation for Use 2-1
2.3 Requirements for Input Power 2-1
2.3.1 Ratings 2-1
2.3.2 Input Connection 2-1
2.4 Output Connection 2-3
2.5 Remote Sense Connection 2-4
2.6 Power On Procedure 2-5
2.7 Maintenance & Cleaning 2-6
2.8 Common Environment Conditions 2-6
3. Local Operation 3-1
3.1 Introduction 3-1
3.2 Using Keyboard & RPG 3-1
3.3 MAIN PAGE (Output Setting & Measurement) 3-3
3.3.1 OUTPUT: More Setting 3-5
3.3.1.1 Coupling Output Mode (AC+DC, AC, DC) 3-5
3.3.1.2 Range 3-7
3.3.1.3 Setting Three Phase Output 3-8
3.3.1.4 Output Degree 3-12
3.3.1.5 Slew Rate of Output Transient 3-12
3.3.1.6 Output Degree of 3-phase Voltage Output 3-13
3.3.1.7 Output Waveform Selection 3-14
3.3.1.8 Zo Program Enable 3-16
3.3.2 Measurement Setting 3-18
3.3.2.1 Current Range 3-19
3.3.2.2 Average Times 3-20
3.3.2.3 Isurge Delay, Isurge Interval 3-21
3.3.3 Waveform Viewer 3-21
3.3.4 Limitation 3-22
3.3.4.1 Vac Limit 3-22
3.3.4.2 Vdc Limit (+), Vdc Limit (-) 3-23
3.4 CONFIG Function Key 3-24
3.4.1 Interface 3-24
3.4.1.1 GPIB Address, RS-232C Parity/Baudrate 3-24
3.4.1.2 Remote Inhibit, EXT. ON/OFF 3-26
3.4.1.3 Ethernet Setting 3-27
3.4.2 External Vref 3-28
3.4.3 Display 3-30
3.4.4 Power ON Status 3-31
3.4.5 Protection 3-32
3.4.6 Others 3-33
3.4.7 Calibration 3-35
3.4.8 System Information 3-35

3.4.9 Factory Default 3-36
3.5 PHASE Function Key 3-36
3.5.1 3_Phase Mode 3-36
3.5.2 1_Phase Mode 3-37
3.6 CURSOR Function Key 3-37
3.7 LOCK Function Key 3-38
3.8 OUTPUT Function Key 3-38
3.9 LOCAL/REMOTE Function Key 3-38
3.10 SAVE/RECALL Function Key 3-39
3.10.1 Save/Recall Output Setting 3-39
3.10.2 Save/Recall System Data 3-40
3.11 Protection 3-41
4. Calibration 4-1
4.1 Introduction 4-1
4.2 Manual Calibration 4-2
4.2.1 Output Voltage and Measurement Calibration 4-3
4.2.2 Current Measurement Calibration 4-11
4.2.3 External Vref Calibration 4-16
5. Application 5-1
5.1 Overview 5-1
5.2 List Mode 5-1
5.3 Pulse Mode 5-6
5.4 Step Mode 5-9
5.5 Synthesis Waveform 5-13
5.6 Inter-harmonics Waveform 5-17
5.7 Harmonic Waveform 5-20
6. Parallel Operation 6-1
6.1 Parallel Connection of AC Source 6-1
6.2 Parallel Connection 6-1
6.3 Setting Up 6-2
6.3.1 Setting the AC Source to Slave 6-2
6.3.2 Setting the Slave of Mixed AC Source and A615103 6-3
6.3.3 Setting the AC Source to Master 6-4
6.4 Troubleshooting 6-5
6.4.1 When the Connecting Cable Falls 6-5
6.4.2 Parallel Setting Error 6-6
7. Theory of Operation 7-1
7.1 Overview 7-1
7.2 Description of Overall System 7-1
8. Self Test & Troubleshooting 8-1
8.1 Overview 8-1
8.2 Self Test 8-1
8.3 Troubleshooting 8-2
9. Remote Operation 9-1
9.1 Introduction 9-1
9.1.1 USB Interface 9-1
9.1.2 GPIB Interface 9-1
9.1.3 RS-232C Interface 9-2
9.1.4 Ethernet Interface 9-2
9.2 Introduction to Programming 9-2
9.2.1 Conventions 9-3
9.2.2 Numerical Data Formats 9-3

9.2.3 Boolean Data Format 9-3
9.2.4 Character Data Format 9-3
9.2.5 Basic Definition 9-3
9.3 Traversal of the Command Tree 9-5
9.4 Execution Order 9-5
9.5 Commands of AC Source 9-5
9.5.1 Common Command Dictionary 9-5
9.5.2 Instrument Command Dictionary 9-7
9.5.2.1 SYSTEM Sub-System 9-7
9.5.2.2 INSTRUMENT Sub-System 9-8
9.5.2.3 FETCH & MEASURE Sub-System 9-9
9.5.2.4 OUTPUT Sub-System 9-13
9.5.2.5 SOURCE Sub-System 9-15
9.5.2.6 CONFIGURE Sub-System 9-19
9.5.2.7 PHASE Sub-System 9-20
9.5.2.8 STATUS Sub-system 9-21
9.5.2.9 TRACE Sub-system 9-23
9.5.2.10 LIST Sub-system 9-23
9.5.2.11 PULSE Sub-system 9-26
9.5.2.12 STEP Sub-system 9-27
9.5.2.13 SYNTHESIS Sub-system 9-29
9.5.2.14 INTERHARMONICS Sub-system 9-32
9.5.2.15 Harmonic Sense Sub-system 9-33
9.6 Command Summary 9-35
Appendix A TTL Signal Pin Assignments A-1
Appendix B Built-in DST Waveform B-1

1. General Information

1.1 Introduction

The Chroma 61511/61512 Series is a highly efficient programmable AC Source, which provides a low distortion sine wave output for power accuracy. The DSP microprocessor generates an accurate stable output voltage and frequency. The PWM designed power stage allows apparent power into loads. Its front panel has a RPG (Rotary Pulse Generator) and keypad control for setting the output voltage and frequency, while the LCD gives users complete operating status. Remote programming is accomplished by the GPIB bus, RS-232C serial port or USB port.

1.2 Key Features

A. Configuration

- Local operation by the keypad on the front panel
- Remote operation via GPIB or RS-232C or USB interface
- Protection against over power, over current, over temperature and fan failure
- Thermostatically controlled fan speed
- Built-in output isolation relays

B. Input/Output

- Selectable output voltage with full scale of 150V/300V/Auto (3 ranges)
- Analog (simulation) reference voltage for remote control
- V, I, Po, CF, PF, Idc, Vdc, Vac, Iac, Ipk, Vpk and VA measurements
- Remote inhibited control
- AC ON/OFF output signal

1.3 Specifications

Following lists the specifications of model 61511/61512. All specifications are tested by Chroma's standard test procedures and follow remote sense for connection under the condition of 25 ± 1°C and resistive load unless specified otherwise.

Model	61511	61512
AC OUTPUT RATING		
Single Phase Power	12KW	18KW
3-Phase Power	12KW	18KW
Power per Phase	4KW	6KW
VOLTAGE		
Range	150V/300V/Auto	
Output Voltage	0~150V / 0~300V	
Accuracy	0.1%+0.2% F.S.	
Resolution	0.1 V	
Distortion *1	0.3% @50/60Hz , 1%@15- 1KHz , 1.5%@>1KHz	
Line Regulation	0.1%	
Load Regulation *2	0.2%	
Temp. Coefficient	0.02% per degree from 25°C	
MAXIMUM CURRENT (single phase)		
RMS	96A / 48A	144A / 72A
Peak (CF=4)	384A / 192A	576A / 288A
MAXIMUM CURRENT (each of 3-phase)		
RMS	32A / 16A	48A / 24A
Peak (CF=4)	128A / 64A	192A / 96A
FREQUENCY		
Range	DC, 15-1.5KHz	
Accuracy	0.005%	
PHASE ANGLE		
Range	0 ~ 360°	
Resolution	0.3°	
Accuracy	<0.8°@50/60Hz	
DC OUTPUT RATING (single phase)		
Power	6KW	9KW
Voltage	212V / 424V	212V / 424V
Current	48A / 24A	72A / 36A
DC OUTPUT RATING (each of 3-phase)		
Power	2KW	3KW
Voltage	212V / 424V	212V / 424V
Current	16A / 8A	24A / 12A
INPUT 3-PHASE RATING (per phase)		
Power Type	3-phase, Delta or Y connection	
Voltage Range	3Φ 200-240V±10% V_{LN} (Delta: L-L, Y: L-N) *4 3Φ 254-277V±10% V_{LN} (Y: L-N) *5	
Frequency Range	47-63 Hz	
Max. Current	Delta: 80A Y: 70A	Delta: 120A Y: 90A
MEASUREMENT		
VOLTAGE		
Range	150V / 300V	
Accuracy	0.1%+0.2% F.S.	
Resolution	0.1 V	

CURRENT (per phase)		
Range	8A/32A/128Apeak	12A/48A/192Apeak
Peak per Phase	128A	192A
Accuracy (rms)	0.4%+0.3% F.S.	
Accuracy (peak)	0.4%+0.6% F.S.	
Resolution	0.006A / 0.025A / 0.1A	
POWER		
Accuracy	0.4%+0.4% F.S.	
Resolution	0.1 W	
OTHERS		
Efficiency *3	0.75 (Typical)	
Size (H×W×D)	1163×546×700 mm 45.78×21.5×27.56 inch	1163×546×700 mm 45.78×21.5×27.56 inch
Weight	220 kg / 505.29 lbs	240 kg / 533.92 lbs
Protection	OVP, OCP, OPP, OTP, FAN-FAIL	
Remote Interface	GPIB, RS-232, USB, Ethernet	
TEMPERATURE RANGE		
Operation	0 °C to 40 °C	
Storage	-40 °C to 85 °C	
Humidity	30 % to 90 %	
Safety & EMC	CE	

Notes

*1: Maximum distortion is tested under output 125VAC (150V RANGE) and 250VAC (300V RANGE) with maximum current to linear load.
*2: Load regulation is tested by sine wave and remote sense.
*3: Efficiency is tested on input voltage: 230V ac or 277Vac.
*4: 3-phase voltage input 380Vac/400Vac (Y: L-L); 208Vac/220Vac (Delta: L-L)
*5: 3-phase voltage input 440Vac/480Vac (Y: L-L)

1.4 Names of Parts

1.4.1 Front Panel

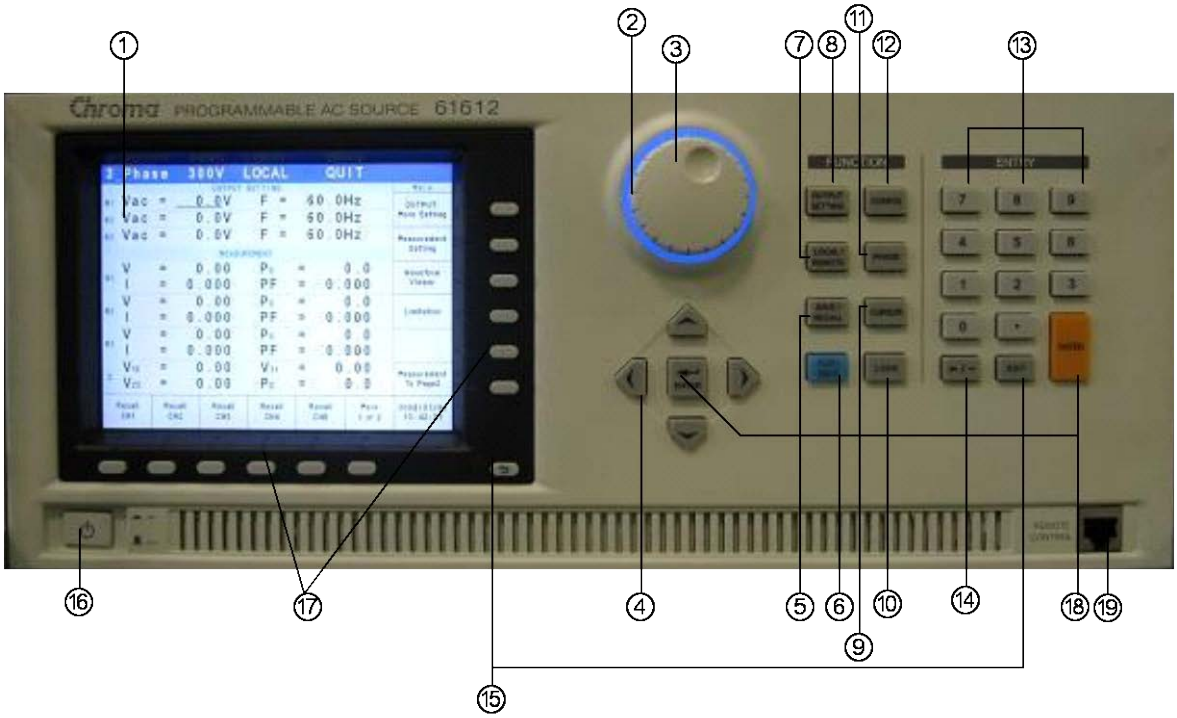
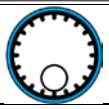
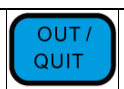


Figure 1-1 Front Panel

Item	Icon	Description
1		***Display:*** The 6.5" LCD displays the configuration, output setup, and measurement results.
2		***Indicator LED:*** The Power On indicator surroounds the rotary knob showing the activation status.
3		***RPG Rotary****:* Users can turn the RPG rotary to adjust the voltage, frequency and input programmed data or options.
4		***Cursor Movement Keys***: These four keys move the cursor in different directions. In normal mode, pressing any of these four keys will change the cursor position.
5		***SAVE or RECALL:*** Press this on MAIN PAGE can save the output setting. By pressing this key on CHOICE PAGE users can save the system data.
6		***OUT/QUIT:*** Press this key to Enable/Disable the output voltage of the AC source.
7		***LOCAL/REMOTE:*** Switch the "Remote" control mode to "LOCAL" from front panel input.
8		***OUTPUT SETTING:*** Change the screen to "Output: More Setting" for additional

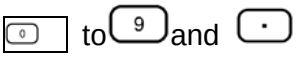
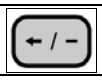
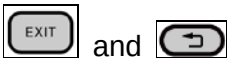
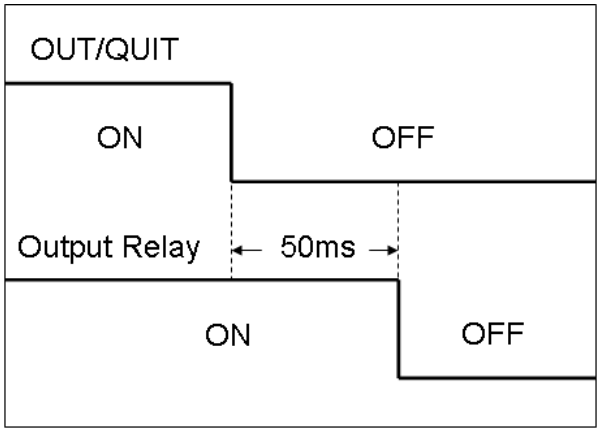
		settings.
9		***CURSOR:*** It is used to set or adjust the value.
10		***LOCK:*** Press it for 1 second can lock up “all keys” and the “rotary”. Press it for 3~3.5 seconds to unlock them.
11		***PHASE:*** It sets single/3-phase.
12		***CONFIG:*** It changes the screen to “config choose page” for various settings.
13		***Numeric and Decimal:*** The user can use “numeric keys” and “decimal key” to input digital data.
14		***Backward and Decreasing:*** Press this key to delete the inputted number. It shows " - " if no number exists.
15		***EXIT:*** Press it to return to previous screen.
16		***Main Power Switch:*** It turns on or shut off the power.
17		***Indicator:*** It refers to the description on screen for parameter and function setting.
18		**ENTER**: It confirms the setting of parameter.
19		***Remote Control Terminal:*** No supported. This functiond is invalid.

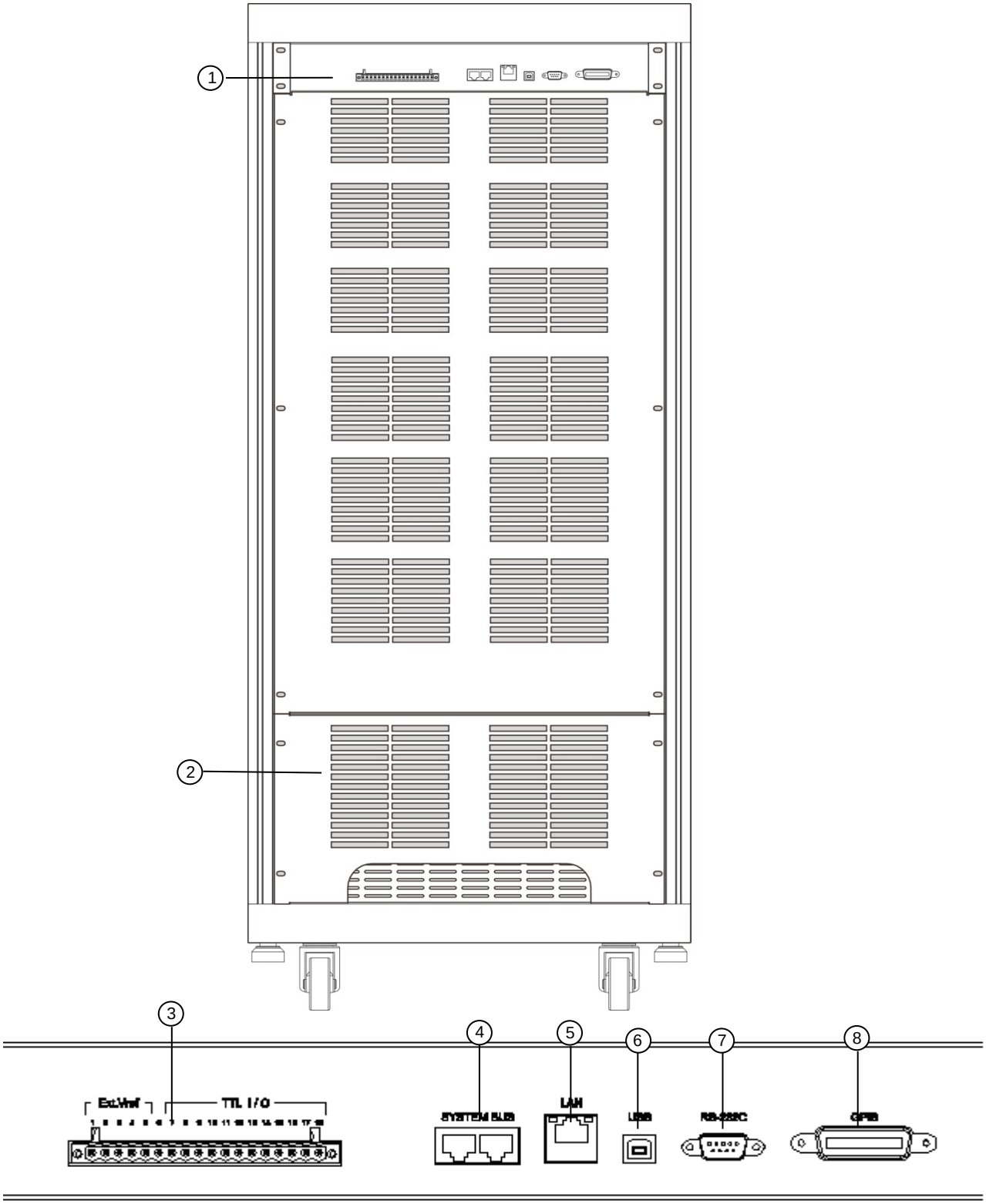
Table 1-1 Front Panel Description

Notice

To extend the product life of output relay, it will delay 50ms for release after pressing **QUIT**. When inductive load is connected, a discharge path will be provided for the inductive current within the period of time delayed due the feature of continuous flow.



1.4.2 Rear Panel



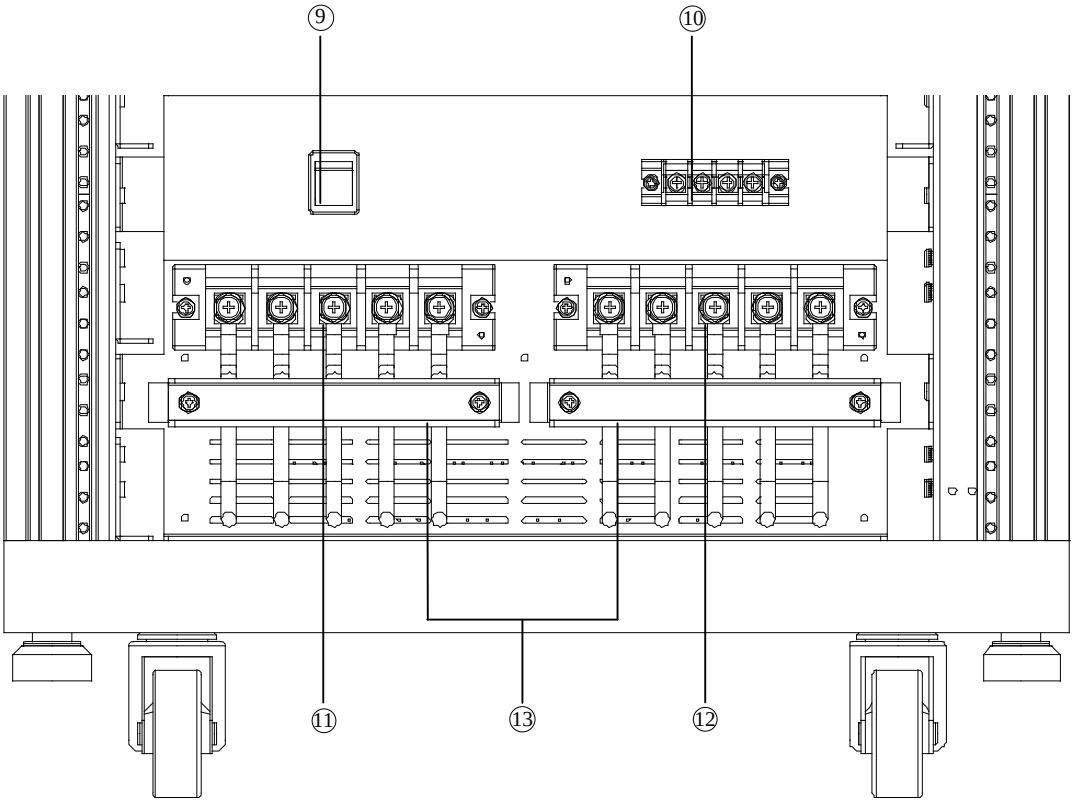


Figure 1-2 Rear Panel

Item	Name	Description
1	Rear Panel Output Interface	It includes Ext.V/TTL, Remote Sense, GPIB and USB…etc.
2	I/O Terminal Case	It has the input/output terminal. The connector inputs power source from the mains (3-phase power) and outputs power source to the UUT.
3	Ext. Vref./TTL I/O	It inputs the control waveform amplitude from external analog (simulated) signal with TTL transmission control signal (Fault_out, Remote inhibit and AC_ON.)
4	SYSTEM BUS	It is applicable for signal transmission in between 2 AC Sources connected in parallel.
5	Ethernet	It is the terminal that can be controlled by a network (LAN).
6	USB	It is used to connect the remote controller to computer for remote operation.
7	RS232C	It is a 9-pin D type male connector that transmits control commands among distant PCs for remote operation.
8	GPIB Connector	Remote controller uses GPIB bus to connect the PC via the connector for remote operation.
9	INPUT WIRING SELECTION	Select the mapping cable connector for different input cable (Δ-Y). (**Note:** Not valid for 3-phase voltage input 440Vac/480Vac (Y: L-L).)
10	Remote Sense	It is the terminal that senses the load directly to avoid any voltage drop when connecting cable. Ensure the “SL” terminal of Remote Sense connector is connected to the “L” terminal of Load, and the “SN” is connected to the “N” of Load. Reverse polarity cannot be connected.

11	Input Connecting Terminal	It connects the mains to AC Source as input.
12	Output Connection Terminal	It connects to UUT for output.
13	I/O Cable Secure Strip	It secures the input/output connection cable.

Table 1-2 Rear Panel Description

2. Installation

2.1 Initial Inspection

Before shipment, this instrument was inspected and found to be free of mechanical and electrical defects. As soon as the instrument is unpacked, inspect for any damage that may have occurred in transit. Save all packing materials in case the instrument has to be returned. If damage is found, please file claim with carrier immediately. Do not return the instrument to Chroma without prior approval.

2.2 Preparation for Use

First the instrument must be connected to an appropriate AC line input. Since the instrument is cooling by fans, it must be installed in a place with good circulation of air. It should be in an area where the ambient temperature does not exceed 40°C. The L1/L2/L3 and NEU may generate maximum current when it is Y connection. Thus, the wire diameter should meet the maximum current requirement.

2.3 Requirements for Input Power

2.3.1 Ratings

Input Voltage Range	:	3Φ 200-240V±10% V_{LN} (Delta: L-L, Y: L-N)
		3Φ 254-277V±10% V_{LN} (Y: L-N)
Input Frequency	:	47-63 Hz
Maximum Current	:	61511 Δ: 80A, Y: 70A
		61512 Δ: 120A, Y: 90A

⚠WARNING The AC Source may be damaged if the input voltage exceeds the configured range.

2.3.2 Input Connection

The input terminal block is located beneath the device's rear panel. The power cord should be rated at least 85°C and the current rating of power line input must be greater than or equal to the maximum current rating of AC Source. The input selector is located on the rear panel (see Figure 2-3.) Adjust the selector according to the power input (Delta or Y) method.

⚠WARNING Select the model in accord with the local voltage specification. The 200-240V_{LL} 3-phase 4-wire (Delta) and 380-400V_{LL} 3-phase 5-wire (Y) can be selected using input wiring selection before power-on. The range cannot be changed during power-on or it may cause the AC Source to be damaged. The 440-480V_{LL} 3-phase 5-wire (Y) is the sole range without selection.

See Figure 2-3 and perform the steps below accordingly:

1. Remove the safety cover from the back of the AC Source.
2. Connect the wire to the AC Source terminal blocks (see Figure 2-3.)
3. Slide the safety cover over the AC input terminal strip.
4. Secure it with the I/O cable trim strip and screws.
5. Assemble the safety cover back to the AC Source.

CAUTION To protect the operators, the wire connected to GND terminal must be connected to the earth. Under no circumstances shall this AC Source be operated without grounding adequately.

Voltage Range	Wire Spec.	Terminal Spec.
3Ø 200-240V±10%V_{LN} (Delta:L-L,Y:L-N)	38mm^2(L1/L2/L3/NEU/GND)	38-8(L1/L2/L3/NEU/GND)
3Ø 254-277V±10%V_{LN} (Y:L-L)	38mm^2(L1/L2/L3/NEU/GND)	38-8(L1/L2/L3/NEU/GND)

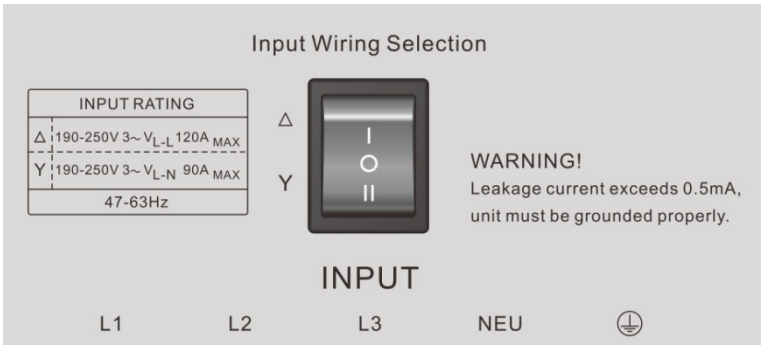


Figure 2-1 Input Wiring Selection

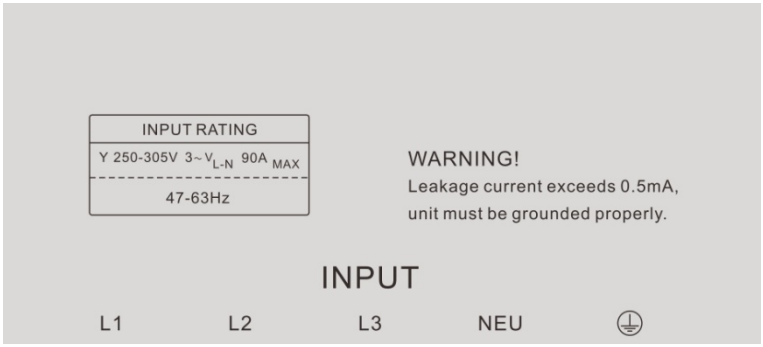


Figure 2-2 No Input Wiring Selection

Notice

1. If users turn the Δ-Y switch to Δ, but the actual input wiring is Y, the AC Source will beep to warn the error. Users need to power it off first and turn the Δ-Y switch to Y to resolve the problem.
2. The 480V model has Y connection only; therefore there is no input selector.

Notice

1. Installation of the wire must be conducted by professional personnel complying with local electrical codes.
2. If the input wiring selection is 220V 3~ (Δ type) Max 120A/Phase, the specification of Circuit Breaker configured for Δ type needs to be 220Vac/80A (61511) & 120A (61512) at least.

3. If the input wiring selection is 380V 3~ (Y type) Max 70A/Phase, the specification of Circuit Breaker configured for Y type needs to be 380Vac/70A (61511) & 90A (61512) at least.

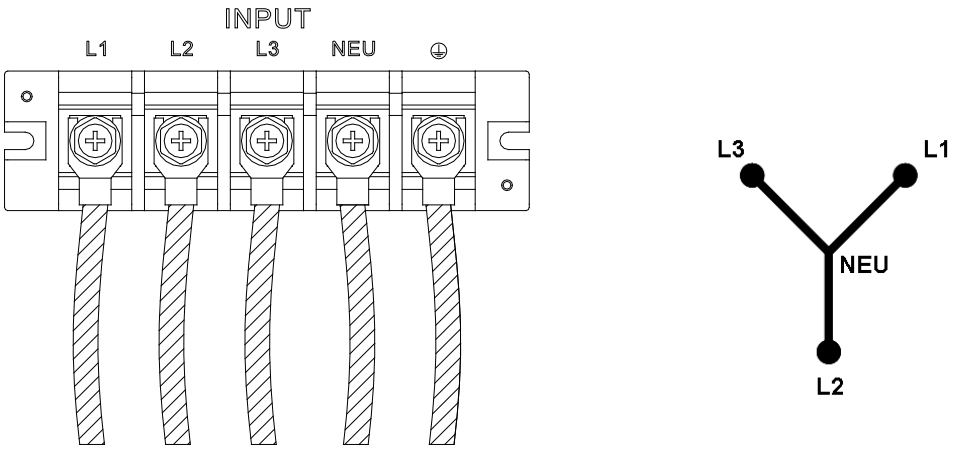


Figure 2-3 3-Phase Power Input Connection (Y Connection)

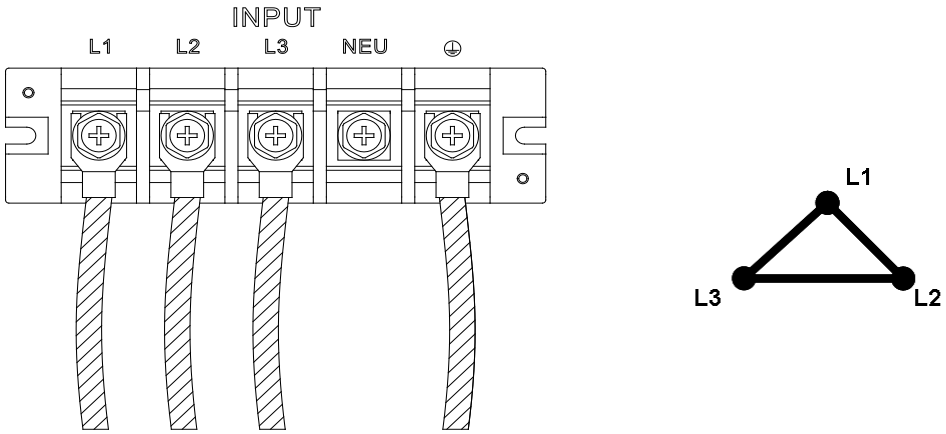


Figure 2-4 3-Phase Power Input Connection (Delta Connection)

Notice

Please be aware of the color distinction of insulation tube or the wire before connecting the power wire. The black insulation tube or power wire is used for L1, L2 and L3, the blue insulation tube or power wire is used for NEU while the green insulation tube or power wire is used for GROUND.

2.4 Output Connection

The output terminal block is located at the rear of AC Source. The Load is connected to the output terminals. To meet the safety requirements, the I/O input/output wires need to be tied up by a safety strip and the cover must be secured. The wire diameter should be large enough to connect to the load so that it will not overheat when outputting current, see Figure 2-6.

Notice The output terminal labeled "L" is the "+" terminal and the output terminal labeled "COM/N" is the "-" terminal when output voltage contains DC composition.

⚠WARNING For propoer ventilation, the hardware should be placed at least 1 meter distance from the device front and rear panel. Do not place the hardware against the wall or other objects.

2.5 Remote Sense Connection

The remote sense function of AC Source monitors the voltage at the load and the automatic compensation ensures the voltage delivered to load is the one programmed.

Remove the connecting wires "ψ1", "ψ2", "ψ3" and "COM" from Remote Sense terminal, and connect remote sense to load as Figure 2-5 shows. As the sensing leads transmit only a few milliamperes, the sensing wires are much thinner than the load leads. The sensing leads are part of the feedback circuit of AC Source, so they must be low resistance for the best performance. Connect the sensing leads carefully so that they will not be open-circuited. If the sensing leads are disconnected or become open-circuited during operation, the AC Source may unable to output. The sensing leads must be a twisted pair to minimize the interference from external voltages. The sensing leads need to be connected to the load as close as possible.

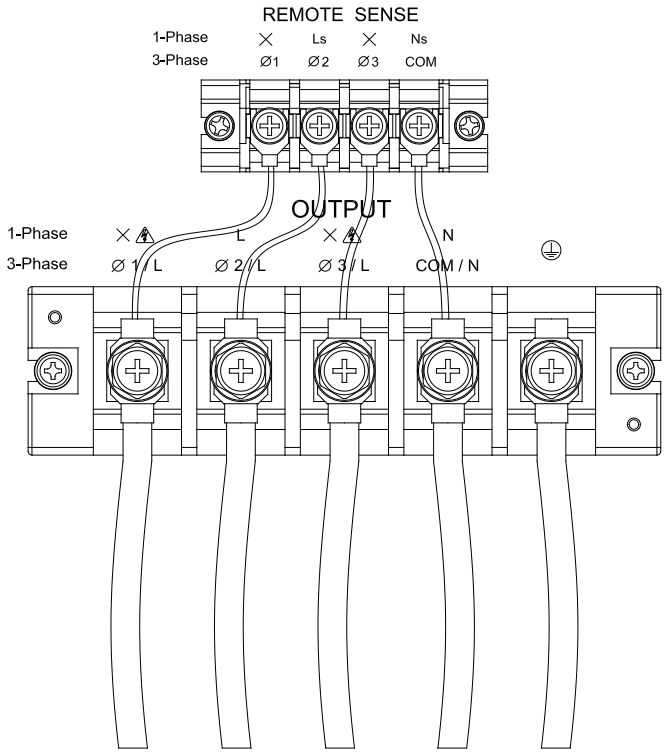


Figure 2-5 Output & Remote Sense Connection

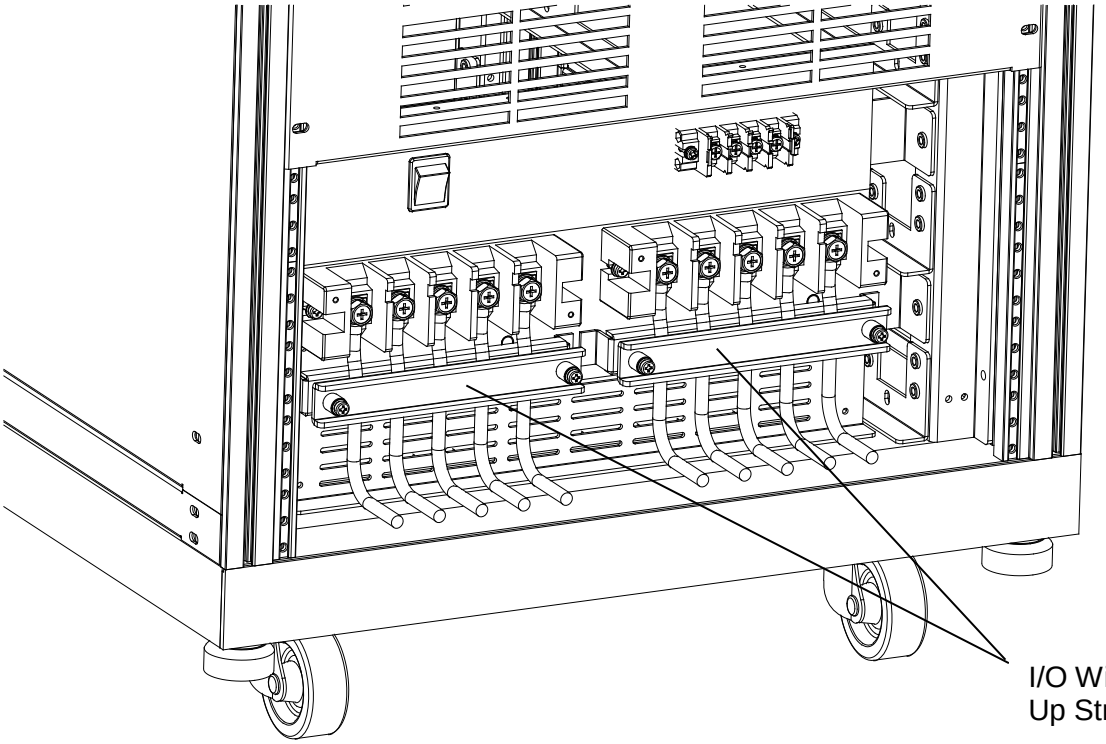
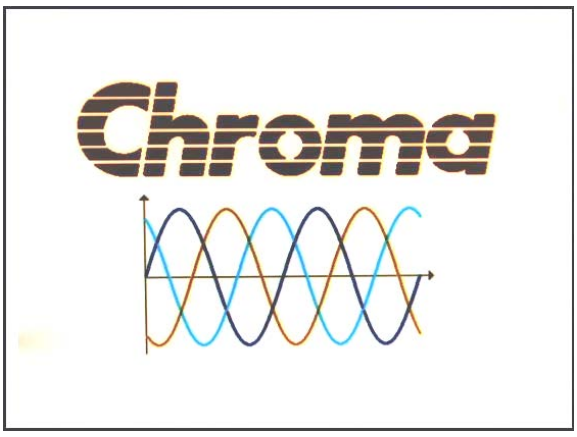


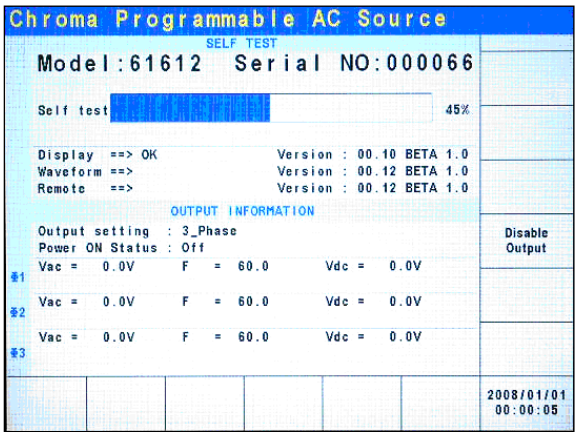
Figure 2-6 Input/Output Wire Securing Diagram

2.6 Power on Procedure

CAUTION Before turning on the instrument, all protective earth terminals, extension cords and devices connected to the instrument must be connected to a protective earth ground. Any interruption of the protective earth grounding may cause potential electric shock hazard that could result in personal injury.

Connect the power line and turn on the power switch on the front panel. The AC Source will begin a series of self tests. The LCD on the front panel will be on and display as the following.





In the mean time the AC Source executes memory, data and communication self tests. The display shows the Model Number and AC Source's Serial No. after executing the self test

routines and each test item will show "OK" on the right if no error is found. It needs about 10 seconds for self test to finish the routines and then the software version will show on the display.

"ERROR CODE" will appear on the right if one of the test items is failed, see section *8.2 Self Test* for detail information.

When the self tests of memory, data and communication are done, the AC Source will conduct a power output self test. The output relay is OFF during the procedure to ensure the load connected to the output terminal won't be damaged. The AC Source sets the output to 300Vac and if the measured voltage exceeds 300V±100V, the power self test fails and the display shows "NG". If everything passes self test, the screen will change to the MAIN PAGE automatically. .

Notice

1. Users can run self diagnosis during power on self test to see if there are any errors or NG (No Good) conditions, see section *8.2 Self Test* for detail information.
2. The AC Source needs about 20 seconds to finish the self test.

2.7 Maintenance & Cleaning

Remove all connected wires and cables on the instrument before cleaning. Use a brush to clean the dust on it and if there are stains on the chassis that cannot be removed by brush, wipe it with a volatile liquid. Do not use any corrosive liquid to avoid damaging the chassis. Use a damp cloth with soap and water or a soft detergent to clean the LCD front panel. Please send it back to the distributors or agents of Chroma for internal cleaning. Do not open the chassis cover arbitrarily

2.8 Common Environment Conditions

1. In door use only.
2. Altitude up to 2000m.
3. Temperature 0°C to 40°C.
4. Transient over voltage is impulse withstand CAT II.
5. Pollution degree 2.

3. Local Operation

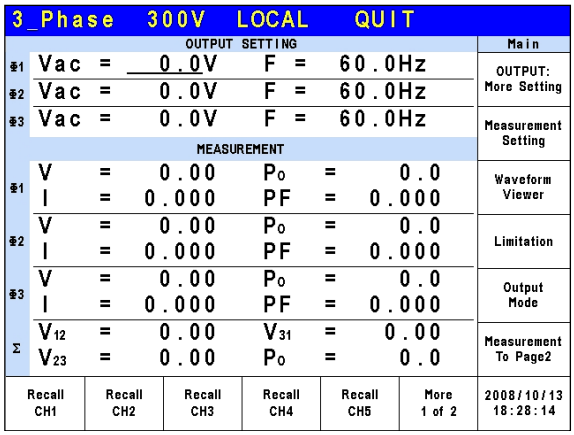
3.1 Introduction

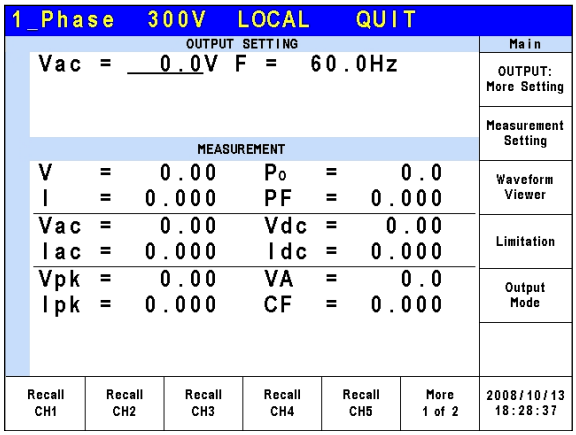
The AC Source can be configured to operate in local or remote mode. The remote mode operation is through a remote GPIB or RS-232C interface as described in Chapter 9. This section describes the operation in local mode using the keypad on the front panel for data entry and test. Local operation can be used directly when the AC Source is turned on.

3.2 Using Keyboard & RPG

The AC Source is equipped with a user friendly interface consisting of a keypad and a RPG (Rotary Pulse Generator) on the front panel. The LCD on AC Source displays the operations menu.

Figure 3-1 shows the command tree. The following describes how to use both the keypad and the RPG to set the commands. When the power-on procedure is completed (see 2.6), the display will show the MAIN PAGE (3_Phase Mode/1_Phase Mode) as below.





Press ▲, ▼, ◀, ▶ keys to move the cursor for item selection. Use numeric and decimal keys or RPG to set values and press **ENTER** to confirm them. Users can use the indicators located at the bottom or lower right of the LCD to set the parameters or functions following the description at the bottom or lower right of the screen, or press ⮌ to return to MAIN PAGE.

In MAIN PAGE, users can press the indicators located at the bottom or lower right of the LCD to select the function list. Use ▲, ▼, ◀, ▶ to move the cursor after inputting each list. For digital setting, users can use the numeric and decimal keys or the RPG to set the value and then press **ENTER** for confirmation. For text setting, users can turn the RPG for selection and press **ENTER** for confirmation.

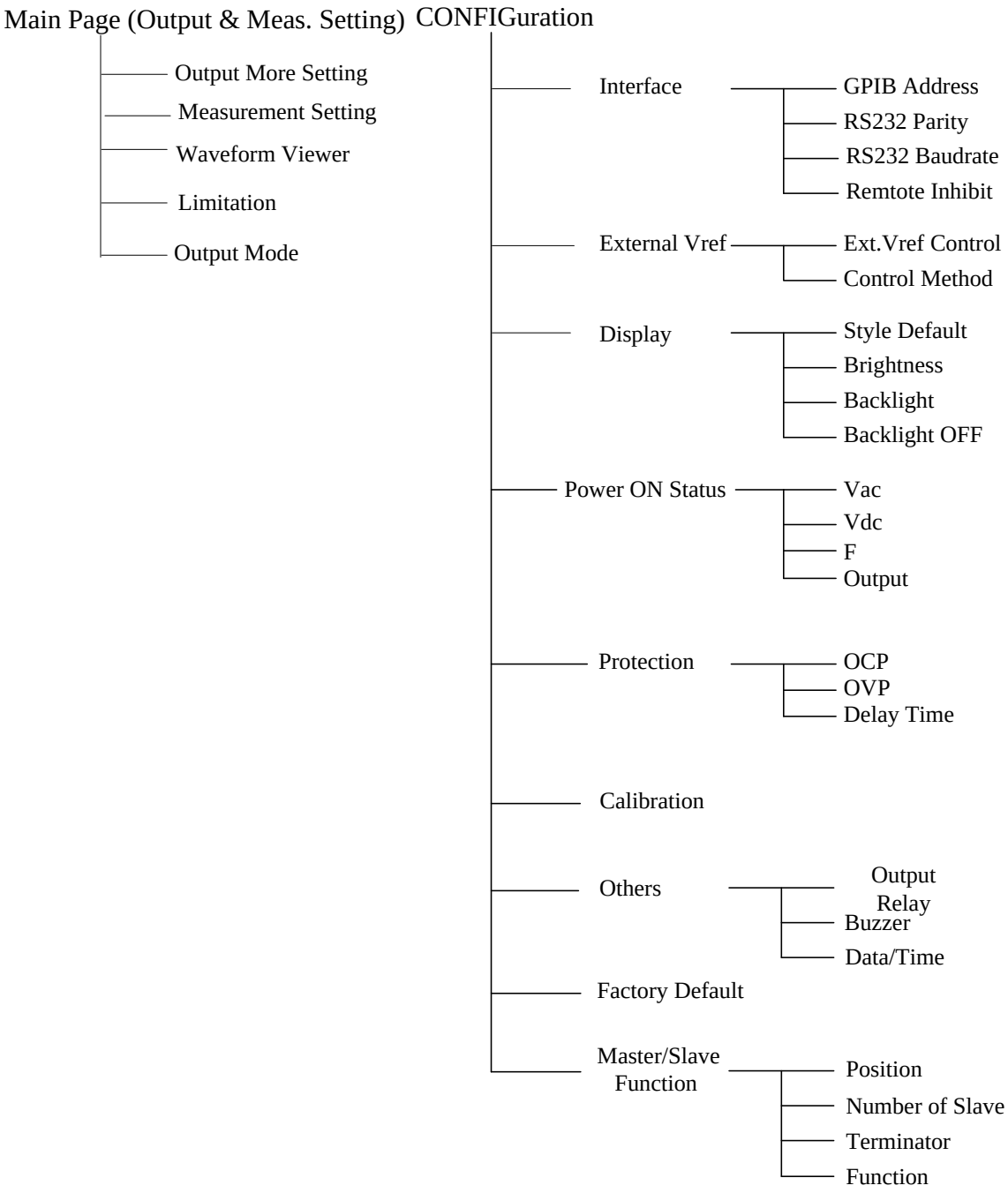

Main Page (Output & Meas. Setting)
Output More Setting
Measurement Setting
Waveform Viewer
Limitation
Output Mode
CONFIGuration
Interface
GPIB Address
RS232 Parity
RS232 Baudrate
Remtote Inhibit
External Vref
Ext.Vref Control
Control Method
Display
Style Default
Brightness
Backlight
Backlight OFF
Power ON Status
Vac
Vdc
F
Output
Protection
OCP
OVP
Delay Time
Calibration
Others
Output Relay
Buzzer
Data/Time
Factory Default
Master/Slave Function
Position
Number of Slave
Terminator
Function

Figure 3-1

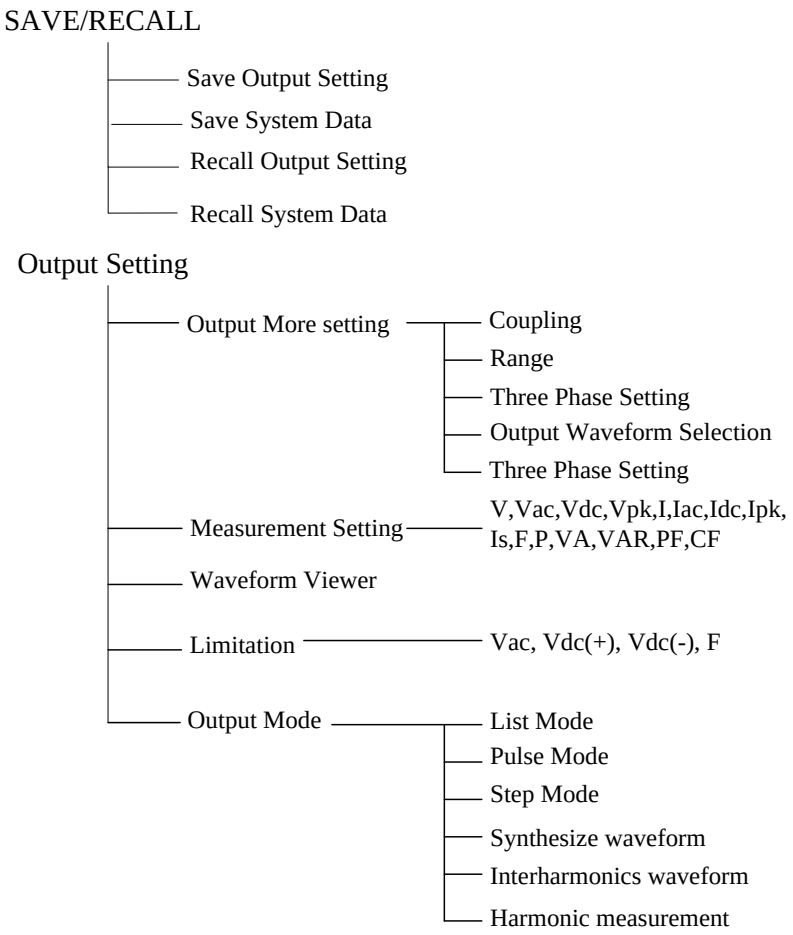
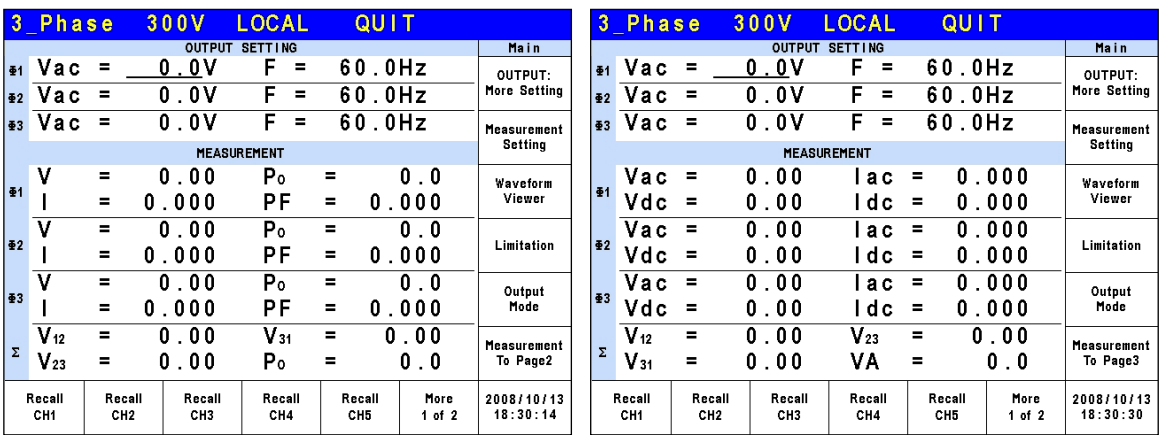
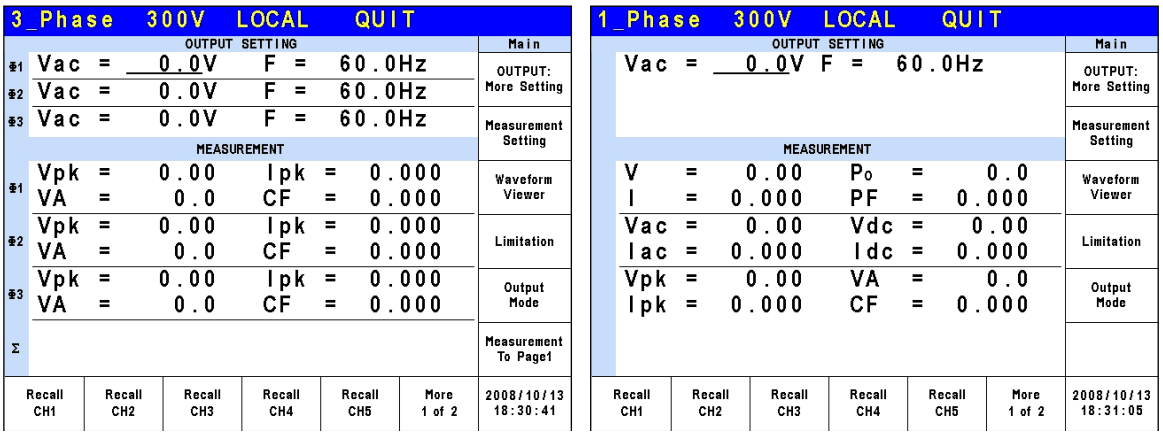


Figure 3-2

3.3 MAIN PAGE (Output Setting & Measurement)

When the AC Source is turned on and finished the self test, the screen displays the MAIN PAGE (3_Phase Mode/1_Phase Mode). A line on the screen shows the output setting. The default output setting can be set by the Power ON Status (see 3.4.4) under the CONFIG function key. The MEASUREMENT on the screen shows the items measured by the AC Source and each of them has 12 types totaling 3 pages as shown below.





On top of the screen, the range displayed 300V is the Range status (see 3.3.1.2). There are 3 ranges

1. 150V Range
2. 300V Range
3. AUTO Range

The definition of output parameters:

Vac : AC output voltage in Volts
F : Output frequency in Hertz.
Vdc : DC output voltage in volts.

Press **OUT/QUIT** enables the AC Source's output with the set Vac, F and Vdc. Press it again the AC Source ouput is disabled

Notice

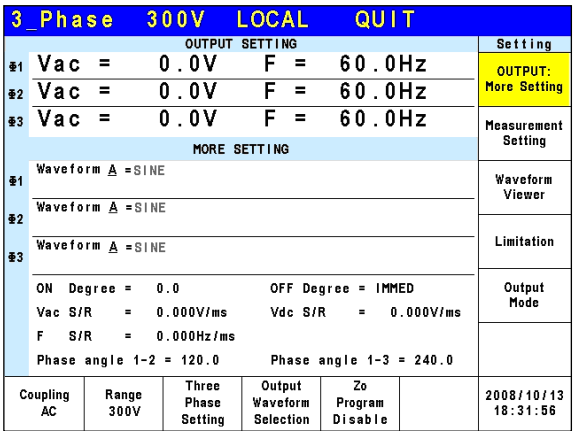
When Coupling = AC+DC the output is the sum of Vac and Vdc. However, the combination of peak voltage cannot exceed the limit of each range (range 150V: 212.1V and range 300V: 424.2V.) The output voltage will skip to 0V automatically and trigger protection if it exceeds the voltage limit (OVP).

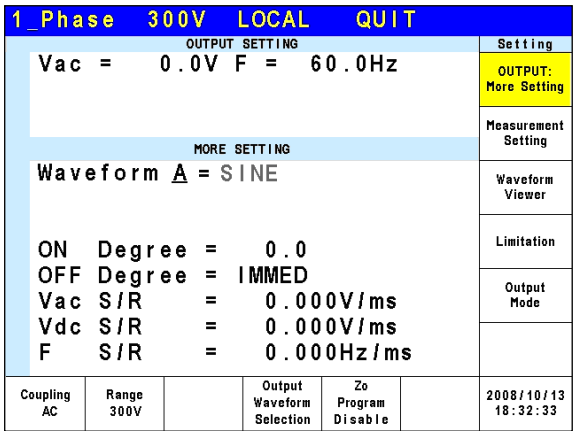
Following lists the definition of measurement parameters:

V : It is the voltage measurement in Volts. (True RMS measurement)
F : It is the output frequency in Hertz.
I : It is the current measurement in Amps. (True RMS measurement)
P : It is the real power measurement in Volts.
PF : It is Power Factor and the calculation formula = Real Power / (Vrms × Irms)
CF : It is Crest Factor and the calculation formula = Ipeak/Irms
Vdc : It is the DC voltage measurement in Volts.
Idc : It is the DC current measurement in Amps.
Ip : It is the peak current measurement in Amps. The Ipeak display is the Ip (+) or Ip (-) whichever is larger.
Is : It is I surge that is only measured when output changes as defined in section 3.3.2.3.
VA It is the apparent power in Volt-Ampere and the calculation formula = Vrms × Irms.
VAR : The calculation formula = $\sqrt{VA^2 - P^2}$

3.3.1 OUTPUT: More Setting

Press OUTPUT: More Setting in the MAIN PAGE (3_Phase Mode/1_Phase Mode) (see section 3.3), a line of output functions will appear at the bottom of the screen as described below.



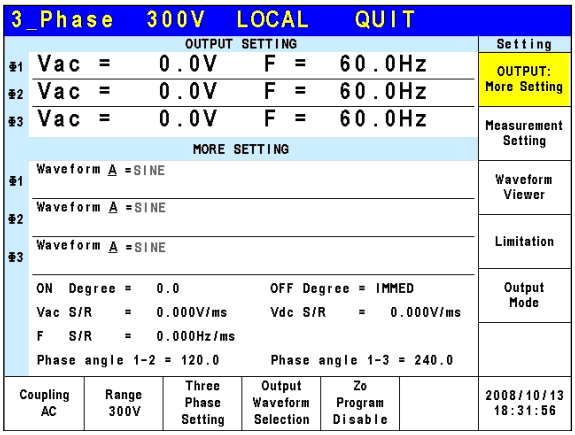


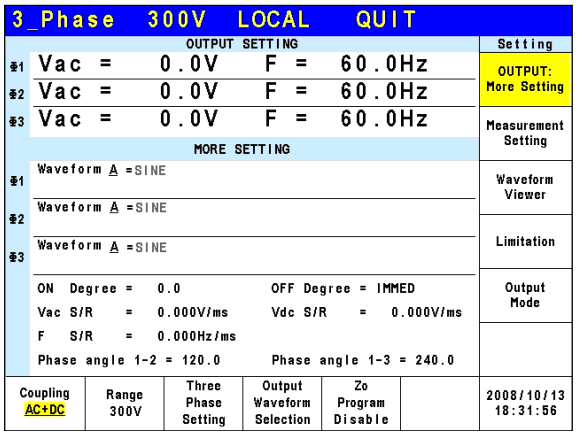
3.3.1.1 Coupling Output Mode (AC+DC, AC, DC)

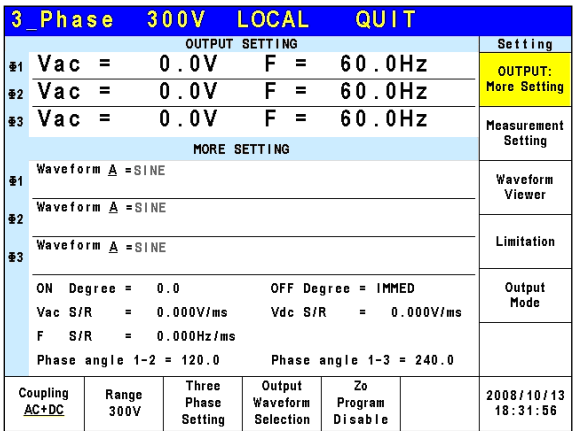
There are 3 types of AC Source output: AC+DC, AC and DC. The coupling can be set to meet a variety of applications.

The setting procedure from AC to AC+DC is described below:

1. Press Coupling at the bottom.
2. Turn the RPG to change the selection from AC to AC+DC and press **ENTER**.





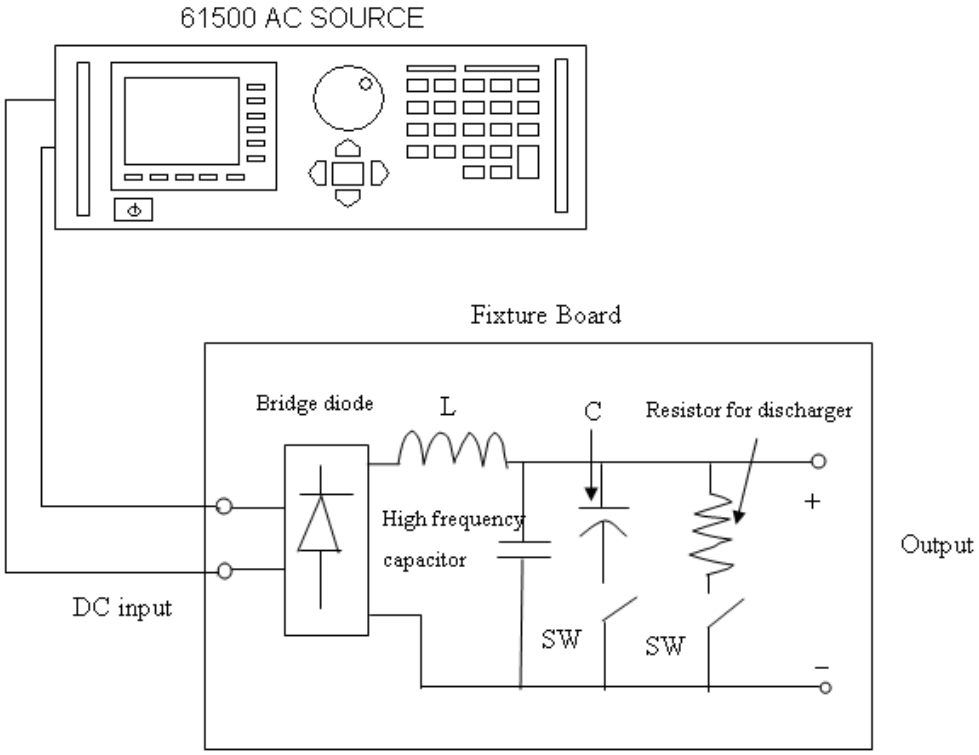


Notice

Since the AC Source does not have as many capacitors as the common DC Power Supply, some voltage fluctuations and transient load characters are not the same. This AC Source is able to provide positive and negative voltage without changing the output connector. The output capacitance cannot exceed 20uF as it may cause the device to be damaged due to unstable output.

Though the AC Source has AC/DC/AC+DC output mode, the features are still different from the common DC Power Supply when in pure DC mode as explained below.

1. The output voltage ripple is bigger because there is no output capacitor.
2. When the output current reaches the current limit set point, the output voltage will be cut off and in protection mode. It will not stay in constant current mode with a voltage drop like common DC sources.
3. It is necessary to connect the fixture as shown below if more than 20uF is to be used.



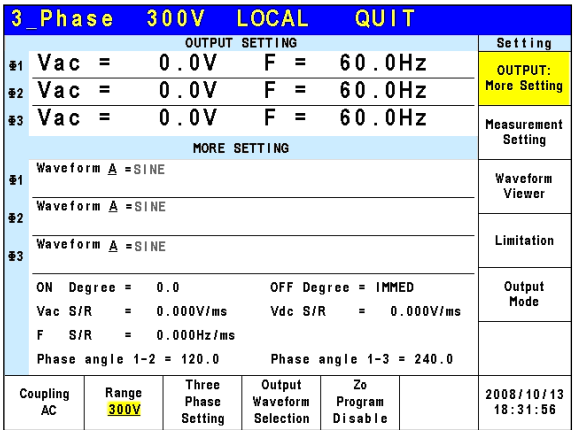
4. The output has DC bias that is smaller than 15mV@150V range (temperature coefficient is 2.5mV/°C typical) or smaller than 30mV@300V range (temperature coefficient is 5mV/°C typical.)

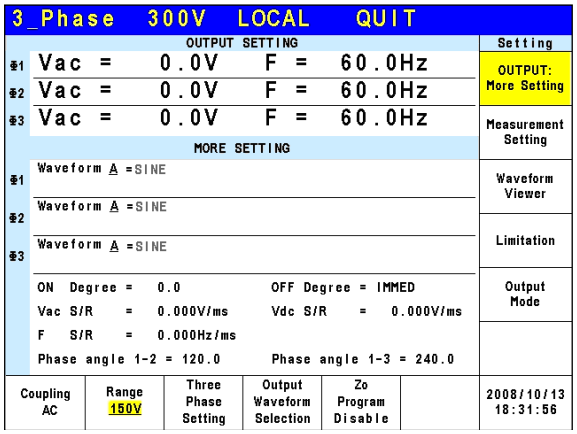
3.3.1.2 Range

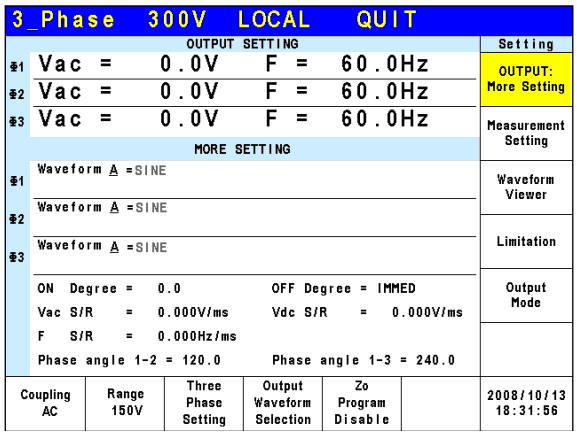
The AC Source has full scale voltage ranges of 150 V, 300 V and AUTO. Users can set Range by the function OUTPUT: More Setting. This parameter controls the power stage relay for parallel (range 150V) or series (range 300V) for more current or higher voltage. AUTO range indicates the output range will change between 150V and 300V automatically as need.

Set the output voltage range to 150V as instructed below.

1. Press Range at the bottom.
2. Turn the RPG to change “300V” to “150V” and press **ENTER**.







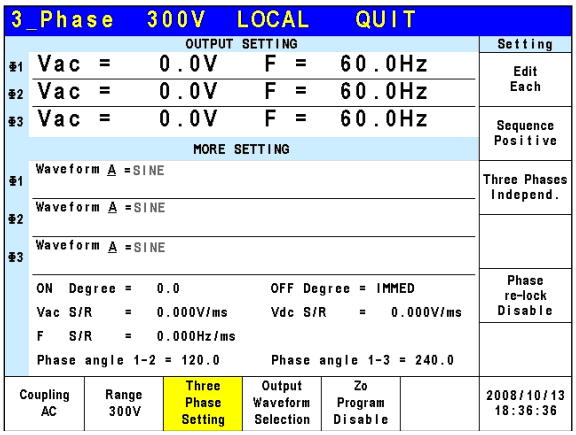
Notice The output voltage will set to 0V before the range changes to eliminate the peak voltage; and then set the output voltage. Please note that it may cause the UUT to be suspended and/or damaged when changing the range.

3.3.1.3 Setting Three Phase Output

Press Three Phase Setting to enter into the function as shown below.

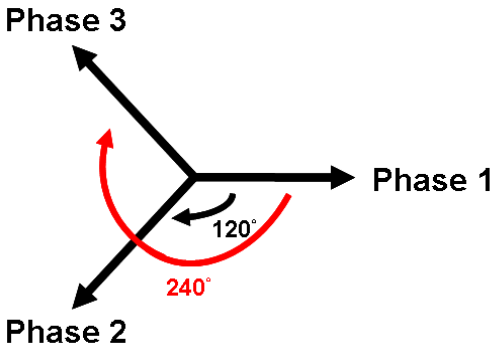
Edit: All and Each.

Press Edit to set "Each" or "All" for 3-phase output voltage limit.



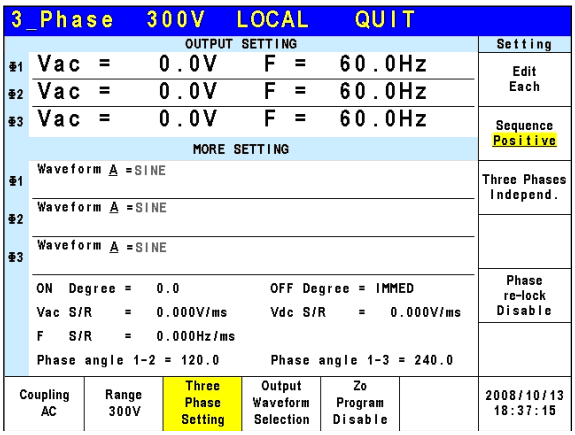
Sequence: Positive and Negative.

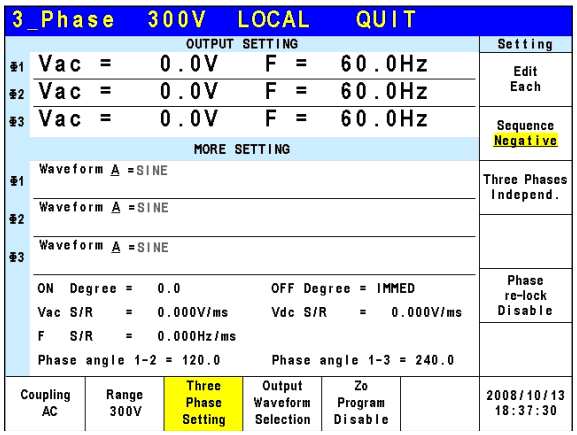
For example, the phase difference degree of 3-phase in positive balance is 120 degrees as shown below.

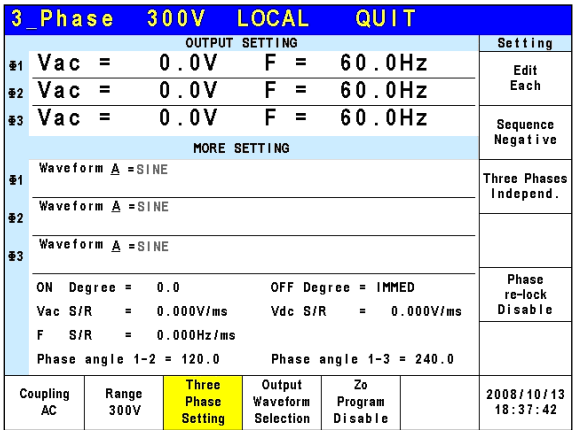


Press Sequence to set the Positive/Negative sequence for AC Source's 3-phase voltage output. The following lists the procedure to set the 3-phase output voltage sequence to Negative.

1. Press Sequence on the right.
2. Use RPG to select "Negative" and press **ENTER**.





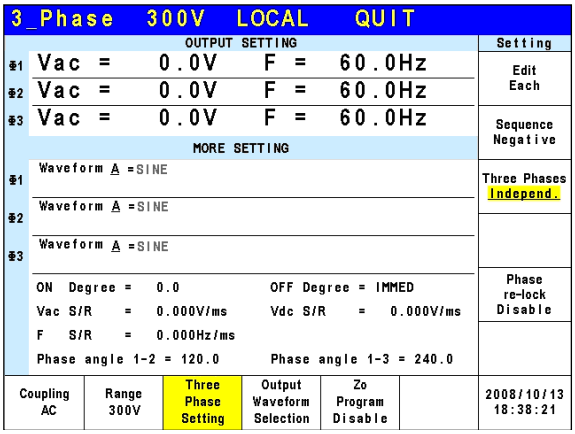


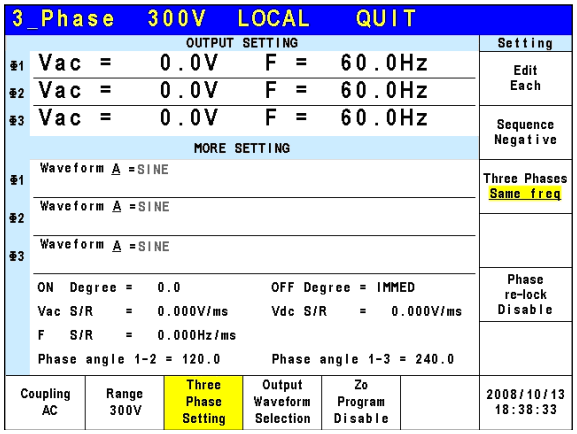
Three Phases: Independ, Same Freq and Balance.

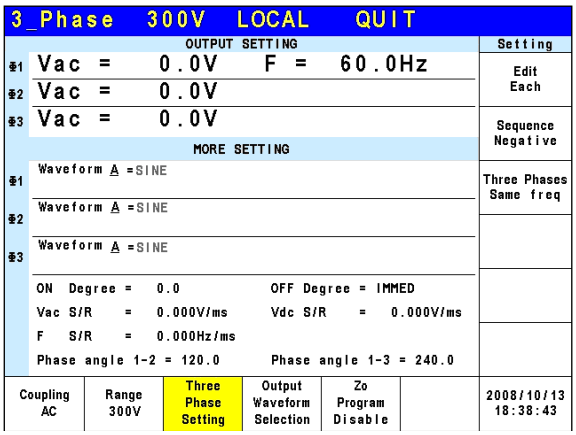
Press Three Phases to set the relationship among the AC Source 3-phase output voltage, which are Independ, Same Freq and Balance.

Following lists the procedure to set the same frequency for 3-phase voltage output.

1. Press Three Phases on the right.
2. Use RPG to select “Same freq” and press **ENTER**.

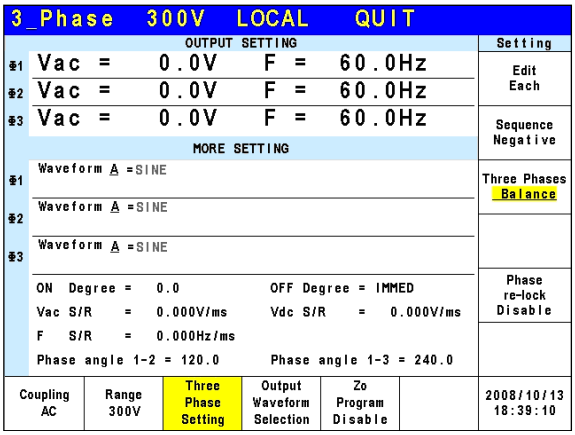


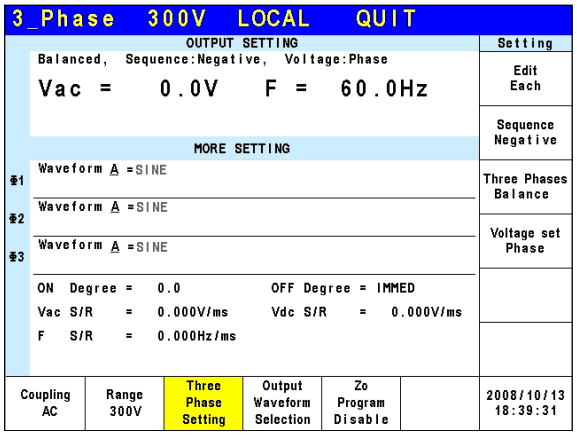


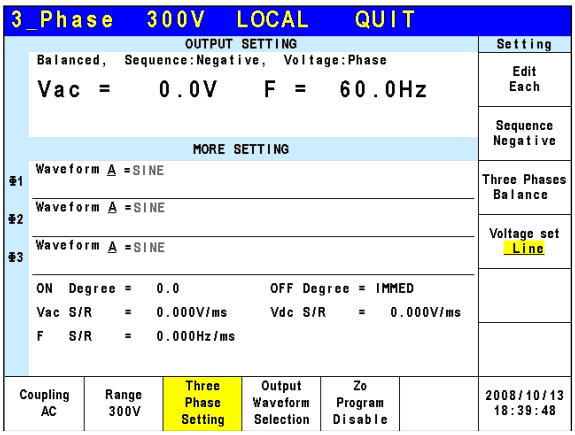


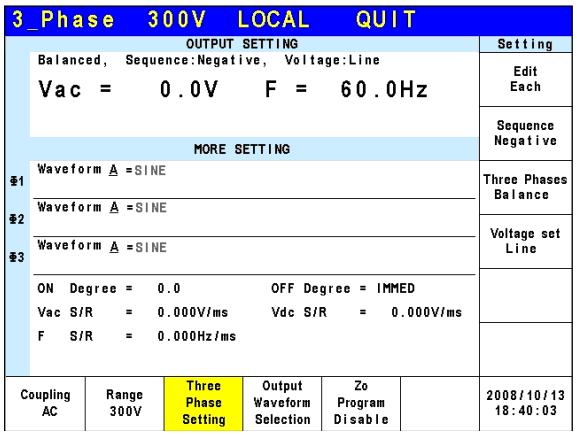
When 3-phase balance is in use, the user may set the output voltage to be Phase Volt or Line Volt. Below is the procedure for setting the 3-phase voltage output to 3-phase balance.

1. Press Three Phases on the right.
2. Use RPG to select "Balance" and press **ENTER**.
3. Press Voltage set on the right.
4. Use RPG to select "Line" and press **ENTER**.









Phase re-lock: Enable and Disable.

Phase re-lock is used to lock the phase again. Since the output voltage and frequency are set separately when the AC Source is in 3-phase mode, users can set the 3-phase for different frequency output. Assuming the 3-phase output frequencies are varied and users set them to the same when the phase re-lock function is disabled, the phase difference of the 3-phase output does not return to default (each phase difference is 120°) as Figure 3-3 shows. The phase difference of 3-phase output will return to default (each phase difference is 120°) as Figure 3-4 shows when the phase re-lock function is enabled.

Press Phase re-lock on the right to enable or disable the function.

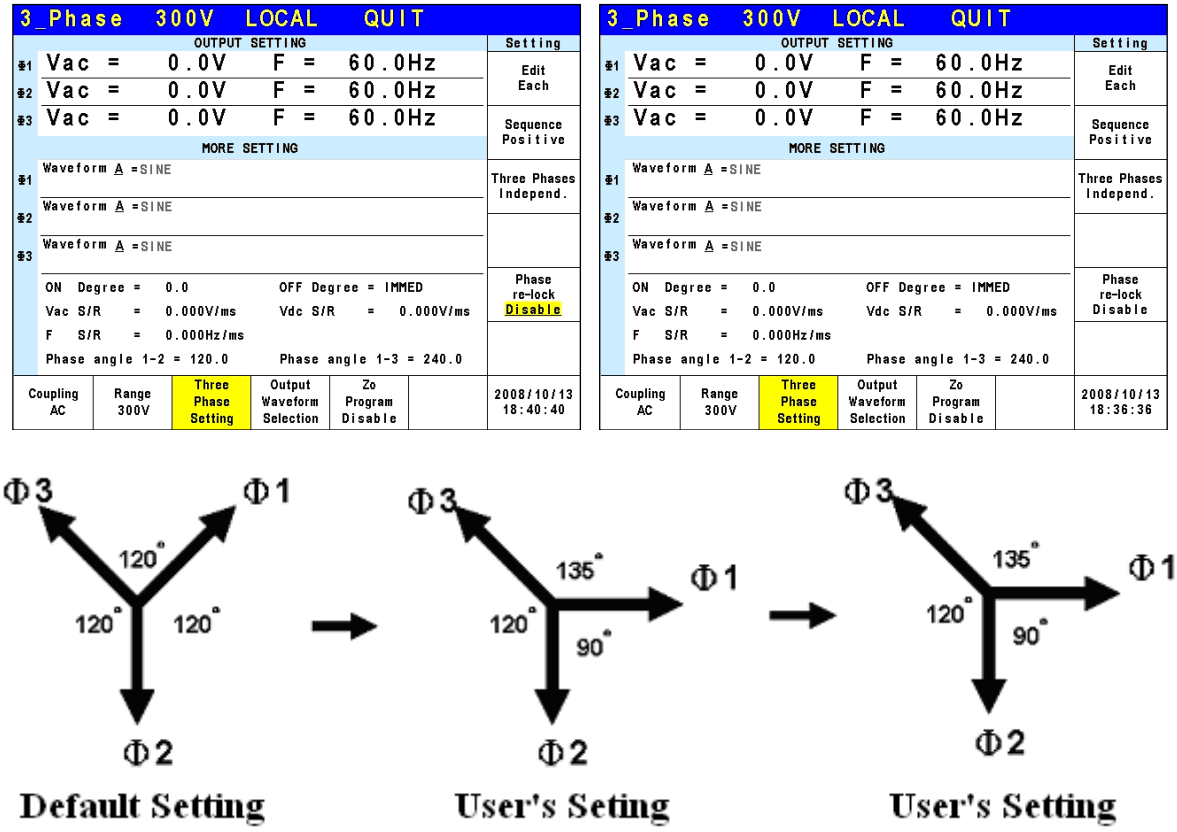


Figure 3-3 Phase Re-lock Disabled

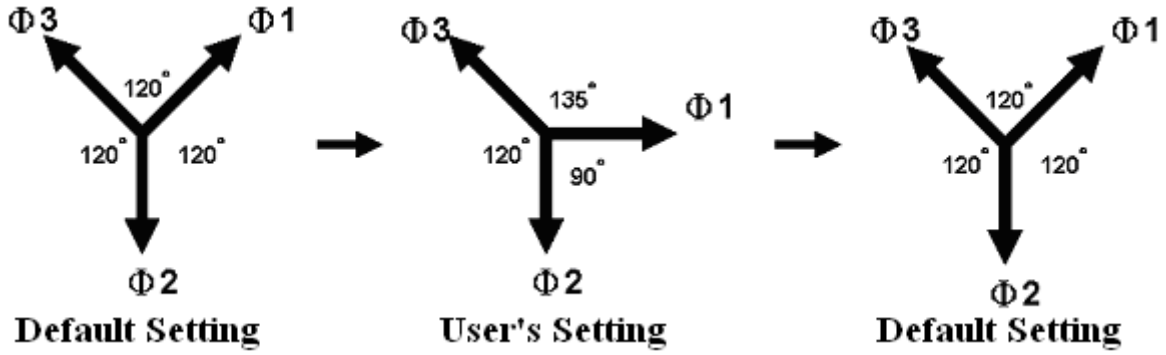


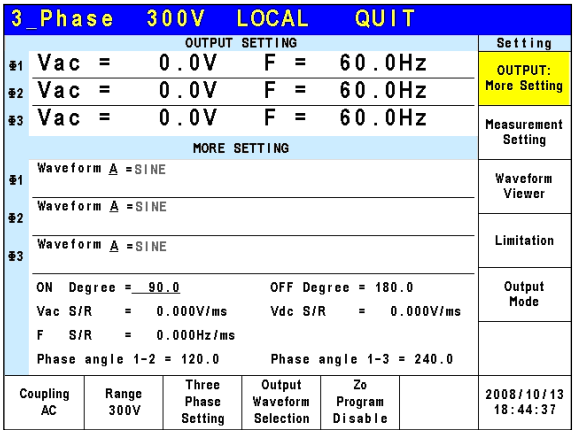
Figure 3-4 Phase Re-lock Enabled

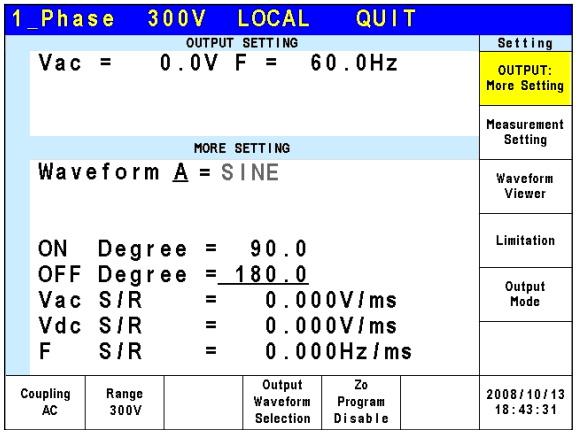
3.3.1.4 Output Degree

The AC Source can control the degree of the waveform during output or when stopping the output. In MAIN PAGE (3_Phase Mode/1_Phase Mode) (see 3.3) press OUTPUT : More Setting on the right to set ON Degree and OFF Degree.

Following lists the procedure for setting the output phase degree to ON Degree = 90 and OFF Degree=180 in 1_Phase Mode /3_Phase Mode.

1. Press OUTPUT: More Setting on the right.
2. Move the cursor to "ON Degree= " command position.
3. Press **9**, **0**, and **ENTER** to change the value to "90.0".
4. The cursor moves to "OFF Degree= " command position automatically.
5. Press **1**, **8**, **0**, and **ENTER** to change the value to "180.0".





Notice

If "OFF Degree=IMMED" when **QUIT** is pressed, the output voltage jumps off immediately. If a degree is already set, it will output voltage till it reaches the set degree. Input "OFF Degree= 360" will turn into "OFF Degree= IMMED".

3.3.1.5 Slew Rate of Output Transient

The AC Source has the ability to set the slew rates of the voltage waveform. This is done through 3 commands in OUTPUT: More Setting, which are Vac S/R, F S/R and Vdc S/R, which control the change speed of voltage waveform.

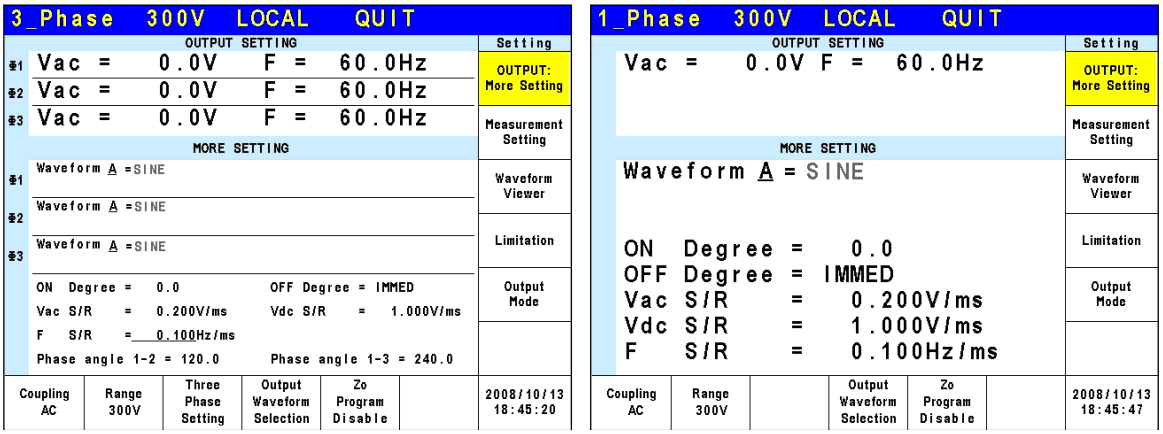
Vac S/R: It is the slew rate of Vac output.
F S/R: It is the slew rate of frequency output.
Vdc S/R: It is the slew rate of Vdc output.

Change the output setting in MAIN PAGE when the AC Source is in OUT mode, the output voltage and frequency will change to follow the setting of Vac S/R, F S/R and Vdc S/R.

The procedure of setting Vac S/R =0.2, F S/R =0.1 and Vdc S/R =1 1_Phase Mode /3_Phase Mode is described below.

1. Move the cursor to "Vac S/R = " command line.
2. Press **0**, **.**, **2** and **ENTER** to change the value to "0.2".

3. The cursor moves to “F S/R =” command automatically, press **0**, **.**, **1** and **ENTER**.
4. The cursor moves to “Vdc S/R =” command automatically, press **1** and **ENTER**.

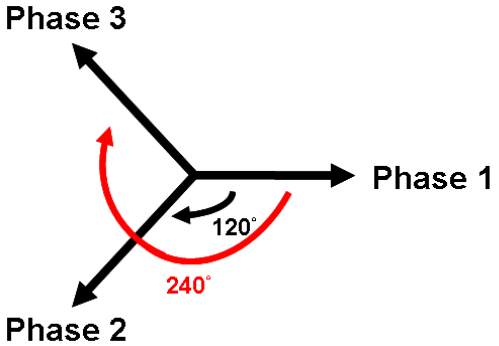


Notice

1. When setting Vac S/R = 0, F S/R = 0, Vdc S/R = 0, the output transient outputs in the highest speed.
2. Though the input range of Vac S/R, F S/R, Vdc S/R is quite large when using the software editor, the output voltage may not apply the slew rate properly due to the hardware limit when the Vac S/R, F S/R and Vdc S/R are too large. The maximum of Vac S/R and Vdc S/R is 1200V/ms and the minimum is 0.001V/ms. The maximum of F S/R is 1600Hz/ms and the minimum is 0.001Hz/ms.
3. When executing **OUT** on the AC Source the output will reach the final state as set. Once QUIT is executed, the output turns to 0V immediately. If users wish to output the set slew rate to 0V, it is necessary to key in 0V and press **ENTER** instead of pressing **QUIT** directly.

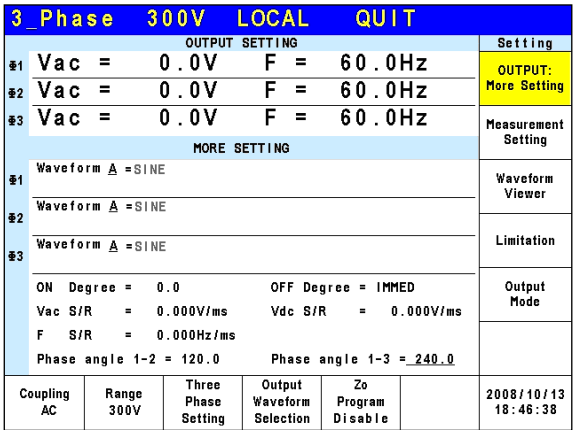
3.3.1.6 Output Degree of 3-phase Voltage Output

On the other hand the AC Source is able to set the phase difference degree for 3-phase output voltage. For instance the phase difference among the 3 phases is 120 degree for the output voltage with 3-phase balance positive sequence as the figure shown below.



Following lists the procedure for setting the output voltage to 3-phase balance with 120 degree phase difference among the 3 phases.

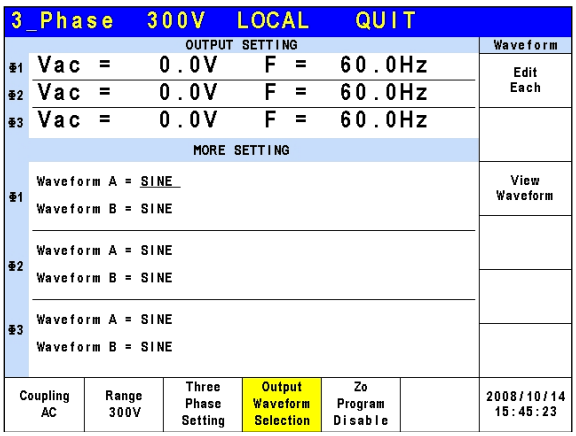
1. Move the cursor to "Phase angle 1-2 =" command line.
2. Press **1**, **2**, **0** and **ENTER**.
3. Move the cursor to "Phase angle 1-3 =" command line.
4. Press **2**, **4**, **0** and **ENTER**.



Notice Since the 3-phase voltage output of the AC Source is running independently, it is able to set the phase difference of 3-phase output to unbalance, such as Phase angle 1-2 = 100, Phase angle 1-3 = 200.

3.3.1.7 Output Waveform Selection

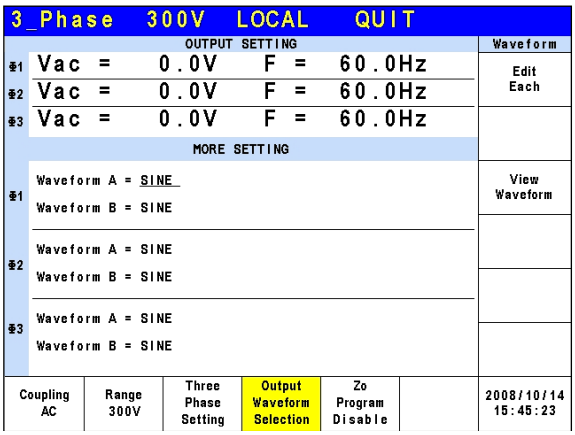
The AC Source has two sets of unique waveforms, A and B. Each of them has sine, square, clipped sine waveforms and 30 sets of built-in waveforms along with 6 sets of user defined waveforms.

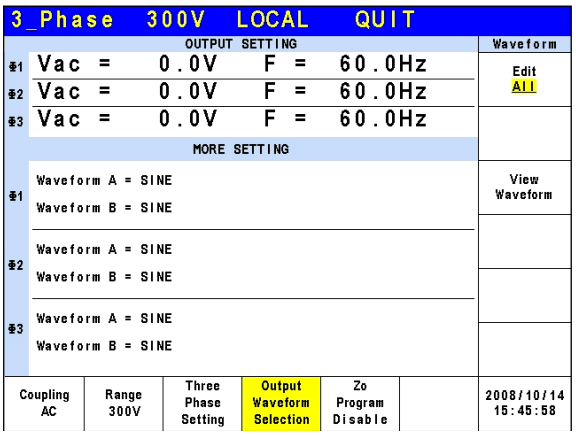


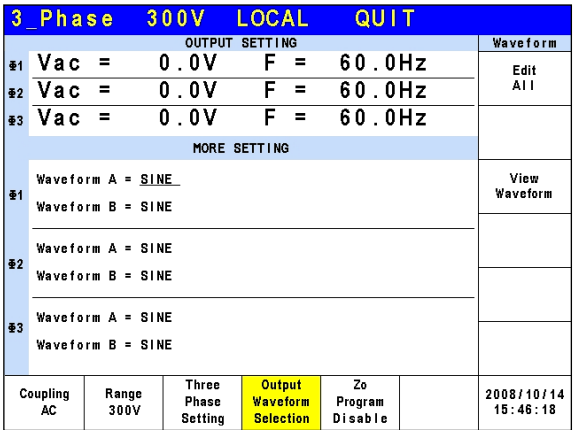
Follow the steps below to set the 3-phase waveform to A and to sine:

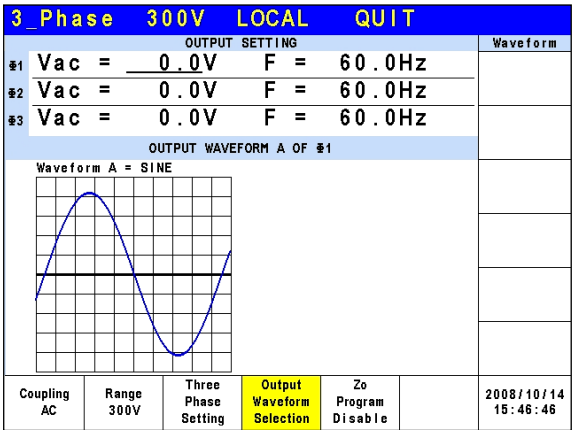
1. Press Edit on the right and use RPG to change the selection to All.
2. Move the cursor to WAVE A command line.
3. Turn the RPG to select "SINE" and press **ENTER**.

Users can press "View Waveform" on the right to view the set waveform.





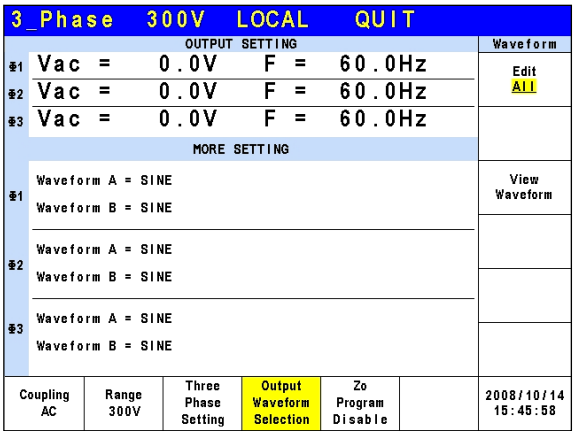


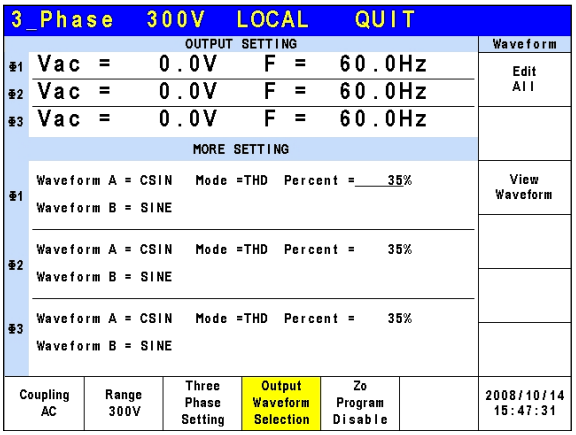


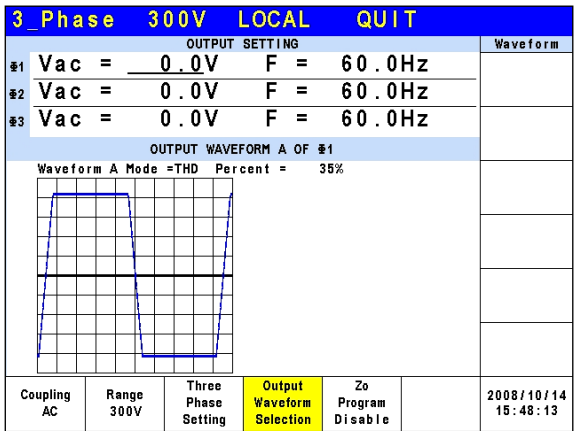
Follow the steps below to set the A waveform of 3-phase to clipped sine with a total harmonic distortion of 35%.

1. Press Edit on the right and use RPG to change the selection to All.
2. Move the cursor to the WAVE A command line and select “CSIN”.
3. The LCD screen to show MODE and PERCENT.
4. Turn the RPG to change MODE to “THD” and press **ENTER**.
5. Press **3**, **5** and **ENTER** to set the THD to be 35%.

Users can press “View Waveform” on the right to view the set waveform.







Notice

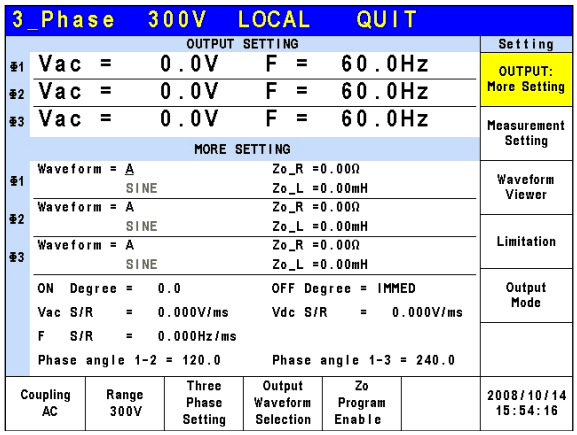
1. Clipped sine waveform can be programmed via "Amplitude" or "Total Harmonic Distortion". The amplitude range is from 0 to 100% (100%: without clipping) while the Total Harmonic Distortion range is from 0 to 43% (0%: without distortion.)
2. User defined waveform needs to be defined by and downloaded from the remote PC.
3. For detail DST waveform, please see *Appendix B Built-in DST Waveform*.

⚠WARNING

1. When using the user defined waveform, it may cause the AC Source to be damaged if the waveform frequency exceeds 1000Hz.
2. Due to the bandwidth restriction of AC Source, distortion may occur on the output especially when the user defined waveform contains high frequency.

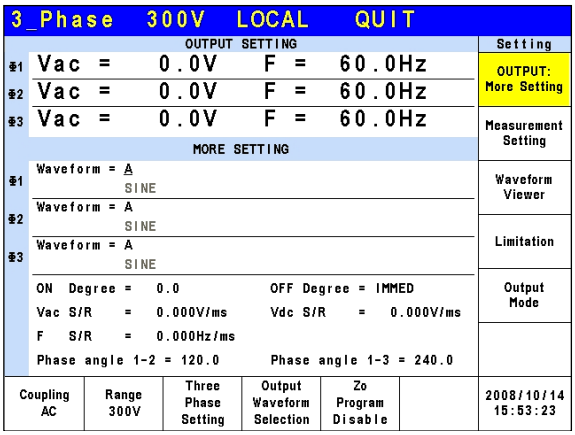
3.3.1.8 Zo Program Enable

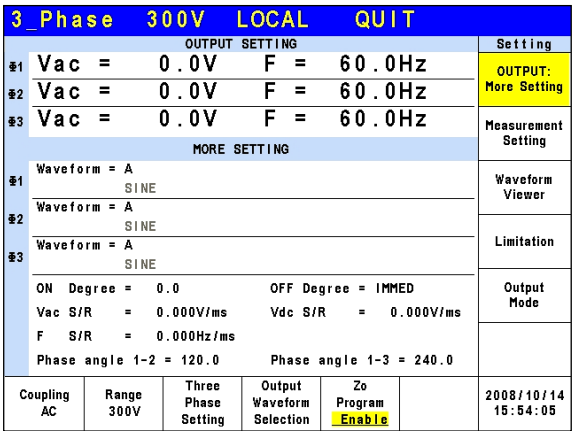
The output impedance of AC Source is very low; however users may need special output impedances in certain test conditions. The output impedance can be programmed within a certain range using the Zo Program under OUTPUT SETTING (3.3.1) in the AC Source.

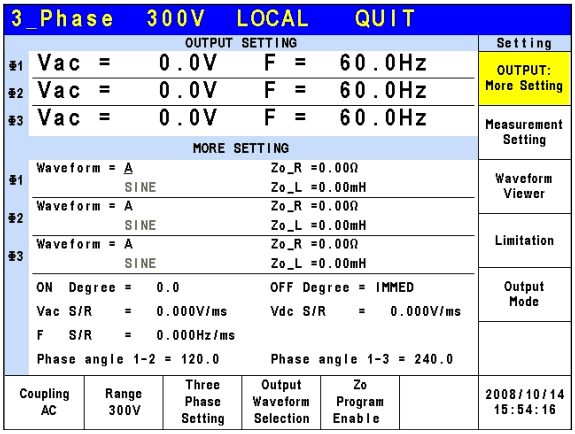


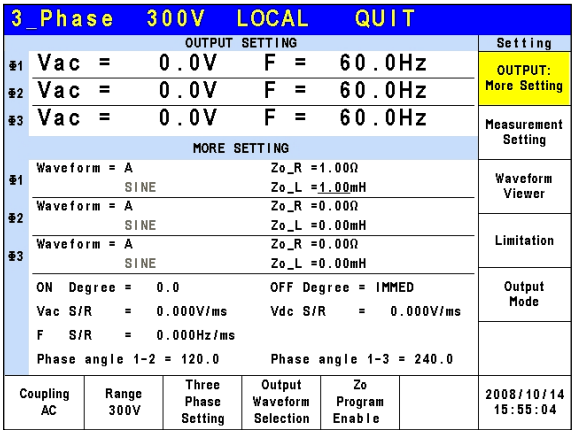
Follow the steps below to set the output impedance Zo Program = Enable, R = 1.0Ω, and L = 1.0mH:

1. Press Zo Program at the bottom.
2. Turn RPG to switch to “Enable” and press **ENTER**.
3. The cursor moves to “Zo_R = ” command line automatically.
4. Press **1**, **.**, **0**, and **ENTER** to change Zo_R to “1.0Ω.”
5. Press **1**, **.**, **0**, and **ENTER** to change Zo_L to “1.0 mH.”









Notice

1. When Zo Program = Enable, the AC Source uses current feedback to reprogram the output waveform to meet the setting. However, the output impedance is the AC Source’s original reading if Zo Program = Disable.
2. The programmable output impedance function is invalid for DC outputs.
3. The programmable output impedance function is invalid for 1_Phase Mode.

⚠WARNING

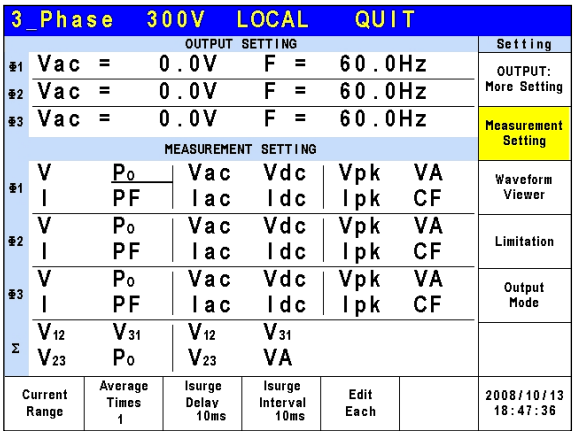
The maximum of Zo_R and Zo_L is 1.0Ω and 1.0 mH. However, if L is over 0.5 mH and the output voltage is too low (<100Vac), it may cause the AC Source to be unstable, especially when the output current is too great. Users have to program the inductance to the desired level slowly. If there is incorrect high frequency/voltage output or noise, monitor the output voltage and the sound of the AC Source. Do not use output impedance program but external impedance circuit when unstable condition occurs.

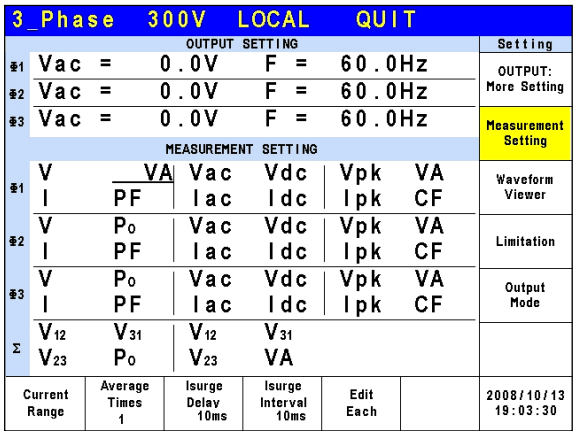
3.3.2 Measurement Setting

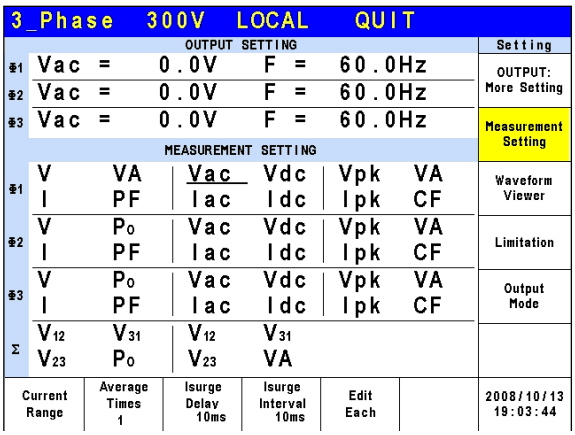
Press Measurement Setting on the right in MAIN PAGE (3_Phase Mode/1_Phase Mode) to set the measurement as the figure shown below. There are 12 measurement items in the setting screen such as voltage, current, output power and etc. The setting is done by moving the cursor to each item and use the RPG to select the required test item and press **ENTER**.

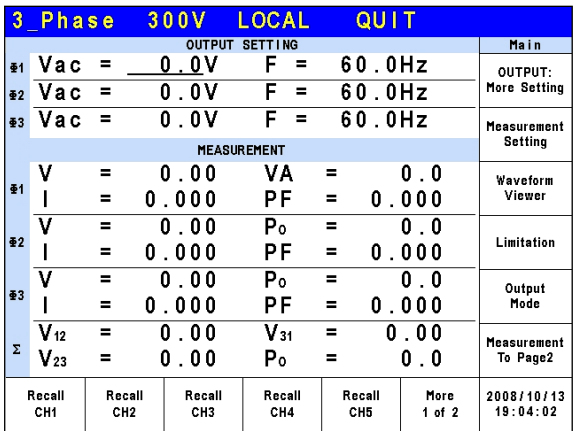
Below is procedure to change the 3rd measurement item from Po to VA in 3-phase mode.

1. Press Measurement Setting on the right in MAIN PAGE (3_Phase Mode).
2. Move the cursor to "Po".
3. Use the RPG to select "VA" and press **ENTER**.
4. Press ⮌ to return to MAIN PAGE.



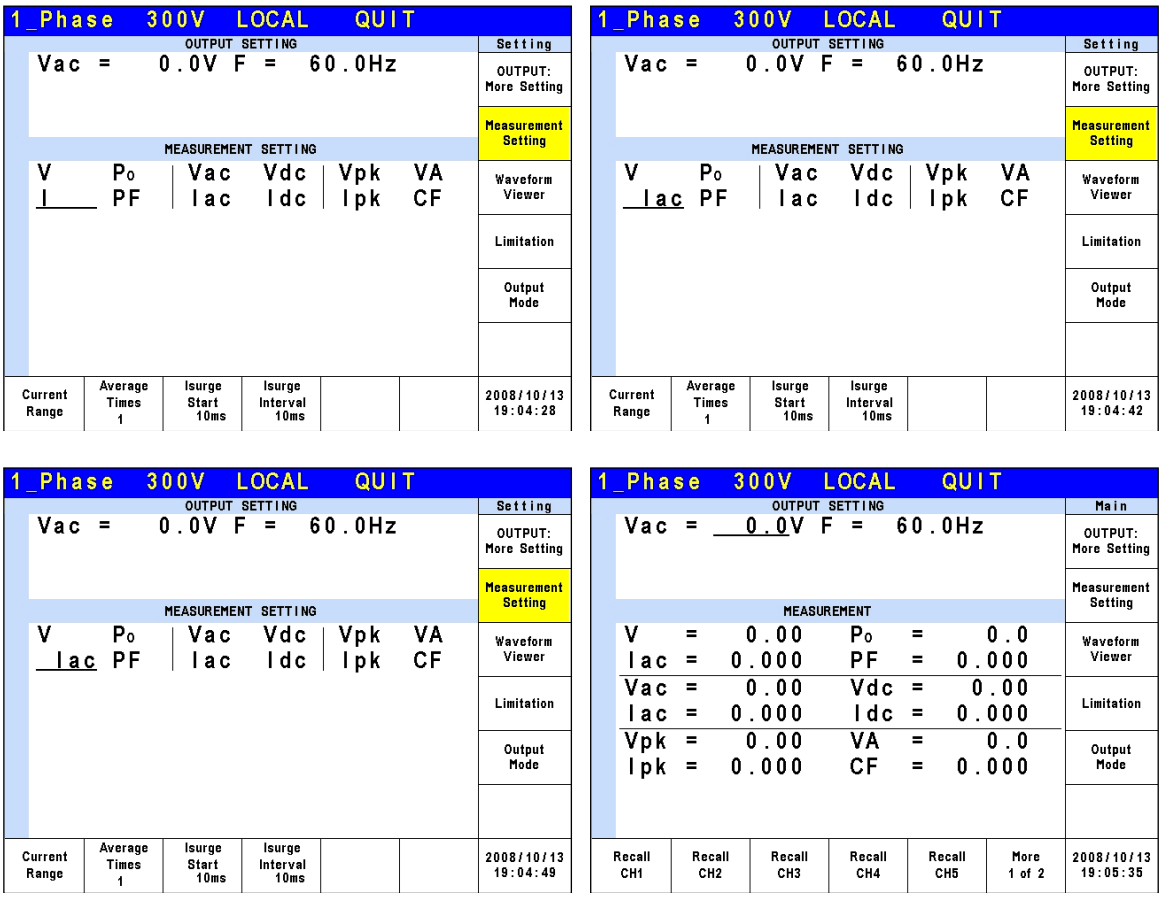






Below is the procedure to the 2nd measurement item from I to Iac in 1 phase mode.

1. Press Measurement Setting on the right in MAIN PAGE (1_Phase Mode).
2. Move the cursor to "I".
3. Use the RPG to select "Iac" and press **ENTER**.
4. Press ⮌ to return to MAIN PAGE.



3.3.2.1 Current Range

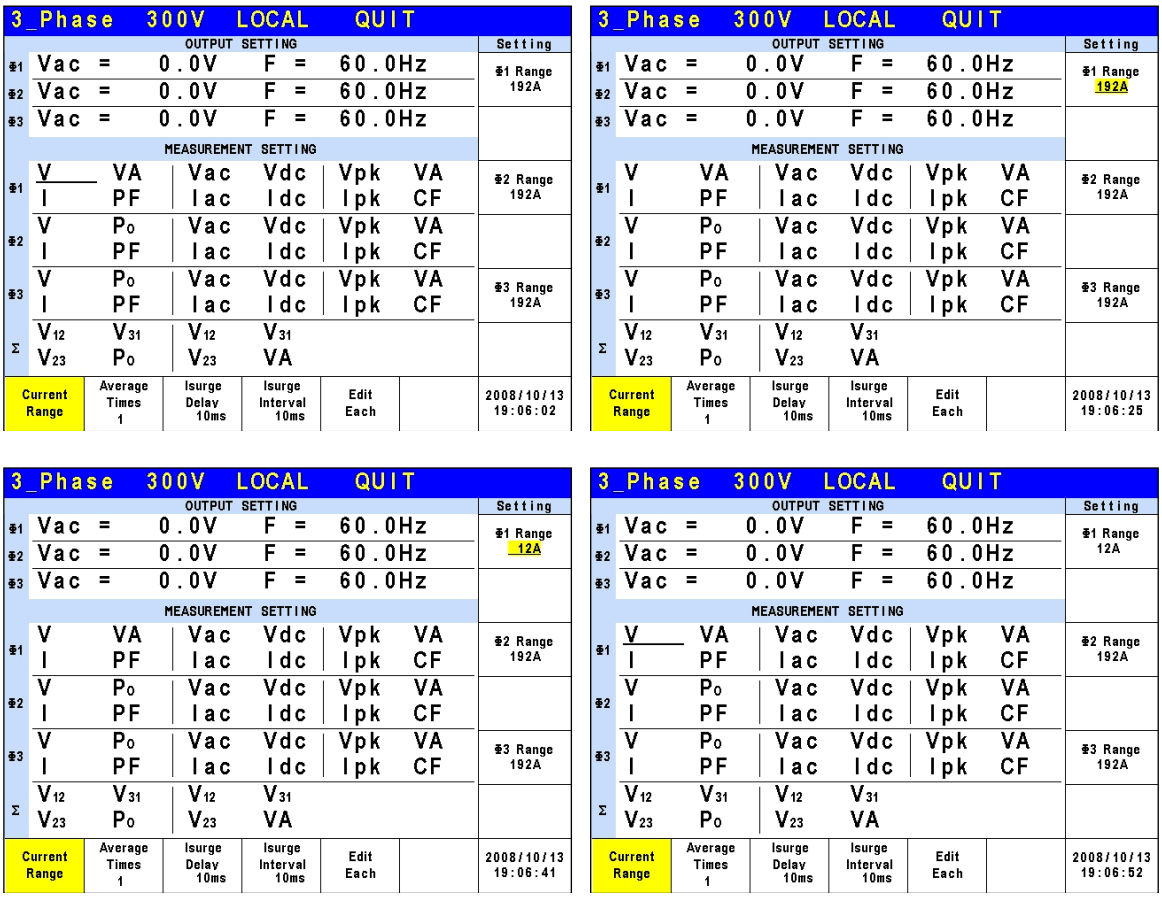
Press Current Range at the bottom to set the current detection range. Setting appropriate current range will result in a more accurate current measurement. The current value of each range is the maximum value it can detect. If the output current is larger than the maximum current the range can detect, the screen will show I = OVRange. The current detection ranges are listed below.

61512:
Φ1 Range: 12A, 48A, 192A, Auto.
Φ2 Range: 12A, 48A, 192A, Auto.
Φ3 Range: 12A, 48A, 192A, Auto.

61511:
Φ1 Range: 8A, 32A, 128A, Auto.
Φ2 Range: 8A, 32A, 128A, Auto.
Φ3 Range: 8A, 32A, 128A, Auto.

Following lists the procedure for setting the current detection range of the 1st phase to 12A.

1. Press Current Range at the bottom.
2. Press Φ1 Range on the right.
3. Turn the RPG to change to “12A” and press **ENTER**.



3.3.2.2 Average Times

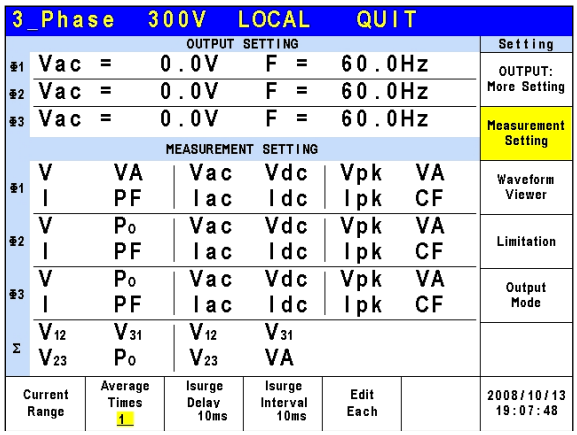
Average Times is the sampling average of voltage/current RMS and voltage/current peak. The AC Source uses moving windows for sampling. When "4" is selected for Average Times it indicates it will be sampling 4 times in moving windows.

Press Average Times at the bottom to set the average times for sampling. When the measurement is fluctuated severely, higher sampling average times can be set to improve the measurement accuracy. The average times for sampling to be set are listed below.

Average Times: 1, 2, 4, 8, 16 and 32.

The steps for setting the sampling average times to 1 are described below.

1. Press Average Times at the bottom.
2. Turn RPG to switch to "1" and press **ENTER**.

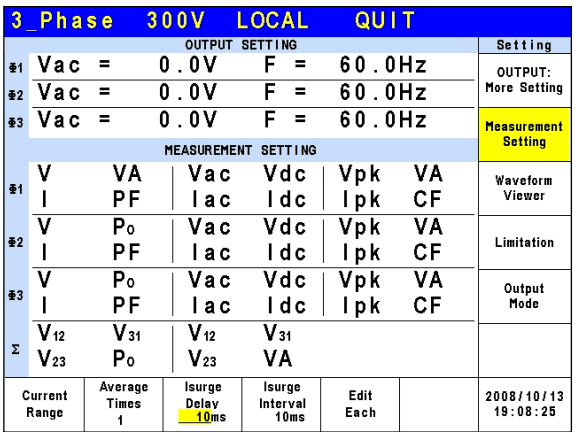


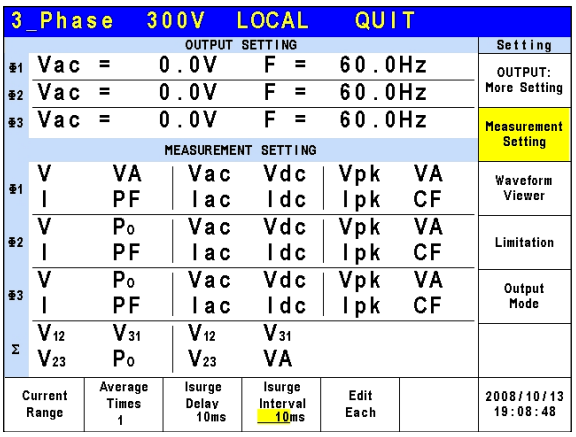
3.3.2.3 Isurge Delay, Isurge Interval

The Isurge in Measurement Setting is the surge peak current output by the AC Source. Isurge measurement starts after Isurge Delay when the voltage output changes. The measurement time is set by Isurge Interval. These two functions can be set by Measurement Setting.

The procedure for setting Isurge Delay = 10 ms, Isurge Interval = 10 ms is described below.

1. Move the cursor to “Isurge Delay =” command line.
2. Press **1**, **0** and **ENTER** to change the value to “10.0”.
3. Move the cursor to “Isurge Interval =” command line.
4. Press **1**, **0** and **ENTER** to change the value “10.0”.





3.3.3 Waveform Viewer

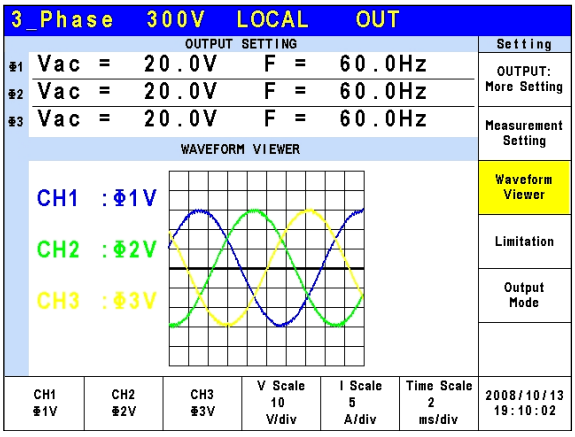
Waveform Viewer can be used to see the real time output voltage/ current waveform. There are a total of 3 CH available. Voltage, current and time can be adjusted by the Scale command. The figure below shows the Waveform Viewer.

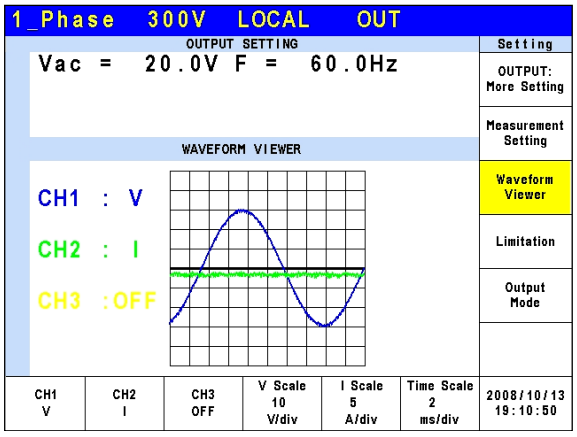
Ch1: Φ1V, Φ2V, Φ3V, Φ1I, Φ2I, Φ3I.
Ch2: Φ1V, Φ2V, Φ3V, Φ1I, Φ2I, Φ3I.
Ch3: Φ1V, Φ2V, Φ3V, Φ1I, Φ2I, Φ3I.

V Scale: 10, 20, 40, 80, 120V/div.
I Scale: 5, 10, 20, 40, 60A/div.
Time Scale: 0.2, 0.5, 1, 2, 5, 10, 50, 100, 200ms/div.

The procedure for setting CH1 =Φ1V, CH2 =Φ2V, CH3 =Φ3V, V Scale = 10 V/div, I Scale = 5A/div, Time Scale = 2 ms/div in 1_Phase Mode /3_Phase Mode is described as below.

1. Press CH1 at the bottom.
2. Turn the RPG to change to "Φ1V" and press **ENTER**
3. Press CH2 at the bottom.
4. Turn the RPG to change to "Φ2V" and press **ENTER**.
5. Press CH3 at the bottom.
6. Turn the RPG to change to "Φ3V" and press **ENTER**.
7. Press V Scale at the bottom.
8. Turn the RPG to change to "10" and press **ENTER**.
9. Press I Scale at the bottom.
10. Turn the RPG to change to "5" and press **ENTER**.
11. Press Time Scale at the bottom.
12. Turn the RPG to change to "2" and press **ENTER**.





3.3.4 Limitation

The Limit of AC Source 1-phase/3-phase output mode is set separately. For instance, the Vac Limit setting will apply the settings of the 1-phase mode when changing it from the 3-phase mode.

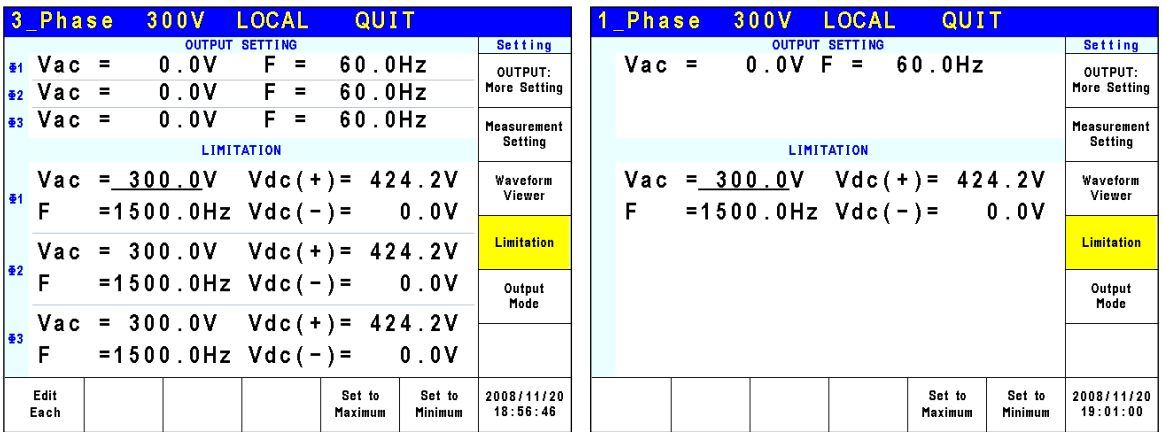
3.3.4.1 Vac Limit

Vac Limit sets the Vac value in MAIN PAGE (3_Phase Mode/1_Phase Mode). Press Limitation on the right in MAIN PAGE (3_Phase Mode/1_Phase Mode) to set the Vac Limit. This command protects the planned program instead of the hardware.

Press Edit at the bottom to set the limitation of the 3-phase voltage output for "Each" or "All".

The procedure to set Vac Limit = 300V in 1_Phase Mode /3_Phase Mode is described below.

1. Move the cursor to “Vac =” command line.
2. Press [3], [0], [0] and [ENTER] to change the value to “300.0”.



Notice

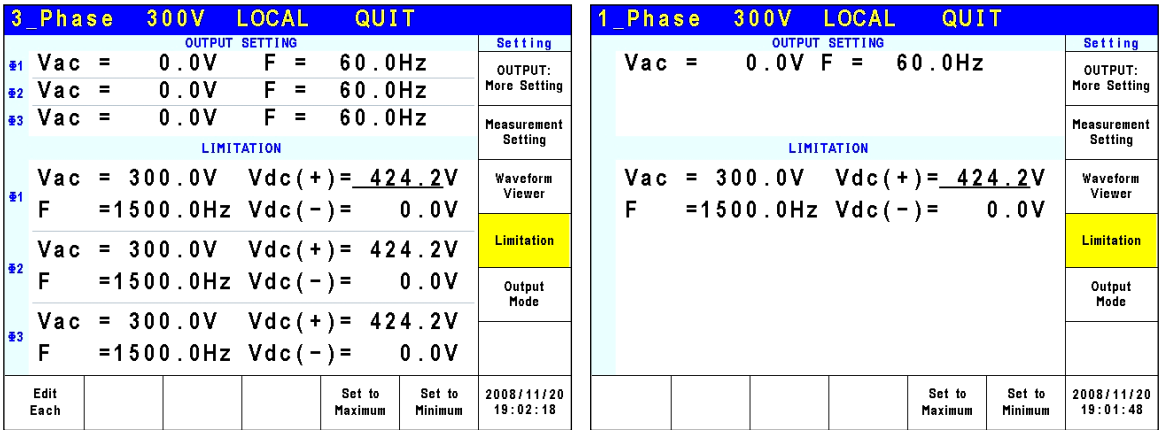
The setting of Vac Limit is not restricted by range; however, the Vac in MAIN PAGE is restricted by the range. For example, assuming the range is 150V, though Vac Limit = 300V the maximum Vac setting is 150V.

3.3.4.2 Vdc Limit (+), Vdc Limit (-)

Vdc Limit (+) and Vdc Limit (-) restrict the Vdc setting in MAIN PAGE (3_Phase Mode/1_Phase Mode). These two items can be set in the Limitation function (see 3.3.4). The Vdc setting can exceed Vdc Limit (+) but cannot be under Vdc Limit (-).

The procedure for setting Vdc (+) = 424.2V, Vdc (-) = 0V in 1_Phase Mode /3_Phase Mode is described below.

1. Move the cursor to “Vdc (+) =” command line.
2. Press [4], [2], [4], [.], [2] and [ENTER] to change the value to “424.2”.
3. Move the cursor to “Vdc (-) =” command line.
4. Press [0] and [ENTER] to change the value to “0.0”.



Notice

1. The setting of Vdc Limit is not restricted by range; however, the Vdc in MAIN PAGE is restricted by the range. For example, assuming the

range is 150V, though Vdc Limit=424.2V the maximum Vdc setting is 212.1V.

2. It is better to restrict the Vdc value when the output contains it. It may cause damage if the output polarity is reversed especially the load polarity.

3.4 CONFIG Function Key

Press **CONFIG** in the **FUNCTION** keys shown below to enter into CONFIG function. (3_Phase Mode/1_Phase Mode).

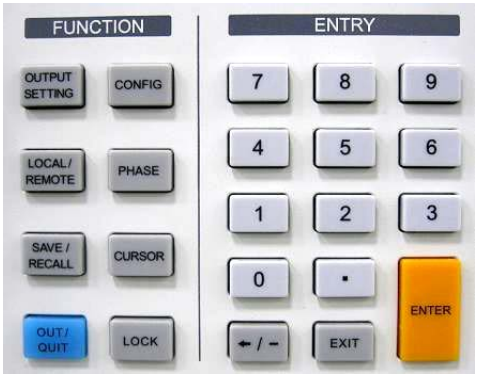
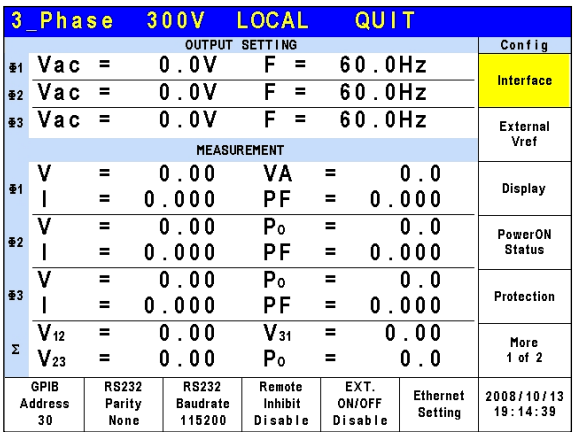
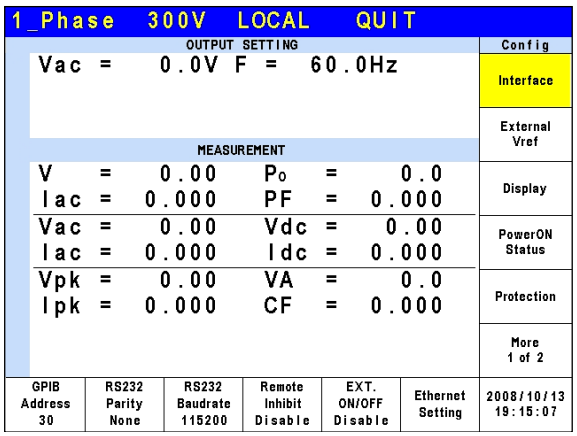


Figure 3-5 FUNCTION Keys



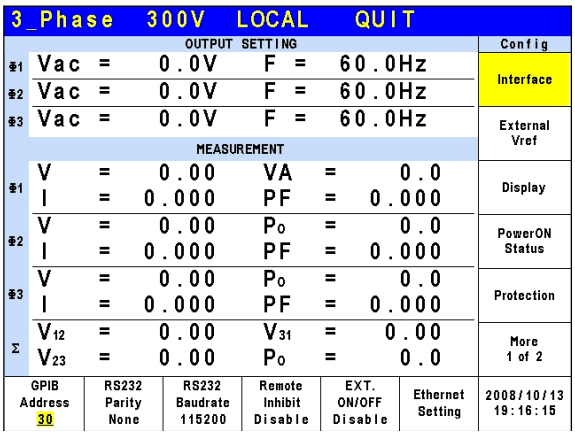


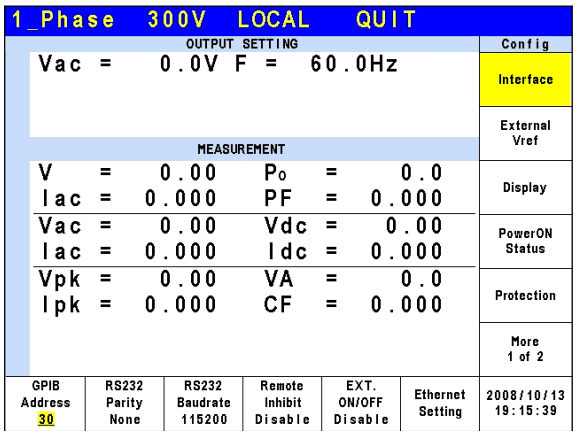
3.4.1 Interface

3.4.1.1 GPIB Address, RS-232C Parity/Baudrate

The AC Source also has remote operation mode that can be activated by the CONFIG function (3_Phase Mode/1_Phase Mode). It is necessary to set GPIB address to 30 before conducting remote operation in 1_Phase Mode /3_Phase Mode.

1. Press GPIB address at the bottom.
2. Turn the RPG to change the address and press **ENTER** to set address 30.

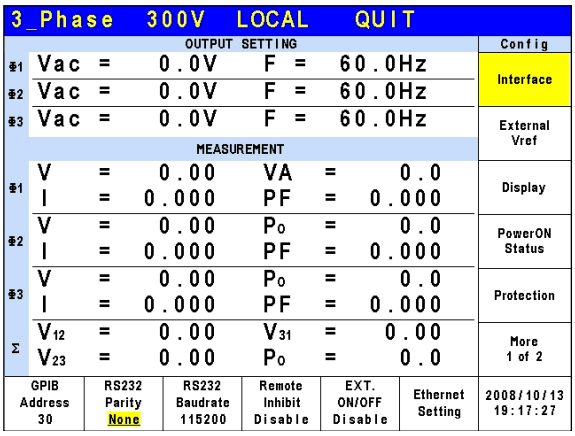


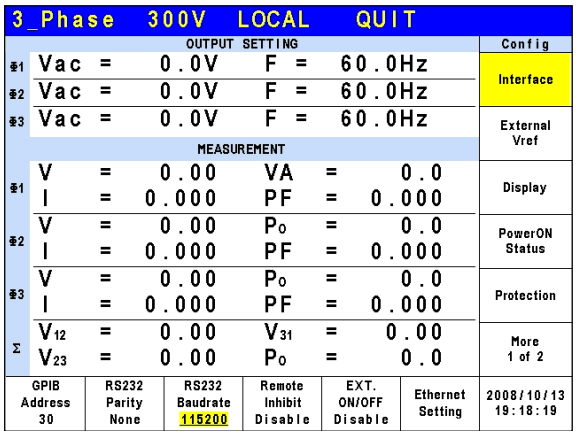


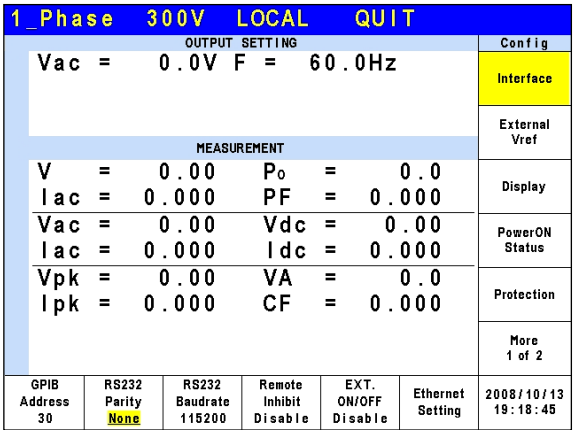
Notice The address range is from 1 to 30.

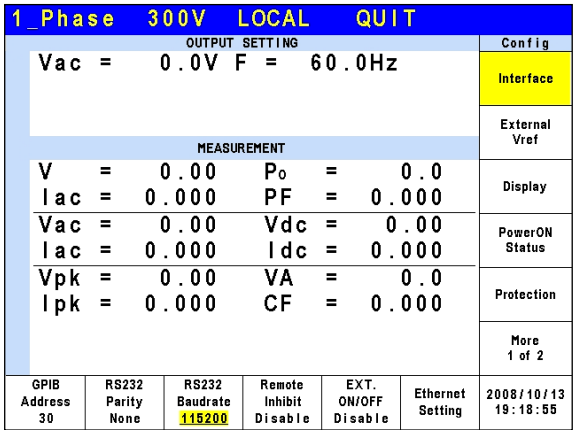
The AC Source uses the RS-232C bus to provide remote operation. Follow the steps below to set the communication protocol. Set Parity=None and Baudrate =115200 in 1_Phase Mode /3_Phase Mode as described below:

1. Press RS232 Parity at the bottom.
2. Turn the RPG to select None and press **ENTER**.
3. Press RS232 Baudrate at the bottom.
4. Turn the RPG to “115200” and press **ENTER**.









Notice The baudrate selections are 9600/19200/38400/57600/115200 and the selections for parity are EVEN/ODD/NON.

3.4.1.2 Remote Inhibit, EXT. ON/OFF

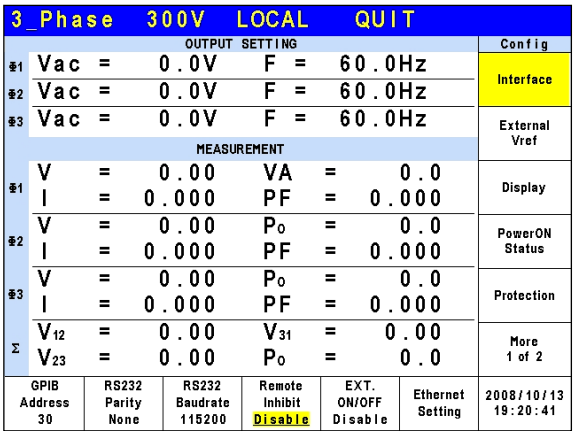
The output of AC Source can be inhibited by external control or manual trigger. The output signal of the remote inhibit (remote control) is received from the TTL terminal on the rear panel (see *Appendix A*.) Remote Inhibit and EXT. ON/OFF are set by the CONFIG function (3_Phase Mode/1_Phase Mode). There are two remote inhibit output states: Enable and Disable.

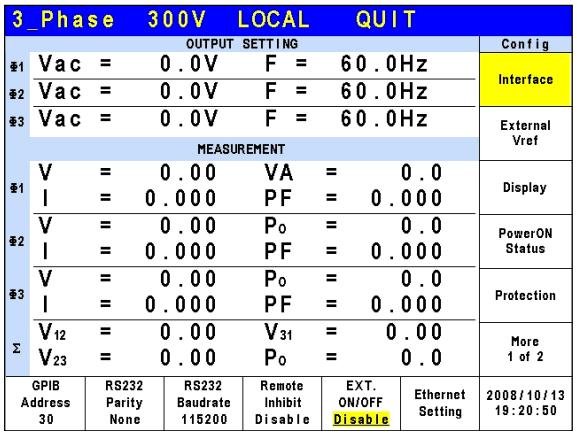
Remote Inhibit: When the Remote Inhibit is enabled on the AC Source and the Remote Inhibit signal is LOW, the AC Source will disable the output. The AC Source holds the ouput disabled even when the Remote Inhibit signal turns to HIGH. In order to re-enable the output, the user must press **OUT/QUIT**.

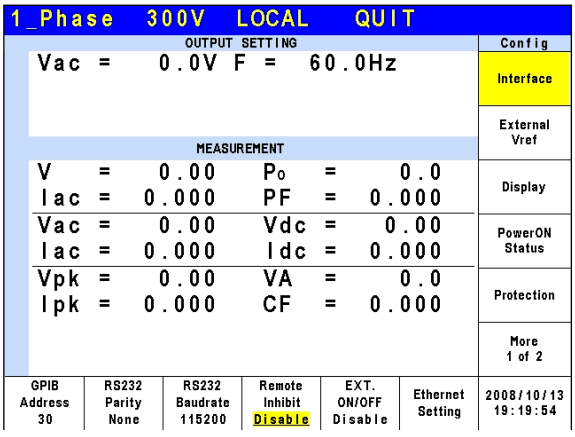
EXT. ON/OFF: When the EXT. ON/OFF is enabled on the AC Source and the EXT. ON/OFF signal is LOW the AC Source will disable the output. The AC Source will re-enable the output when the EXT. ON/OFF signal turns to HIGH.

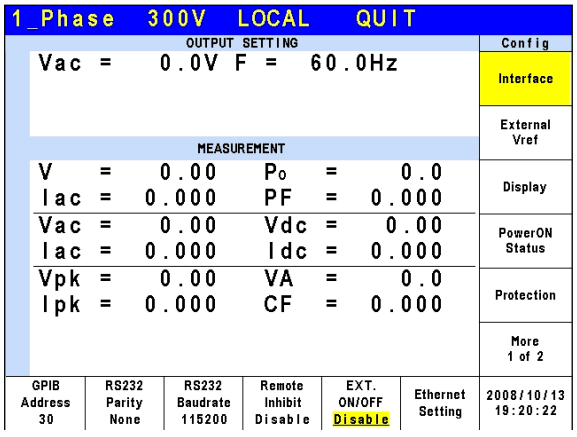
The procedure for setting Remote Inhibit/EXT. ON/OFF to disable in1_Phase Mode /3_Phase Mode is described below.

1. Press Remote Inhibit/EXT. ON/OFF at the bottom.
2. Turn the RPG to change to "Disable" and press **ENTER**.









Notice The output of the Remote Inhibit (Remote Control) transmits the TTL signals via a special I/O connector. See *Appendix A* for the detail TTL signal pin assignments.

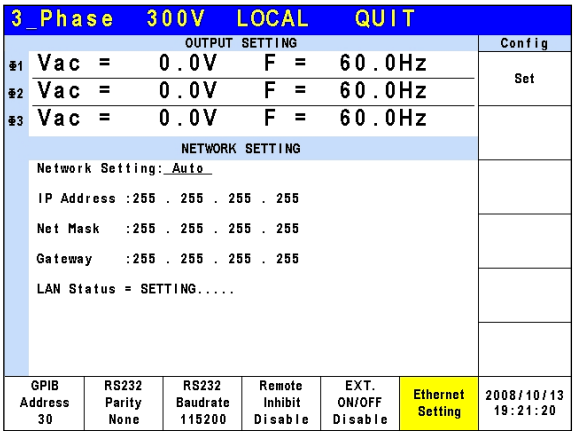
3.4.1.3 Ethernet Setting

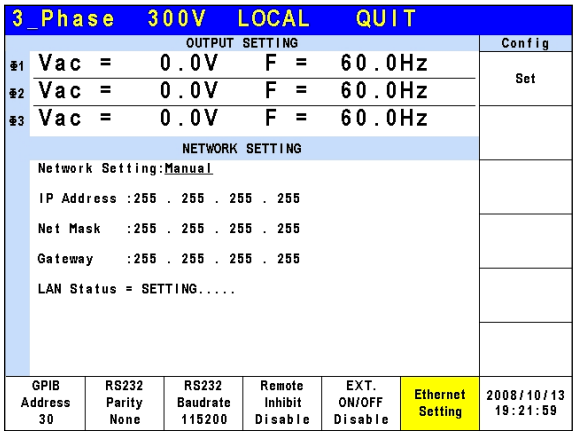
The AC Source can be operated remotely through a network once the Ethernet Settings are complete.

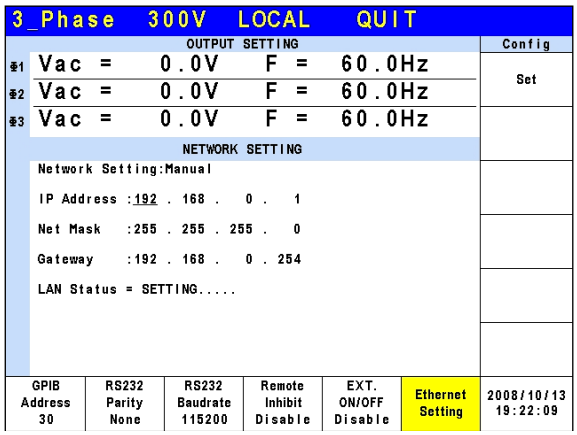
Network Setting: Auto and Manual.

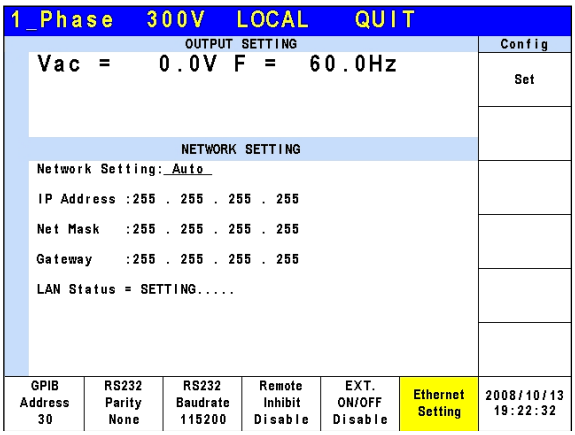
The procedure for setting Network Settings manually in 1_Phase Mode/3_Phase Mode is described below.

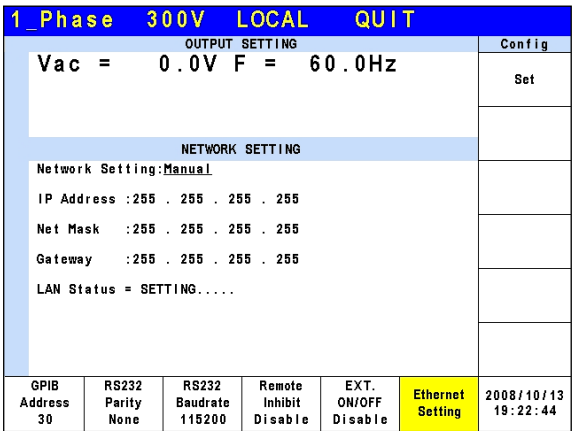
1. Press Ethernet setting at the bottom.
2. Move the cursor to “Network Setting:”
3. Turn the RPG to change to Manual and press **ENTER**.
4. Set the IP Address, Net Mask and Gateway.

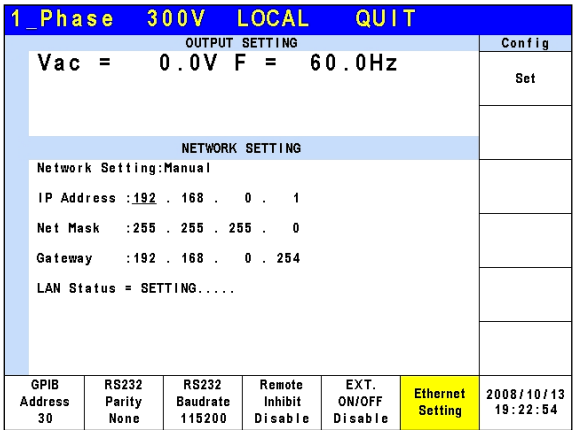












3.4.2 External Vref

The AC Source allows the user to use analog control signals (simulated) from an external device to set its output (optional card is required.) The External Vref terminal socket at the rear panel allows users to apply signals to the AC Source for output voltage setting. The External Vref and the Control Method can be set by the CONFIG function (3_Phase Mode/1_Phase Mode). External Vref has two coupled modes to indicate the output of AC Source: Amplifier and Level. When the user is using single phase Ext. Vref, the signal inputted by terminal pin Ext-V Φ2 is the main control signal. Refer to Appendix A for the pin assignment of TTL terminal.

Amplifier: The output voltage (Vout) is the composition of the voltage set in MAIN PAGE and the suplimental programmed voltage inputted externally. The external V reference voltage range is from -10 V to 10V. When Vac=0 and Vdc=0 in MAIN PAGE, the following formula can be used to calculate Vout.

Vout (dc) = Vref (dc) / 10 Vdc × 424.2 Vdc (range 300V)
Vout (dc) = Vref (dc) / 10 Vdc × 212.1 Vdc (range150V)
or
Vout (ac) = Vref (ac) / 7.072 Vac × 300 Vac (range300V)
Vout (ac) = Vref (ac) / 7.072 Vac × 150 Vac (range150V)

Ex (1): Set Vout to 100Vdc:

1. When selecting range 300V in SETUP function, the applied external output

voltage is V= 2.357Vdc, Vout = 100Vdc.

2. When selecting range 150V in SETUP function, the applied external output voltage is V= 4.715Vdc, Vout = 100Vdc.

Ex. (2): Set Vout to 100Vac:

1. When selecting range 300V in SETUP function, the applied external output voltage is V= 2.357Vac, Vout = 100Vac.
2. When selecting range 150V in SETUP function, the applied external output voltage is V= 4.715Vac, Vout = 100Vac.

Level: It is the linear proportional output of output voltage (Vout (ac)) RMS programmed by the DC V reference. The Vreference range is from -10V to 10V. The following formula can be used to calculate Vout:

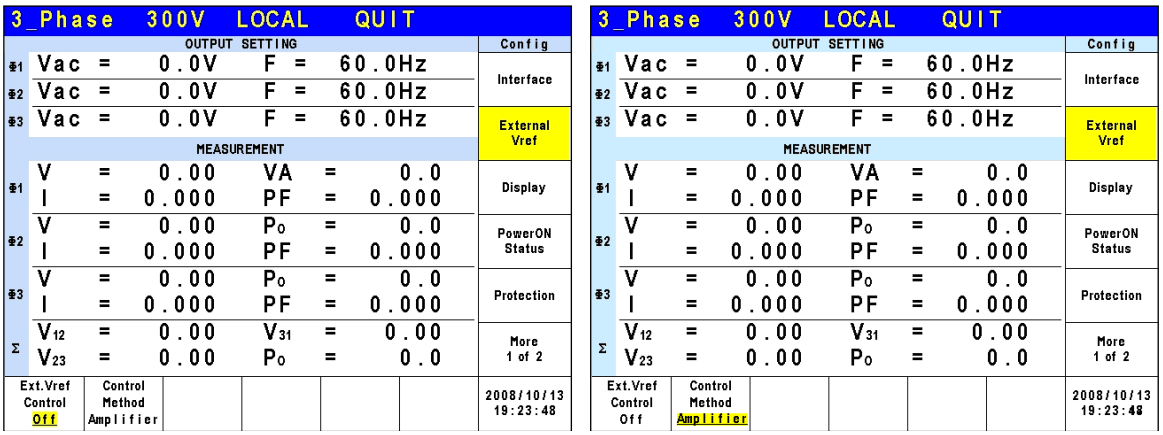
Vout (ac) = ｜Vref (dc)｜ / 10 Vdc × 300Vac (range 300V)
Vout (ac) = ｜Vref (dc)｜ / 10 Vdc × 150Vac (range 150V)

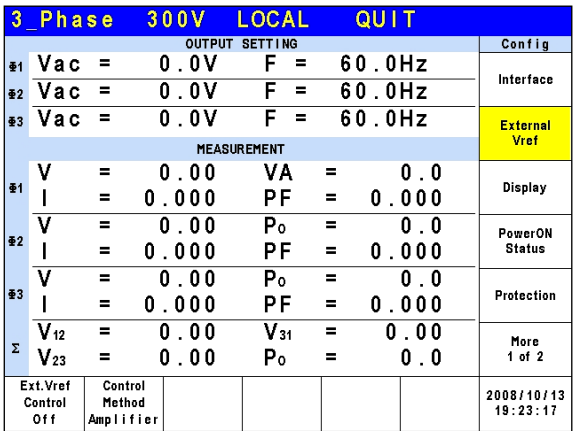
Ex. (1): Set Vout to 100Vac:

1. When selecting range 300V in SETUP function, the applied external output voltage is V= 3.333Vdc (or -3.333Vdc), Vout = 100Vac.
2. When selecting range 150V in SETUP function, the applied external output voltage is V= 6.667Vdc (or -6.667Vdc), Vout = 100Vac.

The setting of Ext. Vref Control = OFF, Control Method = Amplifier is described below.

1. Press Ext. Vref Control at the bottom.
2. Turn the RPG to change ON to OFF and press **ENTER**.
3. Press Control Method at the bottom.
4. Turn the RPG to select Amplifier and press **ENTER**.





5. Press Exit to return to the Main screen. The output parameter F for measurement frequency should be the same as the Ext.V input frequency.

Notice

When Ext. Vref Control =ON, Control Method =Level, the output voltage (Vout) can only be controlled by the level of the external DC programming voltage. It is unable to control the Vout amplitude from the front panel keys until Ext. Vref Control=OFF is set.

⚠WARNING

1. When Control Method = Amplifier and the Vref frequency exceeds 1500Hz, it could damage the AC Source. This formula should be followed exactly – Vref (pk-pk, V) × F (Vref, Hz) < 10000 VHz.
2. The output may be distorted due to the bandwidth restriction of AC Source, especially when the external V reference has too many high frequency components.
3. When the input voltage range is over ±10V (it could damge the AC Source if the input signal voltage exceeds ±12V), the AC Source will trigger Over Voltage Protection (OVP).

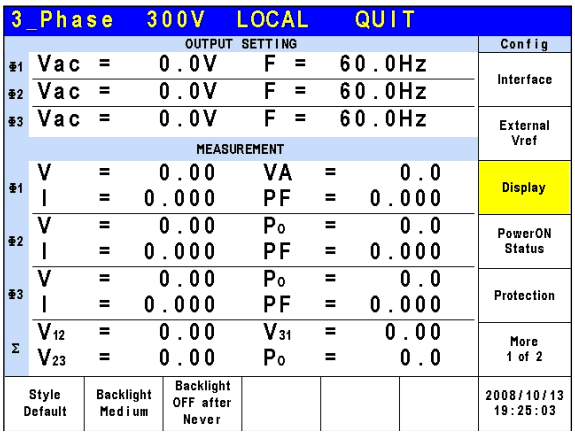
3.4.3 Display

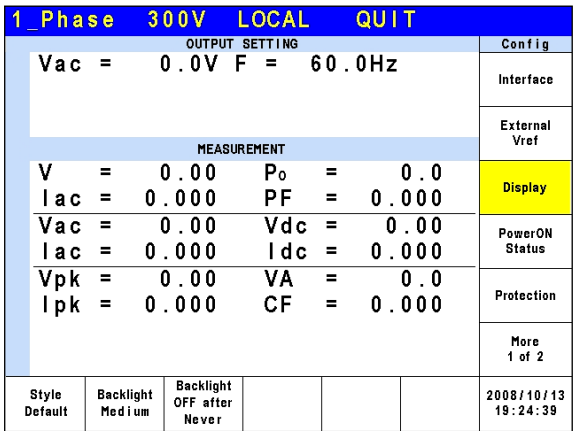
The brightness of the backlight and power save mode settings of the LCD can be set in the CONFIG function. (3_Phase Mode/1_Phase Mode).

Style: Default.
Backlight: Low, Medium and High.
Backlight OFF after: Never, 1 min, 3 mins, 5 mins, 10 mins, 30 mins, 1 hour and 3 hours.

The procedure for setting Backlight = Medium, Backlight OFF after = Never in 1_Phase Mode /3_Phase Mode is listed below.

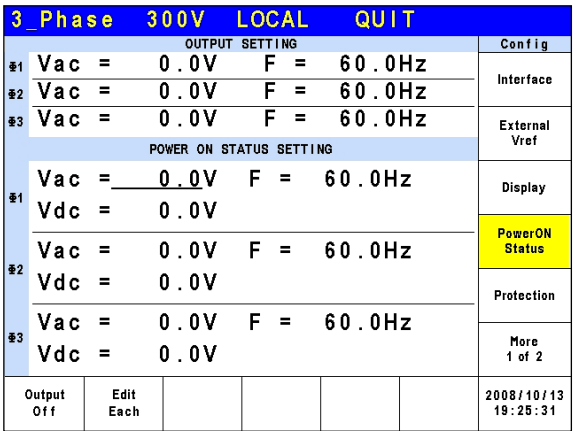
1. Press Backlight at the bottom.
2. Turn the RPG to Medium and press **ENTER**.
3. Press Backlight OFF after at the bottom.
4. Turn the RPG to select Never and press **ENTER**.

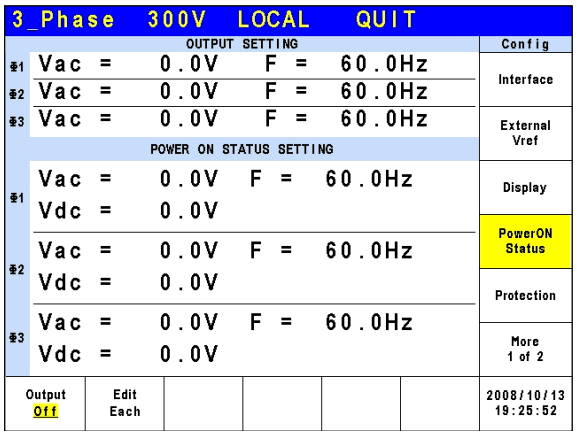


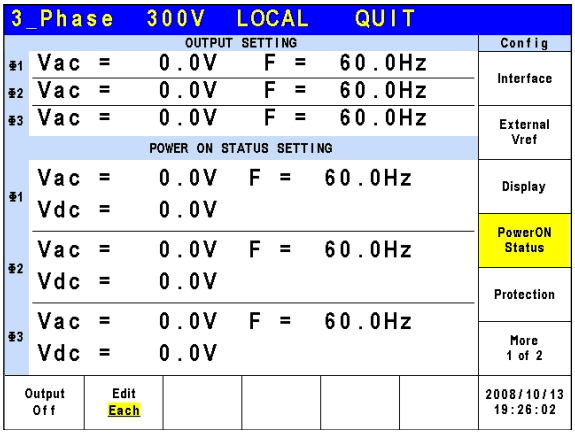


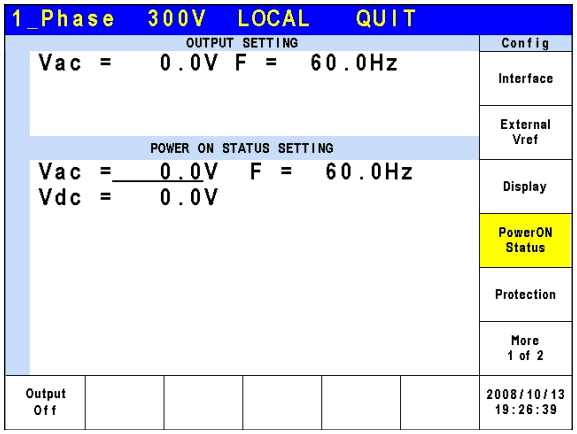
3.4.4 Power ON Status

Users can set the output state of AC Source during power on using the Power ON Status in the CONFIG function (3_Phase Mode/1_Phase Mode). Once it is set users should save the data before power off. With the output set to Off, the AC Source will not enable the output voltage after it is powered on. With it set to On, the AC Source will enable the output by default after powered on.









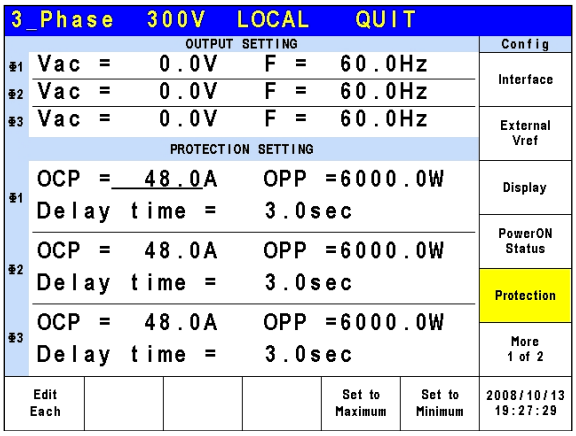
3.4.5 Protection

The AC Source's Protection for 1-phase/3-phase output mode is set separately. For instance, the Protection will apply the settings of 1-phase when switching from 3-phase to 1-phase mode rather than the Protection settings of any phase under 3-phase mode.

The Protection in the CONFIG function (3_Phase Mode/1_Phase Mode) is able to set the limit of the output RMS current (OCP), output power (OPP) and the Delay Time for triggering the current protection. The limit in this command is to protect the program instead of the hardware.

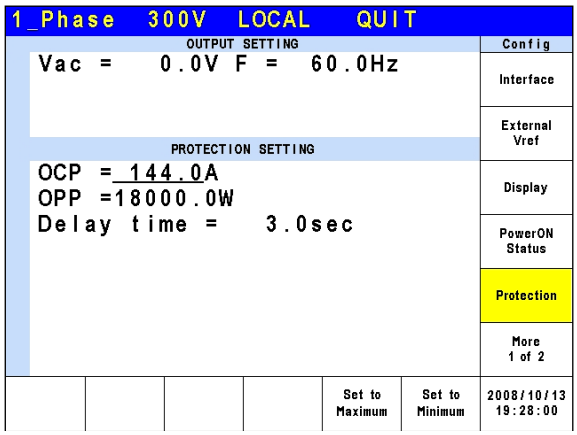
Following shows the procedure of setting the current limit = 48A (32A for 61511), power limit = 6000W (4000W for 61511), delay time for trigger current protection = 3 sec. for 61512 in 3_Phase Mode.

1. Move the cursor to "OCP =" command line.
2. Press **4**, **8** and **ENTER** to change the value to "48.0".
3. Move the cursor to "OPP =" command line.
4. Press **6**, **0**, **0**, **0**, **ENTER** to change the value to "6000.0".
5. Move the cursor to "Delay time =" command line.
6. Press **3**, **ENTER** to change the value to "3.0".



Following shows the procedure of setting the current limit = 144A (96A for 61511), power limit = 18000W (12000W for 61511), delay time for trigger current protection = 3 sec. for 61512 in 1_Phase Mode.

1. Move the cursor to "OCP =" command line.
2. Press **1**, **4**, **4** and **ENTER** to change the value to "144.0".
3. Move the cursor to "OPP =" command line.
4. Press **1**, **8**, **0**, **0**, **0**, **ENTER** to change the value to "18000.0".
5. The cursor moves to "Delay time =" command line automatically.
6. Press **3**, **ENTER** to change the value to "3.0".



Notice

1. When “OCP = 0.0 A”, it means the limit of output current equals to the specification limit.
2. The setting of the delay time for trigger current protection is only valid when the current is within the specification. When the output is over the specification, the time delay set between 0.1 and 1s for triggering current protection is valid. However, if the current is over the output specification and the protection delay time is set more than 1s, the 1s will be the maximum delay protection time. The resolution is 0.1s.

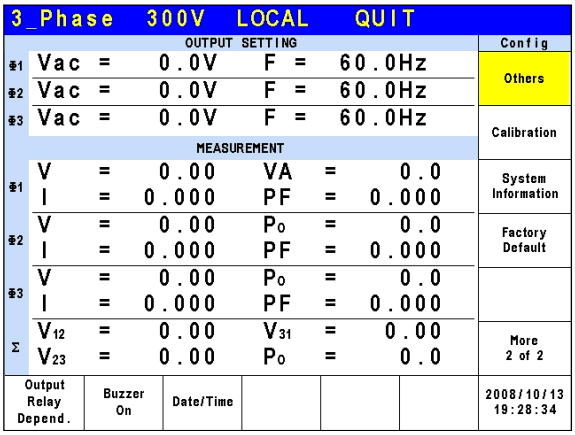
Notice

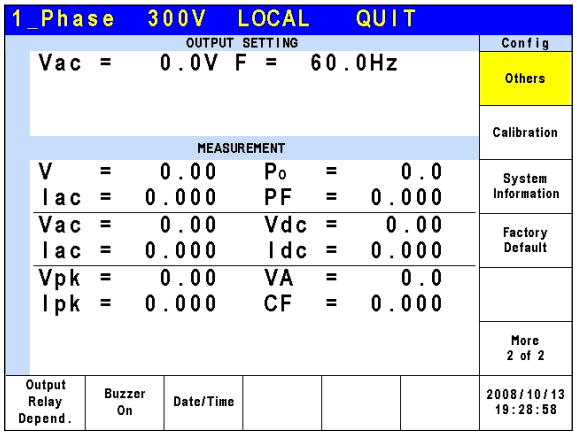
The protection point varies by the measurement error, thus it may act before reaching the protection point set.

3.4.6 Others

Press MORE on the right in CONFIG function (3_Phase Mode/1_Phase Mode) to go to the second page and press Others on the right to set Output Relay, Buzzer and Date/Time.

Output Relay: Depend and Always ON.
Buzzer: on and off.
Date/Time: Year, Month, Day, Hour, Minute and Second.



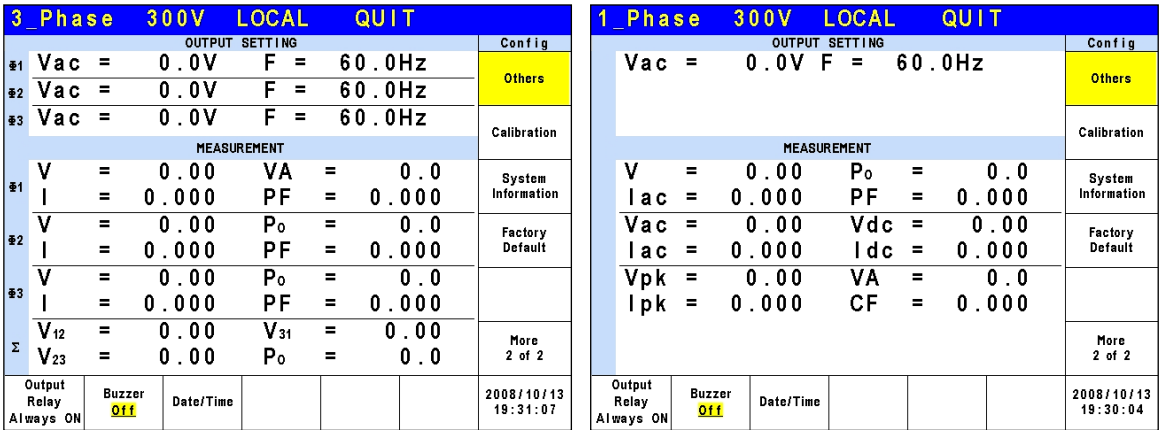


The output circuit on the AC Source has a relay to connect to the load. When the output relay is “Always ON”, it indicates the output relay is closed (connected) even if the AC Source output state is in QUIT mode. When the output relay is “Depend.” the output relay is closed

(connected) only when the output state is in OUT mode. If the output state is in QUIT mode, the output relay will be opened (disconnected.) Output relay can be set in the SETUP function.

The procedure for setting the output relay to Always ON in 1_Phase Mode /3_Phase Mode is described below.

1. Press Output Relay at the bottom.
2. Turn the RPG to set the output relay to Always ON and press **ENTER**. When the output relay is working, the AC Source will click once.

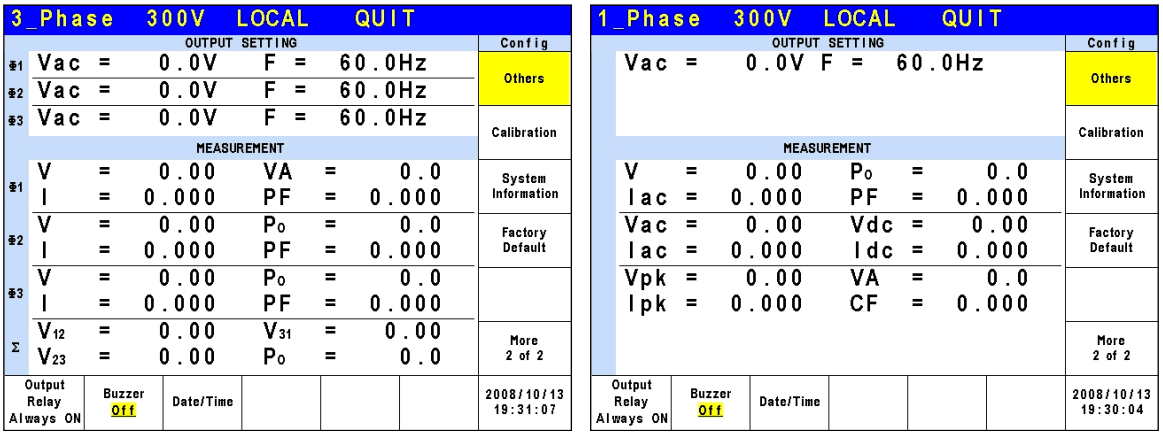


Notice Check if the AC Source has voltage output before powering it off. To ensure the safety of hardware, it is prohibited to power off the AC Source in Output state.

Next, the AC Source buzzer beeps when the panel keys are pressed or the RPG rotary is turned. If the user does not want the buzzer active, it may be turned off.

Following procedure describes the procedure for turning off the buzzer in 1_Phase Mode /3_Phase Mode.

1. Press Buzzer at the bottom.
2. Turn the RPG to change ON to OFF and press **ENTER**.

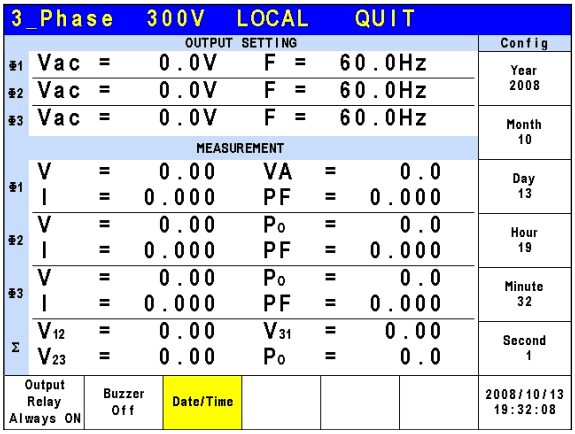


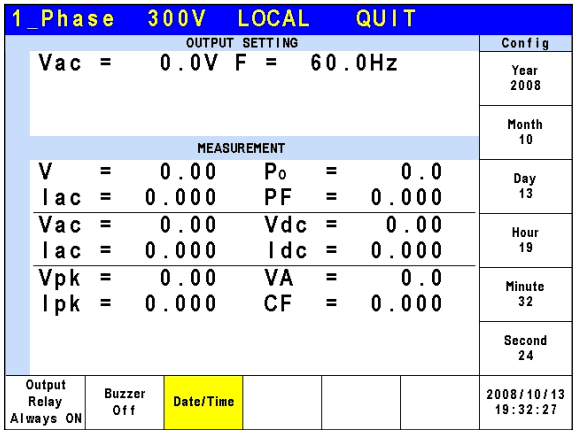
At last, set the time and date of AC Source.

Date/Time: Year, Month, Day, Hour, Minute, Second.

Follow the procedure below to set the time and date in 1_Phase Mode /3_Phase Mode.

1. Press Date/Time at the bottom.
2. Select the item (Year/Month/Day/Hour/Minute/Second) to be set and press the button on the right.
3. Use the RPG to change the selected item and press **ENTER**.



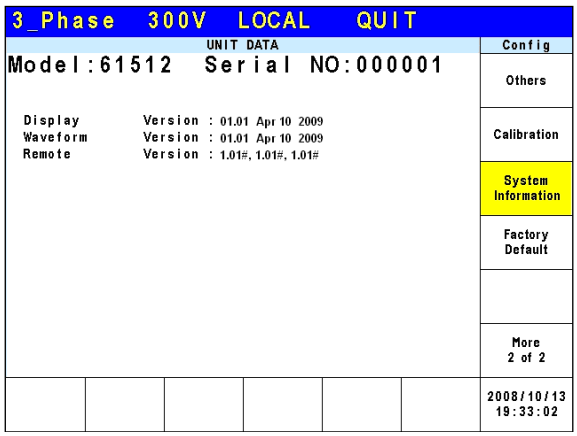


3.4.7 Calibration

For detail calibration procedure please refer to the description in Chapter 4.

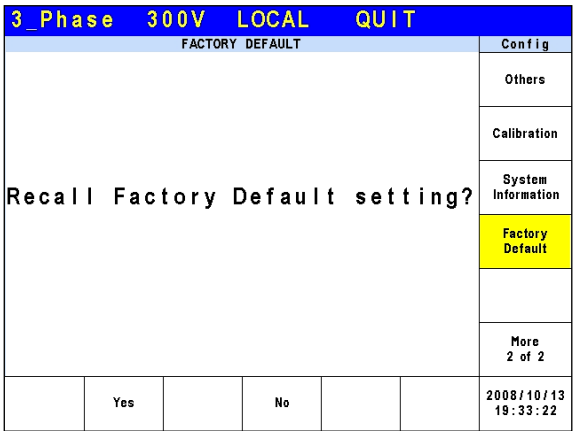
3.4.8 System Information

Press MORE on the right in the CONFIG function (3_Phase Mode/1_Phase Mode) to go to next page. Press System Information on the right to see the system information of the AC Source.



3.4.9 Factory Default

Press MORE on the right in the CONFIG function (3_Phase Mode/1_Phase Mode) to go to next page. Press Factory Default on the right and Yes at the bottom to return to the factory default.



3.5 PHASE Function Key

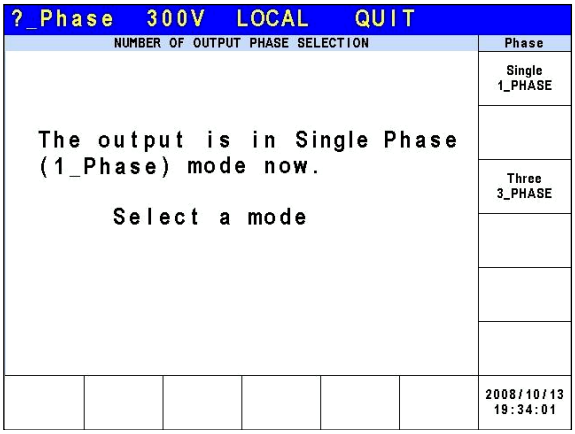
Press **PHASE** function key in Figure 3-5 to go to the switch 3_Phase Mode/1_Phase Mode.

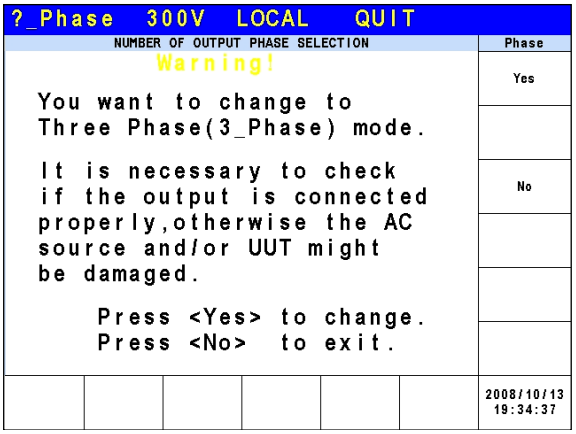
3.5.1 3_Phase Mode

The AC Source can be set to 3-phase AC power by pressing the **PHASE** function key to switch to 3_Phase Mode when it is required.

The procedure for setting the AC Source to 3-phase mode is described below.

1. Press **PHASE** function key.
2. Press Three 3_PHASE on the right.
3. Press Yes on the right to confirm the change.



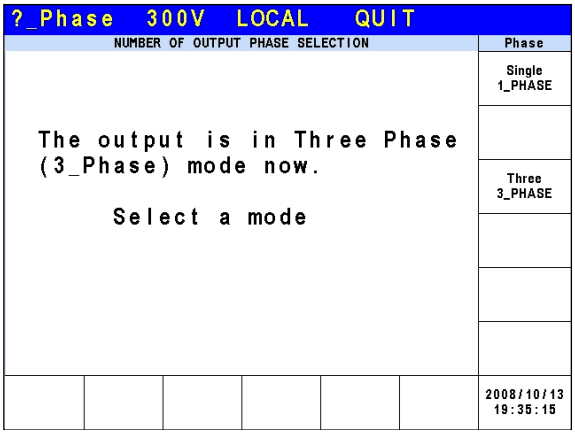


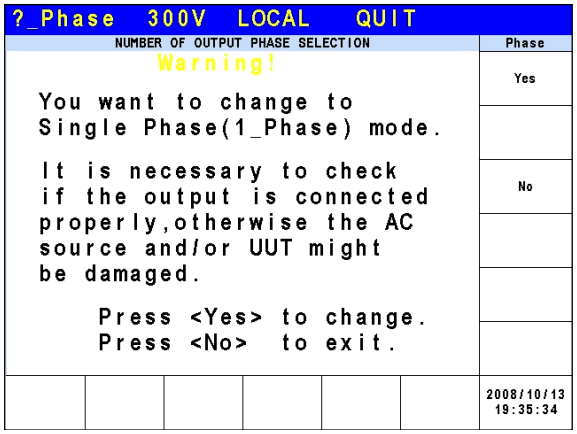
3.5.2 1_Phase Mode

When the 3-phase power of the AC Source is not enough to drive the load, the 3-phase output can be paralleled to one of the phases. Pressing the **PHASE** function key can change the AC Source setting from 3-phase to 1-phase.

The procedure for setting the AC Source to 1-phase mode is described below.

1. Press **PAHSE** function key.
2. Press Single 1_PHASE on the right.
3. Press Yes on the right to confirm the change.





Notice When switching between 1-phase and 3-phase mode, the set output value will be reset to zero to avoid damaging the Unit Under Test (UUT).

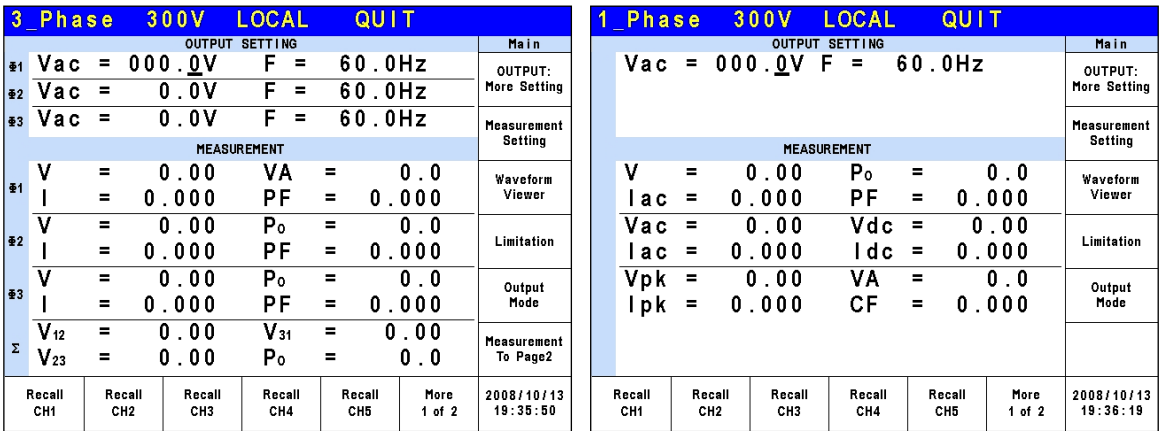
3.6 CURSOR Function Key

Press **CURSOR** function key in Figure 3-5 to set the value of a single digit.

The RPG can be used to set the digit of hundred, decade, figure and 1st place after the decimal point for voltage or frequency to save time in inputting the values.

The procedure for setting the 1st place after the decimal point for output voltage Vac in 1_Phase Mode /3_Phase Mode is described below.

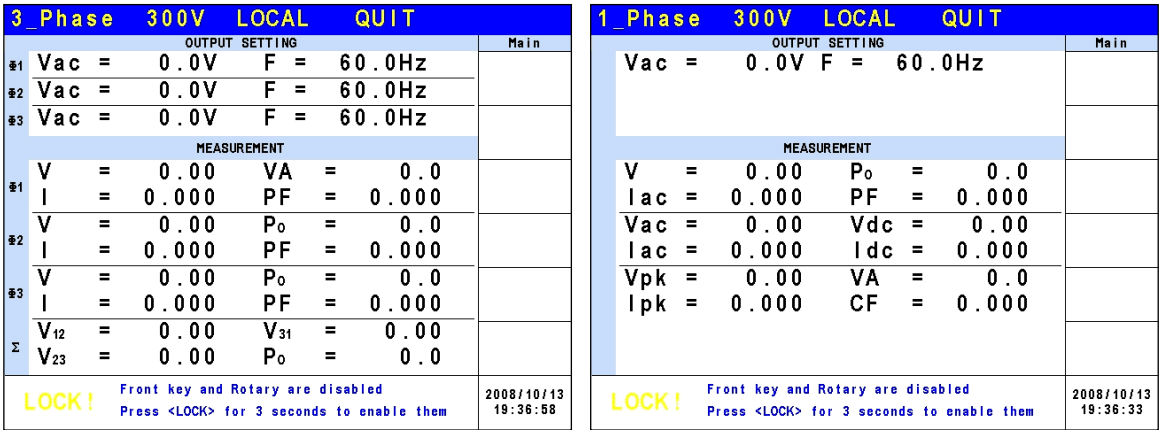
1. Move the cursor to “Vac =” command line.
2. Press **CURSOR** function key.
3. The cursor will shorten to one digit range.
4. Move the cursor to the 1st digit after decimal point and use the RPG to change the value.
5. Press **CURSOR** function key again to exit it.



3.7 LOCK Function Key

Press **LOCK** function key in Figure 3-5 to lock the function.

Press this key to lock all functions on the panel and making all keys invalid. Press **LOCK** for 3~3.5 seconds to unlock it.



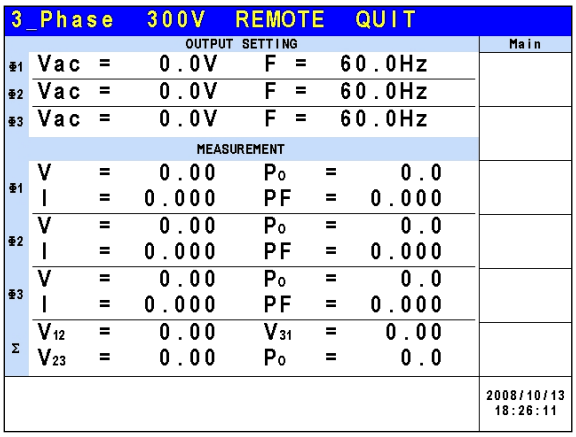
3.8 OUTPUT Function Key

Please refer to section 3.3.1 for the detail description of OUTPUT function key.

3.9 LOCAL/REMOTE Function Key

Press **LOCAL/REMOTE** function key in Figure 3-5 to switch to remote control.

When the AC Source is in REMOTE state and controlled by an external device, press this key to release the REMOTE state and return to LOCAL control.

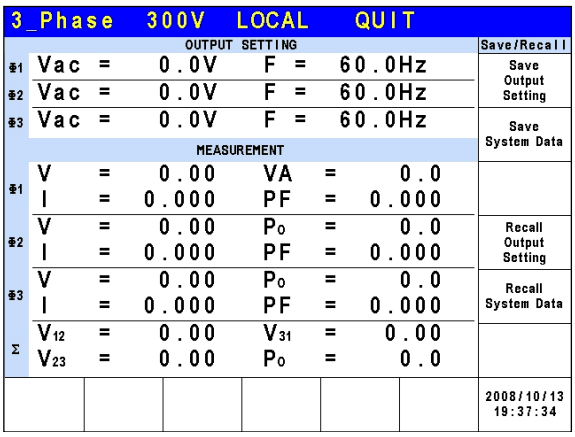


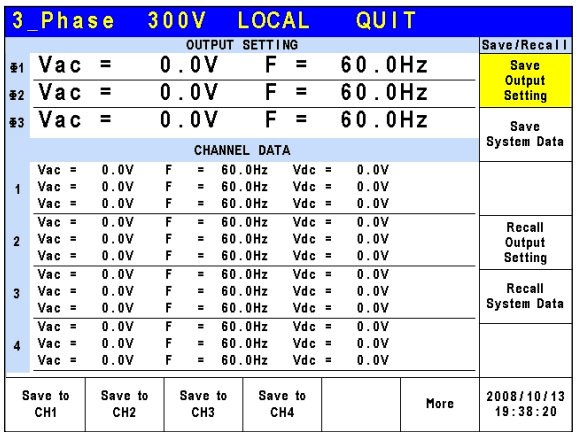
3.10 SAVE/RECALL Function Key

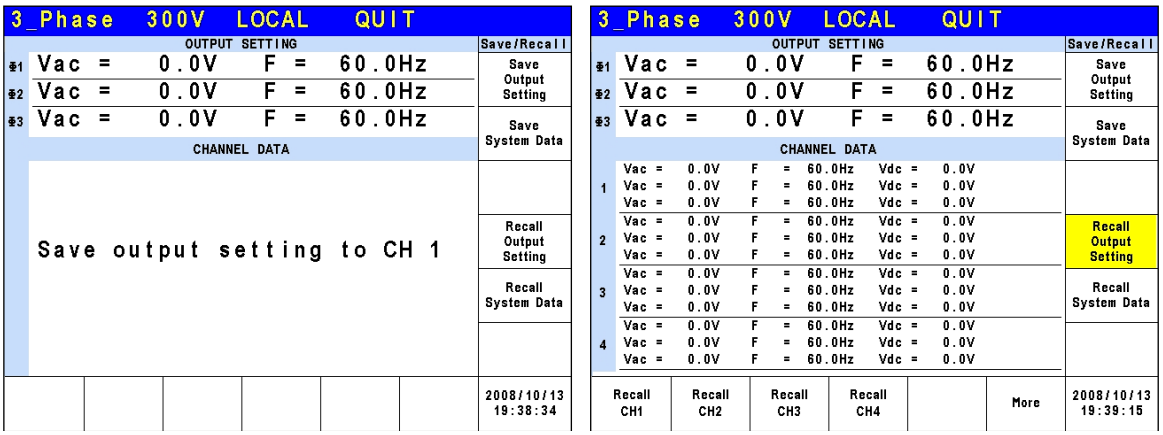
The AC Source has two modes for users to save and recall the output setting or system information as described in section 3.10.1 and 3.10.2. Press **SAVE/RECALL** function key as shown in Figure 3-5 to access the save and recall functions.

3.10.1 Save/Recall Output Setting

The AC Source has 10 channels for users to save the frequently used Vac, F and Vdc for recall. For example, enter the setting and save it to CH1 memory in MAIN PAGE (3_Phase Mode) (see 3.3.)





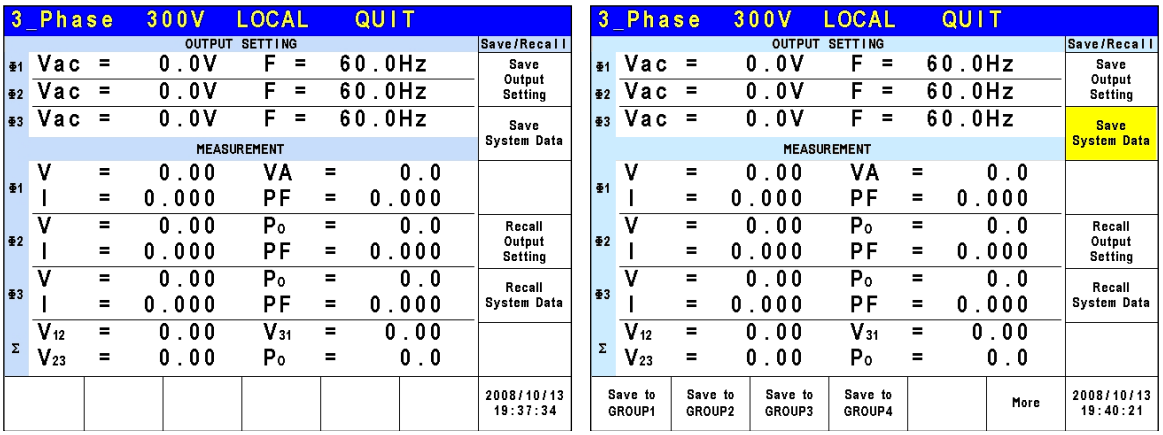


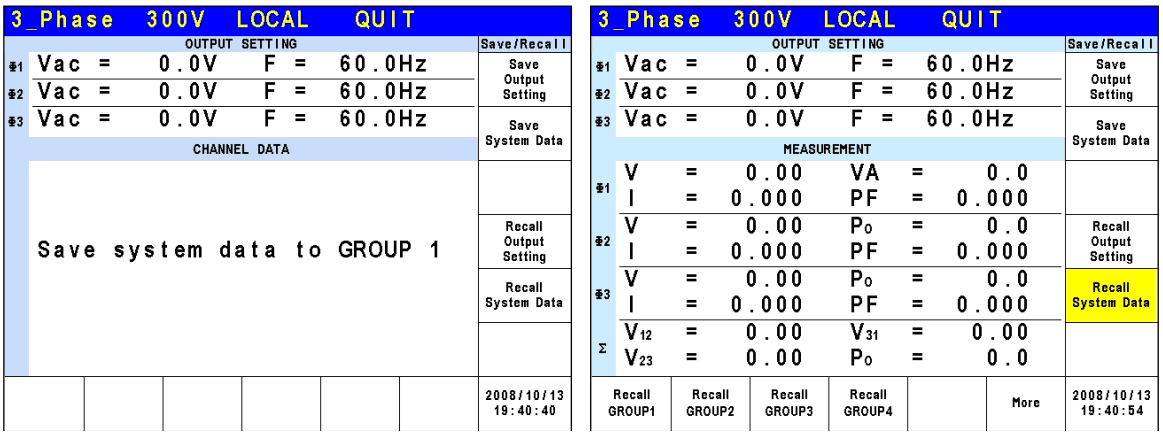
Notice

1. Only the save and recall settings are set in MAIN PAGE. Other parameters are ignored.
2. In different output coupling modes (see 3.3.1.1) the missing settings will be adjusted to Vac=0V, F=60Hz, Vdc=0V automatically. For example, when executing save in DC output mode Vac=0V, F=60Hz, Vdc is the setting in MAIN PAGE.

3.10.2 Save/Recall System Data

The AC Source has 10 groups of memory for users to save and recall system data. System data contains all parameters in the function keys such as MAIN PAGE (see 3.3) and CONFIG (see3.4). Press **SAVE/RECALL** in MAIN PAGE (3_Phase Mode) (see 3.3) and press the LCD at the bottom to save the system data as shown below.





Notice

The AC Source has 11 groups of memory: GROUP 0, GROUP1~10. GROUP 0 will save the power-on default. The data saved in GROUP 0 will be recalled automatically and loaded when the AC Source powers on again. As to the data saved in GROUP 1~10 memory groups, they need to be called manually for loading.

3.11 Protection

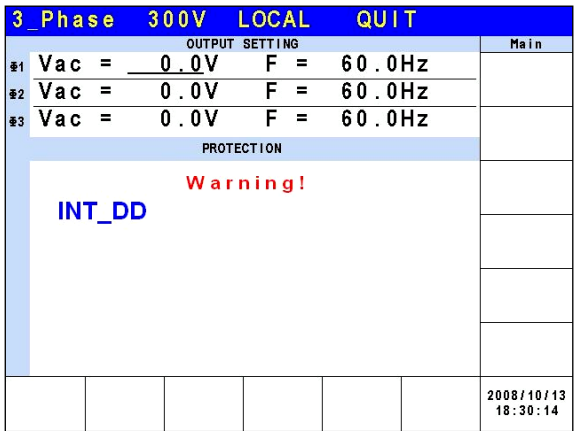
The AC Source has both software and hardware protection. When protection occurs the AC Source will stop the output and disconnect the output relay. The display shows that the source is in protection mode. To return to normal output after the protection is triggered, please address any issues and press **ENTER** to release protection for normal operation.

The table below lists the software protection:

Protection	Description
OCP	It occurs when output current exceeds the limit or specification.
OPP	It occurs when output power exceeds specification.
OVP	It occurs when output voltage exceeds the limit of each range.
Remote - Inhibit	It executes remote inhibit.

The table below lists the hardware protection:

Protection	Description
FAN - FAIL	It occurs when the cooling fan is out of order.
INT - AD	It is the internal AD power stage protection indicating the output voltage is over or under the specification.
INT - DD	It is the internal DD power stage protection indicating the output voltage is over or under the specification.
INT - SHORT	It is the short circuit protection.
INT - LINE	It occurs when the line input voltage is over or under specification.
OTP	It occurs when the AC Source's internal temperature is too high.



Notice The protection point varies by the measurement error, thus it may act before reaching the protection point set.

4. Calibration

4.1 Introduction

The AC Source has a simple procedure built in to calibrate the output and measure the accuracy without opening the chassis. Users simply need to follow the procedure step by step for operation. A voltage meter, current meter and an adequate load with a＋5V DC power supply are required to perform the calibration. For the connections of these instruments please refer to Figure 4-1. There are 3 items required for calibration: output voltage, output current and external reference. However, they don't need to be calibrated at the same time. Select one of them for calibration is needed.

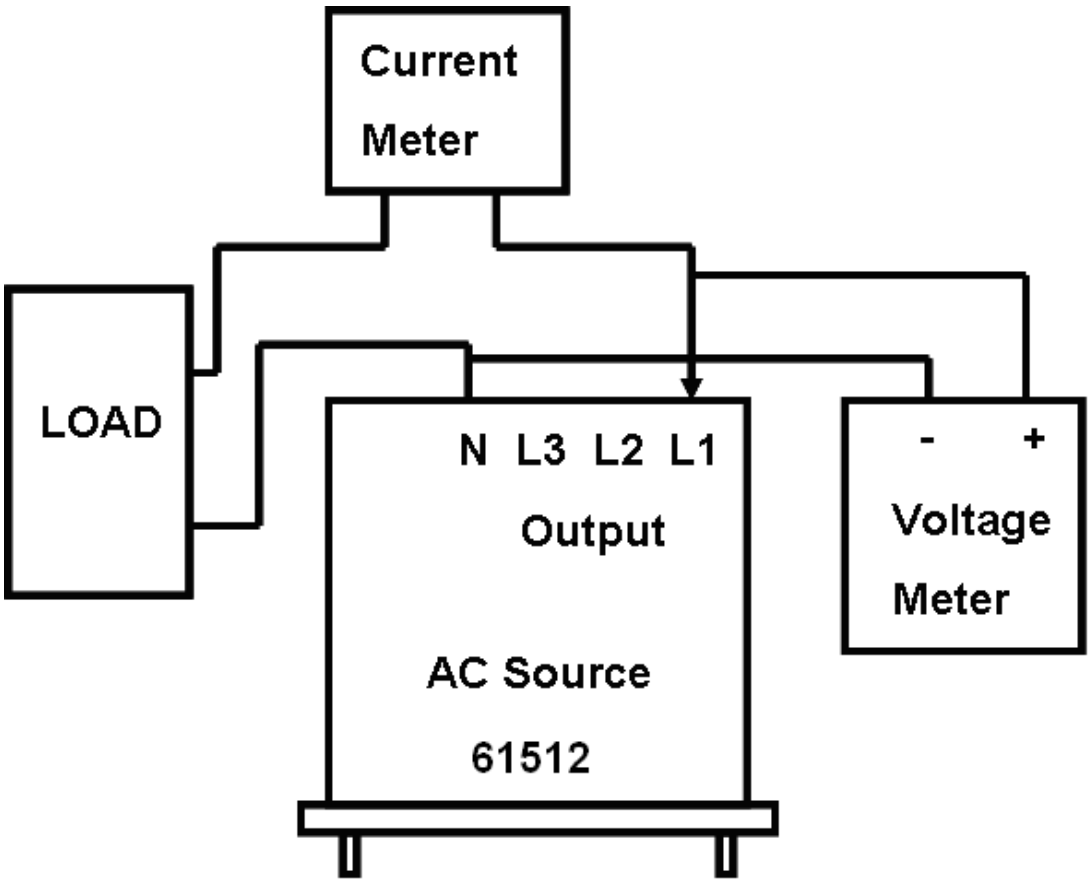


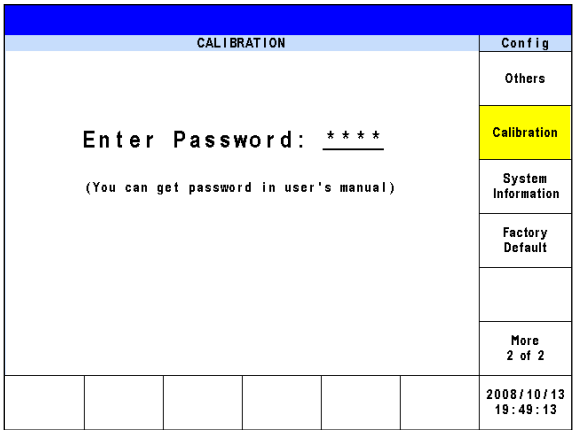
Figure 4-1

Notice

When in the ambient temperature 25°C, it needs to warm up for 20 minutes before calibration to allow the device internal to reach the normal operation temperature and ensure the calibration is correct.

4.2 Manual Calibration

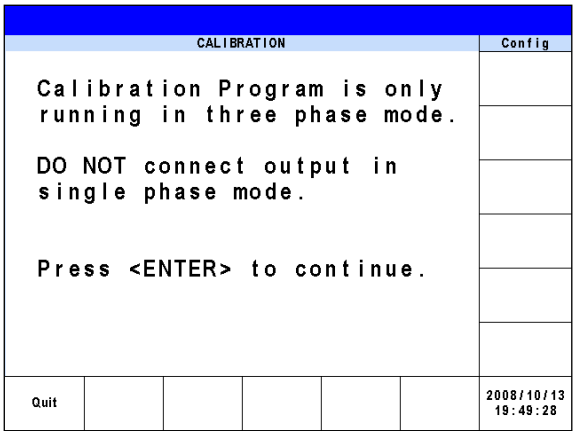
Select "Calibration" in CONFIG function (3_Phase Mode/1_Phase Mode) to input the calibration procedure. Before any calibration items appear, users have to input a password to eliminate accidental input. The password is included in the manual to ensure users read this manual before executing the calibration procedure.



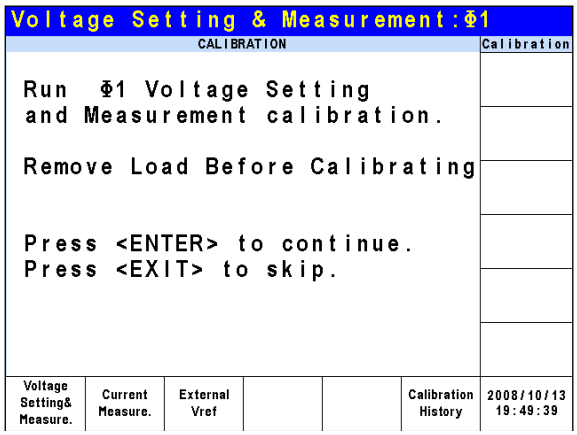
Notice

1. The password for calibration procedure is "3621", press **ENTER** to confirm it.
2. Users should read the procedure clearly before calibrating the AC Source, or partial memory data could be lost due to incorrect operation.

Once the correct password is entered, the LCD shows that the calibration procedure can only be runin 3-phase mode and is prohibited in 1-phase mode. Press **ENTER** to continue the calibration procedure.



Next users can select the voltage, current and external reference voltage for calibration.

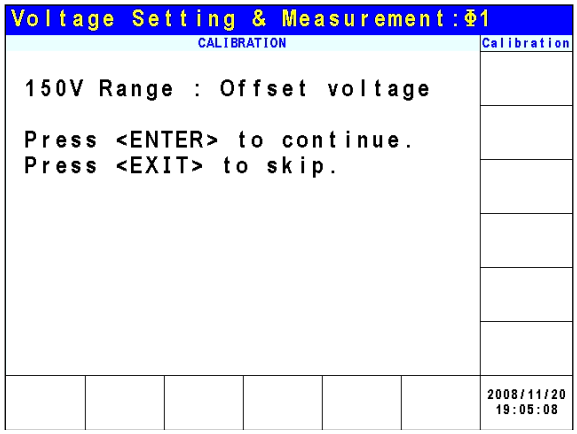


Voltage setting & Measure: This is the calibration for output voltage and measurement accuracy.

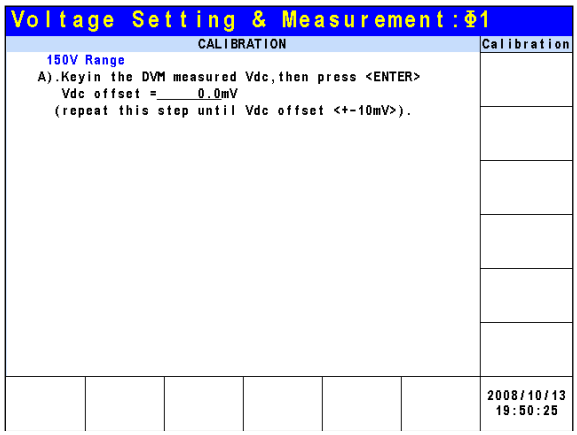
Current Measure: This is the calibration for current measurement accuracy.
External Vref.: This is the calibration of external Vref.

4.2.1 Output Voltage and Measurement Calibration

CALIBRATION CHOICE can be input after you enter the password, see section 4.2. Press Voltage setting & Measure at the bottom to calibrate the output voltage and measurement.



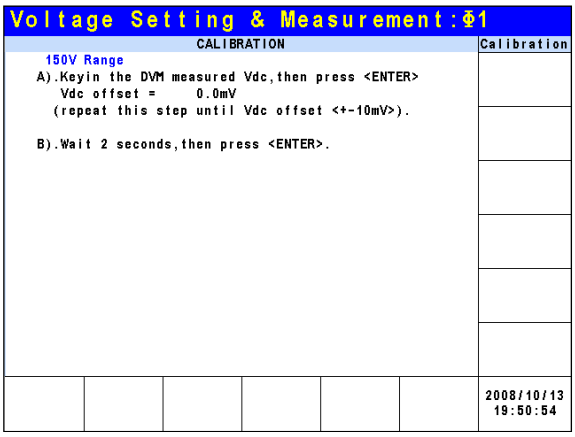
When in Voltage Setting & Measurement Calibration, the screen will ask the user if conducting the 150V Range Offset voltage calibration. Press **ENTER** to continue the offset voltage calibration and press **EXIT** to skip it to go into 150V Range Voltage Setting & Meas. calibration procedure.

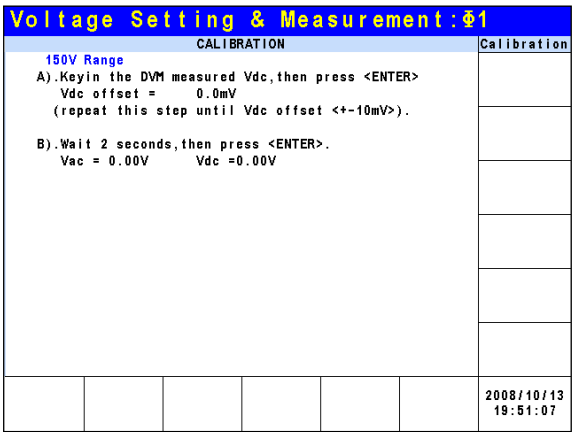


For step A in 150V Range Offset voltage calibration procedure, users should use a Digital Voltage Meter (DVM) to measure the AC Source's output DC voltage with the unit of mV and key in the measured value to LCD. Keep monitoring the DVM readings and input/output of the DC voltage repeatedly until the DC output is lower than ±10 mV.

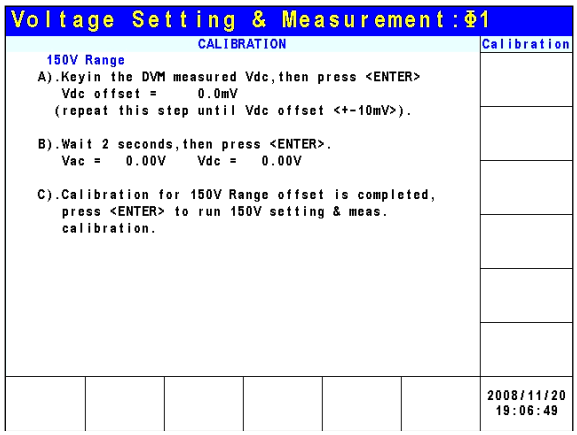
Notice

1. The Vdc offset can be positive or negative. Connect the positive terminal of DVM to the AC Source's Line output and the negative terminal to the AC Source's Neutral output as shown in Figure 4-1.
2. The load must be off for all of the steps in ACCURACY CALI under Voltage setting & Measure.

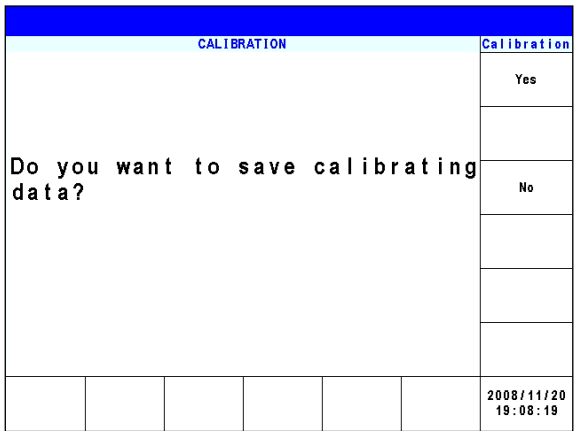




For step B in 150V Range Offset voltage calibration procedure, the display shows the difference between Vac and Vdc measured by the AC Source. It is generated by an internal component. Wait for 2 seconds and press **ENTER**, the display will show the offset voltage Vac and Vdc calculated by the AC Source at present.



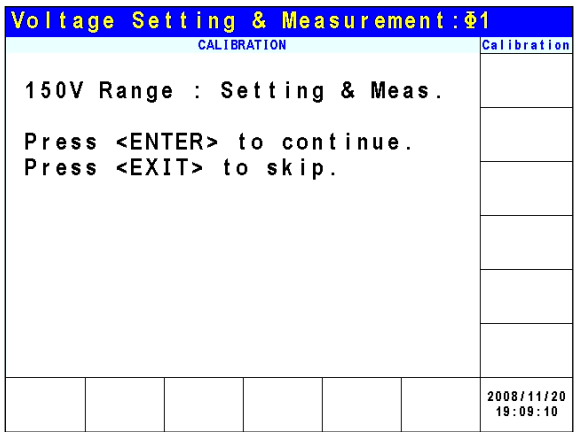
For step C in 150V Range Offset voltage calibration procedure, the display shows the 150V range offset voltage calibration has been done. Press **EXIT** to go into save screen as shown below, or press **ENTER** to continue for next 150V range voltage setting and measurement calibration procedure.



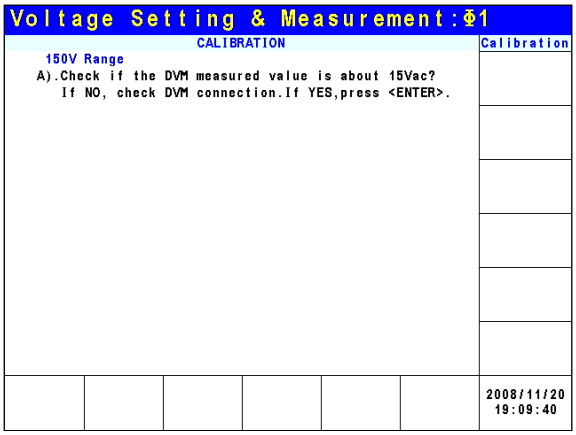
In step C, press **EXIT** the display will show the save screen and press Yes on the right can save the calibrated result.

Notice

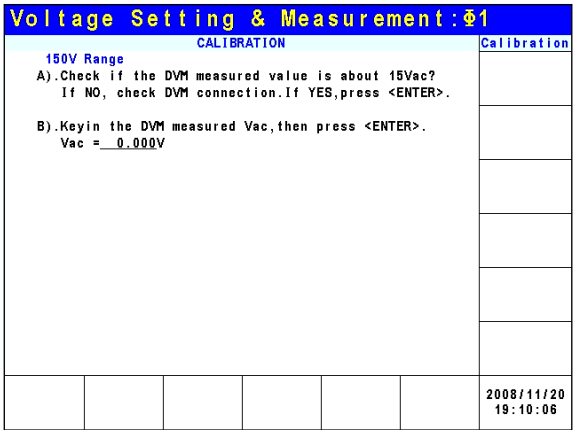
The AC Source calibration procedure can be executed separately; however, it is better to follow the calibration sequence step by step (step A, step B ...) or it may cause an output and measurement error.



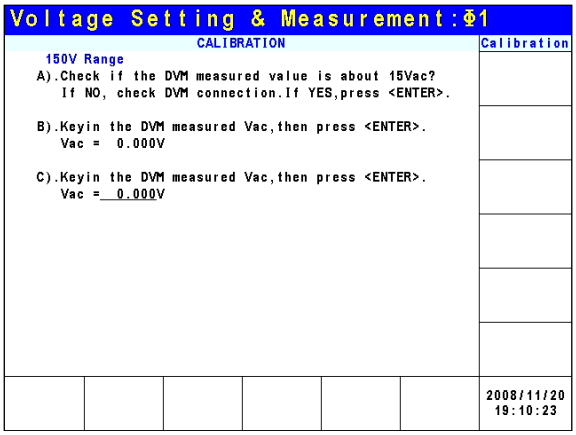
Once the 150V Range Offset voltage calibration is done, the screen will ask the user if conducting the 150V Range Setting & Meas. calibration. Press **ENTER** to continue the Setting & Meas. calibration and press **EXIT** to skip it to go into 300V Range Offset voltage calibration procedure.



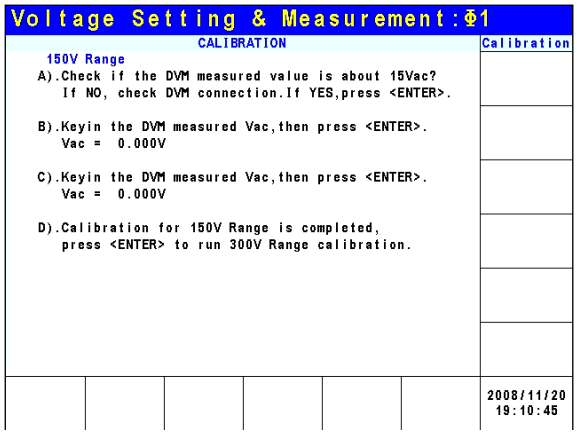
For step A in the 150V Range Setting & Meas. calibration procedure, the user should remove the load. Check if the output AC voltage measured by the DVM is about 15Vac. This is to confirm the connection is correct, and press **ENTER**.



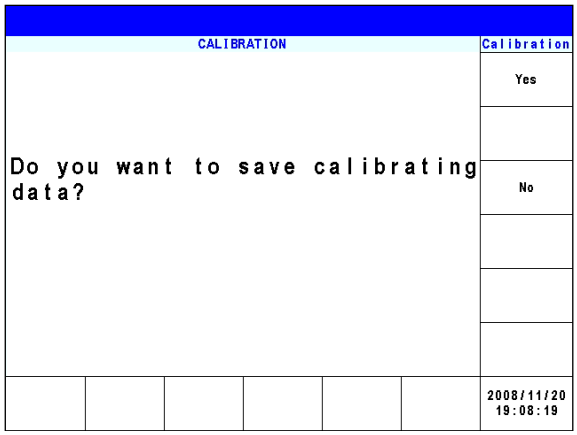
For step B in the 150V Range Setting & Meas. calibration procedure, check if the DVM measured output voltage is about 120VAC. Input the correct value measured by the DVM and press **ENTER**.



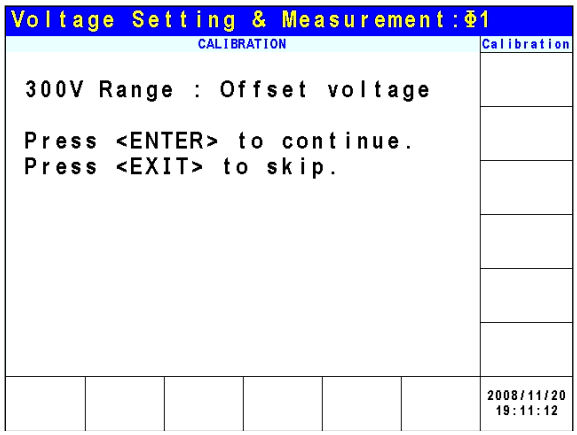
For step C in the 150V Range Setting & Meas. calibration procedure, check if the DVM measured output voltage is about 150VAC. Input the correct value measured by the DVM and press **ENTER**.



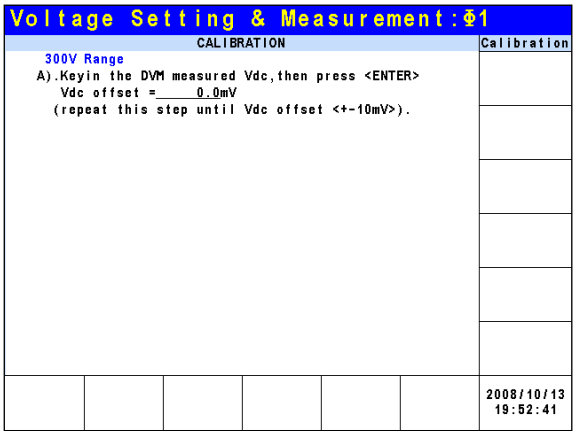
For step D in 150V Range Setting & Meas. calibration procedure, the display shows the 150V Range Setting & Meas. calibration has been done. Press **EXIT** to go into save screen as shown below, or press **ENTER** to continue for next 300V Range offset voltage calibration.



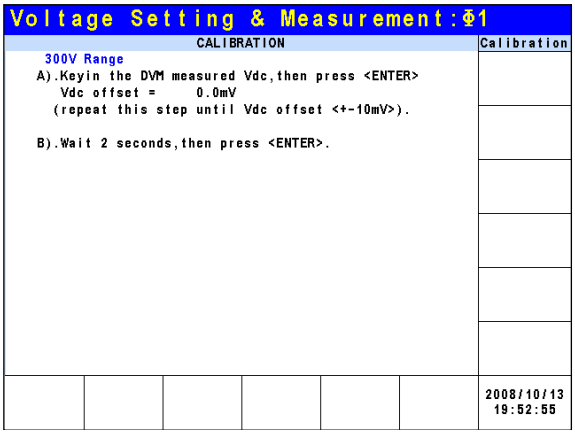
In step D, press **EXIT** the display will show the save screen and press Yes on the right can save the calibrated result.

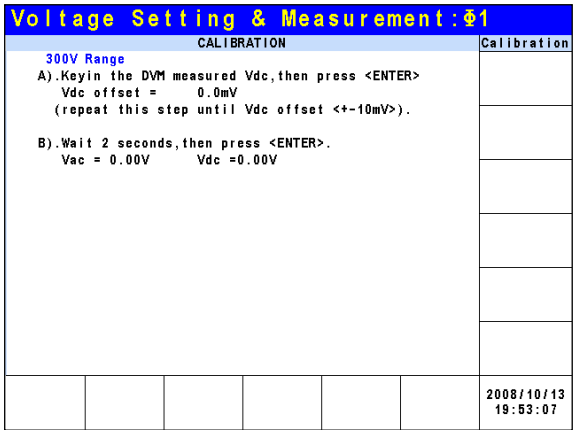


Once the 150V Range Setting & Meas. calibration is done, the screen will ask the user if conducting the 300V Range Offset voltage calibration. Press **ENTER** to continue the Offset voltage calibration and press **EXIT** to skip it to go into 300V Range Setting & Meas. calibration.

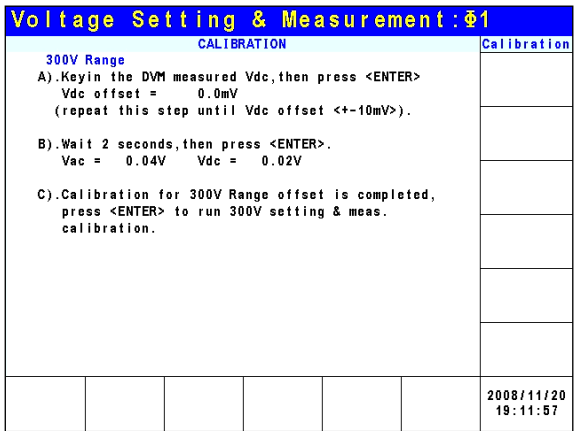


For step A in the 300V range Offset voltage calibration procedure, users should use a Digital Voltage Meter (DVM) to measure the AC Source's output DC voltage with the unit of mV and key in the measured value to the LCD. Keep monitoring the DVM readings, and the input/output and the DC voltage repeatedly until the DC output is lower than ±10 mV.

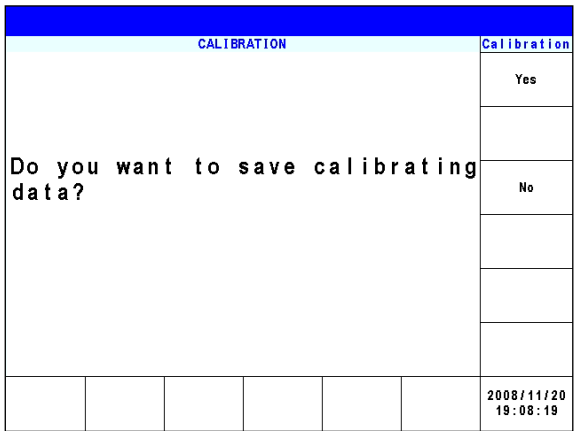




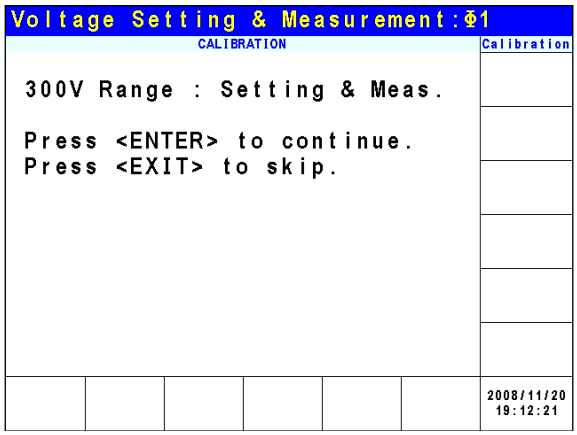
For step B in the 300V range Offset voltage calibration procedure, the display shows the difference betweenVac and Vdc measured by the AC Source. It is generated by an internal component. Wait for 2 seconds and press **ENTER**, the display will show the offset voltage Vac and Vdc calculated by the AC Source at present.



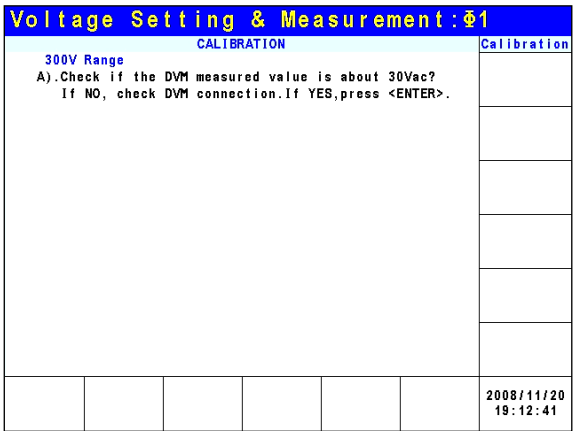
For step C in 300V range Offset voltage calibration procedure, the display shows the 300V range offset voltage calibration has been done. Press **EXIT** to go into save screen as shown below, or press **ENTER** to continue for next 300V range voltage setting and measurement calibration procedure.



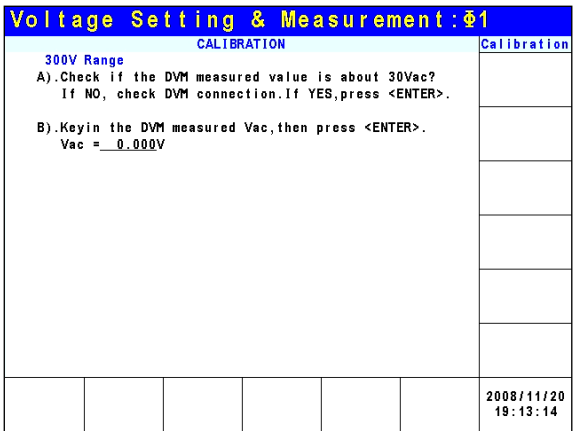
In step C, press **EXIT** the display will show the save screen and press Yes on the right can save the calibrated result.



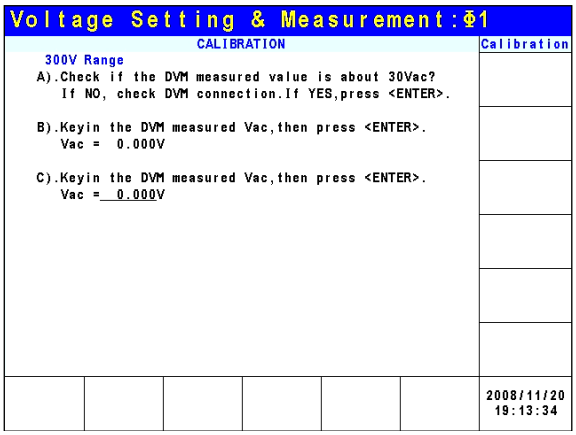
Once the 300V Range Offset voltage calibration is done, the screen will ask the user if conducting the 300V Range Setting & Meas. calibration. Press **ENTER** to continue the Setting & Meas. calibration and press **EXIT** to skip it to go into the calibration main scrren.



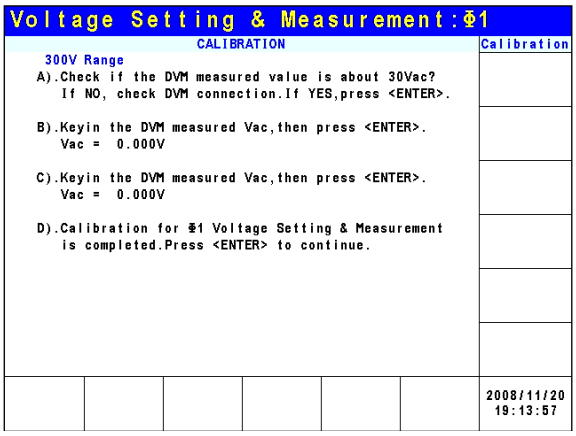
For step A in the 300V Range Setting & Meas. calibration procedure, the user should remove the load. Check if the output AC voltage measured by the DVM is about 30Vac. This is to confirm the connection is correct, and press **ENTER**.



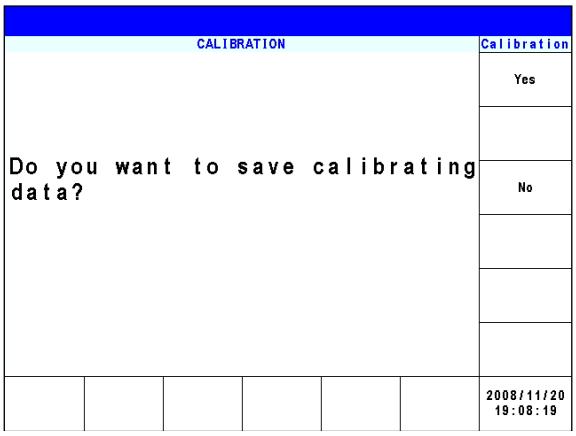
For step B in the 300V Range Setting & Meas. calibration procedure, check if the DVM measured output voltage is about 240VAC. Input the correct value measured by the DVM and press **ENTER**.



For step C in the 300V Range Setting & Meas. calibration procedure, check if the DVM measured output voltage is about 300VAC. Input the correct value measured by the DVM and press **ENTER**.



For step D in 300V Range Setting & Meas. calibration procedure, the display shows the 300V Range Setting & Meas. calibration has been done. Press **EXIT** to go into save screen as shown below, or press **ENTER** to continue voltage calibration for other phases.



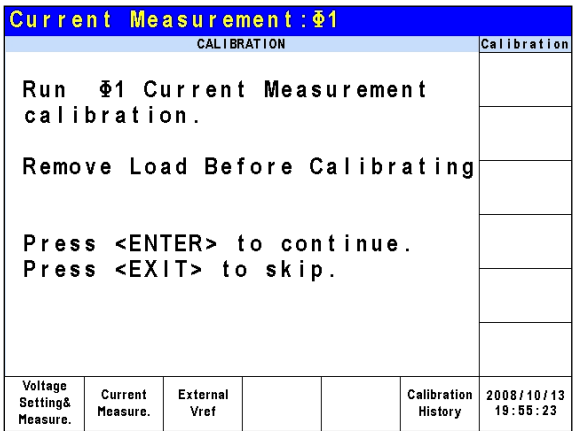
In step D, press **EXIT** the display will show the save screen and press Yes on the right can save the calibrated result.

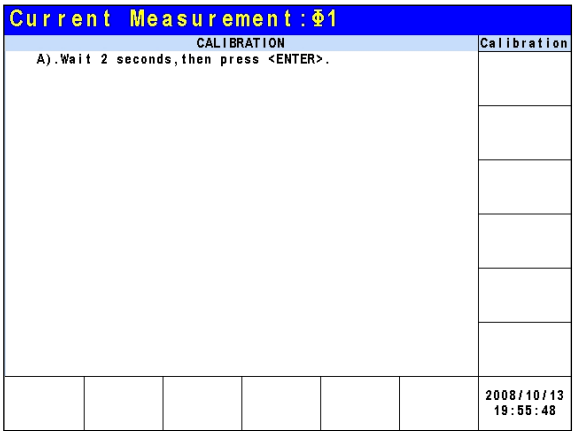
Notice

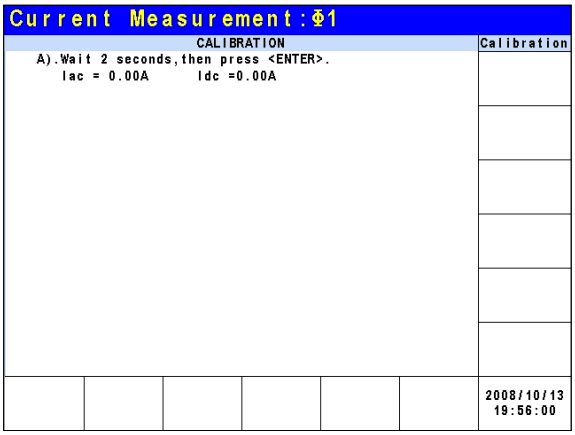
1. Users can press **ENTER** at the last step to continue calibrating the 2nd and 3rd phase.
2. If **EXIT** is pressed without saving the result, the calibration result is kept till power-off.

4.2.2 Current Measurement Calibration

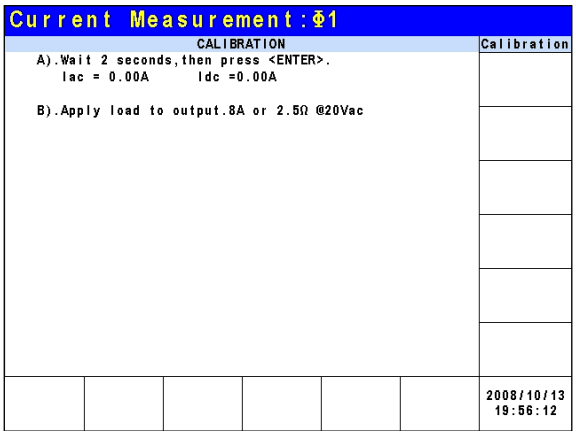
CALIBRATION CHOICE can be input after the password is entered, see section 4.2. Press Current Measure at the bottom to calibrate the current measurement. The calibration value is different for the 61511 and the 61512 and will be specified in each step.



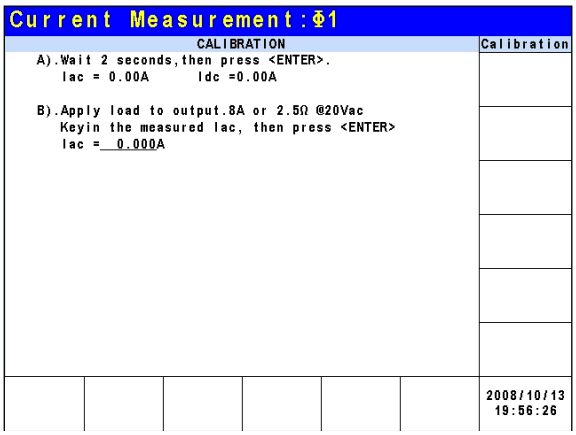




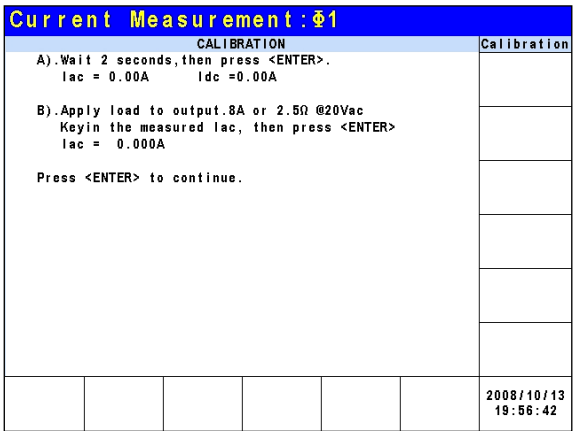
For step A of ACCURACY CALI in Current Measure the display shows the difference between Iac and Idc measured by the AC Source. It is generated by an internal component. Wait for 2 seconds and press **ENTER**, the Iac = 0.00A and Idc = 0.00A.



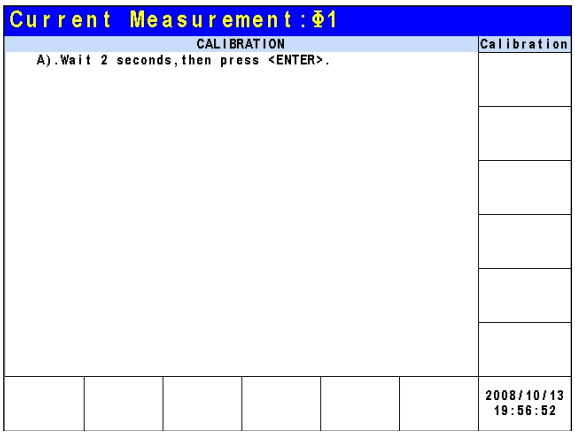
For step B, adjust the load to 2.5Ω for output and press **ENTER**. The AC Source will output 20Vac for the 61512 and 12.5Vac for the 61511.

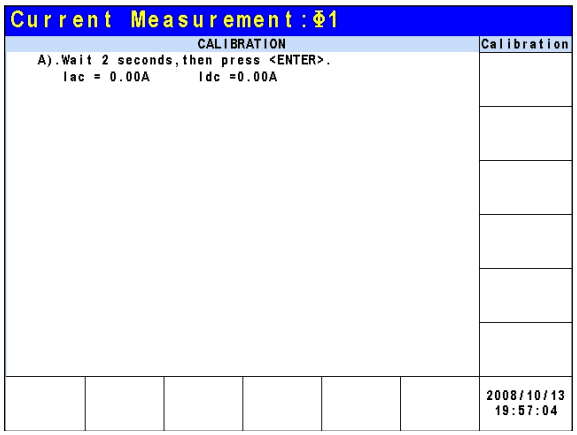


Use a Current Meter (or Power Analyzer) to measure the output current. Input the measured value and press **ENTER**.

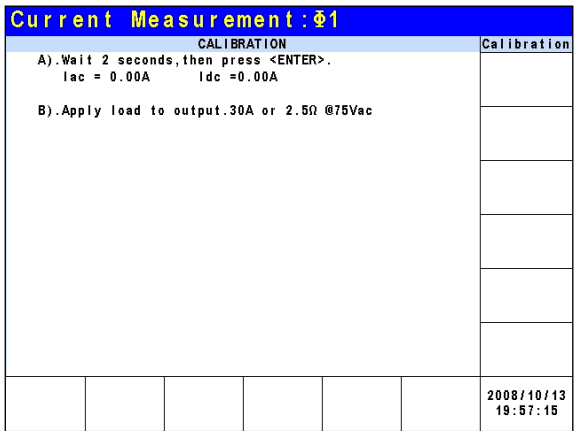


Press **ENTER** to continue the calibration procedure. The load will be disconnected.

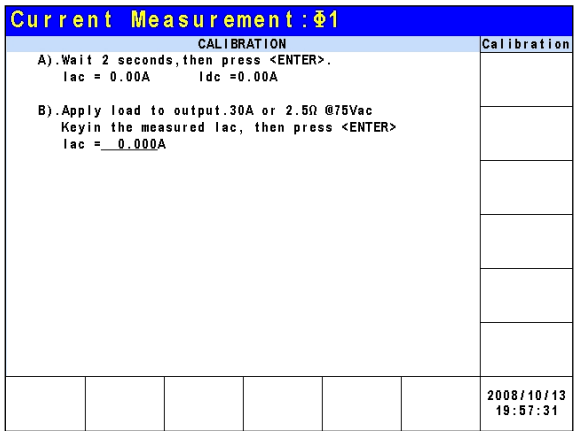




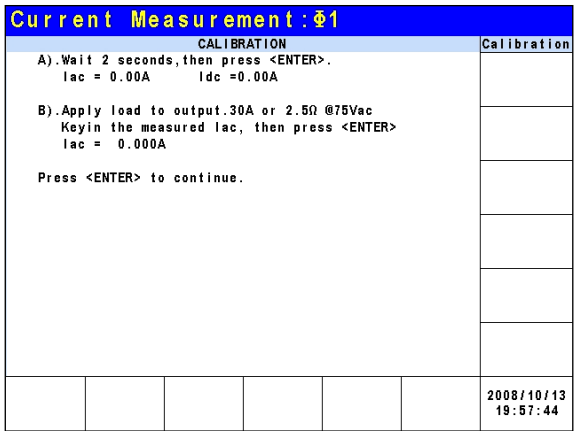
In step A the display shows the difference betweenIac and Idc measured by the AC Source. It is generated by an internal component. Wait for 2 seconds and press **ENTER**, the Iac = 0.00A and Idc = 0.00A.



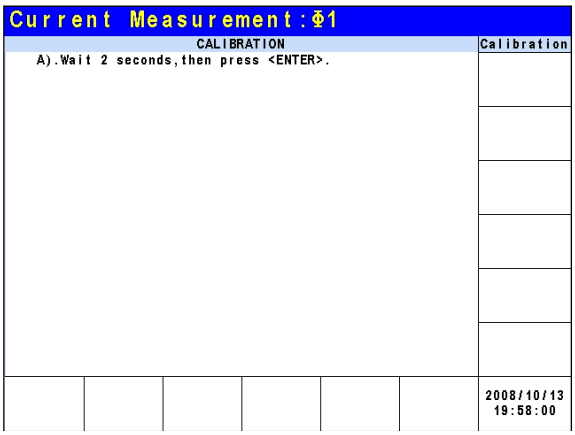
For step B, adjust the load to 2.5Ω for output and press **ENTER**. The AC Source will output 75Vac for the 61512 and 50Vac for the 61511.

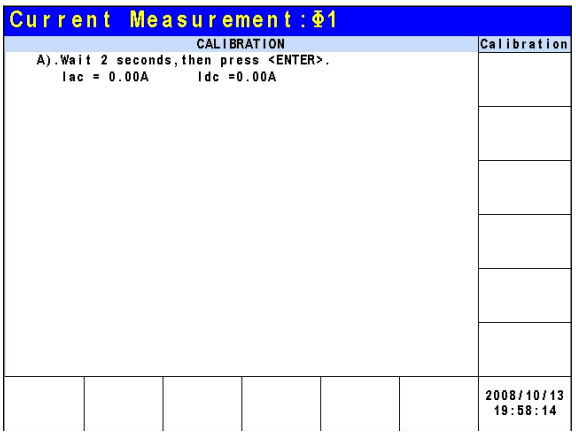


Use a Current Meter (or Power Analyzer) to measure the output current. Input the measured value and press **ENTER**.

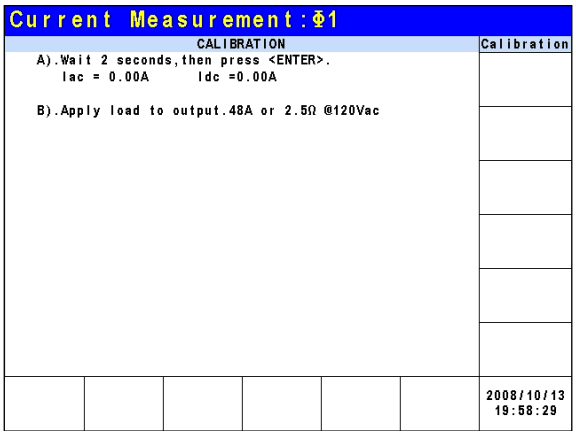


Press **ENTER** to continue the calibration procedure. The load will be disconnected at this time.

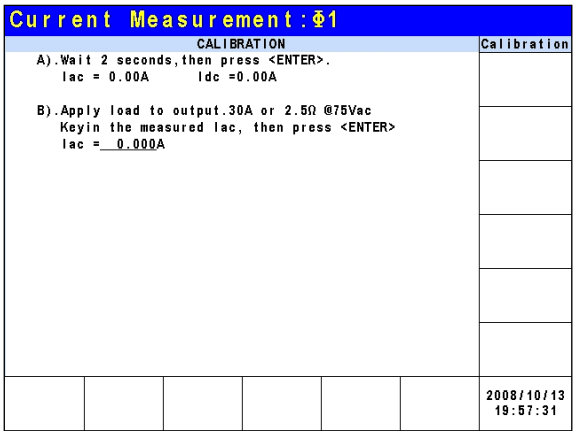




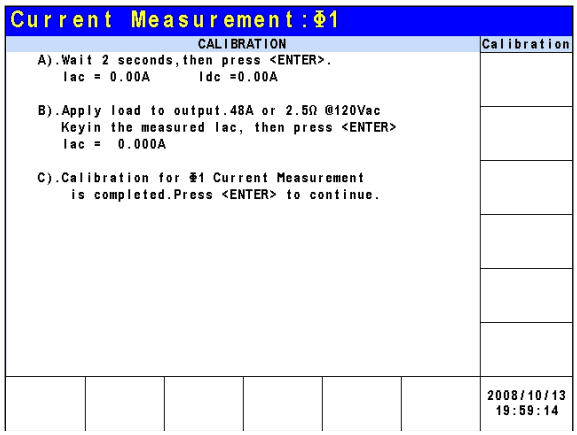
In step A the display shows the difference betweeenIac and Idc measured by the AC Source. It is generated by an internal component. Wait for 2 seconds and press **ENTER**, the Iac = 0.00A and Idc = 0.00A.



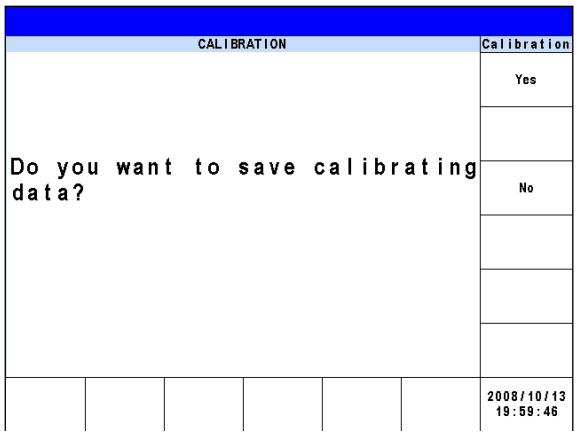
For step B, adjust the load to 2.5Ω for output and press **ENTER**. The AC Source will output 120Vac for the 61512 and 80Vac for the 61511.



Use a Current Meter (or Power Analyzer) to measure the output current. Input the measured value and press **ENTER**.



Step C is the last step of ACCURACY CALI in Current Measure. Press **ENTER** to continue calibrating the 2nd and 3rd phase or press **EXIT** to leave this page. The display shows the following. Press Yes on the right to save the calibration results.

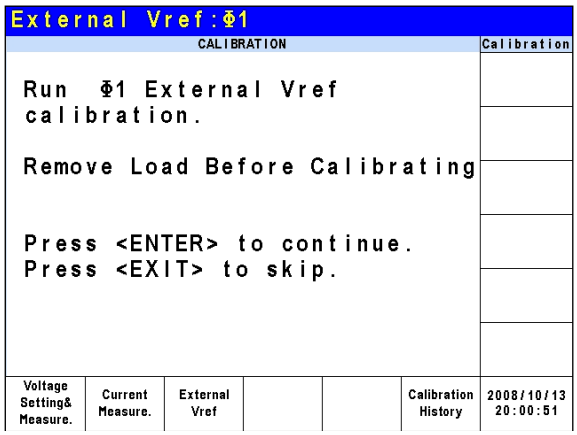


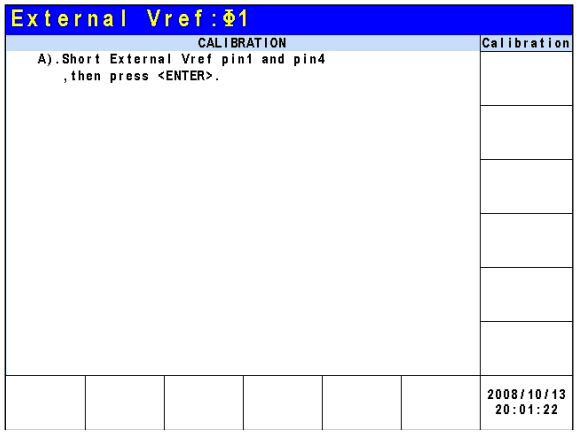
Notice

1. The resistance of the external load has to be constant; therefore the load current and output voltage should be proportional or step B of CURRENT MEAS. ACCURACY will be meaningless. Only when the current complies with step C (output voltage is 125VAC) can this be used for calibration.
2. Protection is removed temporary when the calibration procedure is running. It may cause the AC Source to be damaged if the incorrect load is applied.

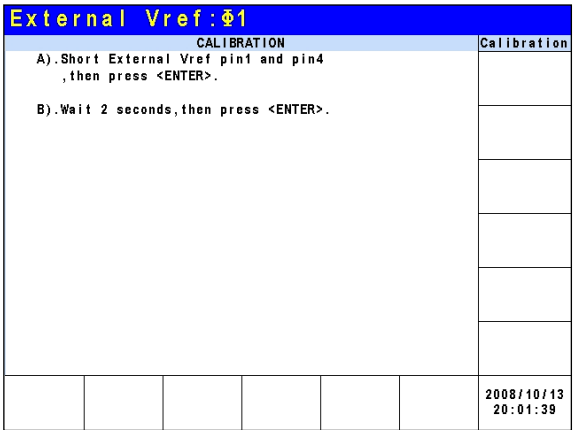
4.2.3 External Vref Calibration

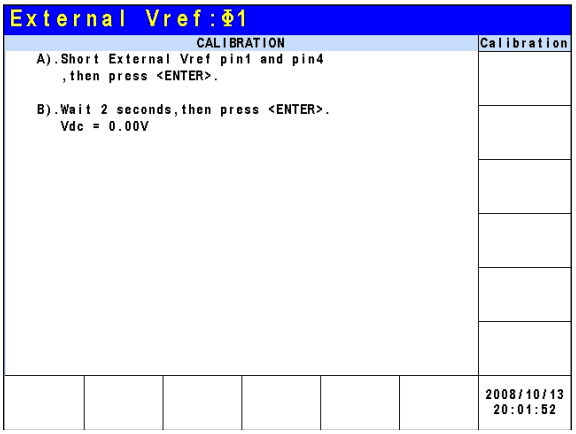
CALIBRATION CHOICE can be input after the password is entered, see 4.2. Press External Vref at the bottom to conduct the external Vref calibration as shown below.



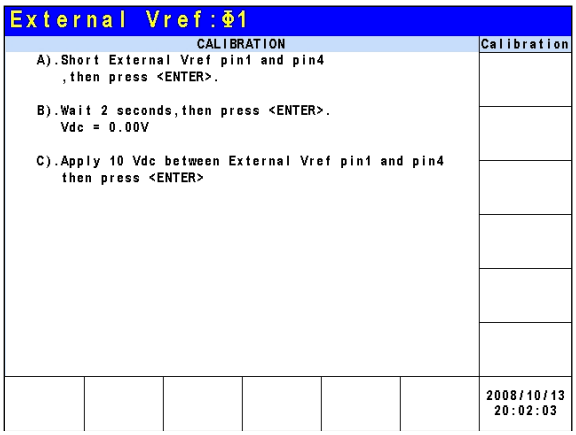


Step A: Short circuit pin 1 and pin 4 of the Ext. Vref input terminal and press **ENTER**.

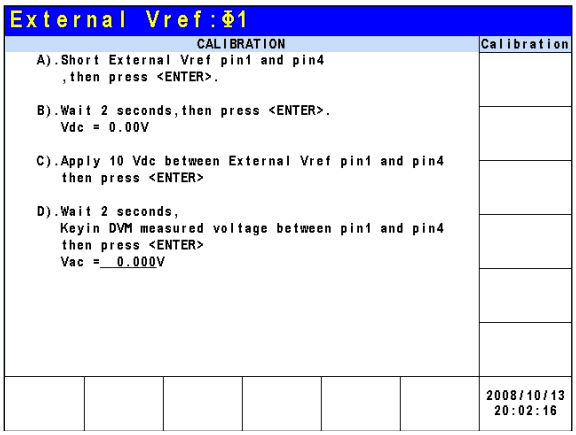




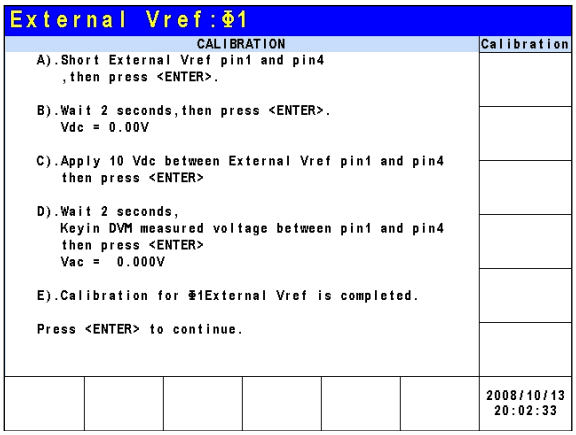
Step B: After short circuiting the external Vref input terminal, make the input 0V and the display will show the AC Source's measured Vdc. The offset voltage is generated by internal components. Wait for 2 seconds and press **ENTER**, the display will show the offset voltage Vdc calculated the AC Source at present.



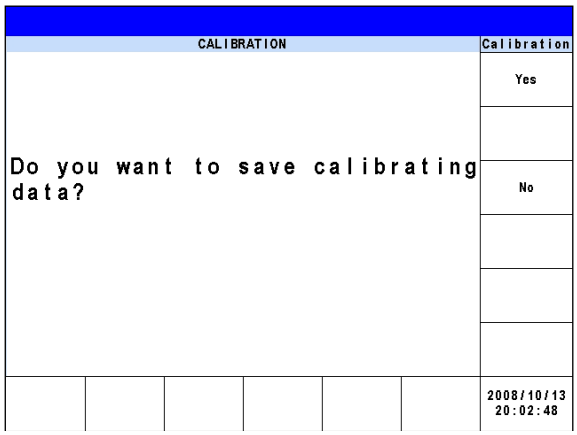
Step C: Disconnect pin 1 and pin 4 of the Ext. Vref input terminal, then input a DC voltage of 10Vdc between pin 1 and pin 4 and press **ENTER**.



Step D: Use a DVM to measure the voltage between pin 1 and pin 4 of Ext. Vref input terminal, then input DC voltage and press **ENTER**.



Step E: It is the last step of External Vref CALI. Press **EXIT** to go into the save screen as shown below, or press **ENTER** to continue the voltage calibration of other phases.



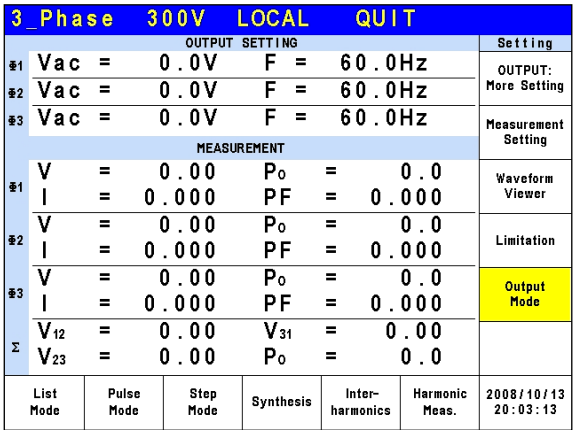
In step E, press **EXIT** the display will show the save screen and press Yes on the right can save the calibrated result.

5. Application

5.1 Overview

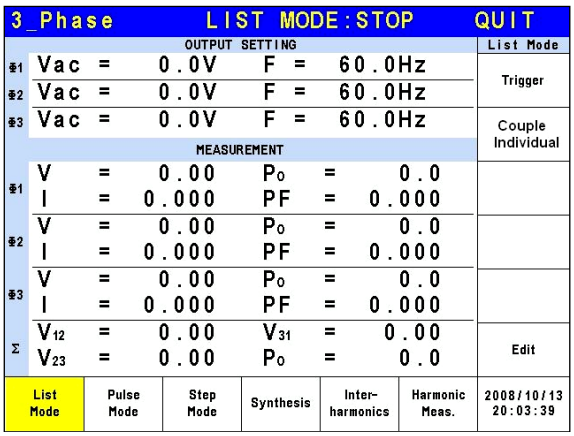
The AC Source model 61511/61512 not only can program a stable sinusoidal output voltage and frequency, but also provides powerful features to simulate power line interrupts. Users can change the output using the Sequences in LIST mode (see 5.2), or change the output to step by step in STEP mode (see 5.4.) With these functions, the simulations of conditions such as cycle loss, transient peak and power attenuation are very easy.

The AC Source model 61511/651512 is able to measure the related power parameters provided in MAIN PAGE (see 3.3), also it can provide harmonic measurements up to 40 orders (see 5.7.) In addition, the AC Source allows the user to edit different harmonic components to synthesize the harmonic distortion waveform (see 5.5). It has the abilityto program the inter-harmonic frequency and components, as well as to sweep and overlap the static fundamental waveforms (see 5.6).

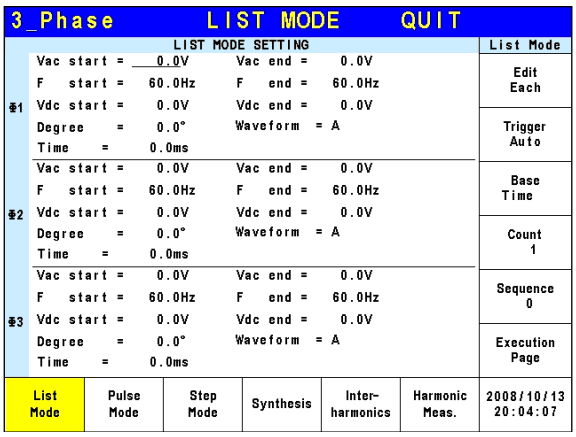


5.2 List Mode

Press Output Mode on the right on the MAIN PAGE (see 3.3) to go into the Output Mode command line and press List Mode at the bottom to go into the List Mode command line.



Press Edit on the right to go to the setting page.



The waveform programming in List mode is a combination of Sequences. The output waveform starts from Sequence = 0 and one Sequence after another until the Time or Cycle = 0, stopping the action. The Sequences following will not be executed. Users can edit the output voltage sequence as needed.

Trigger method: Auto / Manual / Excite.
Auto: It finishes all counts when triggered.
Manual: It executes the sequence waveform once, same as Count = 1.
Excite: It is Remote-Excite via the pin 13 of TTL terminal that is triggered by the external trigger signal. See *Appendix A TTL Signal Pin Assignments* for the detail pin assignment.

Couple: Individual / Φ1+Φ2+Φ3.
Individual: The three phases are set separately.
Φ1+Φ2+Φ3: The setting of second/third phase is the same as the setting of the first phase, so the user only needs to set the first phase.

Phase Continue: Disable/Enable.
Disable: The start angle of every Sequence will follow the Degree setting of each Sequence for setting.
Enable: The start angle of every Sequence will change automatically based on the last output angle of previous Sequence. The Degree setting of every Sequence will be invalid when Enable is set.

Base sequence unit: Time / Cycle.
Time: The sequence unit is time.
Cycle: The sequence unit is cycle.

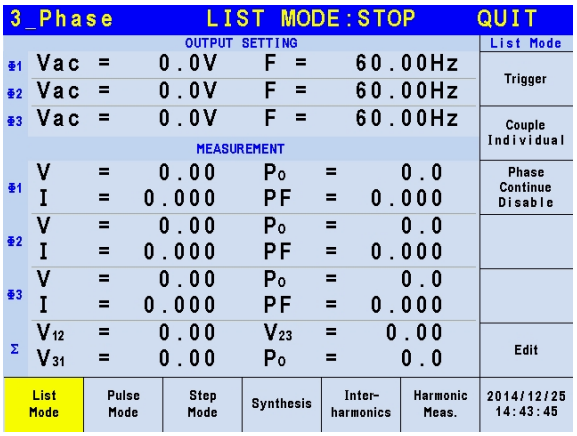
Count: The entire sequence execution times.
Count = 0: unlimited execution.

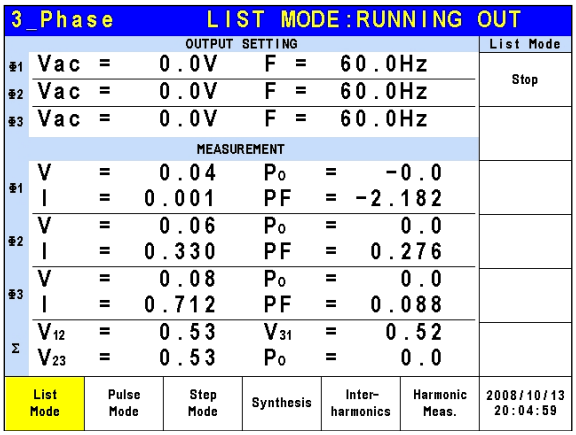
Sequence: Sequence number.
The sequence has to start from 0 and the maximum sequence number is 99. The phase difference of the second/third phase and the first phase of Sequence 0 is fixed to differ 120°. Therefore, the user cannot use the angle of the second/thired phase in Sequence 0.

Degree: The phase angle when the sequence starts.
Vac start, F start, Vdc start: The initial waveform when the sequence starts.

Vac end, F end, Vdc end: The final waveform when the sequence ends.
Waveform= A / B: Select waveform (see 3.3.3.)

After setting the sequences, press Execution Page on the right to exit List mode and the LCD will show LIST MODE: STOP on the top. STOP indicates the present trigger state. Users can press Trigger on the right to trigger the output and the LCD will show RUNNING to indicate that the List mode is under execution. At the same time users can press Stop to cease the List waveform output. When the AC Source finishes all Sequences and Counts, the LCD will return to its initial state and display STOP. The AC Source will QUIT at the same time, as shown below.





If the AC Source is under operation, pressing **OUT/QUIT** will stop the output and the waveform will be zero volts. Press **OUT/QUIT** again and the AC Source only outputs the waveform set in MAIN PAGE. Trigger must be pressed to re-trigger the source.

When pressing ⮌ to exit LIST page, the programmed LIST mode waveform will be closed.

Example of LIST Mode in 1_Phase Mode:

Trigger: Auto，**Base**: Time，**Count**: 1

LIST MODE SETTING:

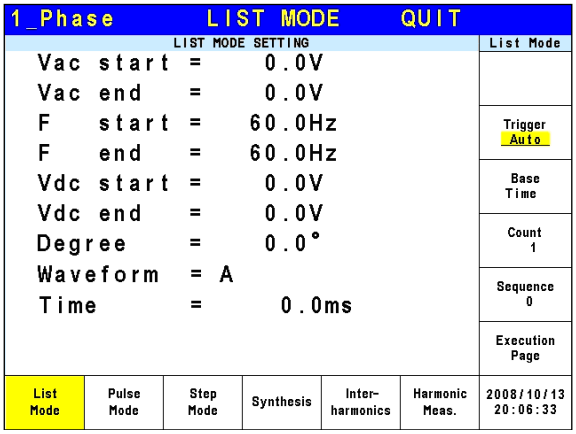
Sequence 0: Vac start = 20V, Vac end = 100V
F start = 50Hz, F end = 50Hz

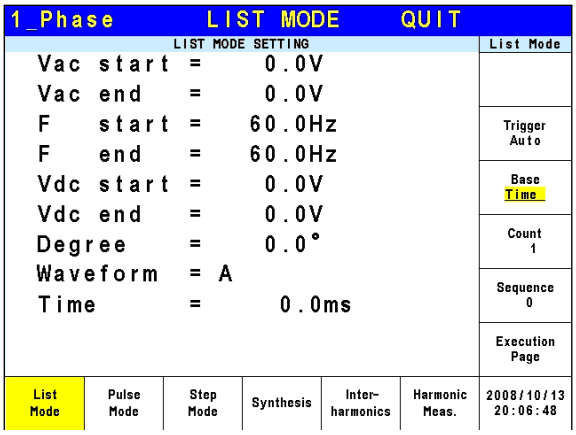
Vdc start = 0V, Vdc end = 0V
Degree = 90°, Time = 75ms
Waveform = A

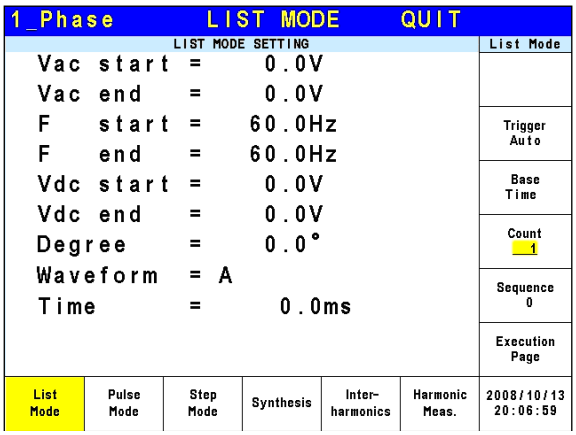
Sequence 1: Vac start = 20V, Vac end = 20V
F start = 50Hz, F end = 50Hz
Vdc start = 0V, Vdc end = 100V
Degree = 0°, Time = 80ms
Waveform = A

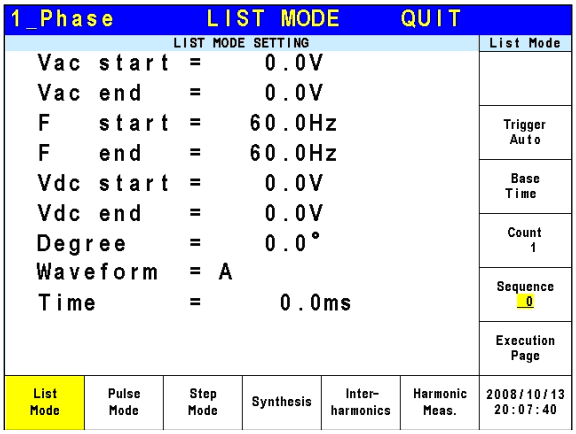
Sequence 2: Vac start = 20V, Vac end = 120V
F start = 50Hz, F end = 500Hz
Vdc start = 0V, Vdc end = 0V
Degree = 0°, Time = 100ms
Waveform = A

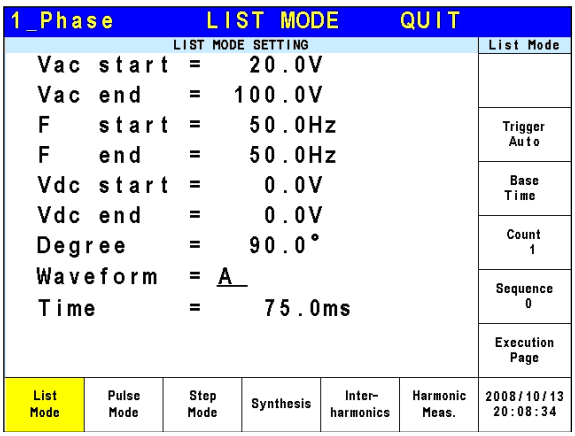
Following lists the setting pages of LIST MODE.

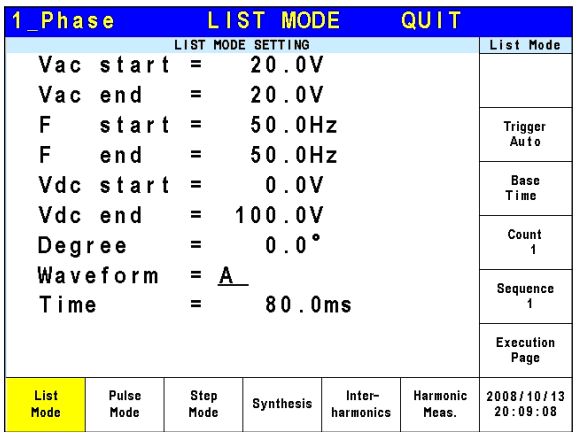


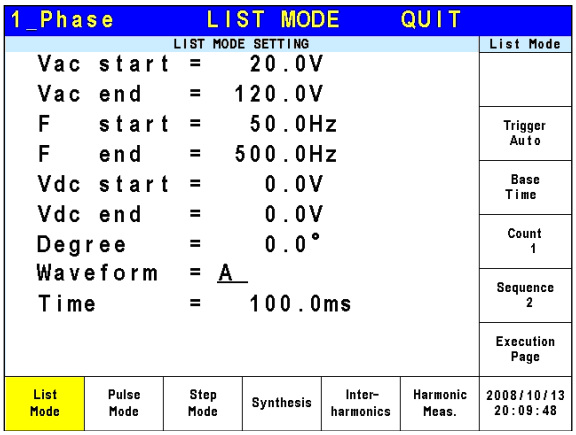



1_Phase
LIST MODE
QUIT
LIST MODE SETTING
List Mode
Vac start = 0.0V
Vac end = 0.0V
F start = 60.0Hz
F end = 60.0Hz
Vdc start = 0.0V
Vdc end = 0.0V
Degree = 0.0°
Waveform = A
Time = 0.0ms
Trigger Auto
Base Time
Count 1
Sequence 0
Execution Page
List Mode
Pulse Mode
Step Mode
Synthesis
Inter-harmonics
Harmonic Meas.
2008/10/13 20:06:59


1_Phase
LIST MODE
QUIT
LIST MODE SETTING
List Mode
Vac start = 0.0V
Vac end = 0.0V
F start = 60.0Hz
F end = 60.0Hz
Vdc start = 0.0V
Vdc end = 0.0V
Degree = 0.0°
Waveform = A
Time = 0.0ms
Trigger Auto
Base Time
Count 1
Sequence 0
Execution Page
List Mode
Pulse Mode
Step Mode
Synthesis
Inter-harmonics
Harmonic Meas.
2008/10/13 20:07:40

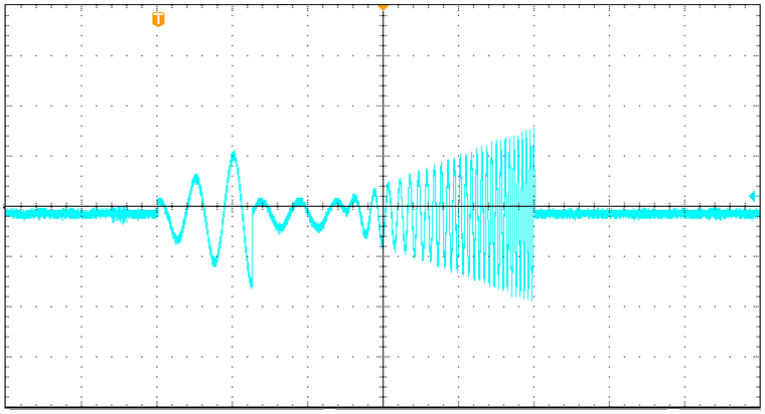

1_Phase
LIST MODE
QUIT
LIST MODE SETTING
List Mode
Vac start = 20.0V
Vac end = 100.0V
F start = 50.0Hz
F end = 50.0Hz
Vdc start = 0.0V
Vdc end = 0.0V
Degree = 90.0°
Waveform = A
Time = 75.0ms
Trigger Auto
Base Time
Count 1
Sequence 0
Execution Page
List Mode
Pulse Mode
Step Mode
Synthesis
Inter-harmonics
Harmonic Meas.
2008/10/13 20:08:34


1_Phase
LIST MODE
QUIT
LIST MODE SETTING
List Mode
Vac start = 20.0V
Vac end = 20.0V
F start = 50.0Hz
F end = 50.0Hz
Vdc start = 0.0V
Vdc end = 100.0V
Degree = 0.0°
Waveform = A
Time = 80.0ms
Trigger Auto
Base Time
Count 1
Sequence 1
Execution Page
List Mode
Pulse Mode
Step Mode
Synthesis
Inter-harmonics
Harmonic Meas.
2008/10/13 20:09:08

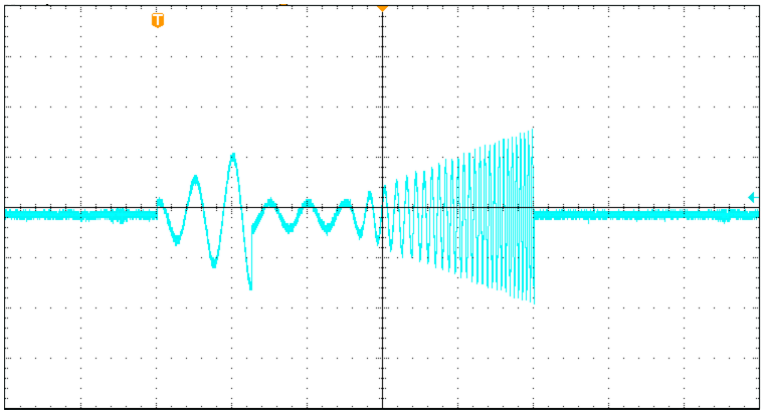

1_Phase
LIST MODE
QUIT
LIST MODE SETTING
List Mode
Vac start = 20.0V
Vac end = 120.0V
F start = 50.0Hz
F end = 500.0Hz
Vdc start = 0.0V
Vdc end = 0.0V
Degree = 0.0°
Waveform = A
Time = 100.0ms
Trigger Auto
Base Time
Count 1
Sequence 2
Execution Page
List Mode
Pulse Mode
Step Mode
Synthesis
Inter-harmonics
Harmonic Meas.
2008/10/13 20:09:48

The trigger waveform when the settings are done is shown below:

Phase Continue Disable

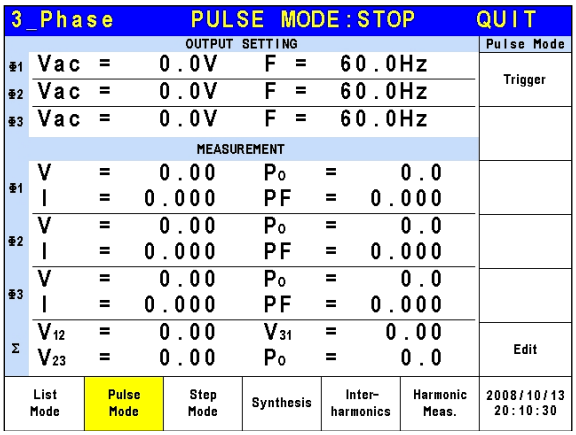


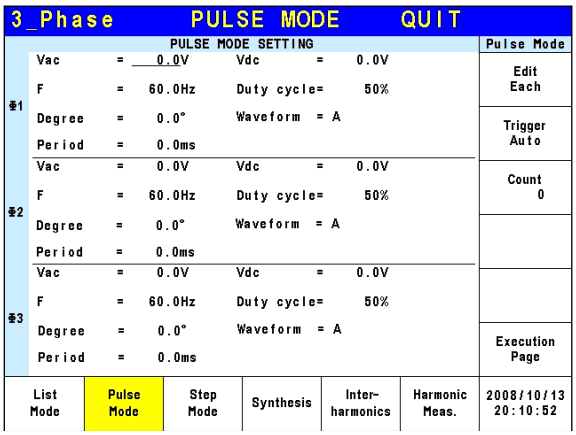
Phase Continue Enable



5.3 Pulse Mode

Press Output Mode on the right on the MAIN PAGE (see 3.3) to go into the Output Mode command line and press Pulse Mode at the bottom to go into the Pulse Mode command line.



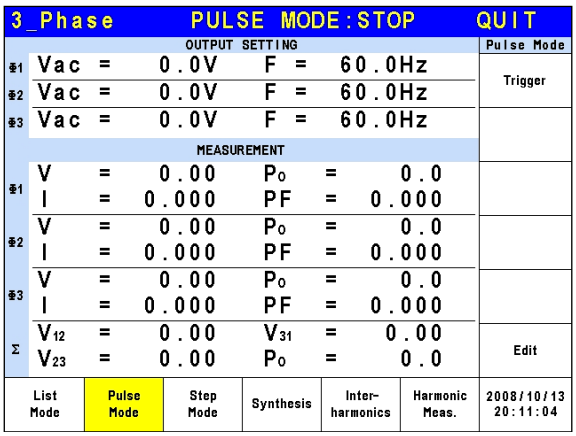


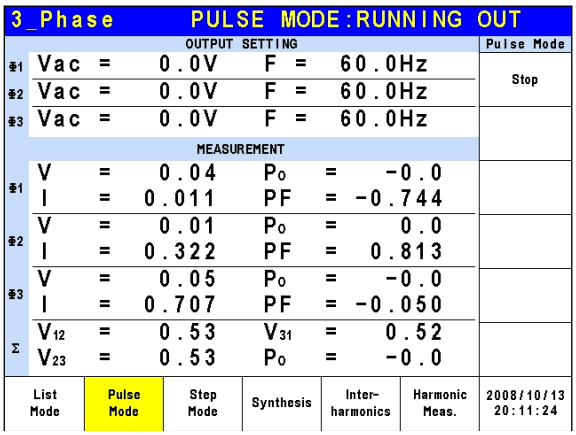
PULSE mode allows users to program a special waveform and add it to the normal output settings in MAIN PAGE. Waveform programming specifies the time ratio and the duty cycle of the pulse voltage.

Trigger method: Auto / Manual / Excite.
Auto: It finishes all counts when triggered.
Manual: It executes the sequence waveform once, same as Count = 1.
Excite: It is Remote-Excite via the pin 13 of TTL terminal that is triggered by the external trigger signal. See *Appendix A TTL Signal Pin Assignments* for the detail pin assignment.

Count: The count number of pulse.
Vac, F, Vdc: The Vac, F and DC output in pulse voltage.
Duty cycle: The pulse ratio during a duty cycle.
Period: The total length of the duty cycle.
Waveform = A / B: Select waveform (see 3.3.3.)
Degree: The output phase degree of pulse.

After setting the sequences, press Execution Page on the right to exit Pulse mode and the LCD will show PULSE MODE : STOP on the top. STOP indicates the present trigger state. Users can press Trigger on the right to trigger the output and the LCD will show RUNNING to indicate Pulse mode is under execution. The user can also press Stop to cease the Pulse waveform output. When the AC Source finishes all Sequences and Counts, the LCD will return to its initial state and display STOP. The AC Source will QUIT at the same time, as shown below.





If the AC Source is operating, pressing **OUT/QUIT** will stop the output and the waveform will be zero volts. Press **OUT/QUIT** again the AC Source will output the waveform set in MAIN PAGE. Trigger must be pressed to re-trigger the source.

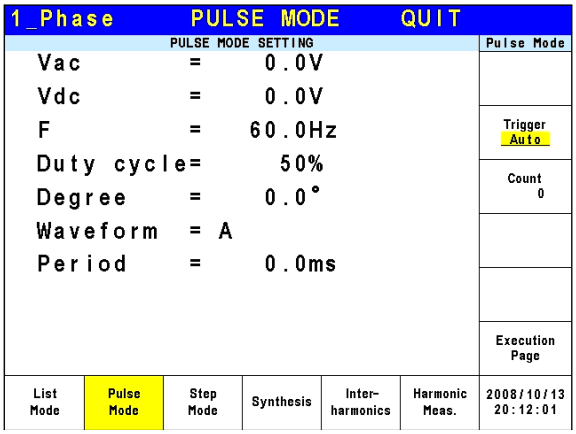
When pressing ⮌ to exit PULSE page, the pulse will be closed.

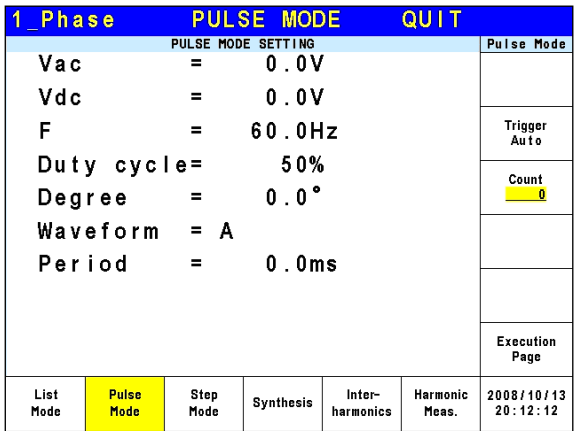
Example of PULSE Mode in 1_Phase Mode:

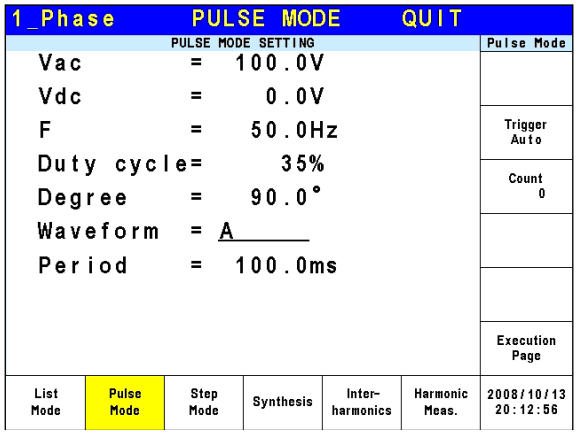
OUTPUT SETTING: Vac = 50V, F = 50Hz
PULSE MODE SETTING:
Vac = 100V, Vdc = 0V
F = 50Hz, Duty cycle = 35%
Period = 100ms, Degree = 90°
Waveform = A

Trigger: Auto, **Count**: 0

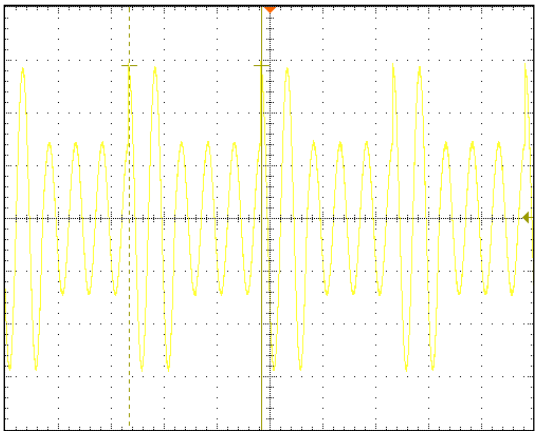
The following lists the setting pages of PULSE MODE.





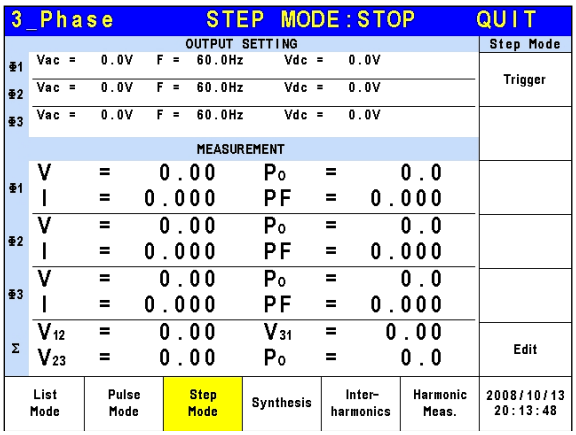


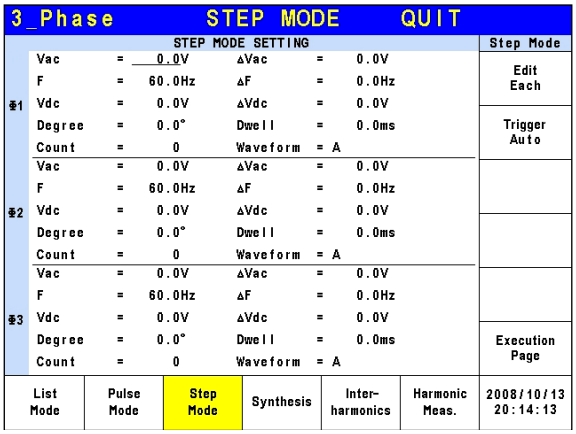
The trigger waveform when the settings are done is shown below:



5.4 Step Mode

Press Output Mode on the right on the MAIN PAGE (see 3.3) to go into the Output Mode command line and press Step Mode at the bottom to go into the Step Mode command line.



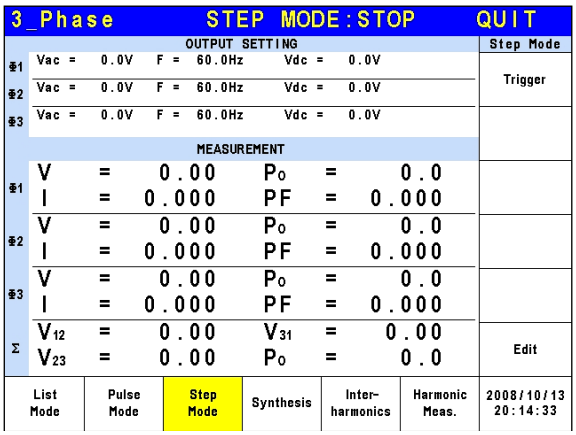


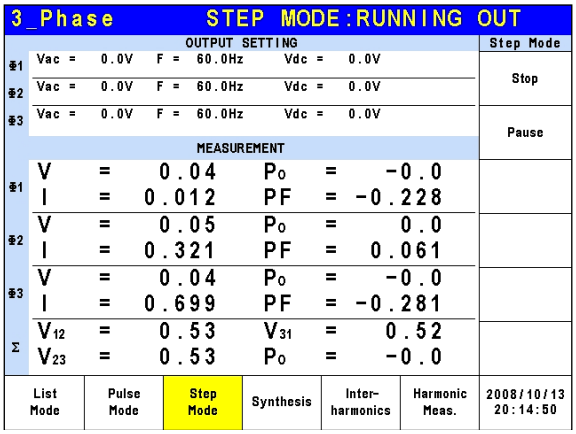
STEP Mode provides a simple auto switch function to change the output voltage by stepping.. Waveform programming sets the item with an initial voltage, specifies the dwell time and the change of each step as well as the step number. The output voltage will keep the last state after execution.

Trigger method: Auto / Manual.
Auto: It finishes all counts when triggered.
Manual: The output voltage changes a step every time it operates.

Count: The count number of each change**.**
Dwell: The time for each step.
Vac, F, Vdc: The Vac, F, DC initial value when STEP mode starts.
ΔVac, ΔF, ΔVdc: The difference value of each step. (It can be negative.)
Waveform = A / B: Select waveform (see 3.3.3.)。
Degree: The output phase angle of each step.

Press Step Mode at the bottom to go STEP page. The LCD shows STEP MODE : STOP on the top. STOP indicates the present trigger state. Users can press Trigger to trigger the output and the LCD will show RUNNING to indicate Step mode is executing the output. Stop and Pause will show on the screen when the output is triggered. Stop ceases the waveform change of STEP, while Pause keeps the STEP waveform until the user presses TRIG_CONTINUE. When the AC Source finishes all Counts, the LCD will show STOP and the AC Source will QUIT.

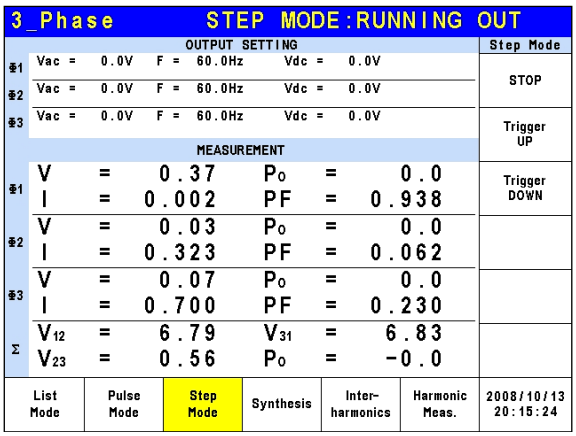




If the AC Source is outputting, pressing **OUT/QUIT** will stop the output and the waveform will be zero volts. Pressing **OUT/QUIT** again and the AC Source will output the waveform set in MAIN PAGE. Users must press Trigger again to re-trigger the output. If the AC Source is not outputting, the user can press **ENTER** to output the STEP waveform directly.

When pressing ⮌ to exit the STEP page, the STEP waveform will stop execution.

The LCD shows Trigger UP and Trigger DOWN when **Trigger = Manual**. The output waveform changes to next voltage if Trigger UP is selected; and the output waveform changes to previous voltage if Trigger DOWN is selected.

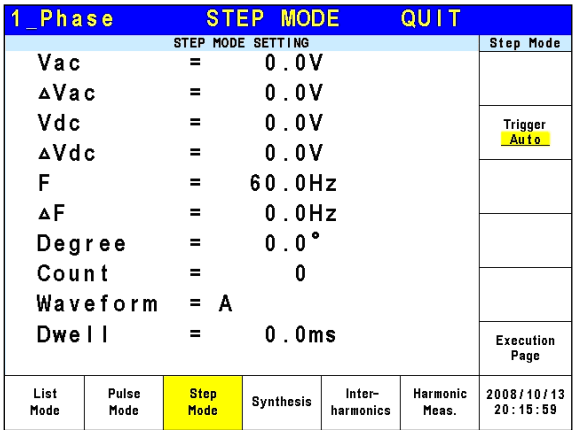


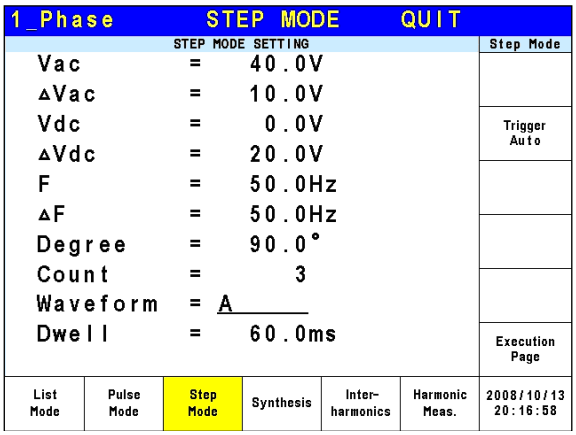
Example of STEP Mode in 1_Phase Mode:

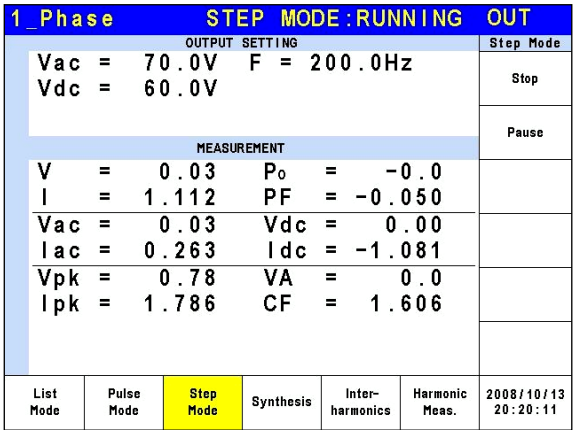
Trigger: Auto

STEP MODE SETTING:
Vac = 40V, ΔVac = 10V
F = 50Hz, ΔF = 50Hz
Vdc = 0V, ΔVdc = 20V
Degree = 90°, Dwell = 60ms
Count = 3, Waveform = A

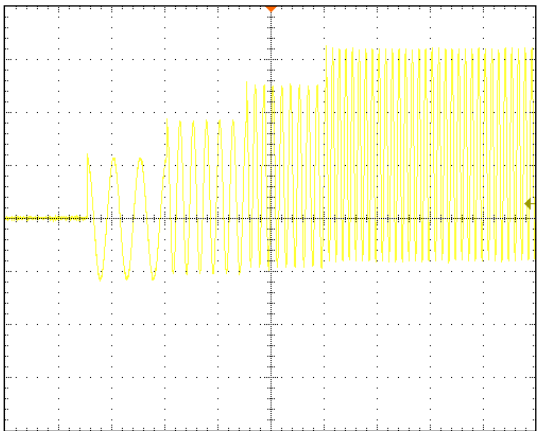
Following lists the setting pages of STEP MODE.





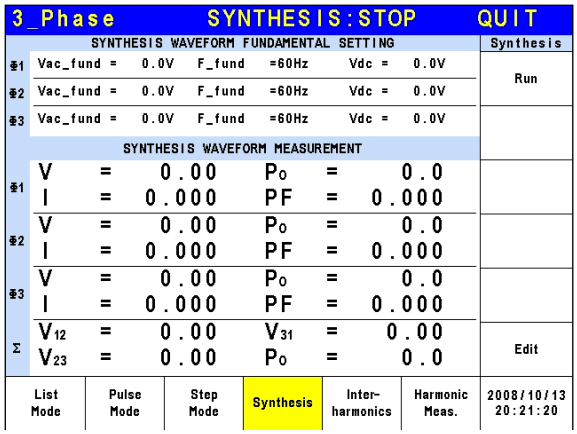


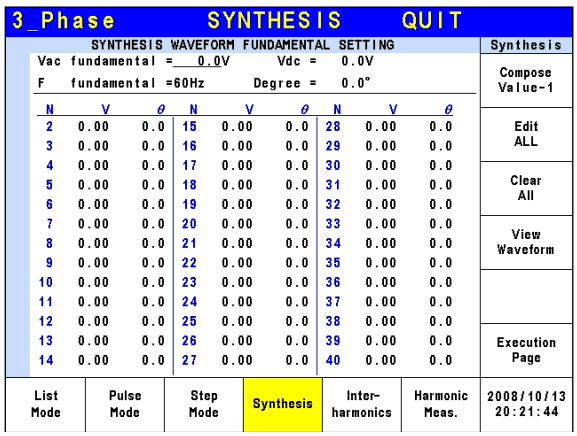
The trigger waveform when the settings are done is shown below:



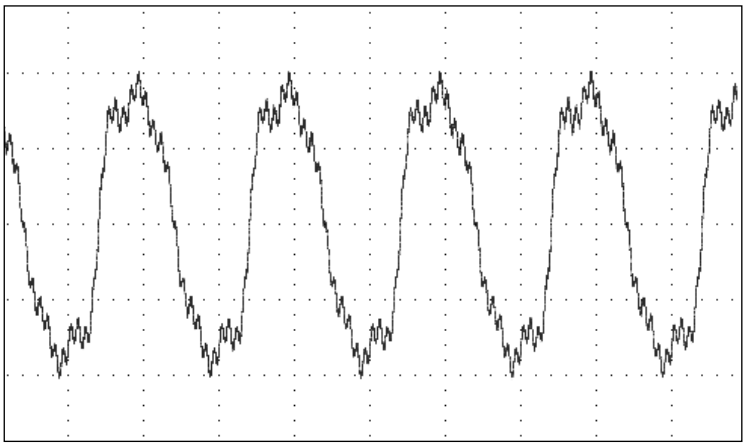
5.5 Synthesis Waveform

Press Output Mode on the right in MAIN PAGE (see 3.3) to enter into the Output Mode command line. Next press Synthesis at the bottom to go into the Synthesis command line. Pressing Edit on the right will enter the Synthesis editing window.





61500 Series AC Source provides a Synthesis function for users to synthesize waveform. The harmonic components range up to 40th order with the fundamental frequency limited to 50Hz or 60Hz. Users can program the size and phase of each order easily on the LCD. The following is an example figure of the synthesis waveform.



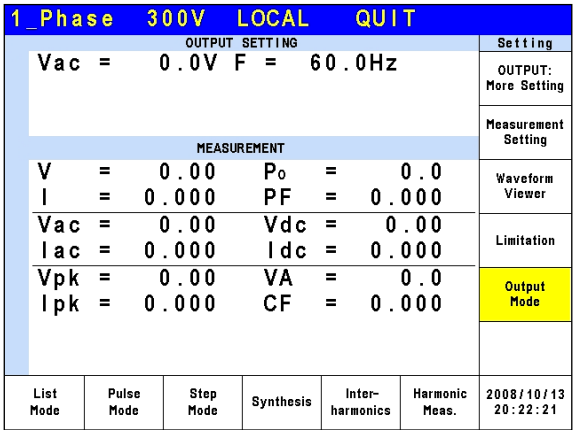
Compose = Value-1 / Value-2 / Value-3/ Percent-1 / Percent-2 / Percent-3: The data form of each harmonic order.

Value: The absolute value.
Percent: The percentage of the fundamental frequency voltage.

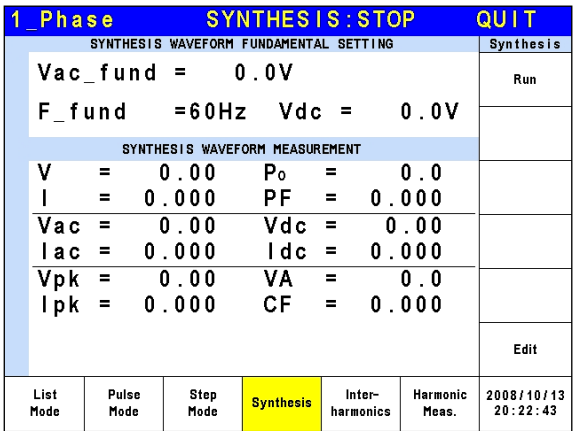
Users can program 6 types of synthesis waveform to execution or save.

Vac fundamental: The fundamental frequency voltage, the maximum is limited by RANGE (see 3.3.1.2.)
F fundamental = 50 / 60Hz: The fundamental frequency.
Vdc: The DC voltage component.
Degree: The start angle of the output waveform.

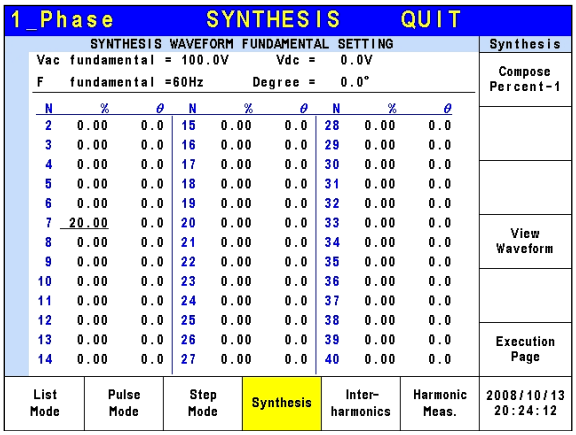
Following is the example of using Synthesis Mode in 1_Phase Mode:



Press Output Mode on the right in MAIN PAGE to select any Mode for application.



Next, press Synthesis at the bottom to go to Synthesis Mode.

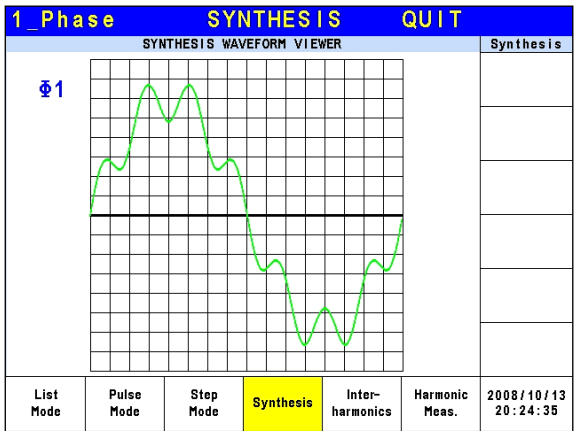


N	%	θ	N	%	θ	N	%	θ
2	0.00	0.0	15	0.00	0.0	28	0.00	0.0
3	0.00	0.0	16	0.00	0.0	29	0.00	0.0
4	0.00	0.0	17	0.00	0.0	30	0.00	0.0
5	0.00	0.0	18	0.00	0.0	31	0.00	0.0
6	0.00	0.0	19	0.00	0.0	32	0.00	0.0
7	20.00	0.0	20	0.00	0.0	33	0.00	0.0
8	0.00	0.0	21	0.00	0.0	34	0.00	0.0
9	0.00	0.0	22	0.00	0.0	35	0.00	0.0
10	0.00	0.0	23	0.00	0.0	36	0.00	0.0
11	0.00	0.0	24	0.00	0.0	37	0.00	0.0
12	0.00	0.0	25	0.00	0.0	38	0.00	0.0
13	0.00	0.0	26	0.00	0.0	39	0.00	0.0
14	0.00	0.0	27	0.00	0.0	40	0.00	0.0

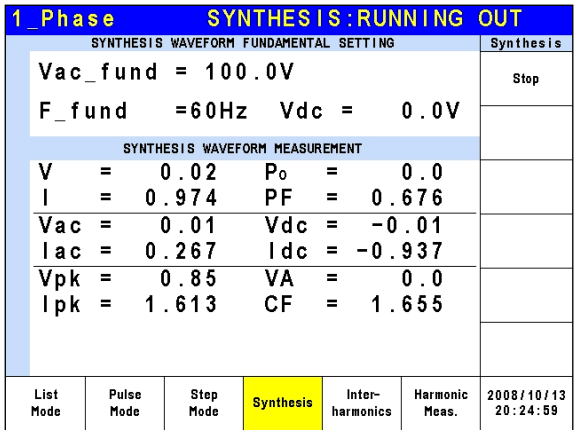
Press Edit on the right to go to editing screen. Use the arrow keys to move the cursor to the appropriate column and use numeric keys to key-in the setting, and then press **ENTER**. The example uses the following settings:

OUTPUT SETTING：Vac = 100V，F = 60Hz

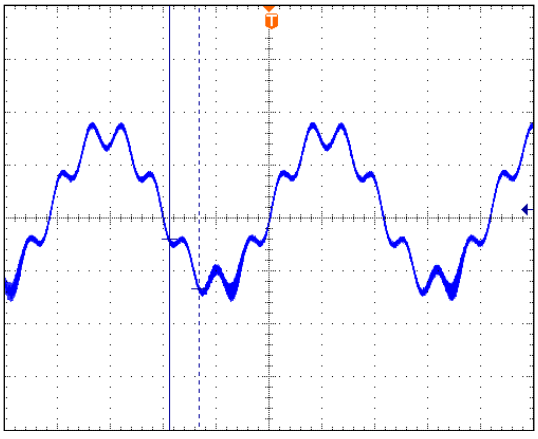
Compose = Percent-1
Edit = Φ3
Vac fundamental = 100.0V
F fundamental = 60Hz
Vdc = 0.0V
Degree = 0.0°



Once the settings are edited, the user can press View Waveform on the right to view the edited output waveform. Press Return to go to previous page.



Press Execution Page on the right to return to the Synthesis Mode page. Next, press Run on the right to output the waveform.



The figure above is the output voltage waveform of the AC Source, measured by an oscilloscope and is the same as the user edited waveform.

Notice

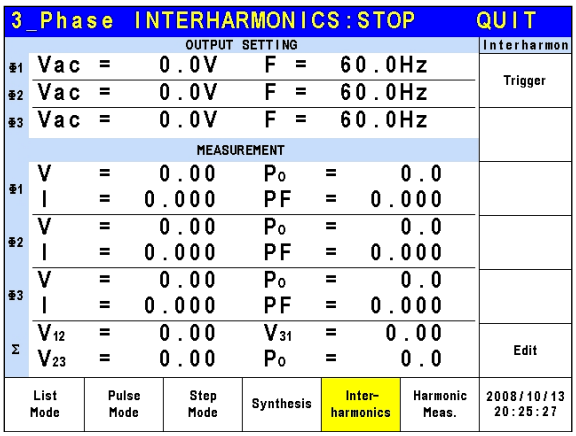
1. In order to protect the power stage of AC Source for practical use, it is necessary to limit the synthesis value or the percentage of each order.
   $2 \leq$ order ≤ 10, value $\leq$ 150V or percentage $\leq$ 100%.

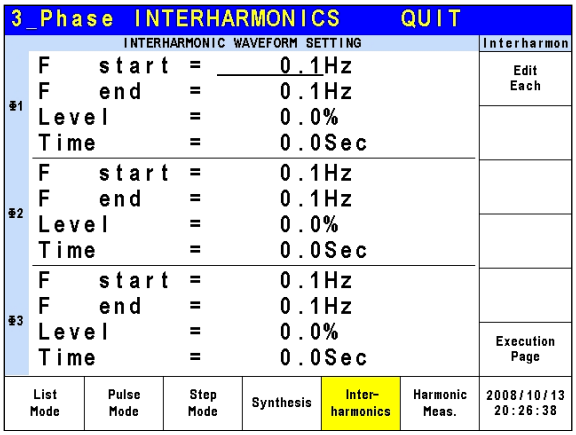
11 ≤ order ≤ 20, value ≤ 120V or percentage ≤ 50%.
21 ≤ order ≤ 30, value ≤ 80V or percentage ≤ 30%.
31 ≤ order ≤ 40, value ≤ 45V or percentage ≤ 15%.

2. If the synthesis waveform exceeds the voltage limit, 424V for 300V range or 212V for 150V range, OUTPUT OVP will occur.

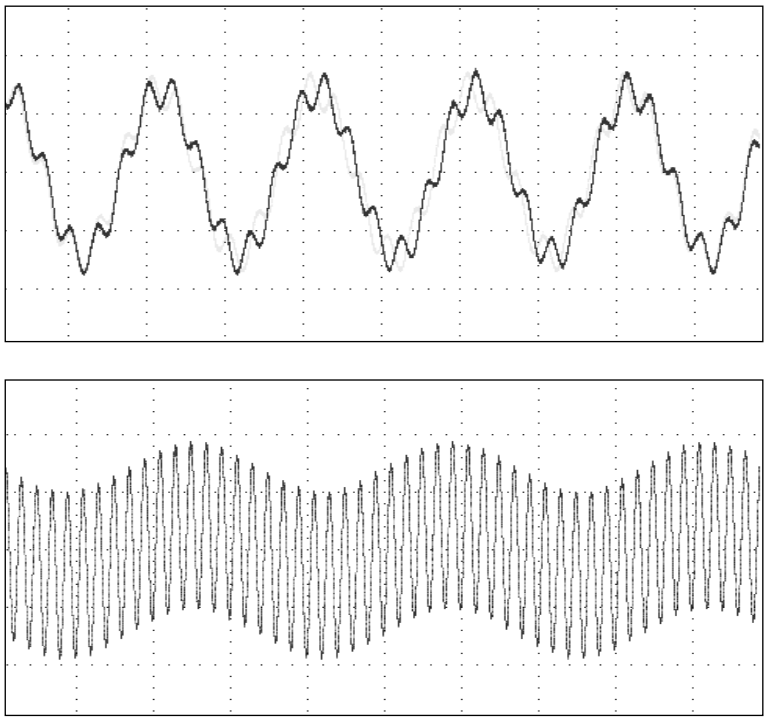
5.6 Inter-harmonics Waveform

Press Output Mode on the right in the MAIN PAGE (see 3.3) to enter into the Output Mode command line. Next press Inter-harmonics at the bottom to go to the Inter-harmonics command line. Press Edit on the right to enter the Inter-harmonics editing window.



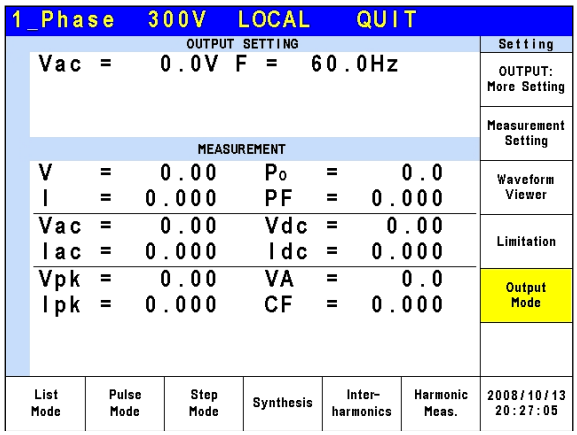


For the AC Source Inter-harmonics function, besides the fundamental voltage output, another frequency of variable voltage component is added to test certain anti-interference. Following is the example figure of an inter-harmonic:

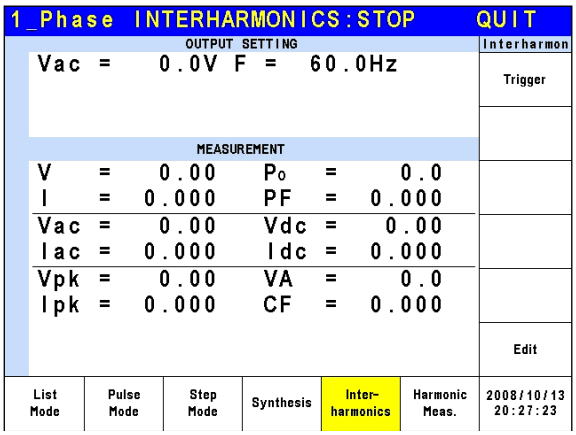


F start : The start frequency of scanning wave. The range is 0.01Hz ~ 2400Hz.
F end : The end frequency of scanning wave. The range is 0.01Hz ~ 2400Hz。
Level : The rms of scanning wave that is the percentage of fundamental voltage set in MAIN PAGE.
Time : The scanning time from F start to F end.

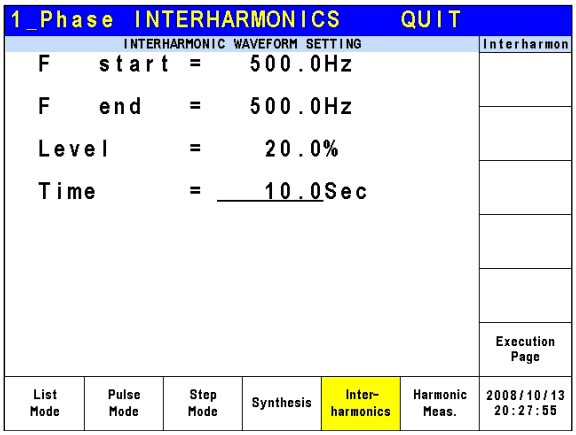
The following is the example of using Inter-harmonics Mode in 1_Phase Mode:



Press Output Mode on the right in the MAIN PAGE to select any Mode for application.

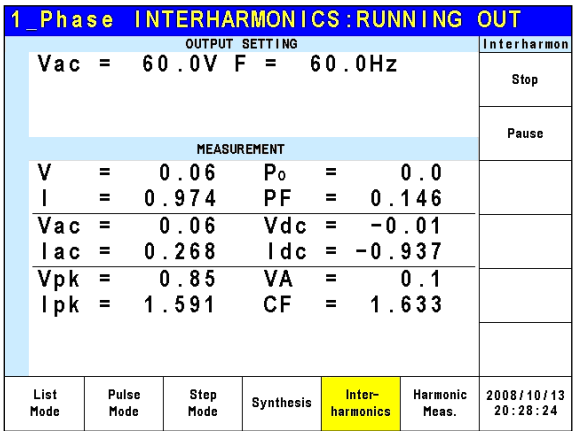


Next, press Inter-harmonics at the bottom to go to Inter-harmonics Mode.

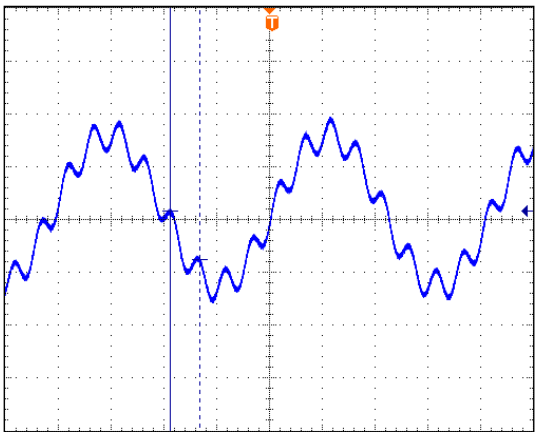


Press Edit on the right to go to the editing screen. Use the arrow keys to move the cursor to the column to be set and use the numeric keys to key-in the setting, then press **ENTER**. The example uses the following settings:

OUTPUT SETTING：Vac = 60.0V F = 60Hz
F start = 500.0Hz
F end = 500.0Hz
Level = 20.0%
Time = 10.0Sec



Press Execution Page on the right to return to the Inter-harmonics Mode page. Next press Trigger on the right to output the waveform.



The figure above is the output voltage waveform of the AC Source measured by an oscilloscope and is the same as the user edited waveform.

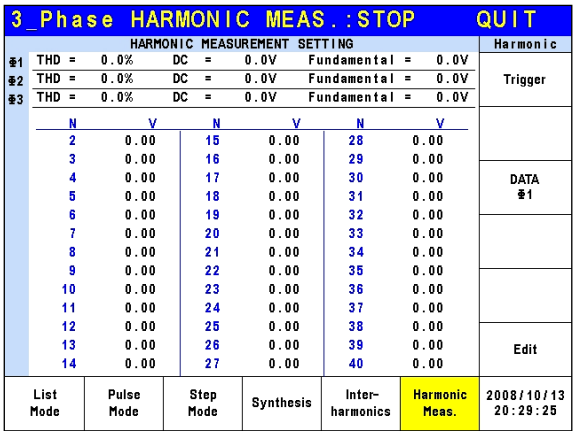
Notice

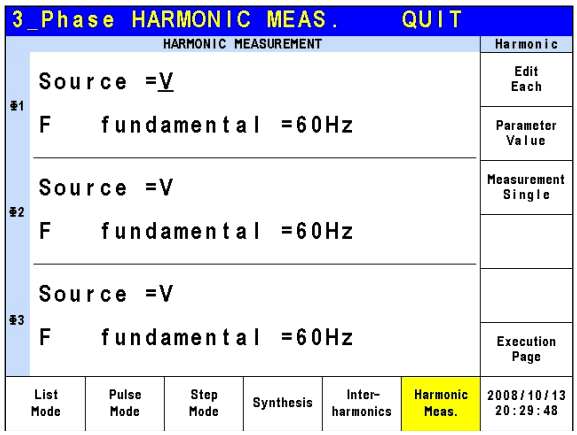
In order to protect the power stage of AC Source for practical use, it is necessary to limit the F start and F end related Level.

If 0.01Hz ≤ F start or F end ≤ 500Hz, Level ≤ 30%.
If 500Hz < F start or F end ≤ 1000Hz, Level ≤ 20%.
If 1000Hz < F start or F end ≤ 2400Hz, Level ≤ 10%.

5.7 Harmonic Waveform

Press Output Mode on the right in the MAIN PAGE (see 3.3) to enter into the Output Mode command line. Next press Harmonic Meas. at the bottom to go to the I Harmonic Meas. command line. Press Edit on the right to enter the Harmonic Meas. editing window.





This function can measure the Total Harmonic Distortion (THD) of the fundament frequency 50Hz or 60Hz, the DC current, and the fundamental frequency of output current or voltage, also can measure 2 ~ 40 orders of harmonic values.

Source = V / I: It measures the source signal output voltage or output current.

V: The output voltage.
I : The output current.

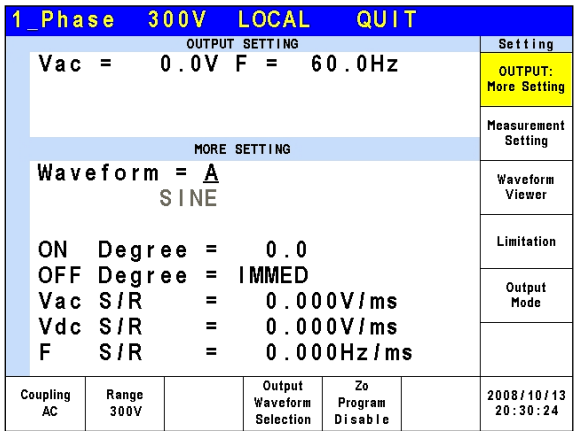
F fundamental = 50 / 60 Hz: The fundamental frequency of source signal.
Measurement = Single / Continue: The way the measurement result displays on LCD.

Single: The display will keep the measured data when set. It takes about 3 seconds to get the results.
Continue: The display updates the measured data when set. It takes about 10 seconds to get stable results.

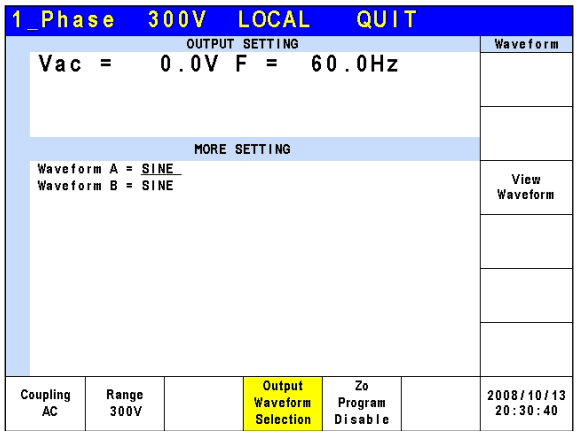
Parameter = Percent / Value: The data form of each harmonic component.

Percent: The percentage of fundament frequency value.
Value: The absolute value.

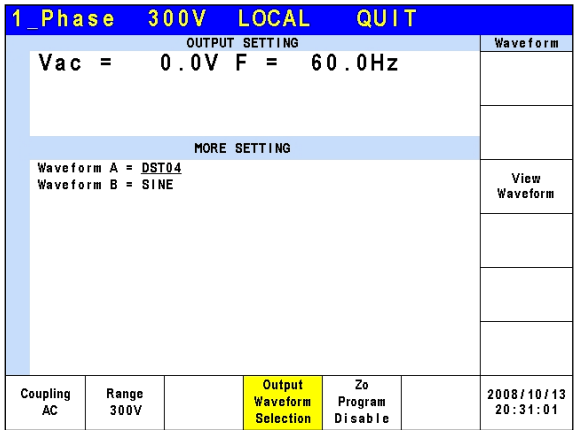
Following is an example of using Harmonic Meas. Mode in 1_Phase Mode:



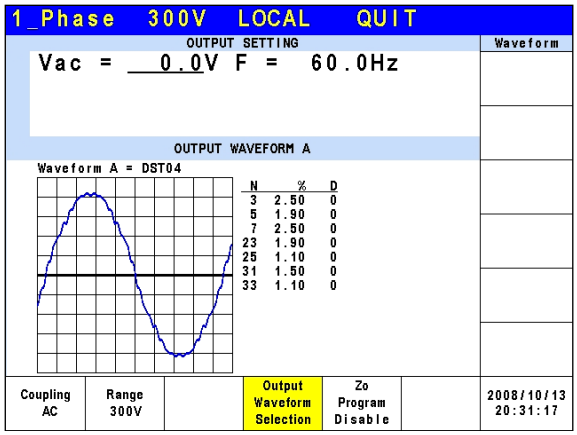
Press OUTPUT: More Settings on the right in the MAIN PAGE to enter into the output selections page.



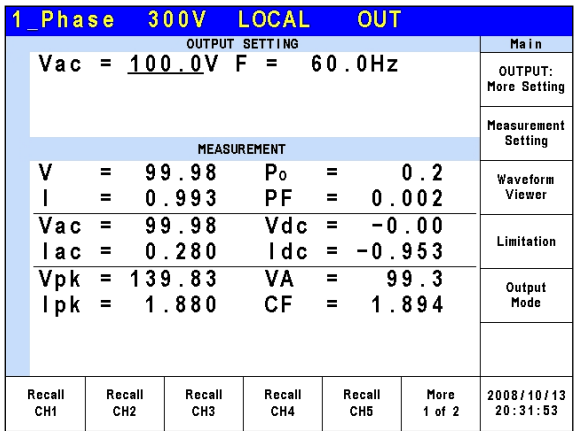
Next, press Output Waveform Selection at the bottom to go to the output waveform selection page.



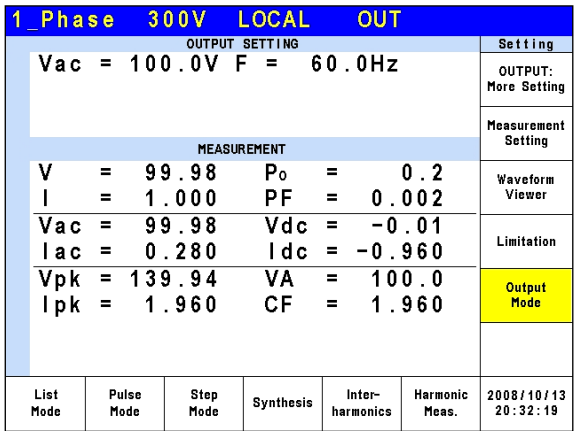
Set the Waveform A of Φ3 to DST04 waveform.



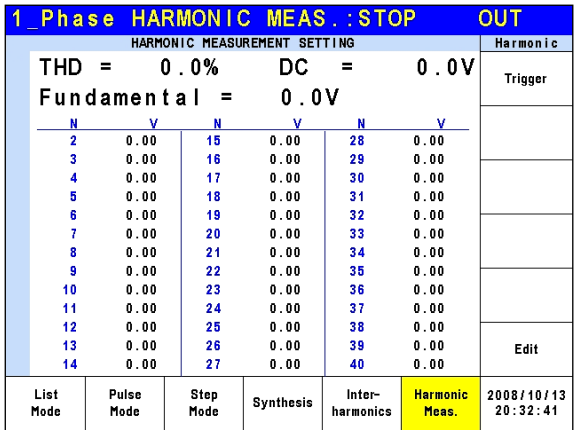
When the waveform setting is done, press View Waveform on the right to view the output waveform, the ratio of each harmonic order and the output angle.



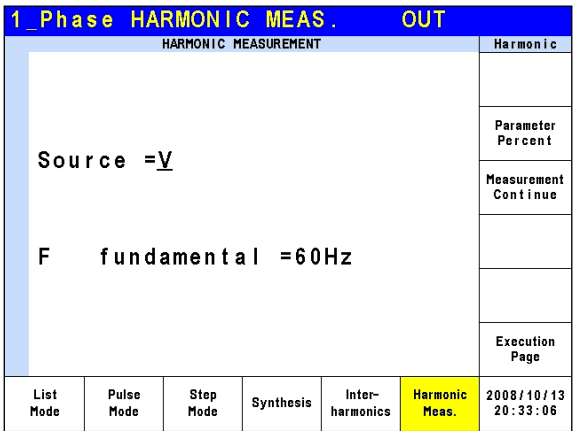
Press Return to go back to the MAIN PAGE and set the Vac of Φ3 to 100.0V, then press **OUT/QUIT** to output waveform.



Press Output Mode on the right in the MAIN PAGE to select any Mode.

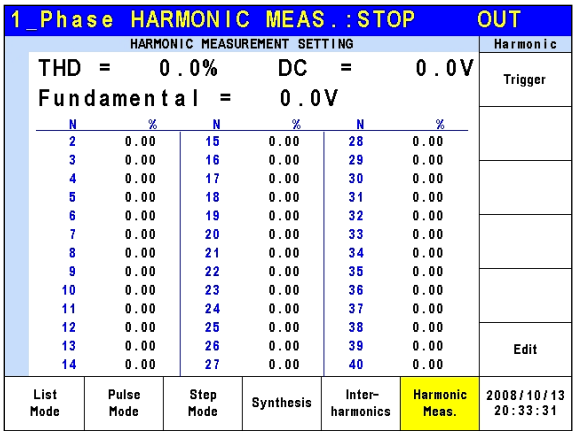


Next, press Harmonic Meas. at the bottom to go to the Harmonic Meas. Mode.



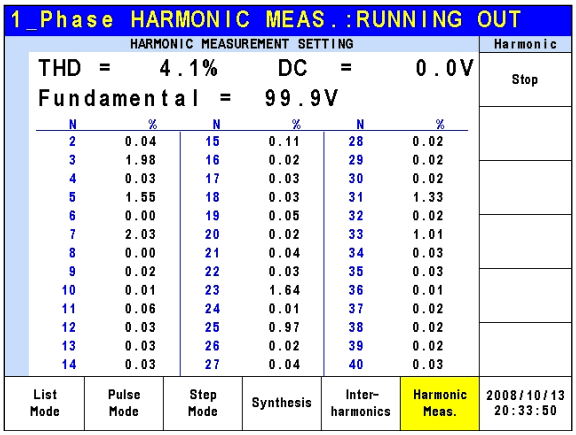
Press Edit on the right to go to the editing screen. Use the arrow keys to move the cursor to the column to be set and use the numeric keys to enter the setting, then press **ENTER**. The example uses the following settings:

Source = V
F fundamental = 60 Hz
Measurement = Continue
Parameter = Percent



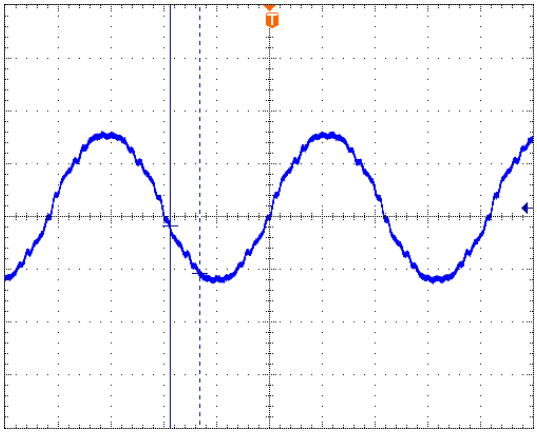
N	%	N	%	N	%
2	0.00	15	0.00	28	0.00
3	0.00	16	0.00	29	0.00
4	0.00	17	0.00	30	0.00
5	0.00	18	0.00	31	0.00
6	0.00	19	0.00	32	0.00
7	0.00	20	0.00	33	0.00
8	0.00	21	0.00	34	0.00
9	0.00	22	0.00	35	0.00
10	0.00	23	0.00	36	0.00
11	0.00	24	0.00	37	0.00
12	0.00	25	0.00	38	0.00
13	0.00	26	0.00	39	0.00
14	0.00	27	0.00	40	0.00

Press Execution Page on the right to return to the Harmonic Meas. Mode page. Next press Trigger on the right to perform the output voltage harmonic measurement.



N	%	N	%	N	%
2	0.04	15	0.11	28	0.02
3	1.98	16	0.02	29	0.02
4	0.03	17	0.03	30	0.02
5	1.55	18	0.03	31	1.33
6	0.00	19	0.05	32	0.02
7	2.03	20	0.02	33	1.01
8	0.00	21	0.04	34	0.03
9	0.02	22	0.03	35	0.03
10	0.01	23	1.64	36	0.01
11	0.06	24	0.01	37	0.02
12	0.03	25	0.97	38	0.02
13	0.03	26	0.02	39	0.02
14	0.03	27	0.04	40	0.03

After triggered, users can press DATA on the right to view the measurement of a phase.



The figure above is the output voltage waveform of the AC Source measured by an oscilloscope and is the same as the user edited waveform.

Notice

When users press Trigger to execute the current harmonic measurement, the AC Source will adjust the internal gain automatically by the measured data so that the AC Source can get more accurate data of each harmonic. Thus, it is better to wait for the load to be stable before executing the harmonic measurement. In addition, the load cannot be changed during measurement or the retrieved data may lose its accuracy or cause over current protection.

6. Parallel Operation

6.1 Parallel Connection of AC Source

When two AC Sources or one AC Source with one Power Stage Unit are applied in parallel mode, it can use an Input/Output Terminal Box for Parallel Connection (2 Units) (A615104) to connect the AC Source and Power Stage Unit (A615103) or another AC Source as the figure shown below. Use the Input/Output Terminal Box for Parallel Connection (3 Units) (A615105) when connecting 3 devices in parallel.

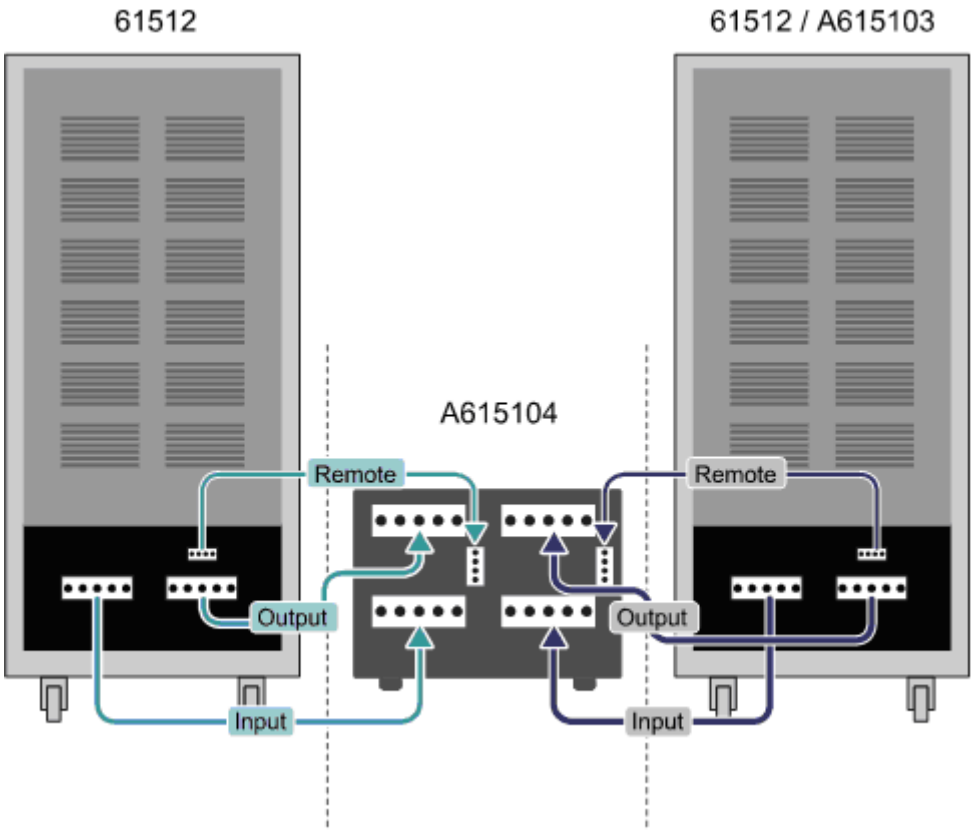


Figure 6-1 Master/Slave Connecting Diagram

6.2 Parallel Connection

When the AC Source and the Power Stage Unit are applied in parallel mode, it needs to use the System Bus and DVI communication cable to transmit parallel data. The following figure shows the parallel connencting diagram when connecting the AC Source and Power Stage Unit. If more AC Sources (61511/61512/61611/61612) or A615103 Power Stage Units are required for parallel connection, just follow the way shown below to connect them.

Notice When the parallel mode is in use, it is necessary to connect the System Bus and DVI cables correctly or it will cause the system conntection error.

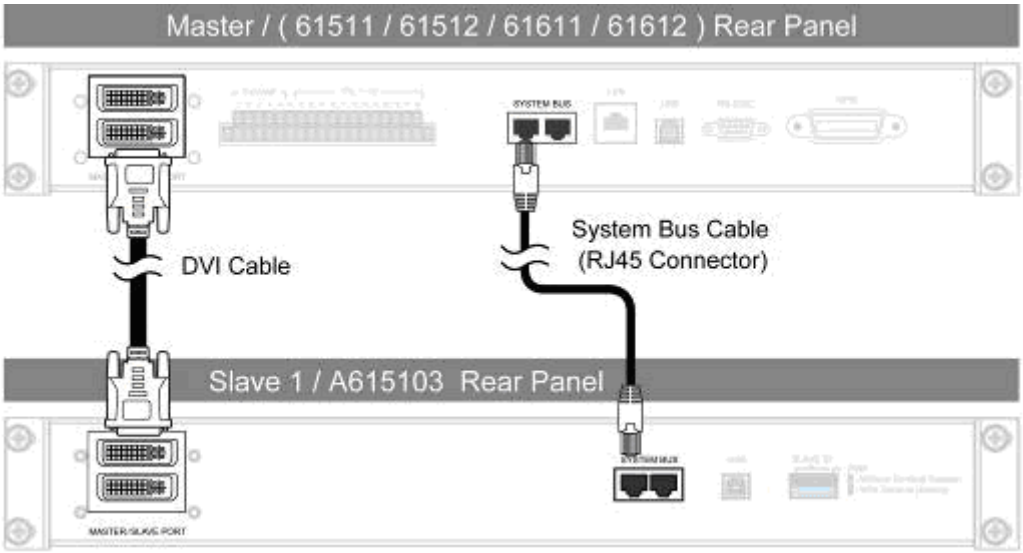


Figure 6-2 Parallel Connection of AC Source and Power Stage Unit

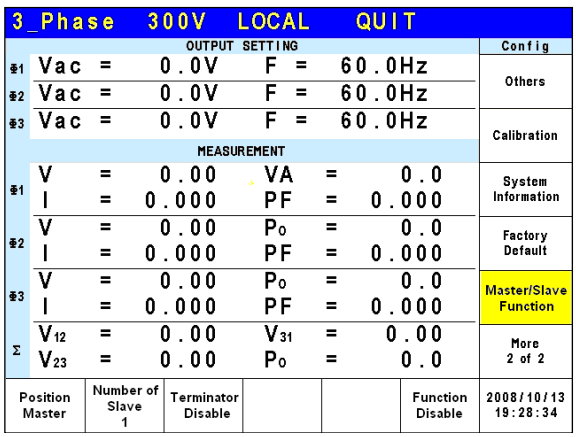
6.3 Setting Up

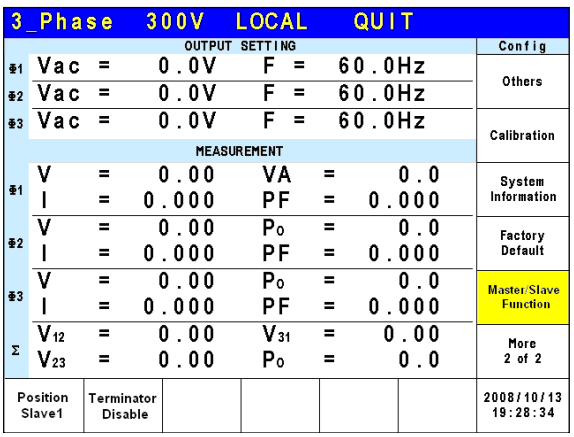
6.3.1 Setting the AC Source to Slave

To set an AC Source to Slave, press **CONFIG** in the **FUNCTION** keys to enter into the CONFIG function and select Master/Slave Function for parallel connection setting. The procedures are listed below.

1. Press Master/Slave Function.
2. Press Position at the bottom.
3. Turn the RPG to change the Position to Slave and press **ENTER** to set it to Slave.
4. If the AC Source to be set is located between two terminals, press Terminator and turn the RPG to change the Terminator to Enable and then press **ENTER** to set it.

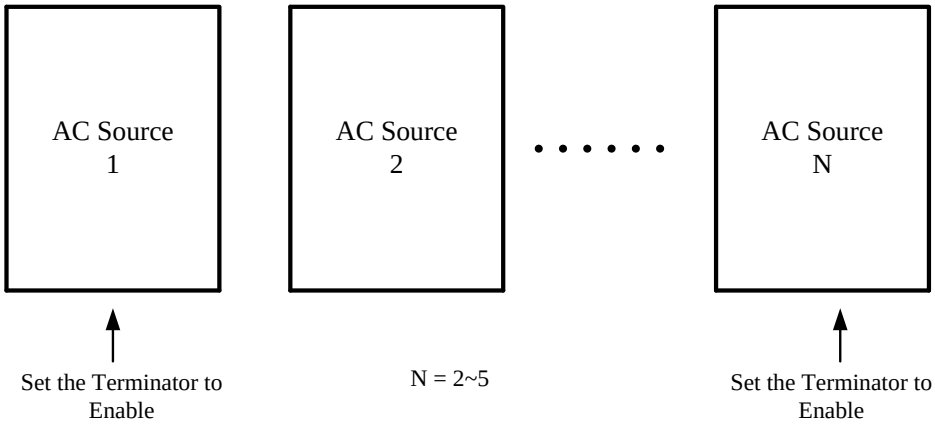
Notice At least one device needs to be set as Slave when applying the parallel connection.



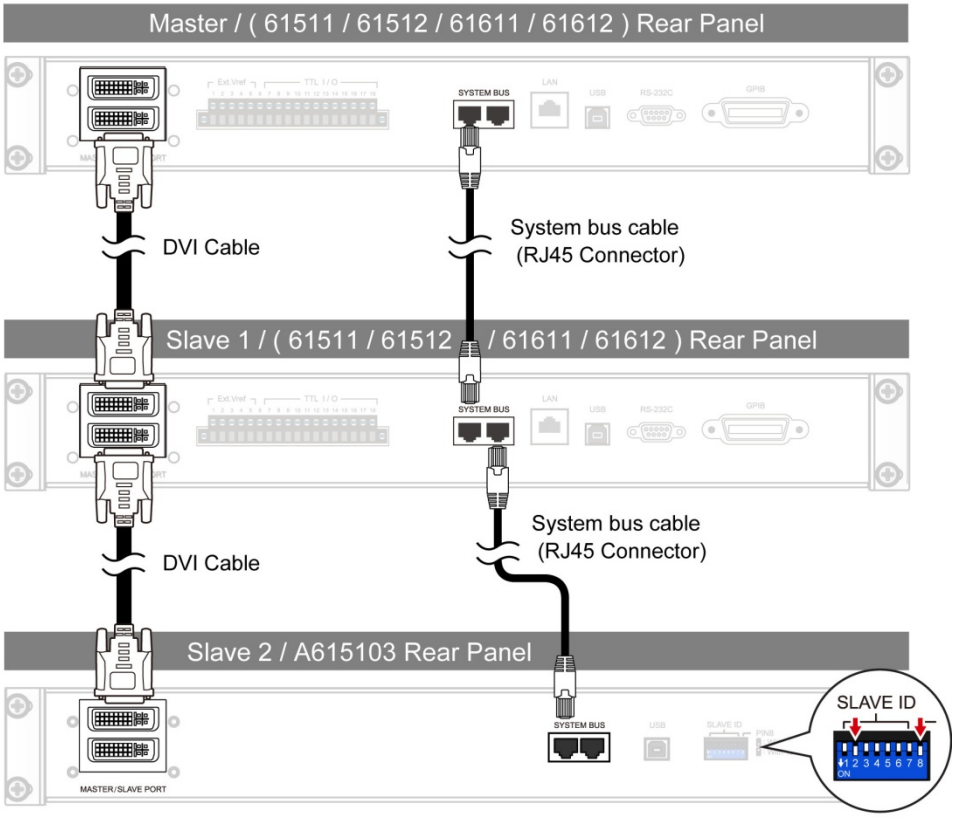


6.3.2 Setting the Slave of Mixed AC Source and A615103

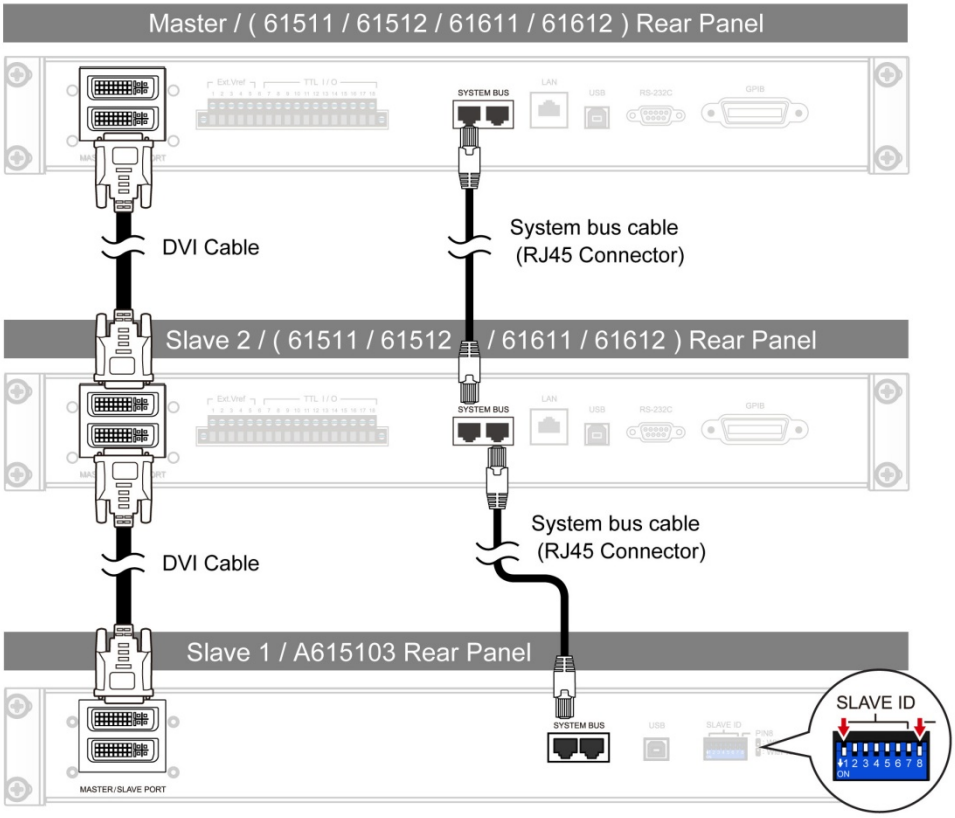
When the parallel connection is mixed with A615103 and AC Source as the Slave, the terminator of these two terminal devices must be enabled as the figure shown below. The maximum AC Sources to be connected in parallel is N = 5. Please refer to the User's Manual of latest version for any changes.



Example 1: if the system has a Slave AC Source and an A615103 parallelable power stage unit, the connection is shown in the figure below. Set the terminator of Master to "Enable" and the "Position" of Slave AC Source to "Slave1". Also set the Slave ID of A615103 to Slave2 with terminator enabled.



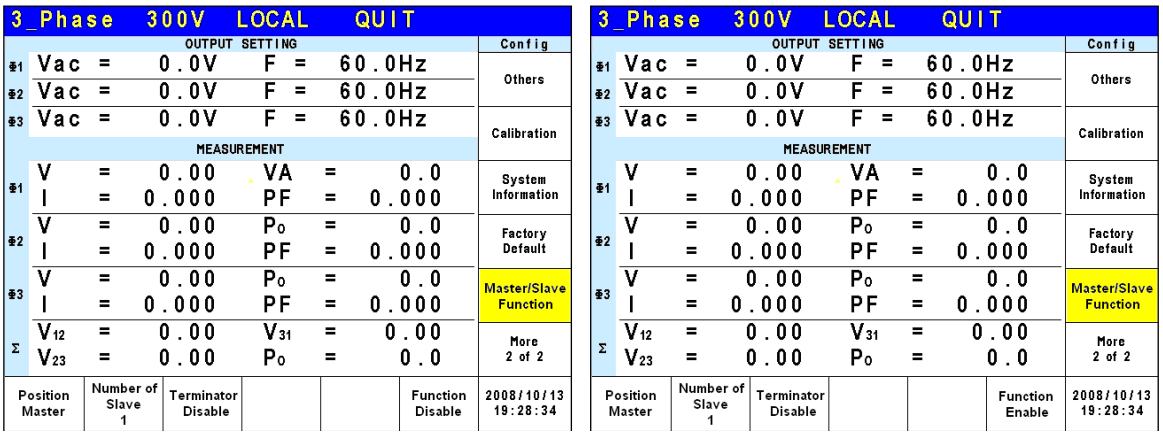
Example 2: if the system has a Slave AC Source and an A615103 parallelable power stage unit, the connection is shown in the figure below. Set the terminator of Master to "Enable" and the "Position" of the Slave AC Source to "Slave2". Also set the Slave ID of A615103 to Slave1 with terminator enabled.



6.3.3 Setting the AC Source to Master

Press **CONFIG** in the **FUNCTION** keys to enter into the CONFIG function and select Master/Slave Function for parallel connection setting. The procedures are listed below.

1. Press Master/Slave Function.
2. Press Position at the bottom.
3. Turn the RPG to change the Position to Master and press **ENTER** to set it to Master.
4. Press Number of Slave.
5. Turn the RPG to select the quantity of Slaves to connect in parallel and press **ENTER** to set it.
6. If the AC Source to be set is located between two terminals, press Terminator and turn the RPG to change the Terminator to Enable and then press **ENTER** to set it.
7. Press Function bottom.
8. Turn the RPG to change the Function to Enable and press **ENTER** to set it.
9. Now, the device set to Master will retrun to the main menu and the one set to Slave will show Slave on the screen.



Slave 1

Notice

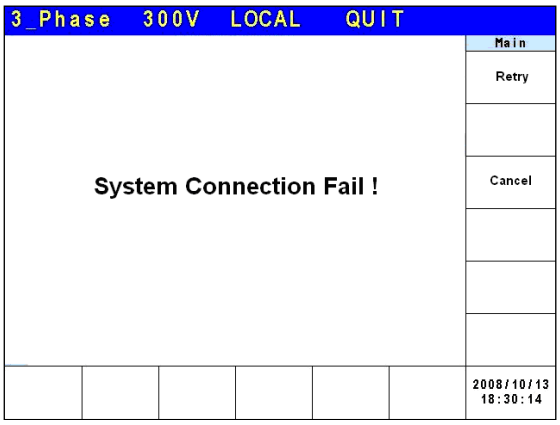
At least one device needs to be set as Slave when in parallel application, or it will show “System Connection Fail!” when setting the Master Enable. See the section below for the detail description of troubleshooting.

6.4 Troubleshooting

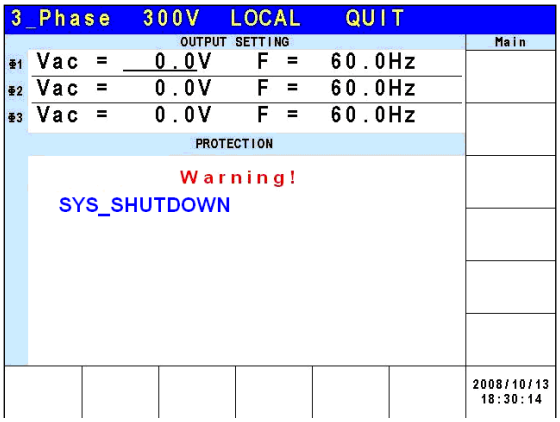
When multiple devices are conneted in parallel for use, each standalone device has to have a System bus and a DVI cable to transmit the signal, or the quantity of the Slave set for connection does not match the one in actual. If the connection is busy or errors occurred during connection, follow the troubleshooting procedure to resolve the problem and redo the parallel connection.

6.4.1 When the Connecting Cable Falls

If “System Connection Fail!” occurs when initiating Master connection, check if the System Bus cable is connected firmly and if the Power Stage Unit or another AC Source is set to Slave. When confirmed, press Retry on Master to redo the connection.

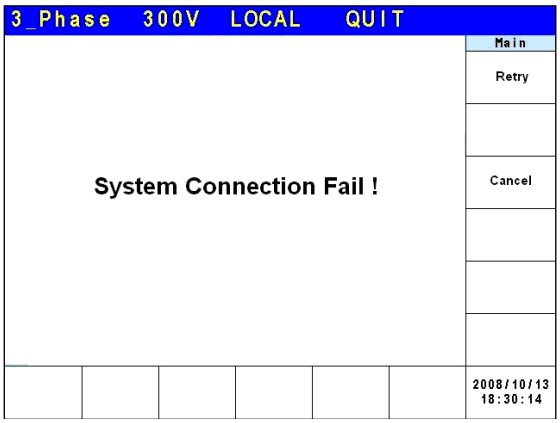


If "SYSTEM SHUTDOWN" occurs during connection, power it off first and check if the DVI cable is connected firmly. If yes, reboot it and redo the connection.



6.4.2 Parallel Setting Error

If "System Connection Fail!" occurred when connecting Master, it could be the connection setting error. First check if the Master connected amount (Number of slave) is the same as the actual slave amount. Next, check if the parallel slave position is duplicated. The position set for slave cannot be duplicated. When confirmed, press Retry on the Master to do the connection again.



7. Theory of Operation

7.1 Overview

The 61511/61512 AC source consists of several Printed Circuit Boards (PCB) and other components. Each of the PCBs has specific functions that are described in the following sections.

7.2 Description of Overall System

Figure 7-1 is an overall system diagram that is composed of the following portions:

- Input Stage I Board:
  It converts the AC power to DC power with passive PFC function.

- Isolation Converter G/GD Board:
  The isolation DC/DC converter isolates the I board output with regulation function. It can also provide the inverter a stable input DC source.

- Output Stage HB/HT/O/A board:
  The above boards are composed of an inverter that draws power from G/GD board to provide 61511/61512 to output DC or AC power.

- Auxiliary Power J/Z board:
  J board converts the mains to a 16-17V DC power for the ICs and fans of entire device use. Z board is an isolation DC/DC converter that converts the J board output to ±12V and +5V power to drive the IC of various PCB and other components.

- Fan Control Circuit R Board:
  R board detects the temperature of each power stage and adjusts the fan speed automatically to control the temperature of entire device. This circuit has Over Temperature Protection (OTP) and FAN- LOCK protection.

- Digital Signal Processor B board:
  B board contains DSP, FPGA and CPLD control elements that are responsible for the actions and measurements of 61511/61512's entire device.

- Communication Interface E board:
  E board connects all of the 61511/61512 communication interfaces such as GPIB, RS-232, USB……and sends the signals back to B board to accomplish the remote control function.

- Signal Transmission C Board:
  The C board is responsible for transmitting the signals from B board and other PCBs.

- Key input KA/KC/KR/KS board:
  It is the front panel key controls for the above PCBs that send the inputted signals to B board.

- 1-phase Output Connecting Device L Board:
  When L board is in 1-phase output, short circuit L1~L3 3 outputs for user wiring.

- Input Wire Selection Switch (Δ-Y wiring selection switch):
  Users can follow the actual power system to change the 61511/61512 internal input connection that enables 61511/61512 to accept the input from Δ or Y.

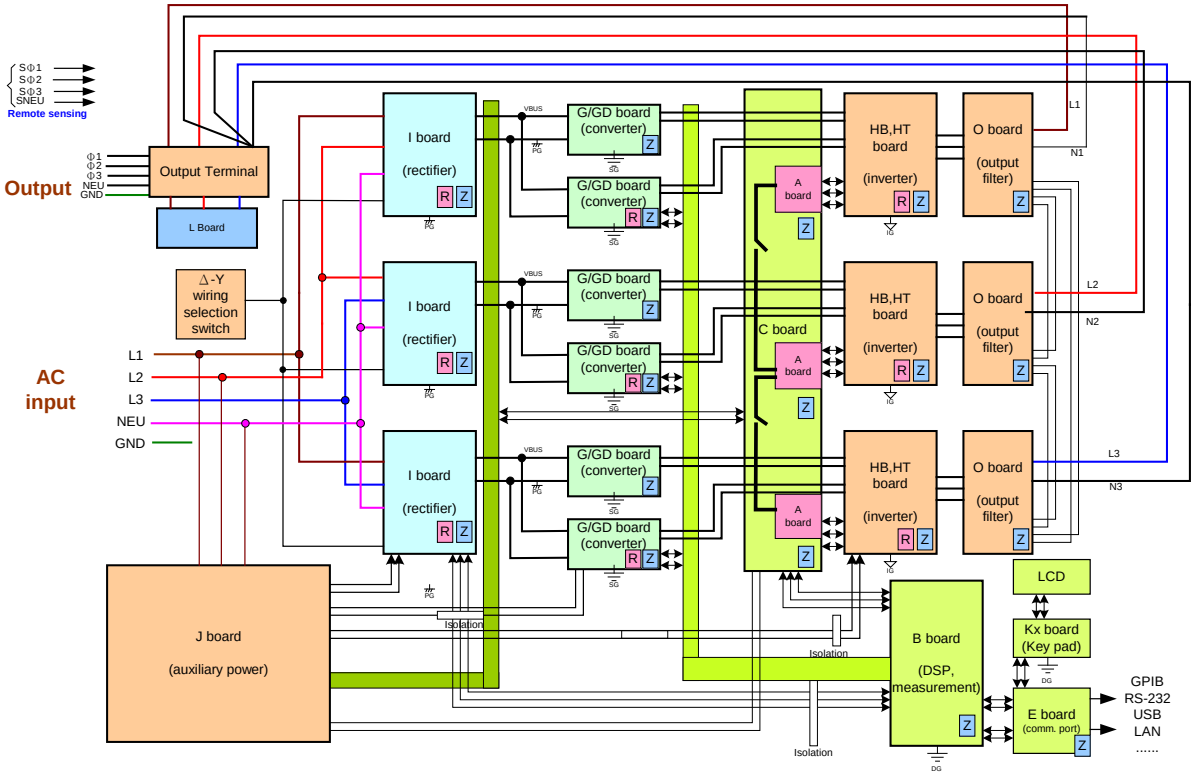


Figure 7-1 Overall System Diagram

8. Self Test & Troubleshooting

8.1 Overview

This chapter describes the procedures of self test and suggestions for troubleshooting when the AC Source is unable to operate normally. If the information provided here is unable to resolve the problem, please contact the local Chroma distributor.

8.2 Self Test

The AC Source runs a series of self tests during power-on. First, it executes the memory, data and communication self tests for the items of DISPLAY, WAVEFORM, and REMOTE. If any failure is detected on a certain item, an “error code” will show on the right of the item. The following table lists all of the error messages.

Error Code	Description	Remark
Bit 0	Memory error	0 – OK, 1 - ERROR
Bit 1	Waveform Generator error	0 – OK, 1 – ERROR
Bit 2	DATA error	0 – OK, 1 – ERROR
Bit 3	Communication error	0 – OK, 1 - ERROR
Bit 4	Output test result	0 – OK, 1 – ERROR
Bit 5	Reserved	
Bit 6	Reserved	
Bit 7	Reserved	

Example: If an error code shows " ERROR = 05 ", it is " 00000101" in binary. The bit 0 and bit 2 are “1”. So “ERROR = 05” means memory error and DATA error occurs.

Error Message	Description	Resolution
Memory error	Memory tested fail.	Consult your dealer for further support
Waveform Generator error	Waveform generator tested fail.	Consult your dealer for further support.
DATA error	The data in Flash or EEPROM tested fail.	Consult your dealer for further support.
Communication error	Unable to send.	1. Power off the AC Source and wait for three seconds to power it on again. 2. Consult your dealer for further support.

After the self test of memory, data and communication, the AC Source executes the power output self test. In this procedure, the output relays are OFF to prevent the load connected to the output terminal from damage. An error message will appear on the panel if abnormal is encountered during self test.

8.3 Troubleshooting

The following table lists the operating problems and suggested corrective actions:

Problem	Cause	Resolution
Poor measurement of V, I.	Aged components result in deviation of characteristics.	Periodic calibration is required. Refer to Chapter 4 *Calibration*.
Output distortion	1. The output voltage of AC Source is too low. 2. The rectified load is too large during high frequency.	1. Program higher output voltage. 2. Reduce the load or output frequency.
Over Temperature Protection (OTP)	1. The ambient temperature is too high. 2. The airway is obstructed.	1. Operate the unit between 0 ~ 40°C. 2. Unblock the airway.
Over Power Protection (OPP)	The output power exceeds specification.	Remove the output power or output voltage.
Over Current Protection (OCP)	The output current exceeds specification or I LIMIT.	Remove the overload or expand the I LIMIT.
Output Short Protection (Short)	1. The output is shorted. 2. External current reversed.	1. Remove the short state. 2. Remove the load.
Input error protection (INT_LINE)	The line input voltage of AC Source is too low or too high.	Measure the input voltage and regulate it if over specification.
AUX output error protection (INT_OFF)	The internal auxiliary power outputs abnormally.	If it is unable to reset the protection, consult the dealer for assistance.
INT _ AD protection	1. The cycle dropout for line input voltage. 2. Instant over current during output. 3. The AD power stage is damaged.	1. Check the stability of input voltage. 2. Remove the load. 3. If it is unable to reset the protection, consult the dealer for assistance.
INT _ DD protection	1. The cycle dropout for line input voltage. 2. Instant over current during output. 3. The DD power stage is damaged.	1. Check the stability of input voltage. 2. Remove the load. 3. If it is unable to reset the protection, consult the dealer for assistance.
OUTPUT OVP protection	1. Remote Sense is open. 2. Output voltage peak exceeds the range.	1. Connect the output to Remote Sense terminals. 2. Check the settings of Vac and Vdc on MAIN PAGE.
Cooling fan protection (FAN-FAIL)	1. The fan stops operation due obstruction. 2. The fan is not inserted.	1. Clear the fan. 2. If it is unable to reset the protection, consult the dealer for assistance.
Unable to control AC Source via GPIB	1. The address of AC Source is incorrect. 2. GPIB cable is loose at rear.	1. Update the address. 2. Check the connection and tighten the screws.

9. Remote Operation

9.1 Introduction

The AC Source is able to do remote control via USB, GPIB, RS-232 or Ethernet. The USB interface supports USB 2.0/USB 1.1. The GPIB interface is an 8-bit parallel data bus that is synchronized by the bus command from the host. RS-232C interface is a serial bus with less powerful functions; however, the user can do basic remote control via simple programs.

9.1.1 USB Interface

(1) Hardware Support: USB 2.0 and USB 1.1
(2) Software Support: USBTMC class and USB488 subclass
(3) OS Support: Windows 98/2000/XP/Vista
(4) Installing Driver: The AC Source USB Interface supports USBTMC, so if the PC OS supports USBTMC (installed NI-VISA runtime version 3.00 or above) it is no need to install other drivers. The OS will search for the standard USBTMC driver installation program automatically.

If the PC OS does not support USBTMC, it is suggested to install the NI-VISA runtime version 3.00 or above first. When the installation of NI-VISA runtime is done, the USBTMC driver program is stored in OS. The PC can communicate with the AC Source via NI-VISA after using the USB cable to connect them.

Related Documents:
1. USB Test and Measurement Class (USBTMC) specification, Revision 1.0, http://www.usb.org
2. USB Test and Measurement Class USB488 subclass specification, Revision 1.0, http://www.usb.org

9.1.2 GPIB Interface

The default of GPIB address is 30 and it can only be changed from the “CONFIG” function menu (see 3.4.)

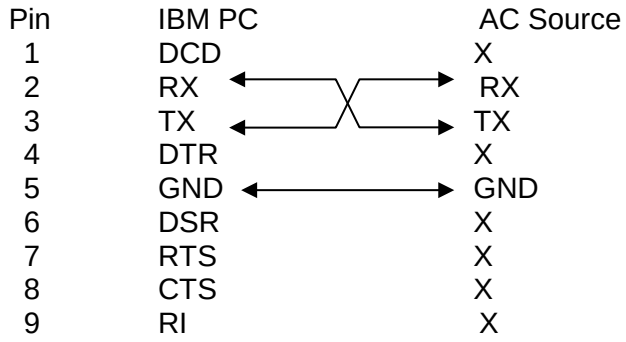
GPIB Capability	Description	Interface Function
Talker/Listener	Commands and response messages can be sent and received via the GPIB bus. Status information can be retrieved by serial query.	AH1, SH1, T6, L4
Service Request	The AC Source sets the SRQ to be true if there is a service request.	SR1
Remote/Local	When the AC Source is powered on in local mode, it can operate the front panel. In remote mode, all other keys are invalid except **LOCAL/REMOTE**. Press **LOCAL/REMOTE** can return to local mode.	RL1

9.1.3 RS-232C Interface

The baud rate of the AC Source is set to **115200** with parity set to None. For the RS-232C parameters such as baudrate and parity can be set via "CONFIG" function menu (see section 3.4.) Only TxD and RxD signals are used for data transmission. The connector is a 9-pin D-subminiature male connector. The following table describes the pins and signals of RS-232C connector.

Pin No.	Input/Output	Description
1	---	No Connection
2	INPUT	RxD
3	OUTPUT	TxD
4	---	No Connection
5	GND	GND
6	---	No Connection
7	---	No Connection
8	---	No Connection
9	---	No Connection

Interconnection between the computer (compatible with IBM PC) and the AC Source is illustrated below:



9.1.4 Ethernet Interface

To remote program an AC Power Supply via a PC with Ethernet interface, it needs to confirm the IP address, Gateway address and Subnet mask in advance. See 3.4.1.3 for detail settings. To ensure reliable data transmission, TCP is used for data transmission and the communication port is 2101.

9.2 Introduction to Programming

All commands and response messages are transmitted in ASCII code. The response messages must be read completely before sending a new command; otherwise the remaining response messages will be lost and a query interrupt error will occur.

9.2.1 Conventions

Angle brackets	<	>	Items in angle brackets are parameter abbreviations.
Vertical bar	|		Vertical bar separates alternative parameters.
Square brackets	[	]	Items in square brackets are optional. For example, OUTP [: STATe] means that : STATe may be omitted.
Braces	{	}	Braces indicate the parameters that may be repeated. The notation <A> {<, B>} means that parameter "A" must be entered while parameter "B" may be omitted or entered once or many times.

9.2.2 Numerical Data Formats

All data programmed to or returned from the AC Source are ASCII. The data can be numerical or character string.

Symbol	Description	Example
NR1	It is a digit with no decimal point. The decimal is assumed to be on the right of the least significant digit.	123, 0123
NR2	It is a digit with a decimal point.	12.3, .123
NR3	It is a digit with a decimal point and an exponent.	1.23E+2

9.2.3 Boolean Data Format

Boolean parameter <Boolean> applies ON|OFF format only.

9.2.4 Character Data Format

The character strings returned by query command may in either of the following forms:

<CRD> Character Response Data: character string with maximum length of 12.
<SRD> String Response Data: character string.

9.2.5 Basic Definition

Command Tree Table:
The commands of the AC Source are structured hierarchically, which is called tree system. Full path must be specified to obtain a particular command. This path is represented in the table by placing the highest node in the farthest left position of the hierarchy. Lower nodes in the hierarchy are indented in the position to the right under the parent node.

Program Header:
Program header is the key word to identify the command according to the IEEE 488.2 syntax described in section 9.5. The AC Source accepts characters in both upper and lower cases without any distinction. Program header consists of two unique types, the common command header and the instrument-controlled header.

Common Command and Query Header:
The syntax of common commands and query headers are described in IEEE 488.2. They are used along with the IEEE 488.2 defined common commands and queries. The commands with leading "*" are common commands.

Instrument-Controlled Header:
Instrument-controlled header can be applied to all instrument commands. Each header has a long form and a short form. The AC Source only accepts the exact short and long forms. A special notation is used to distinguish the short form header from the long one of the same in this section. The short form of header is shown by upper case characters while the rest of the headers are shown in lower case.

Program Header Separator (:):
If a command has more than one header, a colon must be used to separate them (FETC: CURR?, VOLT:DC 10). At least one space is required to separate the data and program header.

Program Message:
The program message consists of many elements including zero sequence or message components that are separated by the separator (semicolon.)

Program Message Component:
A program component is a single command, programming data, or query.

Example: FREQ?, OUTPut ON.

Program Message Component Separator (;):
The separator (semicolon ;) separates the program message components from another in a program message.

Example: VOLT:AC 110 ; FREQ 120<PMT>

Program Message Terminator (<PMT>):
A program message terminator can end the program message. Three permitted terminators are:

(1) <END>: end or identify (EOI)
(2) <NL>: new line which is a single ASCII encoded byte 0A (10 decimals).
(3) <NL> <END>: new line with EOI.

Notice The response message is terminated by <NL> <END> for GPIB, and <NL> for RS-232C.

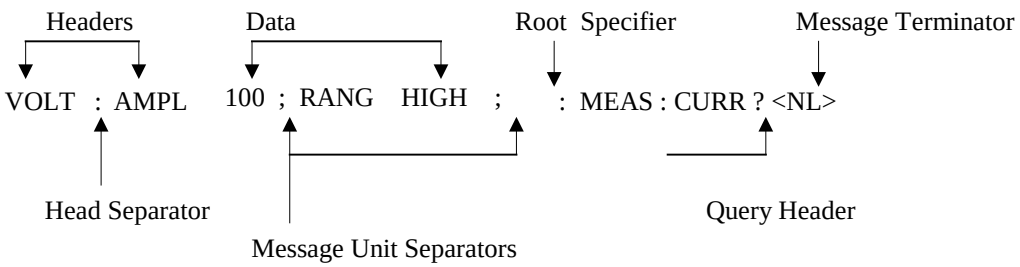


Figure 9-1 Structure of Command Message

9.3 Traversal of the Command Tree

Multiple program message units can be sent in one program message. The first command usually refers to the root node. Subsequent commands refer to the tree level same as the previous command in a program message. When the colon is ahead of the program message component it changes the header path to root level.

Example:

OUTPut : PROTection : CLEar	All colons are header separators.
OUTPut : PROTection : CLEar; : VOLT : AC 100	Only the third colon is a specified root.

9.4 Execution Order

The AC Source executes program messages by the order received. Problems may occur if the sequence is not followed.

For example, assuming the current output voltage range is LOW, the output voltage range desired for new state is HIGH with amplified 220 Volt. If the commands

VOLTage : AC 220<PMT>
VOLTage : RANGe HIGH<PMT>

are sent out, the error of out of range will appear.

9.5 Commands of AC Source

This section talks about the syntax and parameters of all commands for the AC Source. The examples of each command can be used in common.

Syntax Form	Syntax definition is in long format header; however, only short format header appears in the examples.
Parameter	Most commands require a parameter.
Return Parameter	All queries return a parameter.
Model	If a command is merely applied to specific models, these models will be listed in the Model only entry. If there is no Model only entry, the command will be applied to all models.

9.5.1 Common Command Dictionary

The common commands begin with a " * " and consist of three letters and/or one " ? " (query). Common commands and queries are listed alphabetically. The command commands and queries are listed in alphabetic order.

*CLS Clear status
This command clears the following registers
(1) Questionable Status Event
(2) Status Byte

(3) Error Queue

*ESE<n> Standard event status enabled
This command programs the Standard Event register bits. If one or more enabled events of Standard Event registers are set, the ESB of Status Byte Register is set as well.

Bit Configuration of Standard Event Status Enabled Register

Bit Position	7	6	5	4	3	2	1	0
Bit Name	PON	- - -	CME	EXE	DDE	QYE	- - -	OPC

CME = Command Error
EXE = Execution Error
PON = Power On
DDE = Device-dependent error
OPC = Operation Completed
QYE = Query Error

*ESE? Return standard event status enabled

*ESR? The query reads the Standard Event readings of Event register and clears it. The bits of configuration are the same as Standard Event Status Enabled Register.

*IDN? Return the AC Source identification string.
Return Parameter Chroma ATE,61500,123456,01.00
Chroma ATE : Company name
61500 : Model name
123456 : Serial number
01.00 : Firmware version

*RCL<n> Restore the values of specified group that stored in memory previously.
Parameter 1 - 10

*SAV<n> Save the values to a specified group in memory.
Parameter 1 - 10

* RST It resets the AC Source to the initial states. It's better to wait for 3 seconds to send the next command.

*SRE It sets conditions of Service Request Enabled Register. If one or more of the enabled events of the Status Byte Register is set, the MSS and RQS of Status Byte Register are set too.

*SRE? This query returns the Service Request Enabled Register.

*STB? This query returns the Status Byte Register.

Bit Configuration of Status Byte Register

Bit Position	7	6	5	4	3	2	1	0
Condition	- -	MSS RQS	ESB	MAV	QUES	- -	- -	- -

ESB = Event Status Byte Summary
QUES = Questionable Status Summary
RQS = Request for Service
MSS = Master Status Summary
MAV = Message Available

* TST? It queries the self-test result of the AC Source.

9.5.2 Instrument Command Dictionary

The commands are listed in alphabetical order. Commands followed by question marks (?) are in query forms. When a command has both command and query forms, it is noted in the description of query syntax.

9.5.2.1 SYSTEM Sub-System

SYSTem
:ERRor?
:VERSion?
:LOCal
:REMote
:DATE
:TIME

SYSTem:ERRor?

Description : This command queries the error string of the command parser.
Query Syntax : SYSTem:ERRor?
Parameter : None
Return Parameter : Error string response: No Error
Data Format Error
Data Range Error
Too Many Errors
Execution Error

SYSTem:VERSion?

Description : This query requests the AC Source to identify itself.
Query Syntax : SYSTem:VERSion?
Parameter : None
Return Parameter : Current version (XX.XX)

SYSTem:LOCal

Description : This command can only be used under the control of RS-232C. If SYST : LOC is programmed, the AC source will be set in the LOCAL state, and the front panel will work.
Query Syntax : None
Parameter : None
Return Parameter : None

SYSTem:REMote

Description : This command can only be used under the control of RS-232C. If SYST : REM is programmed, the AC source will be set in the REMOTE state, and the front panel will be disabled except the "<PAGE/EXIT> key.
Query Syntax : None

Parameter : None
Return Parameter : None

SYSTem:DATE
Description : This command sets the date of the AC Source real time clock.
Query Syntax : **SYSTem:DATE?**
Parameter : <year>,<month>,<day>
Return Parameter : 2008,01,01

SYSTem:TIME
Description : This command sets the time (24H) of the AC Source real time clock.
Query Syntax : **SYSTem:TIME?**
Parameter : <hour>,<minute>,<second>
Return Parameter : 20,30,01

9.5.2.2 INSTRUMENT Sub-System

INSTrument
:EDIT
:Couple
:NSELect
:SELect
:PHASe

INSTrument:EDIT
Description : It is very convenient to use a programmed command to set all phases at the same time for an AC Source that equipped with multiple phases. If INST:EDIT ALL has been programmed, it will be sent to all phases. INST:EDIT EACH command disables EDIT ALL command.
Query Syntax : INSTrument:EDIT?
Parameter : EACH | ALL
Return Parameter : None

INSTrument : COUPle
Description : It is easy to use a command to program all phases in an AC Source with multiple phases. If INST: COUP ALL is programmed, the command will be sent to all phases. INST: COUP NONE command will cancel COUP ALL command.
Query Syntax : INSTrument : COUPle?
Parameter : NONE | ALL
Return Parameter : None

INSTrument : NSELect
Description : This command sets individual output for subsequent commands or queries in the multi-phase model. If INST: COUP NONE has been programmed, the phase selection command will send to a specific output phase set by INSTrument: NSELect. If INST: COUP ALL has been programmed, all remote operation commands will send to all output phases. This command only affects the set voltage and

queries the measurement data. For instance, if “INST: COUP ALL ”, “INST : NSEL 2” and “Meas : VOLT?” are programmed, the AC Source will return Φ 2 measurement voltage. INST: NSEL follows the number to select phase.

Query Syntax : INSTrument : NSELect?
Parameter : 1 | 2 | 3
Return Parameter : 1 | 2 | 3

INSTrument : SELect

Description : This command sets individual output for subsequent commands or queries in the multi-phase model. If INST: COUP NONE has been programmed, the phase selection command will send to a specific output phase set by INSTrument: SELect. If INST: COUP ALL has been programmed, all remote operation commands will send to all output phases. This command only affects the set voltage and queries the measurement data. For instance, if “INST: COUP ALL ”, “INST: SEL OUTPUT2” and “Meas: VOLT?” are programmed, the AC Source will return Φ 2 measurement voltage. INST: SELect follows the number to select phase.

Query Syntax : None
Parameter : OUTPUT1 | OUTPUT2 | OUTPUT3
Return Parameter : None

INSTrument : PHASe

Description : It switches between single phase and three-phase mode.
Query Syntax : INSTrument : PHASe?
Parameter : THREE | SINGLE
Return Parameter : THREE | SINGLE

9.5.2.3 FETCH & MEASURE Sub-System

FETCh | MEASure

```
[ : SCALar]
    : CURRent
        : AC?                       It queries the rms current of AC component.
        : DC?                       It queries the DC current level.
        : ACDC?                     It queries the current (AC+DC) rms.
        : AMPLitude : MAXimum?      It queries the peak current.
        : CRESTfactor?              It queries the current crest factor.
        : INRush?                   It queries the inrush current.
    : FREQuency?                    It queries the frequency.
    : POWer
        : AC
            [: REAL]?               It queries the real power.
            : APParent?             It queries the apparent power.
            : REACtive?             It queries the reactive power.
            : PFACtor?              It queries the power factor.
            : TOTal?                It queries the total power.
            : TOTal : APParent?     It queries the total apparent power.
```

:VOLTage	
: AC?	It queries the rms voltage of AC component.
: DC?	It queries the DC voltage.
: ACDC?	It queries the rms voltage
: AMPLitude : MAXimum?	It queries the peak voltage.
:LINE	
:V12?	It queries the voltage difference of phase 1 & 2.
:V23?	It queries the voltage difference of phase 2 & 3.
:V31?	It queries the voltage difference of phase 3 & 1.

This command enables users to get measurement data from the AC Source via MEASure and FETCh. MEASure triggers the acquisition to get new data before returning data, while FETCh returns the previously acquired data from measurement buffer.

FETCh [: SCALar] : CURRent : AC?
MEASure [: SCALar] : CURRent : AC?
Description : These queries return the rms current of AC component that is output from the output terminal.
Query Syntax : FETCh : CURRent : AC?, MEASure : CURRent : AC?
Return Parameter : <NR2>

FETCh [: SCALar] : CURRent : DC?
MEASure [: SCALar] : CURRent : DC?
Description : These queries return the DC current that is output from the output terminal.
Query Syntax : FETCh : CURRent : DC?, MEASure : CURRent : DC?
Return Parameter : <NR2>

FETCh [: SCALar] : CURRent : ACDC?
MEASure [: SCALar] : CURRent : ACDC?
Description : These queries return the rms current that is output from the output terminal.
Query Syntax : FETCh : CURRent : ACDC?, MEASure : CURRent : ACDC?
Return Parameter : <NR2>

FETCh [: SCALar] : CURRent : AMPLitude : MAXimum?
MEASure [: SCALar] : CURRent : AMPLitude : MAXimum?
Description : These queries return the absolute value of peak current.
Query Syntax : FETCh : CURRent : AMPLitude : MAXimum?,
MEASure : CURRent : AMPLitude : MAXimum?
Return Parameter : <NR2>

FETCh [: SCALar] : CURRent : CREStfactor?
MEASure [: SCALar] : CURRent : CREStfactor?
Description : These queries return the output current crest factor. It is the ratio of peak output current to rms output current.
Query Syntax : FETCh : CURRent : CREStfactor?
MEASure : CURRent : CREStfactor?
Return Parameter : <NR2>

FETCh [: SCALar] : CURRent : INRush?
MEASure [: SCALar] : CURRent : INRush?

Description : These queries return the inrush current that is output from the output terminal.
Query Syntax : FETCh:CURRent: INRush?, MEASure: CURRent : INRush?
Return Parameter : <NR2>

FETCh [: SCALar] : FREQuency?
MEASure [: SCALar] : FREQuency?

Description : These queries return the output frequency in Hertz.
Query Syntax : FETCh : FREQuency?
MEASure : FREQuency?
Return Parameter : <NR2>

FETCh [: SCALar] : POWer : AC [: REAL] ?
MEASure [: SCALar] : POWer : AC [: REAL] ?

Description : These queries return the real power that is output from the output terminals in watt.
Query Syntax : FETCh : POWer : AC?
MEASure : POWer : AC?
Return Parameter : <NR2>

FETCh [: SCALar] : POWer : AC : APParent?
MEASure [: SCALar] : POWer : AC : APParent?

Description : These queries return the apparent power that is output from the output terminals in volt-ampere.
Query Syntax : FETCh : POWer : AC : APParent?
MEASure : POWer : AC : APParent?
Return Parameter : <NR2>

FETCh [: SCALar] : POWer : AC : REACtive?
MEASure [: SCALar] : POWer : AC : REACtive?

Description : These queries return the reactive power that is output from the output terminals in volt-ampere. Reactive power is calculated by the following formula:

$$VAR = \sqrt{APPARENTPOWER^2 - REALPOWER^2}$$

Query Syntax : FETCh : POWer : AC : REACtive?
MEASure : POWer : AC : REACtive?
Return Parameter : <NR2>

FETCh [: SCALar] : POWer : AC : PFACtor?
MEASure [: SCALar] : POWer : AC : PFACtor?

Description : These queries return the power factor that is output from the output terminals. Power factor is computed by:
PF = TRUE POWER / APPARENT POWER
Query Syntax : FETCh : POWer : AC : PFACtor?
MEASure : POWer : AC : PFACtor?
Return Parameter : <NR2>

FETCh [: SCALar] : POWer : AC : TOTal ?
MEASure [: SCALar] : POWer : AC : TOTal ?

Description : These queries return the total of real power that is output from 3-phase output terminal in watt.
Query Syntax : FETCh : POWer : AC : TOTal?
MEASure : POWer : AC : TOTal?
Return Parameter : <NR2>

FETCh [:SCALar]:POWer:AC:TOTal:APParent?
MEASure [:SCALar]:POWer:AC:TOTal:APParent?

Description : These queries return the total apparent power that is output from 3-phase output terminal in volt-ampere.
Query Syntax : FETCh:POWer:AC:TOTal:APParent?
MEASure:POWer:AC:TOTa**l:APParent?**
Return Parameter : <NR2>

FETCh [: SCALar] : VOLTage : AC?
MEASure [: SCALar] : VOLTage : AC?

Description : These queries return the rms of AC component that is output from the output terminal.
Query Syntax : FETCh [: SCALar] : VOLTage : AC?
MEASure [: SCALar] : VOLTage : AC?
Return Parameter : <NR2>

FETCh [: SCALar] : VOLTage : DC?
MEASure [: SCALar] : VOLTage : DC?

Description : These queries return the DC composite voltage that is output from the output terminal.
Query Syntax : FETCh [: SCALar] : VOLTage : DC?
MEASure [: SCALar] : VOLTage : DC?
Return Parameter : <NR2>

FETCh [: SCALar] : VOLTage : ACDC?
MEASure [: SCALar] : VOLTage : ACDC?

Description : These queries return the rms that is output from the output terminal.
Query Syntax : FETCh [: SCALar] : VOLTage : ACDC?
MEASure [: SCALar] : VOLTage : ACDC?
Return Parameter : <NR2>

FETCh [: SCALar] : VOLTage: AMPLitude : MAXimum?
MEASure [: SCALar] : VOLTage : AMPLitude : MAXimum?

Description : These queries return the absolute value of peak voltage.
Query Syntax : FETCh : **VOLTage**: AMPLitude : MAXimum?,
MEASure : **VOLTage** : AMPLitude : MAXimum?
Return Parameter : <NR2>

FETCh [: SCALar] : LINE : V12?
MEASure [: SCALar] : LINE : V12?

Description : These queries return the line voltage between phase 1 and 2.

Query Syntax : FETCh [: SCALar] : LINE : V12?
MEASure [: SCALar] : LINE : V12?
Return Parameter : <NR2>

FETCh [: SCALar] : LINE : V23?
MEASure [: SCALar] : LINE : V23?
Description : These queries return the line voltage between phase 2 and 3.
Query Syntax : FETCh [: SCALar] : LINE : V23?
MEASure [: SCALar] : LINE : V23?
Return Parameter : <NR2>

FETCh [: SCALar] : LINE : V31?
MEASure [: SCALar] : LINE : V31?
Description : These queries return the line voltage between phase 3 and 1.
Query Syntax : FETCh [: SCALar] : LINE : V31?
MEASure [: SCALar] : LINE : V31?
Return Parameter : <NR2>

9.5.2.4 OUTPUT Sub-System

OUTPut
[: STATe]
: RELay
: SLEW
: VOLTage
: AC
: DC
:FREQency
: COUPling
: MODE
: PROTection
:CLEar
: IMPedance
: STATe
: RESistor
: INDuction

OUTPut [: STATe]
Description : This command enables or disables the output of the AC Source. Disabled output is to set the output voltage amplitude to 0 Volt.
Query Syntax : OUTPut [: STATe]?
Parameter : OFF | ON
Return Parameter : OFF | ON

OUTPut : RELay
Description : This command sets output relay on or off.
Query Syntax : OUTPut : RELay?
Parameter : OFF | ON, ON sets the output relay of the AC Source on (close), OFF sets the output relay of the AC source off (open).
Return Parameter : OFF | ON

OUTPut : SLEW : VOLTage : AC

Description : This command sets the slew rate of the AC output voltage.
Query Syntax : OUTPut : SLEW : VOLTage : AC?
Parameter : <NR2>, the valid range is 0.000V/ms ~ 1200.000V/ms.
Return Parameter : <NR2>

OUTPut : SLEW : VOLTage : DC

Description : This command sets the slew rate of the DC composite voltage.
Query Syntax : OUTPut : SLEW : VOLTage : DC?
Parameter : <NR2>, the valid range is 0.000V/ms ~ 1200.000V/ms.
Return Parameter : <NR2>

OUTPut : SLEW : FREQuency

Description : This command sets the slew rate of the output frequency.
Query Syntax : OUTPut : SLEW : FREQuency?
Parameter : <NR2>, the valid range is 0.000 Hz/ms ~ 1600.000Hz/ms
Return Parameter : <NR2>

OUTPut : COUPling

Description : This command selects the coupling of the output signals.
Query Syntax : OUTPut : COUPling?
Parameter : AC | DC | ACDC
Return Parameter : AC | DC | ACDC

OUTPut : MODE

Description : This command sets the operation mode and "FIXED" mode is the general operation mode.
Query Syntax : OUTPut : MODE?
Parameter : FIXED | LIST | PULSE | STEP | SYNTH | INTERHAR
Return Parameter : FIXED | LIST | PULSE | STEP | SYNTH | INTERHAR

OUTPut : PROTection : CLEar

Description : This command clears the latch that disables the output when over current (OCP), over temperature (OTP), over power (OPP) or remote inhibit (RI) is detected. All conditions that generate the faults must be resolved before the latch is cleared.
Query Syntax : None
Parameter : None
Return Parameter : None

OUTPut : IMPedance : STATe

Description : This command sets if enabling the output impedance control.
Query Syntax : OUTPut : IMPedance : STATe?
Parameter : ON | OFF
Return Parameter : ON | OFF

OUTPut : IMPedance : RESistor

Description : This command sets the resistance of output impedance.
Query Syntax : OUTPut : IMPedance : RESistor?
Parameter : <NR2>, the valid range is 0.00Ω ~ 1.00Ω.

Return Parameter : <NR2>

OUTPut : IMPedance : INDuction

Description : This command sets the inductance of output impedance.
Query Syntax : OUTPut : IMPedance : INDuction?
Parameter : <NR2>, the valid range is 0.00mH ~ 1.00mH.
Return Parameter : <NR2>

9.5.2.5 SOURCE Sub-System

[SOURce :]

```
CURRent
    : LIMit
    : DELay
    : INRush
        : STARt
        : INTerval
: RANGe
FREQency
    [: {CW | IMMediate}]
     : LIMit
VOLTage
    [: LEVel][: IMMediate][:AMPLitude]
        : AC
        : DC
    : LIMit
        : AC
        : DC
            : PLUS
            : MINus
    : RANGe

POWer
   : PROTection

FUNCtion
    : SHAPe
    : SHAPe
            : A
            : A
                : MODE
                : THD
                : AMP
           : B
           : B
              : MODE
              : THD
              : AMP
```

[SOURce :] CURRent : LIMit

Description : This command sets the rms current limit of the AC Source for protection.

Query Syntax : [SOURce :] CURRent : LIMit?
Parameter : <NR2>, the valid range is 0.00 ~ maximum current spec. of the specific model (unit: A.)
Return Parameter : <NR2>

[SOURce :] CURRent : DELay
Description : This command sets the time delayed for triggering over current protection.
Query Syntax : [SOURce :] CURRent : DELay?
Parameter : <NR2>, the valid range is 0.0 ~ 5.0 (unit: 0.1 second.)
Return Parameter : <NR2>

[SOURce :] CURRent : INRush : STARt
Description : This command sets the time to start the inrush current measurement.
Query Syntax : [SOURce :] CURRent : INRush : STARt?
Parameter : <NR2>, the valid range is 0 ~ 9999 (unit: ms.)
Return Parameter : <NR2>

[SOURce :] CURRent : INRush : INTerval
Description : This command sets the measuring interval for inrush current measurement.
Query Syntax : [SOURce :] CURRent : INRush : INTerval?
Parameter : <NR2>, the valid range is 0 ~ 9999 (unit: ms.)
Return Parameter : <NR2>

[SOURce:]CURRent:RANGe
Description : This command sets the current measurement range for output.
Query Syntax : [SOURce:]CURRent:RANGe?
Parameter :

Para. / Model	1	2	3	AUTO
61512	12A	48A	192A	Auto
61511	8A	32A	128A	Auto
61612	12A	48A	192A	Auto
61611	8A	32A	128A	Auto

Return Parameter :1 |2 |3 | Auto

[SOURce :] FREQuency [: {CW | IMMediate}]
Description : This command sets the output waveform frequency for the AC Source in Hz.
Query Syntax : [SOURce :] FREQuency [: {CW | IMMediate}]?
Parameter : <NR2>, the valid range is 15.00 ~ 1500.0 (unit: Hz.)
Return Parameter : <NR2>

[SOURce :] FREQuency : LIMit
Description : This command sets the output frequency limit for the AC Source.
Query Syntax : [SOURce :] FREQuency : LIMit?
Parameter : <NR2>, the valid range is 15.00 ~ 1500.00 (unit: Hz)

Return Parameter : <NR2>

[SOURce :] POWer:PROTection

Description : This command sets the OPP (Over Power Protection) for AC Source.
Query Syntax : [SOURce :] POWer:PROTection?
Parameter : <NR2>, the valid range is 0.0 ~ maximum power of specific model (unit: W.)
Return Parameter : <NR2>

[SOURce :] VOLTage [: LEVel][: IMMediate][: AMPLitude] : AC

Description : This command sets the AC composite output voltage in Volts.
Query Syntax : [SOURce :] VOLTage [: LEVel][: IMMediate][: AMPLitude] : AC?
Parameter : <NR2>, the valid range is 0.0 ~ 150.0 (low range), 0.0 ~ 300.0 (high range.)
Return Parameter : <NR2>

[SOURce :] VOLTage [: LEVel][: IMMediate][: AMPLitude] : DC

Description : This command sets the DC composite output voltage in Volts.
Query Syntax : [SOURce :] VOLTage [: LEVel][: IMMediate][: AMPLitude] : DC?
Parameter : <NR2>, the valid range is -212.1 ~ 212.1 (low range), -424.2 ~ 424.2 (high range.)
Return Parameter : <NR2>

[SOURce :] VOLTage : LIMit : AC

Description : This command sets the Vac LIMIT to restrict the value of Vac.
Query Syntax : [SOURce :] VOLTage : LIMit : AC?
Parameter : <NR2>, the valid range is 0.0 ~ 300.0 (unit: V.)
Return Parameter : <NR2>

[SOURce :] VOLTage : LIMit : DC : PLUS

Description : This command sets the Vdc Limit(+).
Query Syntax : [SOURce :] VOLTage : LIMit : DC : PLUS?
Parameter : <NR2>, the valid range is -424.2 ~ 424.2 (unit: V)
PS: The lower limit cannot exceed Vdc Limit(-).
Return Parameter : <NR2>

[SOURce :] VOLTage : LIMit : DC : MINus

Description : This command sets the Vdc Limit(-).
Query Syntax : [SOURce :] VOLTage : LIMit : DC : MINus?
Parameter : <NR2>, the valid range is -424.2 ~ -424.2 (unit: V)
PS: The upper limit cannot exceed Vdc Limit(+).
Return Parameter : <NR2>

[SOURce :] VOLTage : RANGe

Description : This command sets the output voltage range to LOW (150 V) or HIGH (300 V) or AUTO 3 selections.
Query Syntax : [SOURce :] VOLTage : RANGe?
Parameter : LOW | HIGH
Return Parameter : LOW | HIGH

[SOURce :] FUNCtion : SHAPe

Description : This command specifies the waveform buffer. The AC Source output has two buffers and users need to specify to use the contents of the waveform buffer A or B.
Query Syntax : [SOURce :] FUNCtion : SHAPe?
Parameter : A | B
Return Parameter : A | B

[SOURce :] FUNCtion : SHAPe : A

Description : This command specifies the waveform buffer A for use.
Query Syntax [SOURce :] FUNCtion : SHAPe : A?
Parameter : SINE | SQUA | CSIN | DST<01..30> | USR<01..06>
Return Parameter : SINE | SQUA | CSIN | DST<01..30> | USR<01..06>

[SOURce :] FUNCtion : SHAPe : A : MODE

Description : This command selects the mode for the clipping in waveform buffer A for use.
Query Syntax : [SOURce :] FUNCtion : SHAPe : A : MODE?
Parameter : AMP | THD
Return Parameter : AMP | THD

[SOURce :] FUNCtion : SHAPe : A : THD

Description : This command sets the clipped THD percentage for the clipping in waveform buffer A.
Query Syntax : [SOURce :] FUNCtion : SHAPe : A : THD?
Parameter : <NR2>, the valid range is 0.0% ~ 43%.
Return Parameter : <NR2>

[SOURce :] FUNCtion : SHAPe: A : AMP

Description : This command sets the clipped peak percentage for the clipping in waveform buffer A.
Query Syntax : [SOURce :] FUNCtion : SHAPe : A : AMP?
Parameter : <NR2>, the valid range is 0.0% ~ 100%.
Return Parameter : <NR2>

[SOURce :] FUNCtion : SHAPe : B

Description : This command specifies the waveform buffer B for use.
Query Syntax : [SOURce :] FUNCtion : SHAPe : B?
Parameter : SINE | SQUA | CSIN | DST<01..30> | USR<01..06>
Return Parameter : SINE | SQUA | CSIN | DST<01..30> | USR<01..06>

[SOURce :] FUNCtion : SHAPe : B : MODE

Description : This command selects the mode for the clipping in waveform buffer B for use.
Query Syntax : [SOURce :] FUNCtion : SHAPe : B : MODE?
Parameter : AMP | THD
Return Parameter : AMP | THD

[SOURce :] FUNCtion : SHAPe : B : THD

Description : This command sets the clipped THD percentage for the clipping in waveform buffer B.
Query Syntax : [SOURce :] FUNCtion : SHAPe : B : THD?
Parameter : <NR2>, the valid range is 0.0% ~ 43%.
Return Parameter : <NR2>

[SOURce :] FUNCtion : SHAPe: B : AMP

Description : This command sets the clipped peak percentage for the clipping in waveform buffer B.
Query Syntax : [SOURce :] FUNCtion : SHAPe : B : AMP?
Parameter : <NR2>, the valid range is 0.0% ~ 100%.
Return Parameter : <NR2>

9.5.2.6 CONFIGURE Sub-System

[SOURce :]

CONFigure
: INHibit
: EXTernal
: COUPling
: EXTON

[SOURce :] CONFigure : INHibit

Description : This command sets the Remote Inhibit function.
Query Syntax : [SOURce :] CONFigure : INHibit?
Parameter : DISABLE | ENABLE
Return Parameter : DISABLE | ENABLE

[SOURce :] CONFigure : EXTernal

Description : This command sets if enabling the External-V Reference function.
Query Syntax : [SOURce :] CONFigure : EXTernal?
Parameter : OFF | ON
Return Parameter : OFF | ON

[SOURce :] CONFigure : COUPling?

Description : This command sets the External-V Reference to be AC_AMPLIFIER or DC_LEVEL to control the AC Source output.
Query Syntax : [SOURce :] CONFigure : COUPling?
Parameter : AC | DC
Return Parameter : AC | DC

[SOURce :] CONFigure : EXTON

Description : This command sets the External ON/OFF control.
Query Syntax : [SOURce :] CONFigure : EXTON?
Parameter : DISABLE | ENABLE
Return Parameter : DISABLE | ENABLE

9.5.2.7 PHASE Sub-System

[SOURce:]

PHASe
: ON
: OFF
: P12
: P13
: SEQuence
: THREE
: RELOCK

[SOURce:] PHASe: ON

Description : This command sets the transition angle when the waveform shifts. The default is ON meaning 0 degree.
Query Syntax : [SOURce :] PHASe : ON?
Parameter : <NR2>, the valid range is 0.0 ~ 359.9.
Return Parameter : <NR2>

[SOURce:] PHASe: OFF

Description : This command sets the transition angle when the waveform ends.
Query Syntax : [SOURce :] PHASe : OFF?
Parameter : <NR2>, the valid range is 0.0 ~ 360.0, 360.0: means IMMED.
Return Parameter : <NR2>

[SOURce:]PHASe:P12

Description : This command sets the phase difference of Φ1 and Φ2.
Query Syntax : [SOURce :]PHASe:P12?
Parameter : <NR2>, the valid range is 0.0 ~ 359.9.
Return Parameter : <NR2>

[SOURce:]PHASe:P13

Description : This command sets the phase difference of Φ1 and Φ3.
Query Syntax : [SOURce :]PHASe:P13?
Parameter : <NR2>, the valid range is 0.0 ~ 359.9.
Return Parameter : <NR2>

[SOURce:]PHASe:SEQuence

Description : This command sets the phase sequence in 3-phase mode.
Query Syntax : [SOURce :]PHASe:SEQuence?
Parameter : POS | NEG
Return Parameter : POSITIVE | NEGATIVE

[SOURce:]PHASe:RELOCK

Description : This command sets the relock function in 3-phase mode.
Query Syntax : [SOURce :]PHASe:RELOCK?
Parameter : ENABLE | DISABLE
Return Parameter : ENABLE | DISABLE

[SOURce:]PHASe:THREE

Description : This command set the operation mode in 3-phase mode.

Query Syntax : [SOURce :]PHASe:THREE?
Parameter : INDEPEND | SAMEFREQ | BALANCE
Return Parameter : INDEPEND | SAMEFREQ | BALANCE

9.5.2.8 STATUS Sub-system

STATus
: OPERation
[: EVENt]?
: ENABle
: QUEStionable
: CONDition
[: EVENt]?
: ENABle
: NTRansition
: PTRansition

STATus : OPERation [: EVENt]?
Description : This command queries the Operation Status register.
Query Syntax : STATus : OPERation [: EVENt]?
Parameter : None
Return Parameter : Always 0.

STATus : OPERation : ENABle
Description : This command sets the Operation Status Enable register. The register is the shield when specific bit is enabled from Operation Status register.
Query Syntax : STATus : OPERation : ENABle?
Parameter : <NR1>, the valid range is 0 ~ 255.
Return Parameter : Always 0.

STATus : QUEStionable : CONDition?
Description : This query command returns the value of Questionable Condition register. It is a read only register that saves the questionable condition of AC Source in real time.
Query Syntax : STATus : QUEStionable : CONDition?
Parameter : NONE
Return Parameter : <NR1>, the valid range is 0 ~ 511.

STATus : QUEStionable [: EVENt] ?
Description : This query command returns the value of Questionable Event register. It is a read only register that saves all items that passed Questionable NTR and/or PTR filter. If the QUES bit in Service Request Enabled register has been set and Questionable Event register > 0, the QUES of Status Byte register will be set too.
Query Syntax : STATus : QUEStionable [: EVENt]?
Parameter : NONE
Return Parameter : <NR1>, the valid range is 0 ~ 511.

STATus : QUEStionable : ENABle

Description : The command sets or reads the value of Questionable Enable register. The register is the shield when specific bit is enabled to set the QUES bit of Status Byte register from Operation Status register.
Query Syntax : STATus : QUEStionable : ENABle?
Parameter : <NR1>, the valid range is 0 ~ 511.
Return Parameter : <NR1>

STATus : QUEStionable : NTRansition

Description : These commands set or read the value of register.
The operation of these registers is the same as polarity filter of Questionable Enable and Questionable Event registers that lead the following actions:

* When a bit of the Questionable NTR register is set to 1, a 1-to-0 transition of the corresponding bit in the Questionable Condition register will make that bit in the Questionable Event register to be set.

* When a bit of the Questionable PTR register is set to 1, a 0-to-1 transition of the corresponding bit in the Questionable Condition register will make that bit in the Questionable Event register to be set.

* If the two same bits in both NTR and PTR registers are set to 0, none transition of that bit in the Questionable Condition register can set the corresponding bit in the Questionable Event register.

Bit Configuration of Questionable Status Register

Bit Position	15-9	8	7	6	5	4	3	2	1	0
Condition	---	OVP	INP	OCP	FAN	SHT	OTP	OPP	INT-DD	INT-AD

OVP: Output voltage protection
INP: Line input protection.
OCP: Over current protection.
FAN: Fan failure.
SHT: Output short protection.
OTP: Over temperature protection.
OPP: Over power protection.
INT-DD: Inner DD power stage protection
INT-AD: Inner AD power stage protection

Query Syntax : STATus : QUEStionable : NTRansition?
Parameter : <NR1>, the valid range is 0 ~ 511.
Return Parameter : <NR1>

STATus : QUEStionable : PTRansition

Description : These commands set or read the values of Questionable PTR register. Please refer to the description of previous command.
Query Syntax : STATus : QUEStionable : PTRansition?
Parameter : <NR1>, the valid range is 0 ~ 511.

Return Parameter : <NR1>

9.5.2.9 TRACE Sub-system

TRACe
: RMS

TRACe
Description : This command sets the user-defined waveform data. It needs 1024 data points to create a period of waveform. Users have to normalize the data and make the maximum point equal to 32767 or the minimum point equal to -32767.
Syntax : TRACe <waveform_name>, <amplitude> {,<amplitude>}
Parameter : <waveform_name>:US<n>, n=1~6, <amplitude>:<NR1>, the valid range is -32767 ~ 32767.
Example : TRACe US1 100 200 …32767... 500 800 <= 1024 points
This command requires about 5 seconds for execution.

TRACe : RMS
Description : This command sets the rms value of user's waveform. Users need to calculate the root mean square value for 1024 data points.
Syntax : TRACe : RMS <waveform_name>, <rms>
Parameter : <waveform_name>:US<n>, n=1~6, <rms>:<NR1>, the valid range is 0 ~ 32767.
Example : TRACe : RMS US1 27000

9.5.2.10 LIST Sub-system

[SOURce :]
LIST
: COUPling
:TRIG
: POINts?
: COUNt
: DWELl
: SHAPe
: BASE
: VOLTage
: AC
: STARt
: END
: DC
: STARt
: END
: FREQuency
: STARt
: END
: DEGRee
OUTPut
: MODE

TRIG
TRIG : STATE?

[SOURce:]LIST : COUPling
Description : This command sets the function of list mode.
Query Syntax : [SOURce:] LIST : Coupling?
Parameter : ALL | NONE
Return Parameter : ALL | NONE

[SOURce:]LIST : TRIG
Description : This command sets the trigger type of list mode.
Query Syntax : [SOURce:] LIST : TRIG?
Parameter : AUTO | MANUAL|EXCITE
Return Parameter : AUTO | MANUAL|EXCITE

[SOURce:] LIST : POINts?
Description : This command returns the valid order number of list mode.
Query Syntax : [SOURce:] LIST : POINts?
Parameter : None
Return Parameter : <NR1>, the valid range is 0 ~ 100.

[SOURce :] LIST : COUNt
Description : This command sets the number of times the list executed before completion.
Query Syntax : [SOURce :] LIST : COUNt?
Parameter : <NR1>, the valid range is 0 ~ 65535.
Return Parameter : <NR1>

[SOURce :] LIST : DWELl
Description : This command sets the sequence of dwell time list points.
Query Syntax : [SOURce:] LIST : DWELl?
Parameter : <NR2>, …, <NR2>, the valid range is 0 ~ 99999999.9 (unit: ms.)
Return Parameter : <NR2>, …, <NR2>

[SOURce :] LIST : SHAPe
Description : This command sets the sequence of waveform buffer list points.
Query Syntax : [SOURce:] LIST : SHAPe?
Parameter : A|B, …, A|B
Return Parameter : A|B, …, A|B

[SOURce :] LIST : BASE
Description : This command sets the time base of list.
Query Syntax : [SOURce:] LIST : BASE?
Parameter : TIME | CYCLE
Return Parameter : TIME | CYCLE

[SOURce :] LIST : VOLTage : AC : STARt
Description : This command sets the sequence of AC start voltage list points.
Query Syntax : [SOURce:] LIST : VOLTage : AC : STARt?
Parameter : <NR2>, …, <NR2>, the valid range is 0.0 ~ 150.0 (low range), 0.0 ~ 300.0 (high range.)
Return Parameter : <NR1>, …, <NR2>

[SOURce :] LIST : VOLTage : AC : END

Description : This command sets the sequence of AC end voltage list points.
Query Syntax : [SOURce:] LIST : VOLTage : AC : END?
Parameter : <NR2>, …, <NR2>, the valid range is 0.0 ~ 150.0 (low range), 0.0 ~ 300.0 (high range.)
Return Parameter : <NR2>, …, <NR2>

[SOURce :] LIST : VOLTage : DC : STARt

Description : This command sets the sequence of DC start voltage list points.
Query Syntax : [SOURce:] LIST : VOLTage : DC : STARt?
Parameter : <NR2>, …, <NR2>, the valid range is -212.1 ~ 212.1 (low range), -424.2 ~ 414.2 (high range.)
Return Parameter : <NR1>

[SOURce :] LIST : VOLTage : DC : END

Description : This command sets the sequence of DC end voltage list points.
Query Syntax : [SOURce:] LIST : VOLTage : DC : STARt?
Parameter : <NR2>, …, <NR2>, the valid range is -212.2 ~ 212.1 (low range), -424.2 ~ 414.2 (high range.)
Return Parameter : <NR2>, …, <NR2>

[SOURce :] LIST : FREQuency : STARt

Description : This command sets the sequence of start frequency list points.
Query Syntax : [SOURce:] LIST : FREQuency : STARt?
Parameter : <NR2>, …, <NR2>, the valid range is 15.00 ~ 1500.00 (unit: Hz.)
Return Parameter : <NR2>, …, <NR2>

[SOURce :] LIST : FREQuency : END

Description : This command sets the sequence of end frequency list points.
Query Syntax : [SOURce:] LIST : FREQuency : END?
Parameter : <NR2>, …, <NR2>, the valid range is 15.0 ~ 1500.0 (unit: Hz.)
Return Parameter : <NR2>, …, <NR2>

[SOURce :] LIST : DEGRee

Description : This command sets the sequence of phase angle list points.
Query Syntax : [SOURce:] LIST : DEGRee?
Parameter : <NR2>, …, <NR2>, the valid range is 0.0 ~ 359.9.
Return Parameter : <NR2>, …, <NR2>

OUTPut : MODE

Description : This command sets the operation mode.
Query Syntax : OUTPut : MODE?
Parameter : FIXED | LIST | PULSE | STEP | SYNTH | INTERHAR
Return Parameter : FIXED | LIST | PULSE | STEP | SYNTH | INTERHAR

TRIG

Description : This command sets LIST mode in OFF, ON execution state after setting OUTPut: MODE LIST. If users wish to change the parameters, it's necessary to set TRIG OFF then OUTPut: MODE FIXED. Then, set OUTPut : MODE LIST again to get ready to set TRIG ON.
Query Syntax : TRIG : STATE?
Parameter : OFF | ON
Return Parameter : OFF | RUNNING

9.5.2.11 PULSE Sub-system

[SOURce :]
PULSe
: VOLTage
: AC
: DC
: FREQuency
: SHAPe
: SPHase
: COUNt
: DCYCle
: PERiod
: TRIG
OUTPut
: MODE

TRIG
TRIG : STATE?

[SOURce :] PULSe : VOLTage : AC
Description : This command sets AC voltage for the duty cycle of PULSE mode.
Query Syntax : [SOURce :] PULSE : VOLTage : AC?
Parameter : <NR2>, the valid range is 0.0 ~ 150.0 (low range), 0.0 ~ 300.0 (high range.)
Return Parameter : <NR2>

[SOURce :] PULSe : VOLTage : DC
Description : This command sets the DC voltage for the duty cycle of PULSE mode.
Query Syntax : [SOURce :] PULSE : VOLTage : DC?
Parameter : <NR2>, the valid range is -212.1 ~ 212.1 (low range), -424.2 ~ 424.2 (high range.)
Return Parameter : <NR2>

[SOURce :] PULSe : FREQuency
Description : This command sets the frequency for the duty cycle of PULSE mode.
Query Syntax : [SOURce :] PULSE : FREQuency?
Parameter : <NR2>, the valid range is 15.0 ~ 1500.0 (unit: Hz.)
Return Parameter : <NR2>

[SOURce :] PULSe : SHAPe
Description : This command selects the waveform buffer for PULSE mode.
Query Syntax : [SOURce :] PULSE : SHAPe?
Parameter : A | B
Return Parameter : A | B

[SOURce :] PULSe : SPHase
Description : This command sets the start phase angle of duty cycle for PULSE mode.
Query Syntax : [SOURce :] PULSE : SPHase?
Parameter : <NR2>, the valid range is 0.0 ~ 359.9.
Return Parameter : <NR2>

[SOURce :] PULSe : COUNt

Description : This command sets the number of times the pulse executed before completion.
Query Syntax : [SOURce :] PULSE : COUNt?
Parameter : <NR2>, the valid range is 0 ~ 65535.
Return Parameter : <NR2>

[SOURce :] PULSe : DCYCle

Description : This command sets the duty cycle of PULSE mode.
Query Syntax : [SOURce :] PULSE : DCYCle?
Parameter : <NR2>, the valid range is 0 % ~ 100 %.
Return Parameter : <NR2>

[SOURce :] PULSe : PERiod

Description : This command sets the period of the PULSE mode.
Query Syntax : [SOURce :] PULSE : PERiod?
Parameter : <NR2>, the valid range is 0 ~ 99999999.9 (unit: ms.)
Return Parameter : <NR2>

[SOURce:]PULSe : TRIG

Description : This command sets the TRIG type of PULSE mode.
Query Syntax : [SOURce:] PULSe : TRIG?
Parameter : AUTO | MANUAL|EXCITE
Return Parameter : AUTO | MANUAL|EXCITE

OUTPut : MODE

Description : This command sets the operation mode.
Query Syntax : OUTPut : MODE?
Parameter : FIXED | LIST | PULSE | STEP | SYNTH | INTERHAR
Return Parameter : FIXED | LIST | PULSE | STEP | SYNTH | INTERHAR

TRIG

Description : This command sets PULSE mode in OFF execution state after setting OUTPut : MODE PULSE. If users want to change the parameters, it's necessary to set TRIG OFF then OUTPut : MODE FIXED. Then, set OUTPut : MODE PULSE again to get ready to set TRIG ON.
Query Syntax : TRIG : STATE?
Parameter : OFF | ON
Return Parameter : OFF | RUNNING

9.5.2.12 STEP Sub-system

[SOURce :]

STEP

: VOLTage
: AC
: DC
: FREQuency
: SHAPe
: SPHase

: DVOLtage
: AC
: DC
: DFRequency
: DWELl
: COUNt
: TRIG

OUTPut
: MODE

TRIG
TRIG : STATE?

[SOURce :] STEP : VOLTage : AC
Description : This command sets the initial AC voltage of STEP mode.
Query Syntax : [SOURce :] STEP : VOLTage : AC?
Parameter : <NR2>, the valid range is 0.0 ~ 150.0 (low range), 0.0 ~ 300.0 (high range.)
Return Parameter : <NR2>

[SOURce :] STEP : VOLTage : DC
Description : This command sets the initial DC voltage of STEP mode.
Query Syntax : [SOURce :] STEP : VOLTage : DC?
Parameter : <NR2>, the valid range is -212.1 ~ 212.1 (low range), -424.2 ~ 414.2 (high range.)
Return Parameter : <NR2>

[SOURce :] STEP : FREQuency
Description : This command sets the initial frequency of STEP mode.
Query Syntax : [SOURce :] STEP : FREQuency?
Parameter : <NR2>, the valid range is 15.0 ~ 1500.0 (unit: Hz.)
Return Parameter : <NR2>

[SOURce :] STEP : SHAPe
Description : This command selects the waveform buffer of STEP mode.
Query Syntax : [SOURce :] STEP : SHAPe?
Parameter : A | B
Return Parameter : A | B

[SOURce :] STEP : SPHase
Description : This command sets the start phase angle of STEP mode.
Query Syntax : [SOURce :] STEP : SPHase?
Parameter : <NR2>, the valid range is 0.0 ~ 359.9.
Return Parameter : <NR2>

[SOURce :] STEP : DVOLtage : AC
Description : This command sets the AC voltage change in each step.
Query Syntax : [SOURce :] STEP : DVOLtage : AC?
Parameter : <NR2>, the valid range is -150.0 ~ 150.0 (low range), -300.0 ~ 300.0 (high range.)
Return Parameter : <NR2>

[SOURce :] STEP : DVOLtage : DC

Description : This command sets the DC voltage change in each step.
Query Syntax : [SOURce :] STEP : DVOLtage : DC?
Parameter : <NR2>, the valid range is -212.2 ~ 212.1 (low range), -424.2 ~ 424.2 (high range.)
Return Parameter : <NR2>

[SOURce :] STEP : DFRequency
Description : This command sets the frequency change in each step.
Query Syntax : [SOURce :] STEP : DFRequency?
Parameter : <NR2>, the valid range is -1500.00 ~ 1500.0 (unit: Hz.)
Return Parameter : <NR2>

[SOURce :] STEP : DWELl
Description : This command sets the dwell time in each step.
Query Syntax : [SOURce :] STEP : DWELl?
Parameter : <NR2>, the valid range is 0 ~ 99999999.9 (unit: ms.)
Return Parameter : <NR2>

[SOURce :] STEP : COUNt
Description : This command sets the number of times the step executed before completion.
Query Syntax : [SOURce :] STEP : COUNt?
Parameter : <NR2>, the valid range is 0 ~ 65535.
Return Parameter : <NR2>

[SOURce:] STEP : TRIG
Description : This command sets the TRIP type of STEP mode.
Query Syntax : [SOURce:] STEP : TRIG?
Parameter : AUTO | MANUAL
Return Parameter : AUTO | MANUAL

OUTPut : MODE
Description : This command sets the operation mode.
Query Syntax : OUTPut : MODE?
Parameter : FIXED | LIST | PULSE | STEP | SYNTH | INTERHAR
Return Parameter : FIXED | LIST | PULSE | STEP | SYNTH | INTERHAR

TRIG
Description : This command sets STEP mode in OFF, ON execution state after setting OUTPut : MODE STEP. If users want to change the parameters, it's necessary to set TRIG OFF then OUTPut : MODE FIXED. Then, set OUTPut : MODE STEP again to get ready to set TRIG ON.
Query Syntax : TRIG : STATE?
Parameter : OFF | ON
Return Parameter : OFF | RUNNING

9.5.2.13 SYNTHESIS Sub-system

[SOURce :]
SYNThesis
: COMPose
: AMPLitude

: PHASe
: FUNDamental
: DC
: FREQuency
: SPHase

OUTPut
: MODE

TRIG
TRIG : STATE?

[SOURce :] SYNThesis : COMPose
Description : This command sets the data format of each harmonic order. VALUE: absolute value, PERCENT: basic computer percentage. Users can program 6 waveforms for execution.
Query Syntax : [SOURce :] SYNThesis : COMPose?
Parameter : VALUE1 | VALUE2 | VALUE3 | PERCENT1 | PERCENT2 | PERCENT3
Return Parameter : VALUE1 | VALUE2 | VALUE3 | PERCENT1 | PERCENT2 | PERCENT3

[SOURce :] SYNThesis : AMPLitude
Description : This command sets the amplitude of each harmonic order. The maximum order is 40.
Query Syntax : [SOURce :] SYNThesis : AMPLitude?
Parameter : <NR2>, …, <NR2>
Valid range:

Order	Value	Percentage
2 ~ 10	0 ~ 150.0	0 ~ 100.00
11 ~ 20	0 ~ 120.0	0 ~ 50.00
21 ~ 30	0 ~ 80.0	0 ~ 30.00
31 ~ 40	0 ~ 45.0	0 ~ 15.00

Return Parameter : <NR2>, …,<NR2>

[SOURce :] SYNThesis : PHASe
Description : This command sets the phase angle of each harmonic order.
Query Syntax : [SOURce :] SYNThesis : PHASe?
Parameter : <NR2>, …, <NR2>, the valid range: 0.0 ~ 359.9
Return Parameter : <NR2>, …, <NR2>

[SOURce :] SYNThesis : FUNDamental
Description : This command sets the fundamental AC voltage in SYNTHESIS mode.
Query Syntax : [SOURce :] SYNThesis : FUNDamental?
Parameter : <NR2>, the valid range: 0.0 ~ 150.0 (low range), 0.0 ~ 300.0 (high range)
Return Parameter : <NR2>

[SOURce :] SYNThesis : DC
Description : This command sets the DC voltage to add the voltage waveform in SYNTHESIS mode.

Query Syntax : [SOURce :] SYNThesis : DC?
Parameter : <NR2>, the valid range: -212.1 ~ 212.1 (low range), -424.2 ~ 424.2 (high range)
Return Parameter : <NR2>

[SOURce :] SYNThesis : FREQuency
Description : This command sets the fundamental frequency in SYNTHESIS mode.
Query Syntax : [SOURce :] SYNThesis : FREQuency?
Parameter : 50 | 60
Return Parameter : 50 | 60

[SOURce :] SYNThesis : SPHase
Description : This command sets the start phase angle in SYNTHESIS mode.
Query Syntax : [SOURce :] SYNThesis : SPHase?
Parameter : <NR2>, the valid range: 0.0 ~ 359.9
Return Parameter : <NR2>

OUTPut : MODE
Description : This command sets the operation mode. User should quit output before setting **OUTPut : MODE SYNTH.**
Query Syntax : OUTPut : MODE?
Parameter : FIXED | LIST | PULSE | STEP | SYNTH | INTERHAR
Return Parameter : FIXED | LIST | PULSE | STEP | SYNTH | INTERHAR

TRIG
Description : This command sets SYNTHESIS mode in OFF, ON execution state after setting **OUTPut : MODE SYNTH**. If users want to change the parameters, it's necessary to set **TRIG OFF** then **OUTPut : MODE FIXED**. Then, set **OUTPut : MODE SYNTH** again to get ready to set **TRIG ON**.
Query Syntax : TRIG : STATE?
Parameter : OFF | ON
Return Parameter : OFF | RUNNING

9.5.2.14 INTERHARMONICS Sub-system

[SOURce :]
INTERHARmonics
: FREQuency
: STARt
: END
: LEVel
: DWELl

OUTPut
: MODE

TRIG
TRIG : STATE?

FETCh | MEASure
: INTERHARmonics
: FREQuency? It queries the sweeping frequency.

[SOURce :] INTERHARmonics : FREQuency : STARt
Description : This command sets the start frequency of sweep wave for INTERHARMONICS mode.
Query Syntax : [SOURce :] INTerharmonics : FREQuency : STARt?
Parameter : <NR2>, the valid range is 0.01 ~ 2400.0 (unit: Hz.)
Return Parameter : <NR2>

[SOURce :] INTERHARmonics: FREQuency : END
Description : This command sets the end frequency of sweep wave for INTERHARMONICS mode.
Query Syntax : [SOURce :] INTerharmonics : FREQuency : END?
Parameter : <NR2>, the valid range is 0.01 ~ 2400.00 (unit: Hz.)
Return Parameter : <NR2>

[SOURce :] INTERHARmonics: LEVel
Description : This command sets the rms. range of sweep wave in percentage level.
Query Syntax : [SOURce :] INTerharmonics : LEVEl?
Parameter : <NR2>, the valid range is 0% ~ 30% in 0.01 Hz ~ 500 Hz
0% ~ 20% in 500.01 Hz ~ 1000 Hz
0% ~ 10% in 1000.01 Hz ~ 2400 Hz
Return Parameter : <NR2>

[SOURce :] INTERHARmonics: DWELl
Description : This command sets the dwell time of sweep wave.
Query Syntax : [SOURce :] INTerharmonics : DWELl?
Parameter : <NR2>, the valid range is 0.00 ~ 99999.99 (unit: sec.)
Return Parameter : <NR2>

OUTPut : MODE
Description : This command sets the operation mode.
Query Syntax : OUTPut : MODE?
Parameter : FIXED | LIST | PULSE | STEP | SYNTH | INTERHAR

Return Parameter : FIXED | LIST | PULSE | STEP | SYNTH | INTERHAR

TRIG
Description : This command sets INTERHARMONICS mode in OFF, ON, PAUSE or CONTINUE execution state after setting OUTPut : MODE INTERHAR. If users wish to change the Parameter, it has to set TRIG OFF and OUTPut : MODE FIXED, next OUTPut : MODE INTERHAR in order to set TRIG ON.
Query Syntax : TRIG : STATE?
Parameter : OFF | ON | PAUSE | CONTINUE
Return Parameter : OFF | RUNNING | PAUSE

FETCh [:SCALar] : INTERHARmonics: FREQuency?
MEASure [:SCALar] : INTERHARmonics: FREQuency?
Description : These query commands return the sweep frequency stacked on base voltage.
Query Syntax : FETCh : INTERHARMonics : FREQuency?
MEASure : INTERHARMonics : FREQuency?
Return Parameter : <NR2>

9.5.2.15 Harmonic Sense Sub-system

[SOURce :]
CONFigure
: HARMonic
: SOURce
: TIMES
: PARameter
: FREQuency
SENSe
: HARMonic

FETCh | MEASure
[: SCALar]
: HARMonic
: THD? It returns the % of total harmonic distortion.
: FUNDamental? It returns the fundamental frequency.
: ARRay? It returns the array of all harmonic orders.

[SOURce :] CONFigure : HARMonic : SOURce
Description : This command sets the measured power source in harmonic analysis mode.
Query Syntax : [SOURce :] CONFigure : HARMonic : SOURce?
Parameter : VOLT | CURR
Return Parameter : VOLT | CURR

[SOURce :] CONFigure : HARMonic : TIMES
Description : This command sets the way the measurement result of harmonic analysis displayed on LCD.
SINGLE: It keeps the measured data on the display when set.
CONTINUE: It updates the measured data on the display when set.

Query Syntax : [SOURce :] CONFigure : HARMonic : TIMes?
Parameter : SINGLE | CONTINUE
Return Parameter : SINGLE | CONTINUE

[SOURce :] CONFigure : HARMonic : PARameter
Description : This command sets the data format for each harmonic order.
Query Syntax : [SOURce :] CONFigure : HARMonic : PARameter?
Parameter : VALUE | PERCENT
Return Parameter : VALUE | PERCENT

[SOURce :] CONFigure : HARMonic : FREQuency
Description : This command sets the fundamental frequency of original waveform.
Query Syntax : [SOURce :] CONFigure : HARMonic : FREQuency?
Parameter : 50 | 60
Return Parameter : 50 | 60

SENSe : HARMonic
Description : This command sets the harmonic measurement on/off. It has to execute "ON" before every new search or measurement. Only 3 seconds are required for the result. The parameter has to set to "OFF" if users wish to measure other data.
Query Syntax : SENSe : HARMonic?
Parameter : ON | OFF
Return Parameter : ON | OFF

FETCh [:SCALar] : HARMonic : THD?
MEASure [:SCALar] : HARMonic : THD?
Description : This query command returns the % of total harmonic distortion.
Query Syntax : FETCh : HARMonic : THD?
MEASure : HARMonic : THD?
Return Parameter : <NR2>

FETCh [:SCALar] : HARMonic : FUNDamental?
MEASure [:SCALar] : HARMonic : FUNDamental?
Description : This query command returns the fundamental frequency output current or voltage.
Query Syntax : FETCh : HARMonic : FUNDamental?
MEASure : HARMonic : FUNDamental?
Return Parameter : <NR2>

FETCh [:SCALar] : HARMonic : ARRay?
MEASure [:SCALar] : HARMonic : ARRay?
Description : This query command returns the array of all harmonic orders.
Query Syntax : FETCh : HARMonic : ARRay?
MEASure : HARMonic : ARRay?
Return Parameter : <NR2>

9.6 Command Summary

Common Commands

* CLS	Clear status
* ESE<n>	Enable standard event status
* ESE?	Return enabled standard event status
* IDN?	Return the AC Source ID
* RCL<n>	Recall the AC Source file
* RST	Reset the AC Source to initial states
* SAV<n>	Save the AC Source status
* SRE	Set request enable register
* STB?	Return status byte
* TST?	Return the self-test result of AC Source

Instrument Commands

SYSTem
: ERRor?
: VERSion?
: LOCal
: REMote
: DATE
: TIME

INSTrument
: EDIT
: Couple
: NSELect
: SELect
: PHASe

FETCh | MEASure
[: SCALar]
: CURRent
: AC?
: DC?
: ACDC?
: AMPLitude:MAXimum?
: CRESTfactor?
: INRush?
: FREQuency?
: POWer
: AC
[: REAL]?
: APPArent?
: REACtive?
: PFACtor?
: TOTal?
: TOTal:APPArent?
:VOLTage

: AC?
: DC?
: ACDC?
: AMPLitude:MAXimum?
:LINE
:V12?
:V23?
:V31?

OUTPut
[: STATe]
: RELay
: SLEW
: VOLTage
: AC
: DC
:FREQency
: COUPling
: MODE
: PROTection
:CLEar
: IMPedance
: STATe
: RESistor
: INDuction

[SOURce :]
CURRent
: LIMit
: DELay
: INRush
: STARt
: INTerval
:RANGe
FREQency
[: {CW | IMMediate}]
: LIMit
VOLTage
[: LEVel][: IMMediate][:AMPLitude]
: AC
: DC
: LIMit
: AC
: DC
: PLUS
: MINus
: RANGe

POWer
: PROTection

FUNCtion

```
        : SHAPe
        : SHAPe
                    : A
                    : A
                            : MODE
                            : THD
                            : AMP
                    : B
                    : B
                        : MODE
                        : THD
                        : AMP

LIST
: Coupling
:TRIG
        : POINts?
        : COUNt
        : DWELl
        : SHAPe
        : BASE
        : VOLTage
            : AC
                    : STARt
                    : END
            : DC
                    : STARt
                    : END
        : FREQuency
            : STARt
            : END
        : DEGRee
PULSe
        : VOLTage
            : AC
            : DC
        : FREQuency
        : SHAPe
        : SPHase
        : COUNt
        : DCYCle
        : PERiod

STEP
        : VOLTage
            : AC
            : DC
        : FREQuency
        : SHAPe
        : SPHase
        : DVOLtage
            : AC
            : DC
        : DFRequency
```

: DWELl
: COUNt

SYNThesis
: COMPose
: AMPLitude
: PHASe
: FUNDamental
: DC
: FREQuency
: SPHase

INTERHARrmonics
: FREQuency
: STARt
: END
: LEVEl
: DWELl
: MODe

[SOURce :]
PHASe
: ON
: OFF

[SOURce :]
CONFigure
: INHibit

STATus
: OPERation
[: EVENt]?
: ENABle
: QUEStionable
: CONDition
[: EVENt]?
: ENABle
: NTRansition
: PTRansition

TRACe
: RMS

TRIG
TRIG : STATE?

Appendix A TTL Signal Pin Assignments

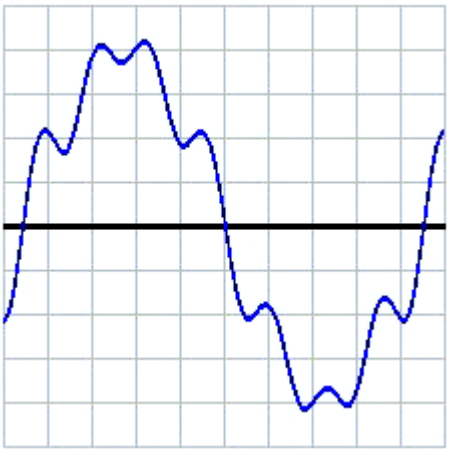
Green terminal with female connector:

Pin No.	Signal	Description
1	Ext-V Φ1	Φ1 External-V Reference signal input (-10V~10V)
2	Ext-V Φ2	Φ2 External-V Reference signal input (-10V~10V) This is the input pin of external voltage signal for single phase use.
3	Ext-V Φ3	Φ3 External-V Reference signal input (-10V~10V)
4	AGND	External-V Reference signal grounding
5	+12V	12V voltage output (providing current 1A)
6	Reserved	
7	DGND	Digital signal grounding
8	DGND	Digital signal grounding
9	AC-ON	This pin turns to HIGH when the AC Source outputs voltage and turns to LOW when quits output.
10	/ FAULT-OUT	The voltage level of this pin is HIGH when the AC Source is in normal mode, it will turn to LOW when the AC Source is in protection mode.
11	/ Ext-ONOFF	When EXT-ONOFF is enabled and the voltage level of this pin turns to LOW, the AC Source output will be open and it will close on the contrary.
12	/ Remote-Inhibit	When the voltage level of this pin turns to LOW, it can inhibit the AC Source output or trigger mode.
13	/Remote-Excite	When this pin receives a negative edge signal (from High to Low), it can trigger the transient output of AC Source.
14	/Transient	When the output of AC Source changes, this pin will send out a low level 64us or remain at high level.
15	/INV_E	It is for the signal terminal of Reverse Current Protection Unit A615106 use.
16	/CON	It is for the signal terminal of Reverse Current Protection Unit A615106 use.
17	Reserved	
18	Reserved	

Appendix B Built-in DST Waveform

The ratios of all built-in waveforms' steps are measured under no load.

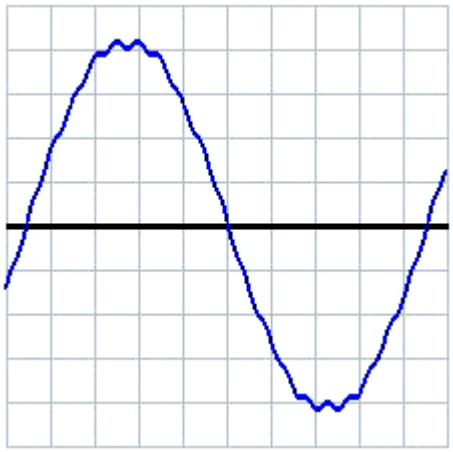
Waveform A = DST01



N	%	D
5	9.80	0
7	15.80	0
8	2.16	0

DST01

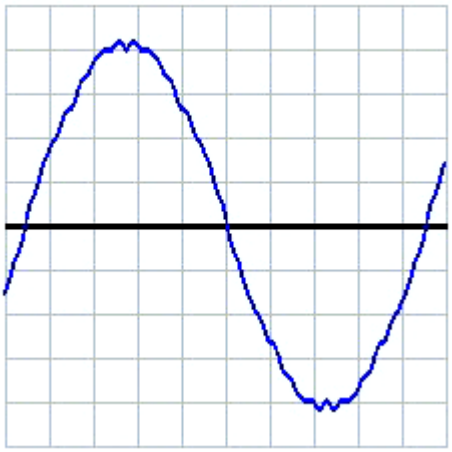
Waveform A = DST02



N	%	D
3	1.50	0
7	1.50	0
19	2.00	0

DST02

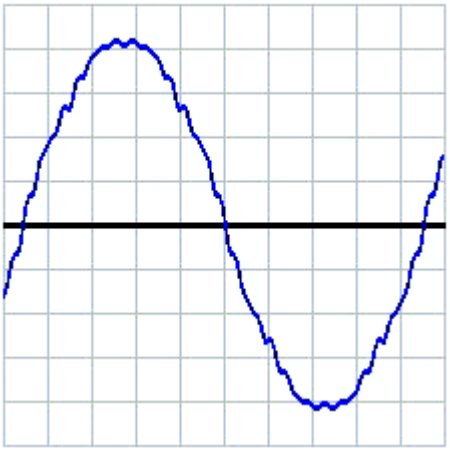
Waveform A = DST03



N	%	D
3	2.00	0
5	1.40	0
7	2.00	0
23	1.40	0
31	1.00	0

DST03

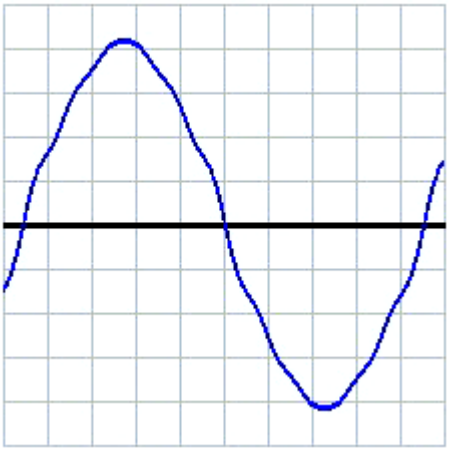
Waveform A = DST04



N	%	D
3	2.50	0
5	1.90	0
7	2.50	0
23	1.90	0
25	1.10	0
31	1.50	0
33	1.10	0

DST04

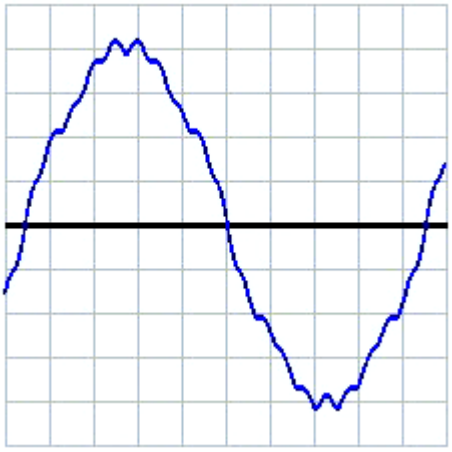
Waveform A = DST05



N	%	D
3	1.10	0
5	2.80	0
7	1.40	0
9	2.30	0
11	1.50	0

DST05

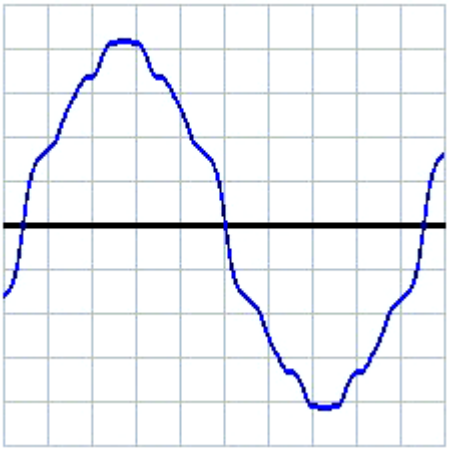
Waveform A = DST06



N	%	D
3	1.65	0
5	4.20	0
7	3.45	0
15	1.05	0
19	3.00	0

DST06

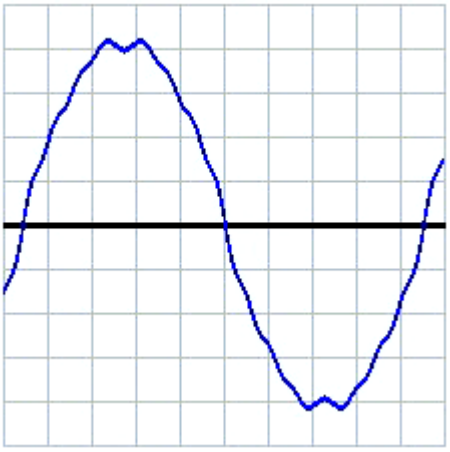
Waveform A = DST07



N	%	D
3	2.20	0
5	5.60	0
7	2.80	0
9	4.60	0
11	3.00	0
15	1.40	0
21	1.00	0

DST07

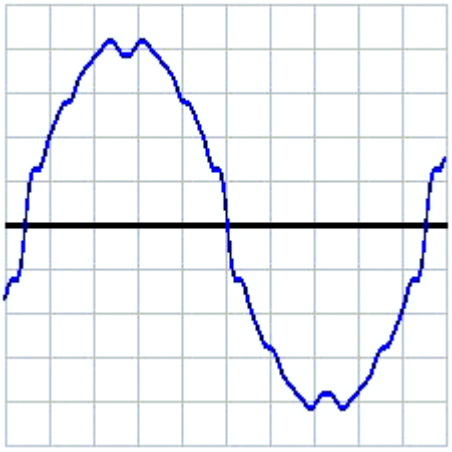
Waveform A = DST08



N	%	D
3	4.90	0
5	1.60	0
7	2.70	0
11	1.40	0
15	2.00	0
17	1.10	0

DST08

Waveform A = DST09

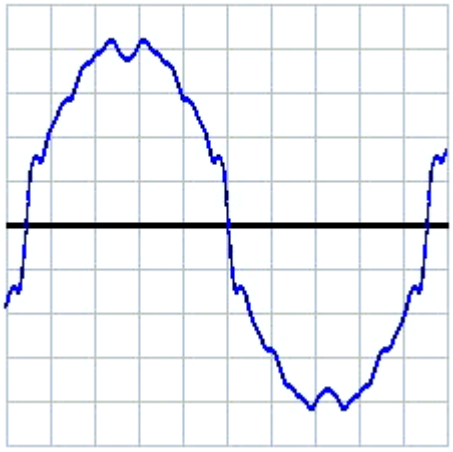


N	%	D
3	7.35	0
5	2.40	0
7	4.05	0
11	2.10	0
13	1.05	0
15	3.00	0
17	1.65	0
19	1.05	0
21	1.05	0

N	%	D
23	1.20	0
25	1.05	0

DST09

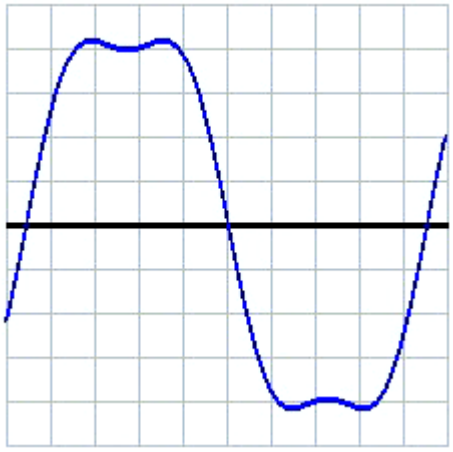
Waveform A = DST10



N	%	D	N	%	D
3	9.80	0	21	1.40	0
5	3.20	0	23	1.60	0
7	5.40	0	25	1.40	0
9	1.20	0			
11	2.80	0			
13	1.40	0			
15	4.00	0			
17	2.20	0			
19	1.40	0			

DST10

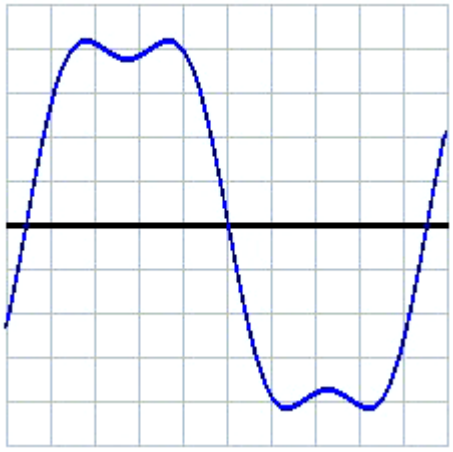
Waveform A = DST11



N	%	D
3	17.75	0

DST11

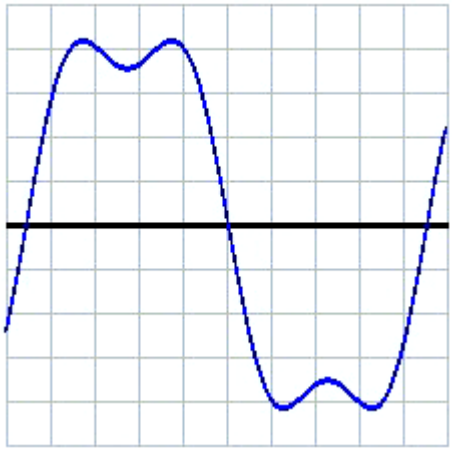
Waveform A = DST12



N	%	D
3	21.25	0

DST12

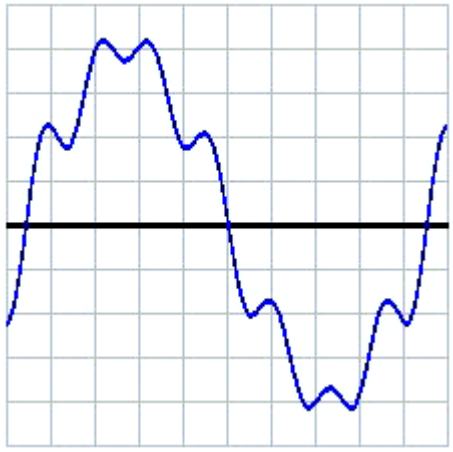
Waveform A = DST13



N	%	D
3	24.50	0

DST13

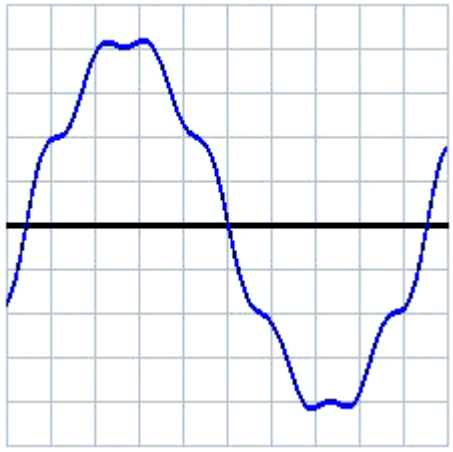
Waveform A = DST14



N	%	D
2	2.30	0
5	9.80	0
7	15.80	0
8	2.50	0

DST14

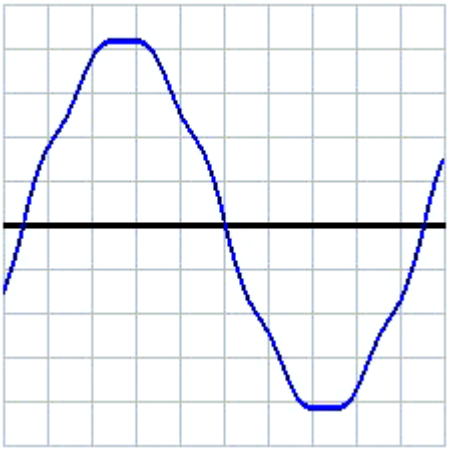
Waveform A = DST15



N	%	D
2	1.15	0
5	4.90	0
7	7.90	0
8	1.25	0

DST15

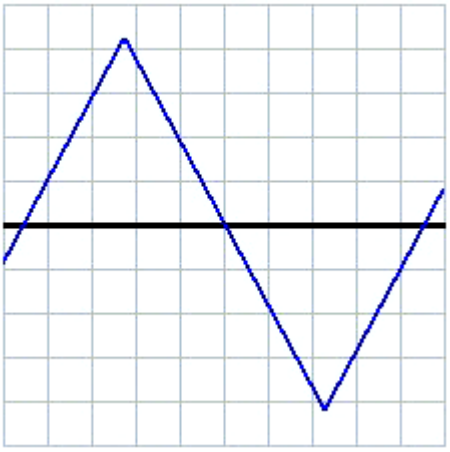
Waveform A = DST16



N	%	D
5	2.45	0
7	3.95	0

DST16

Waveform A = DST17

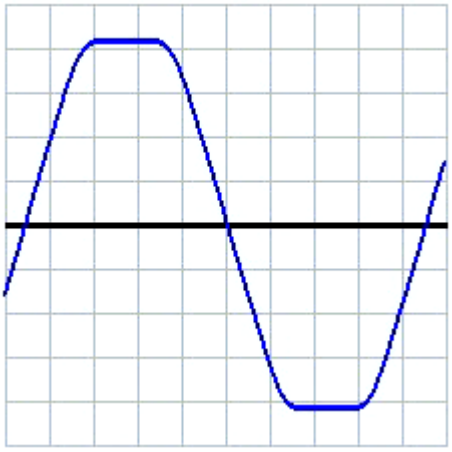


N	%	D
3	11.11	180
5	4.00	0
7	2.04	180
9	1.23	0
11	0.83	180
13	0.59	0
15	0.44	180
17	0.35	0
19	0.28	180

N	%	D
21	0.23	0
23	0.19	180
25	0.16	0
27	0.14	180

DST17

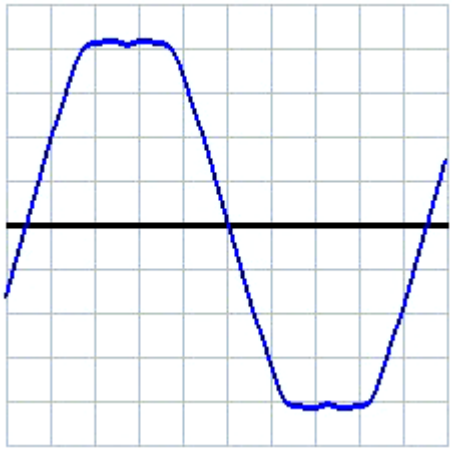
Waveform A = DST18



N	%	D
3	7.17	0
5	3.42	180
9	0.80	0

DST18

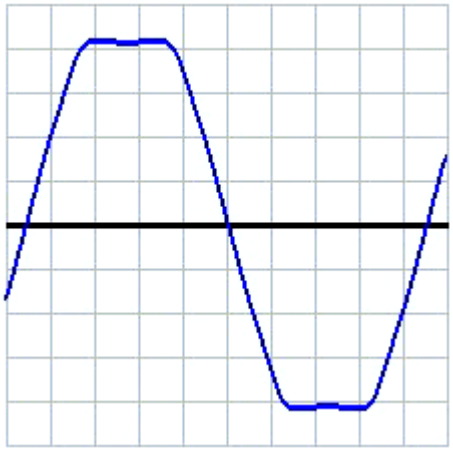
Waveform A = DST19



N	%	D
3	8.07	0
5	3.55	180
9	0.96	0
13	0.92	180

DST19

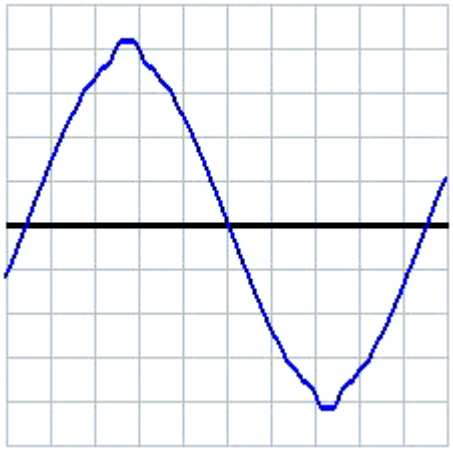
Waveform A = DST20



N	%	D
3	9.38	0
5	3.44	180
9	1.12	0
13	0.50	180

DST20

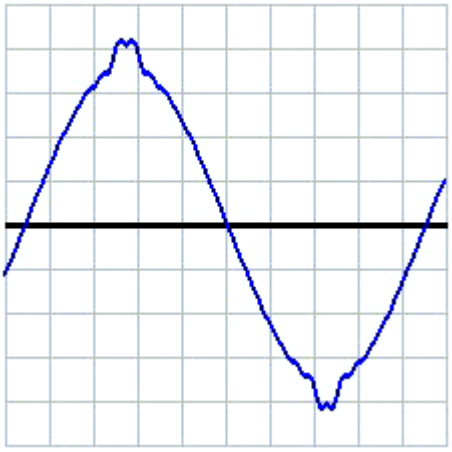
Waveform A = DST21



N	%	D
3	2.06	180
5	1.77	0
7	1.62	180
9	1.23	0
11	0.91	180
13	0.54	0
23	0.51	0
25	0.53	180

DST21

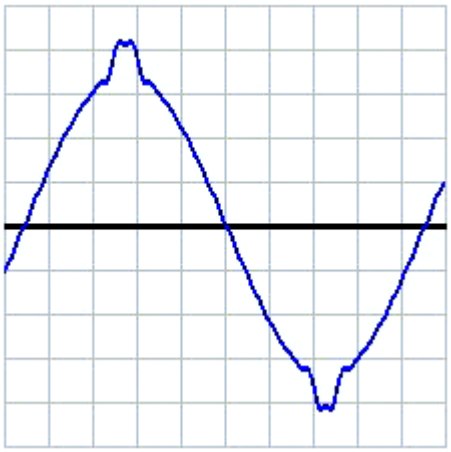
Waveform A = DST22



N	%	D	N	%	D
3	3.08	180	27	0.69	0
5	2.72	0	29	0.56	180
7	2.43	180			
9	1.97	0			
11	1.41	180			
13	0.86	0			
21	0.62	180			
23	0.73	0			
25	0.77	180			

DST22

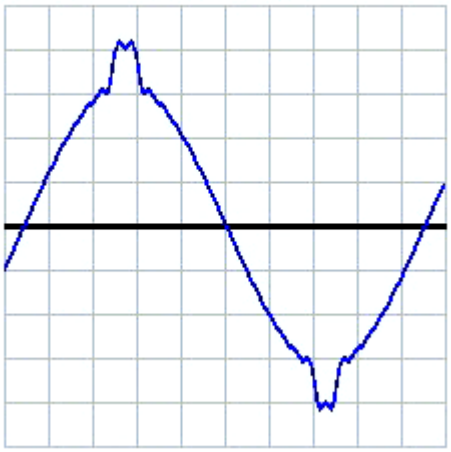
Waveform A = DST23



N	%	D	N	%	D
3	4.28	180	23	0.97	0
5	3.77	0	25	1.04	180
7	3.27	180	29	0.75	180
9	2.57	0			
11	1.93	180			
13	1.22	0			
15	0.55	180			
19	0.46	0			
21	0.83	180			

DST23

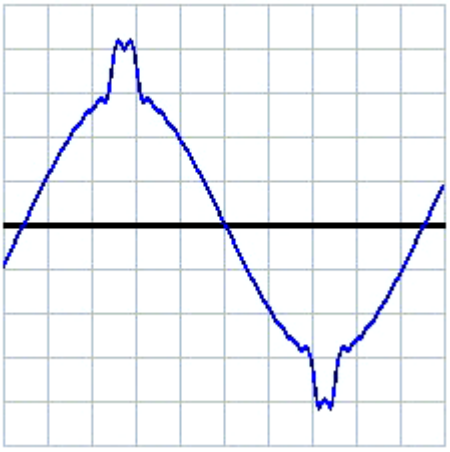
Waveform A = DST24



N	%	D	N	%	D
3	5.74	180	23	1.28	0
5	5.11	0	25	1.35	180
7	4.44	180	27	1.22	0
9	3.52	0	29	0.98	180
11	2.63	180			
13	1.65	0			
15	0.80	180			
19	0.61	0			
21	1.07	180			

DST24

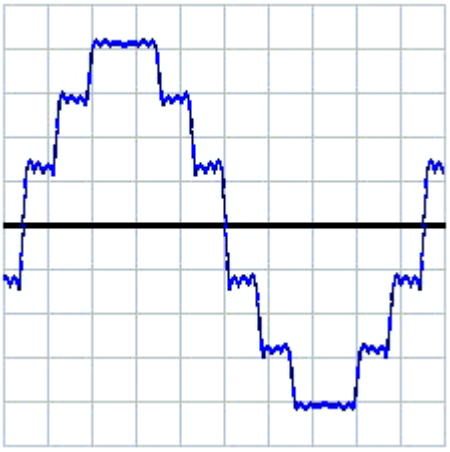
Waveform A = DST25



N	%	D	N	%	D
3	7.35	180	23	1.64	0
5	6.60	0	25	1.73	180
7	5.74	180	27	1.56	0
9	4.57	0	29	1.24	180
11	3.41	180			
13	2.16	0			
15	1.04	180			
19	0.74	0			
21	1.35	180			

DST25

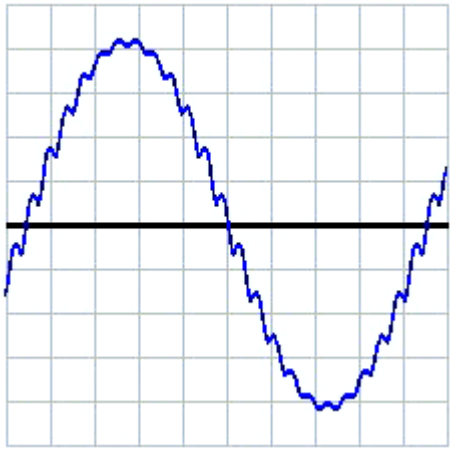
Waveform A = DST26



N	%	D	N	%	D
5	3.41	0	35	2.34	0
7	2.55	0	37	2.21	0
11	9.22	0			
13	7.68	0			
17	0.90	0			
19	0.90	0			
23	3.88	0			
25	3.56	0			
31	0.50	0			

DST26

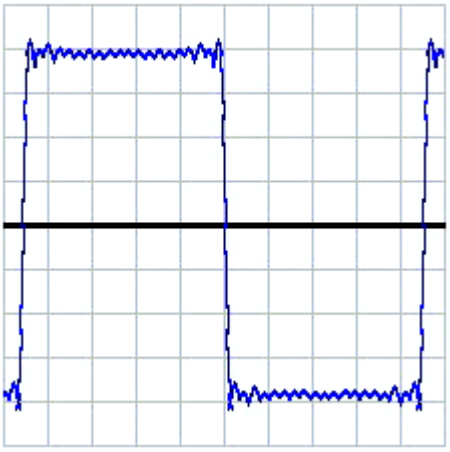
Waveform A = DST27



N	%	D
21	1.24	0
23	4.91	0
25	2.21	0

DST27

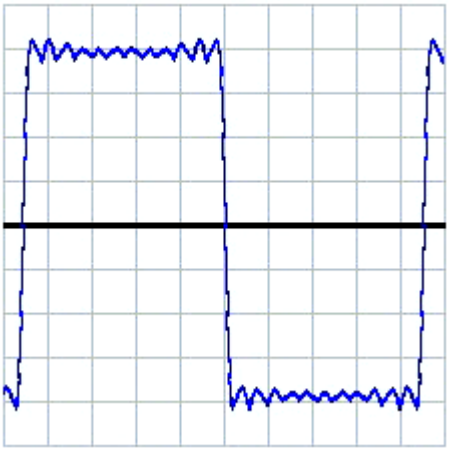
Waveform A = DST28



N	%	D	N	%	D
3	33.39	0	21	4.52	0
5	20.01	0	23	4.00	0
7	13.76	0	25	3.49	0
9	10.70	0	27	2.91	0
11	8.39	0	29	2.45	0
13	7.06	0	31	1.94	0
15	5.85	0	33	1.95	0
17	4.86	0	35	1.91	0
19	4.86	0	37	1.89	0
			39	1.83	0

DST28

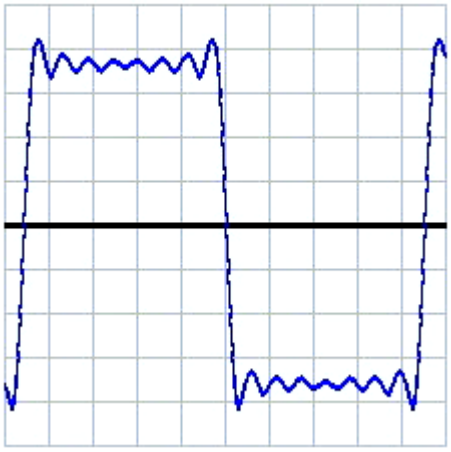
Waveform A = DST29



N	%	D	N	%	D
3	33.39	0	21	4.48	0
5	20.01	0	23	3.93	0
7	13.75	0	25	0.89	0
9	10.70	0	27	0.92	0
11	8.37	0	29	0.94	0
13	7.05	0	31	0.94	0
15	5.84	0	33	0.94	0
17	4.84	0	35	0.93	0
19	4.83	0	37	0.92	0
			39	0.91	0

DST29

Waveform A = DST30



N	%	D
3	33.39	0
5	20.01	0
7	13.75	0
9	10.70	0
11	8.33	0
13	6.99	0
15	5.26	0

DST30

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