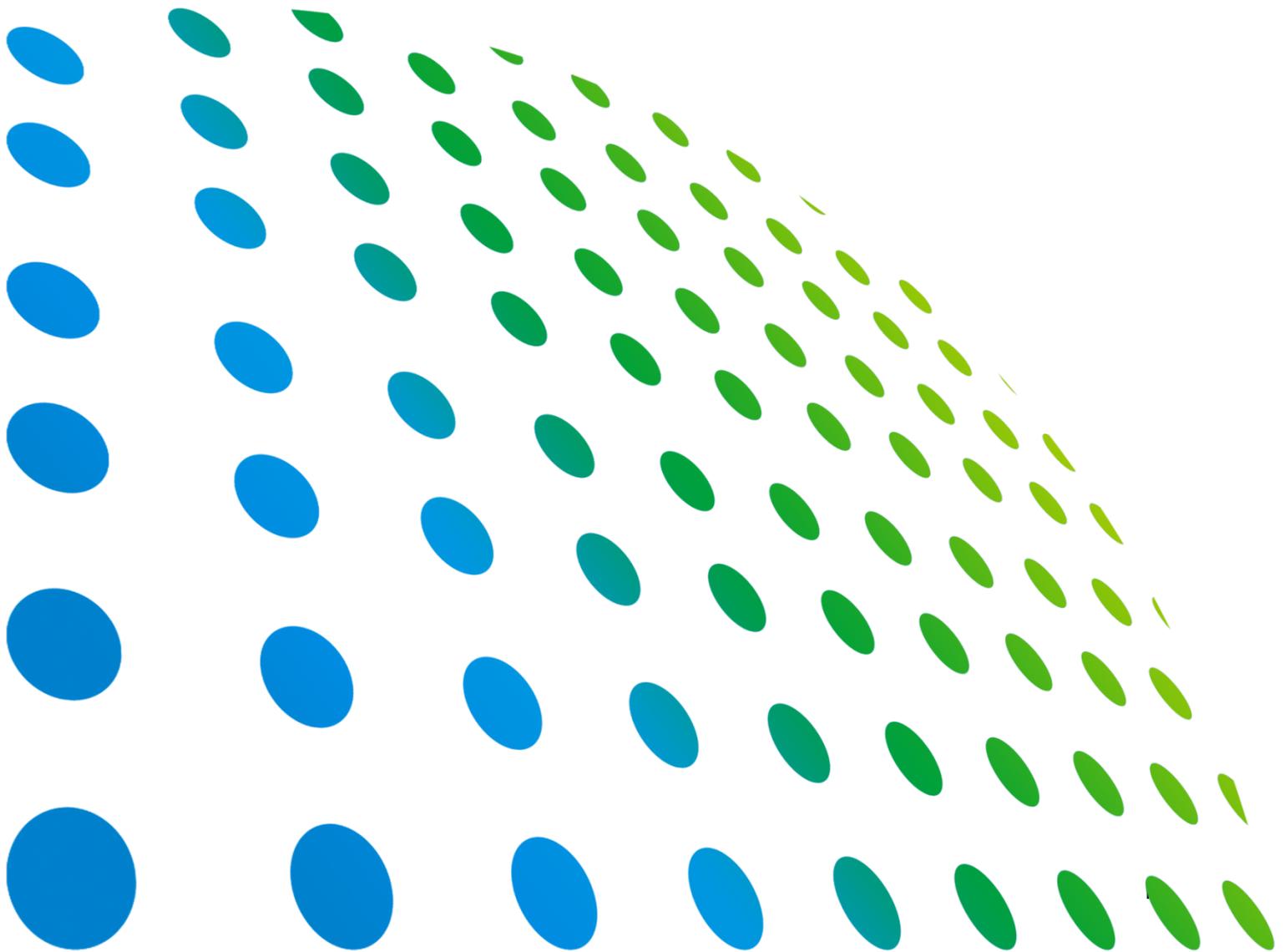




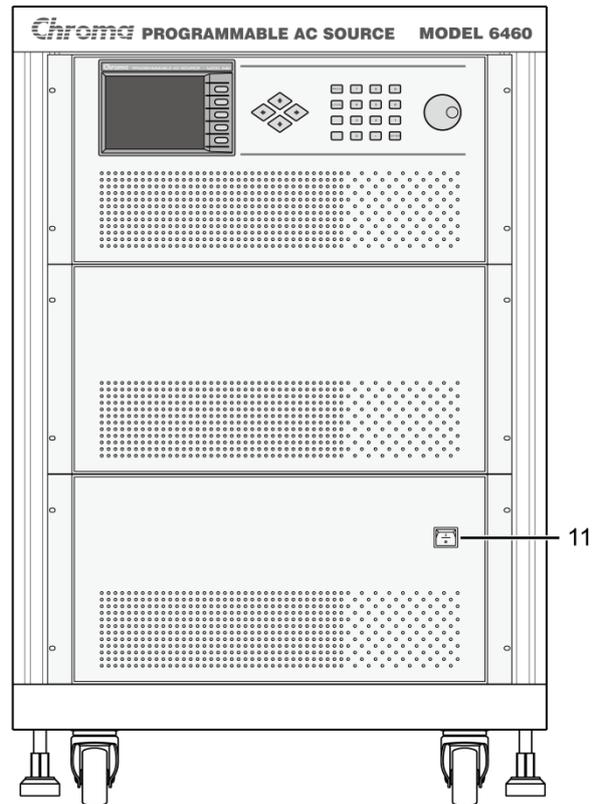
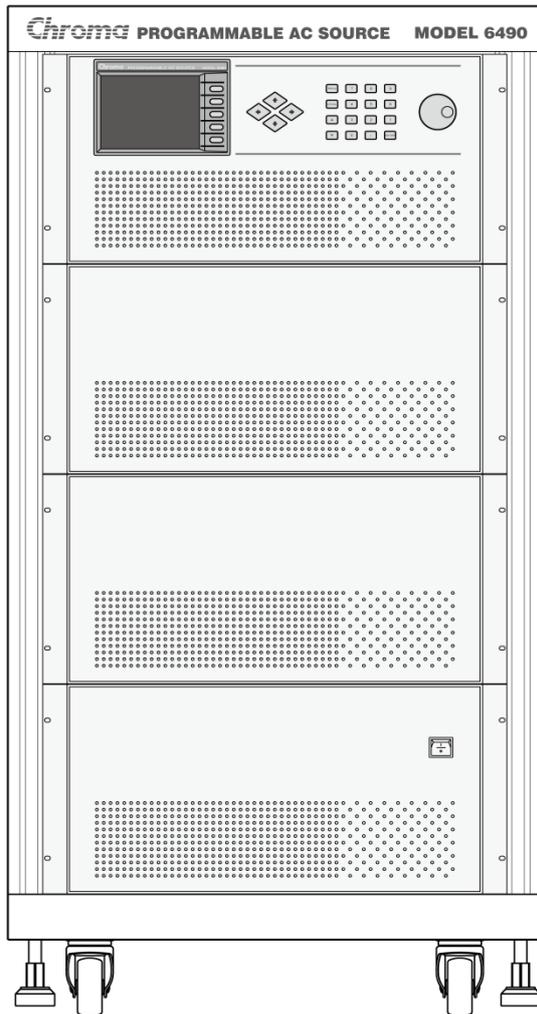
Programmable AC Source

6460/6463/6490

User's Manual



Programmable AC Source 6460/6463/6490 User's Manual



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CHROMA ATE INC.

66 Huaya 1st Road, Guishan, Taoyuan 33383, Taiwan

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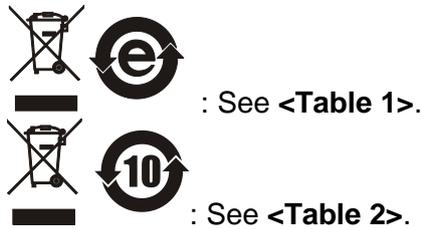
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<http://www.chromaate.com>

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.

“x” 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 | × | ○ | ○ | ○ | ○ | ○ |
| CHASSIS | × | ○ | ○ | ○ | ○ | ○ |
| ACCESSORY | × | ○ | ○ | ○ | ○ | ○ |
| PACKAGE | ○ | ○ | ○ | ○ | ○ | ○ |

“○” 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.





Declaration of Conformity

For the following equipment :

Programmable AC Source

(Product Name/ Trade Name)

6415, 6420, 6430, 6460, 6463, 6490, 6512, 6520, 6530, 6560, 6590

(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 61326-1:2013 Class A, EN 61326-2-1:2013, EN 55011:2009+A2:2010 Group1 Class A

EN 61000-3-11:2000, EN61000-3-12:2011

EN 61326-1:2013 (Industrial Locations)

EN 61000-4-2:2009, EN 61000-4-3:2006+A1:2008+A2:2010,

EN 61000-4-4:2012, EN 61000-4-5:2006, EN 61000-4-6:2009,

EN 61000-4-8:2010, EN 61000-4-34:2007+A1:2009

EN 61010-1:2010(Third Edition)

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. Vincent Wu

(Name, Surname)

T&M BU Deputy Director

(Position/Title)

Taiwan

(Place)

2014.6.20

(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.



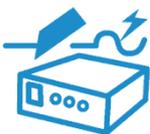
BEFORE APPLYING POWER

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 sources can supply 707 V peak at their output.
2. DEATH on contact may result if the output terminals or circuits connected to the output are touched when power is applied.

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 |
|-----------|---------|--|
| May 1998 | 1.0 | Complete this manual |
| May 2005 | 1.1 | Change the address and phone number of Chroma |
| Dec. 2007 | 1.2 | <p>Add the following</p> <ul style="list-style-type: none"> - <i>“Material Contents Declaration”</i> - NOTICE in the section of <i>“The Setting of Output Relay”</i>. <p>Modify the following</p> <ul style="list-style-type: none"> - the Accuracy of Voltage, Current and Power Factor of INPUT RATINGS and Range(peak) of Current/phase in the section of <i>“Specifications”</i>. - Max. Current in the section of <i>“Ratings”</i>. - Figure 2-2-a-d and Table 2-1 in the section of <i>“Output Connection”</i>. <p>Del NOTICE in the section of <i>“Remote Sense”</i>.</p> |
| Mar. 2008 | 1.3 | Interchange the section of <i>“Remote Sense”</i> and <i>“External Reference”</i> . |
| Oct. 2008 | 1.4 | <p>Add the chapter of <i>“Appendix B Pin Assignment of TTL I/O”</i>.</p> <p>Modify the following:</p> <ul style="list-style-type: none"> - the description of “B. Input/Output” in the section of <i>“Key Features”</i>. - the figure and description in the section of <i>“The Rear Panel”</i>. - the description in the section of <i>“Ratings”</i>. - the figures in the sections of <i>“The Setting of Configuration”</i> & <i>“The Setting of Setup”</i>. - “Hardware Protection Table List” in the section of <i>“Protection”</i>. - the description in the section of <i>“Common Command Dictionary”</i>. - the description in the section of <i>“Instrument Command Dictionary”</i>. - the description in the section of <i>“Command Summary”</i>. |
| Jul. 2014 | 1.5 | <p>Modify the following sections:</p> <ul style="list-style-type: none"> - <i>“CE Declaration”</i> - the description of “Input Ratings” in the section of <i>“Specifications”</i>. - “Figure 1-1, 1-2 and Table 1-2” in the section of <i>“Names of Parts”</i>. - “Input Voltage Range description and Figure 2-1” in the section of <i>“Requirements of Input Power”</i>. - “Figure 2-2” in the section <i>“Output Connection”</i>. |
| Oct. 2015 | 1.6 | Delete the word of <i>“remote inhibit”</i> in the manual. |

Table of Contents

| | |
|---|------------|
| 1. General Information | 1-1 |
| 1.1 Introduction | 1-1 |
| 1.2 Description..... | 1-1 |
| 1.3 Key Features | 1-1 |
| 1.4 Specifications..... | 1-2 |
| 1.5 Names of Parts | 1-4 |
| 1.5.1 The Front Panel..... | 1-4 |
| 1.5.2 The Rear Panel | 1-6 |
| 2. Installation | 2-1 |
| 2.1 Inspection | 2-1 |
| 2.2 Preparation for the Use | 2-1 |
| 2.3 Requirements of 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 | 2-5 |
| 2.6 The Procedures of Power-on | 2-5 |
| 3. Local Operation | 3-1 |
| 3.1 Introduction | 3-1 |
| 3.2 Operation through Keypad | 3-1 |
| 3.2.1 Introduction | 3-1 |
| 3.2.2 Data Entry | 3-2 |
| 3.2.3 Output Setting | 3-3 |
| 3.2.4 The Setting of Configuration | 3-6 |
| 3.2.5 The Setting of Setup..... | 3-9 |
| 3.3 Applications | 3-11 |
| 3.3.1 The Execution of Output..... | 3-11 |
| 3.4 Measurement..... | 3-12 |
| 3.4.1 The Selection of Measurement Items | 3-13 |
| 3.4.2 Measurement Functions | 3-15 |
| 3.5 Protection..... | 3-15 |
| 4. Theory of Operation | 4-1 |
| 4.1 General Information | 4-1 |
| 4.2 Description of Overall System | 4-1 |
| 5. Remote Operation | 5-1 |
| 5.1 General Information | 5-1 |
| 5.1.1 Setting the GPIB Address and RS-232C Parameters | 5-1 |
| 5.1.2 Wire Connection of RS-232C | 5-2 |
| 5.2 The GPIB Capability of the AC Source..... | 5-2 |
| 5.3 Introduction to Programming..... | 5-3 |
| 5.3.1 Conventions | 5-3 |
| 5.3.2 Numerical Data Formats..... | 5-3 |
| 5.3.3 Boolean Data Format | 5-3 |
| 5.3.4 Character Data Format..... | 5-3 |
| 5.3.5 Basic Definition..... | 5-4 |
| 5.4 Traversal of the Command Tree | 5-5 |
| 5.5 Execution Order..... | 5-5 |
| 5.6 The Commands of the AC Source | 5-6 |
| 5.6.1 Common Command Dictionary..... | 5-6 |
| 5.6.2 Instrument Command Dictionary | 5-8 |

| | | |
|-------------------|---|------------|
| 5.7 | Command Summary | 5-13 |
| Appendix A | Pin Assignment of User Interface | A-1 |
| Appendix B | Pin Assignment of TTL I/O..... | B-1 |

1. General Information

1.1 Introduction

This manual describes five major things of the Chroma 6460/6463/6490 programmable ac source. They are specifications, installation, instructions on operation and theory of operation. In the manual the term, AC source, is applied to the Chroma 6460/6463/6490 programmable ac source.

1.2 Description

The series of AC source is a high efficiency programmable ac power source, which is capable of simulating a wide variety of AC line conditions and accurate measurement of power. The microprocessor-controlled waveform oscillator generates accurate, stable output voltage and frequency. The PWM design of power stage allows for full volt-ampere into loads. The front panel has both RPG (rotary pulse generator) and keypad controls for setting the output voltage and frequency. The LCD provides a complete operating state of the unit to the user. Remote programming is accomplished either through the GPIB bus or the RS-232C serial port.

1.3 Key Features

A. Configuration

- Local operation from the keypad on the front panel.
- Remote operation via GPIB or RS-232C interface.
- Protection against Over-power, Over-load, Over-temperature, and Fan-fail.
- Temperature-controlled fan speed.
- Built-in output isolation relays.

B. Input/Output

- Selective output voltage with full scale of 150V/300V for 6463/6490, and 150V/300V/500V for 6460.
- Remote control by the use of analog voltage reference.
- Full-page display of setup and measurement results.
- Measurement of V, I, F, P, CF, and PF.
- AC ON/OFF output signal

1.4 Specifications

The operation specifications of the model 6460/6463/6490 are listed below (on the next page). All specifications have been tested according to the standard Chroma test procedures. All specifications are based on a remote sense connection, $25 \pm 1^\circ\text{C}$, and resistor load unless specified otherwise.

| Model | 6460 | 6463 | 6490 |
|---------------------------|---|---|---|
| OUTPUT PHASE | 1 (parallel or series) | 1 or 3 selectable | 1 or 3 selectable |
| OUTPUT RATINGS | | | |
| Power / Phase | 6000VA | 2000VA | 3000VA |
| Voltage | | | |
| Range/Phase | 150V/300V(parallel) 300V/500V(series) | 150V/300V | 150V/300V |
| Accuracy | 0.2% reading + 0.2% of F.S. | 0.2% reading + 0.2% of F.S. | 0.2% reading + 0.2% of F.S. |
| Resolution | 0.1V | 0.1V | 0.1V |
| Distortion | 1% | 1% | 1% |
| Line Regulation | 0.1% | 0.1% | 0.1% |
| Load Regulation | 0.2%(series) 0.8 %(parallel) | 0.2%(3 phases) 0.8%(1 phase) | 0.2%(3 phases) 0.8%(1 phase) |
| Temp. coefficient | 0.02%per°C | 0.02%per°C | 0.02%per°C |
| Max. current/phase | | | |
| rms | 60A/30A/15A (150V/300V/500V) | 20A/10A (150V/300V) | 30A/15A (150V/300V) |
| peak | 180A/90A/45A(45-100Hz) 150A/75A/38A(>100-1KHz) | 60A/30A (45-100Hz) 50A/25A(>100-1KHz) | 90A/45A(45-100Hz) 75A/38A(>100-1KHz) |
| Frequency | | | |
| Range | 45-1KHz | 45-1KHz | 45-1KHz |
| Accuracy | 0.15% | 0.15% | 0.15% |
| Resolution | 0.01Hz (45-99.9Hz) 0.1Hz (100-999.9Hz) | 0.01Hz (45-99.9Hz) 0.1Hz (100-999.9Hz) | 0.01Hz (45-99.9Hz) 0.1Hz (100-999.9Hz) |
| INPUT RATINGS | | | |
| Voltage Range | 200-240V \pm 10%,3 ϕ | 200-240V \pm 10%,3 ϕ | 200-240V \pm 10%,3 ϕ |
| Frequency Range | 47-63Hz | 47-63Hz | 47-63Hz |
| Current | 23A Max./Phase | 15A Max./Phase | 23A Max./Phase |
| Power Factor | 0.98 Min.under full load | 0.97 Min.under full load | 0.98 Min.under full load |
| MEASUREMENT | | | |
| Voltage/Phase | | | |
| Range | 0-150V/0-300V | 0-150V/0-300V | 0-150V/0-300V |
| Accuracy(rms) | 0.1%F.S. + 0.25% | 0.1%F.S. + 0.25% | 0.1%F.S. + 0.25% |
| Resolution | 0.1V | 0.1V | 0.1V |
| Current/phase | | | |
| Range(peak) | 0-280A | 0-100A | 0-140A |
| Accuracy(rms) | 0.1%F.S. + 0.4% | 0.15%F.S. + 0.4% | 0.1%F.S. + 0.4% |
| Accuracy(peak) | 0.2%F.S. + 0.4% | 0.3%F.S. + 0.4% | 0.2%F.S. + 0.4% |
| Resolution | 0.01A | 0.01A | 0.01A |
| Power/phase | | | |
| Accuracy | 1%F.S.(CF<6) | 1%F.S.(CF<6) | 1%F.S.(CF<6) |
| Resolution | 0.01W | 0.01W | 0.01W |
| Frequency | | | |

| | | | |
|---------------|---|----------------------------|----------------------------|
| Range | 45-1K Hz | 45-1K Hz | 45-1K Hz |
| Accuracy | 0.01%+2count | 0.01%+2count | 0.01%+2count |
| Resolution | 0.01Hz | 0.01Hz | 0.01Hz |
| OTHERS | | | |
| Efficiency | 80% typ. | 80% typ. | 80% typ. |
| Protection | OPP, OCP, OTP, FAN Fail | OPP, OCP, OTP, FAN Fail | OPP, OCP, OTP, FAN Fail |
| Temperature | | | |
| Operating | 0-40°C | 0-40°C | 0-40°C |
| Storage | -40 to +85°C | -40 to +85°C | -40 to +85°C |
| SAFETY | CE (INCLUDE LVD and EMC REQUIREMENT) | | |

- Note**
1. Maximum distortion for voltage varies from half to full range with linear load.
 2. Test with sinewave and remote sense.

1.5 Names of Parts

1.5.1 The Front Panel

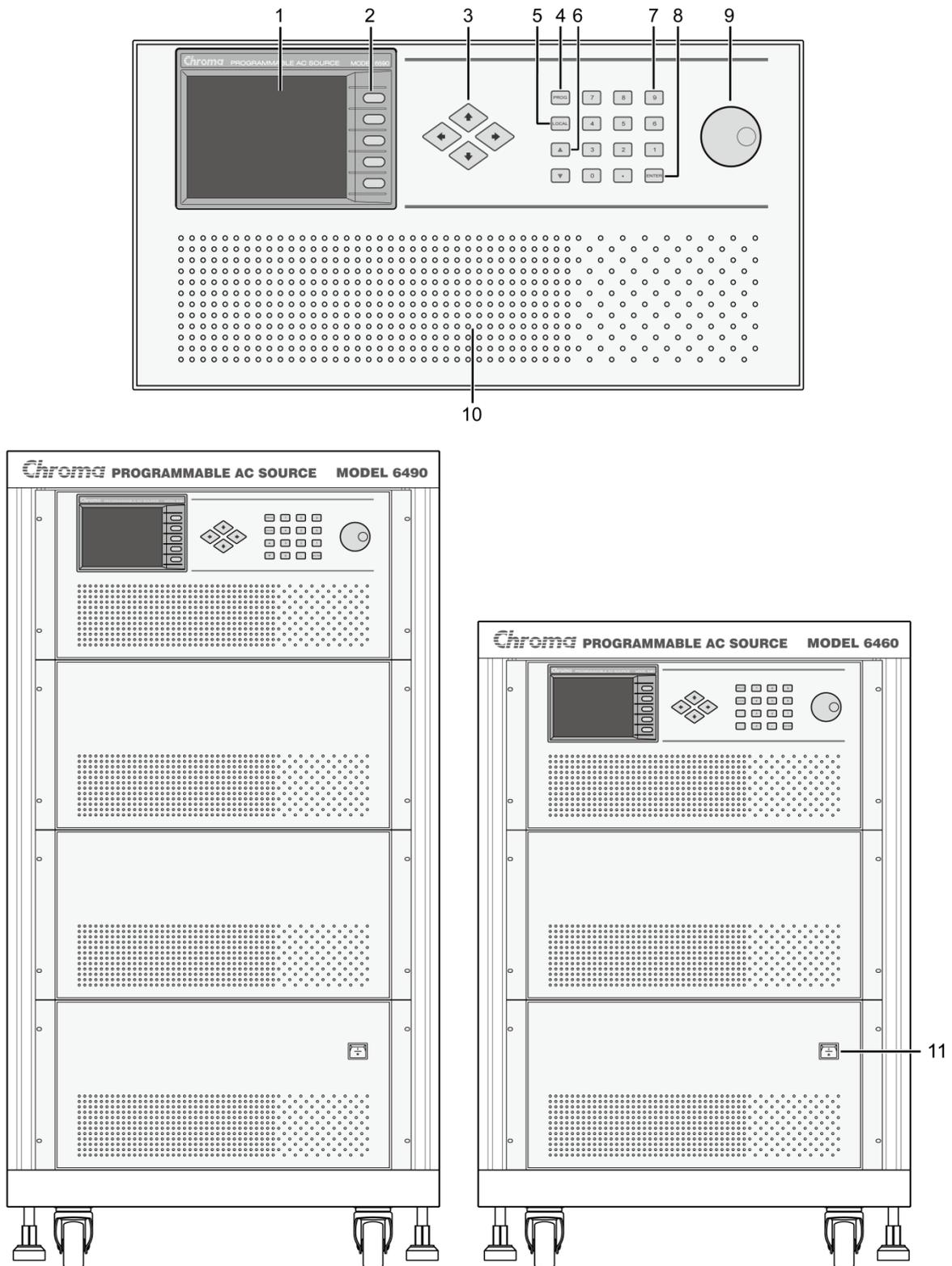
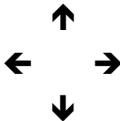
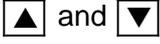
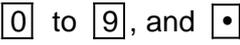
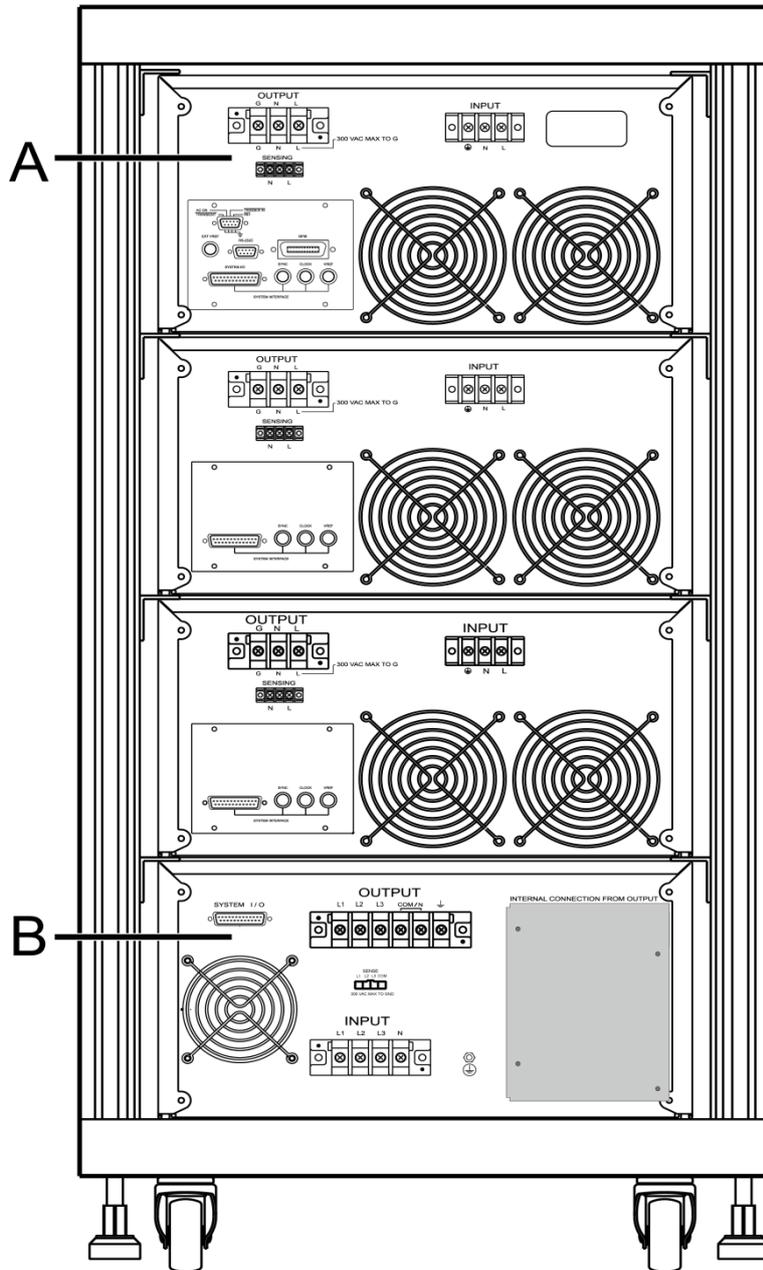


Figure 1-1 The Front Panel

Table 1-1 The Description of the Front Panel

| Item | Symbol | Description |
|------|---|---|
| 1 | | Display: The LCD is to display configuration, output setup, and measurement results. |
| 2 |  | Soft keys: Five soft keys are located at the right side of the LCD. Each of them gives a command as indicated on the corresponding command block on the LCD next to the soft keys to guide the user unless that block is blank. Each valid soft key denotes the command string lying within the symbol of a soft key; for example, CONFIG represents that the soft key next to command block "CONFIG" is for entering configuration menu. |
| 3 |  | Cursor moving keys: These four keys are to move the cursor to different directions respectively. In normal mode (non-editing mode), pressing any of these four keys will change the place of the cursor. In editing mode, pressing  or  will move the cursor from digit to digit for the programming of a parameter. |
| 4 |  | Edit command key: Pressing this key will make the user enter into or quit from editing mode while he is programming V or F. |
| 5 |  | Local command key: Pressing this key will switch the control of the AC source from remote operation to operation through the keypad on the front panel. |
| 6 |  | Up and down keys: Press  to search upward for the desired programming parameter. Press  to search downward. |
| 7 |  | Numeric and decimal keys: The user can program numeric data by pressing the digital keys and the decimal key. |
| 8 |  | ENTER key: It is to confirm the setting of parameters. |
| 9 |  | RPG: The user can input programming data or options by turning the RPG to the desired ones. |
| 10 | | Airflow inlets: Cool airflow enters the AC source through these holes. |
| 11 | | Main power switch: It is to power on or off. |

1.5.2 The Rear Panel



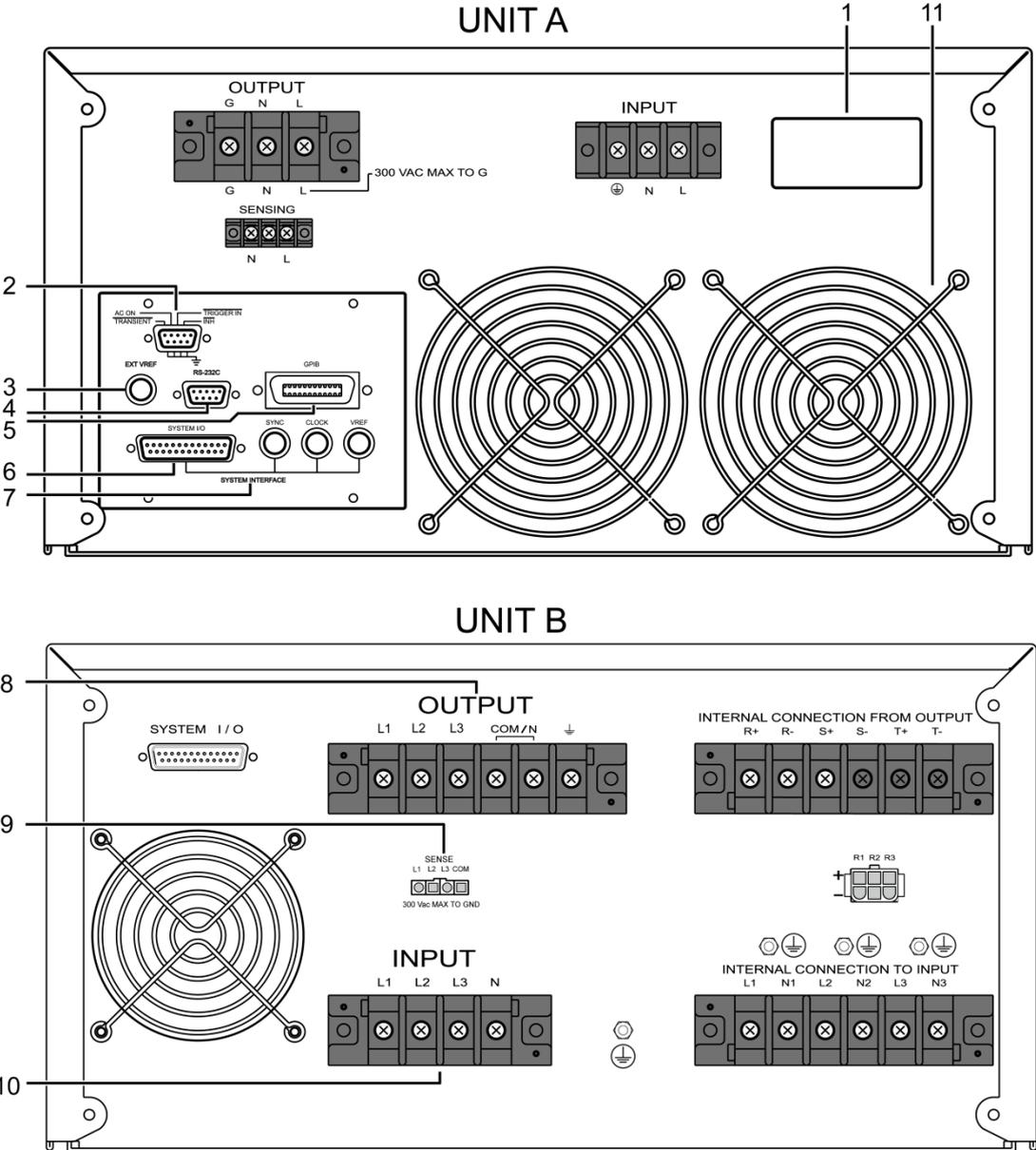


Figure 1-2 The Rear Panel

Table 1-2 The Description of the Rear Panel

| Item | Name | Description |
|------|-------------------------|---|
| 1 | Label | The label includes model number, series number of the AC source and input ratings. |
| 2 | TTL I/O | The 9-pin, D-type male connector transfers the control signals of trigger in, transient and AC ON. |
| 3 | Ext. Ref. | The BNC connector inputs control waveform amplitude from external devices. |
| 4 | RS-232C | The 9-pin, D-type female connector transfers control commands to and from the remote PC for remote operation. |
| 5 | GPIB Connector | A remote controller using GPIB bus is connected to the AC source through this connector for remote operation. |
| 6 | Special I/O | The 25-pin, D-type male connector transfers control signals (trigger and transient) and 3-phase, parallel operation signals. |
| 7 | System I/O | Three BNC connectors are for 3-phase and parallel connectivity. |
| 8 | Output Connector | This connector outputs power to the loading device. |
| 9 | Remote Sense Connector | It senses directly at the terminals of the load to eliminate any voltage drop on the connecting cable. Make sure of connecting the terminal "L" of the remote sense connector to the terminal "L" of the load, and the "N" to the "N" of the load. Reverse polarity is not allowed. |
| 10 | Power Line in Connector | Power line input is connected to the AC source through this connector. |
| 11 | Cooling Fan | Its speed automatically increases or decreases as temperature rises or falls. |
| 12 | Safety Cover | It is to protect the user from being shocked. |

2. Installation

2.1 Inspection

After unpacking the instrument, please inspect any damage that may have occurred during the shipment. Save all packing materials in case the instrument has to be returned one day.

If any damage is found, please file a claim with the carrier immediately. Do not return the instrument to the factory without obtaining the prior RMA acceptance from Chroma.

2.2 Preparation for the Use

In the beginning, the instrument must be connected with an appropriate AC line input. Then, since fans intelligently cool it, it must be installed in sufficient space for circulation of air. It should be used in an area where the ambient temperature does not exceed 40°C.

Before connecting input/output cable, the user must remove the safety cover mounted on the rear downside panel first. Then, the user has to refer to sections 2.3.2, 2.4, and 2.5 for corresponding cable connection. After completion of the connection, the user should mount the safety cover on the rear panel again.

2.3 Requirements of Input Power

2.3.1 Ratings

| | | |
|---------------------|---|--|
| Input Voltage Range | : | 200-240V \pm 10% V_{LL} , 3 phases 4 wires Δ , or 380-400V \pm 10% V_{LL} , 3 phases 5 wires Y |
| Input Frequency | : | 47-63 Hz |
| Max. Current/Phase | : | 6460/6490: 23 A (Y type) 35 (Δ type) 6463: 15A (Y type) 20A (Δ type) |

 **CAUTION** : The AC source will be damaged if it is operated at an input voltage that is outside its configured input range.

2.3.2 Input Connection

The input terminal block is located on the rear downside panel of the instrument. The power cord must be rated at least for 85°C. The power line input must have a current rating which is greater than or equal to the maximum current rating of the AC source.

 **CAUTION** : There are two different input voltage rating models. One is 380 V_{LL} 3 phases 5 wires (Y), and another is 220 V_{LL} 3 phases 4 wires (Δ). Be careful to verify that what kind of the model you have, and make sure that the main voltage is correct for the model.

See *Figure 2-1* and do the following things one by one:

1. Remove the safety cover from the back downside of the AC source.
2. Open the line clamp on the safety cover, and screw the power cord to the instrument through the cable gland.
3. Position the power cord, and tighten the cable gland to secure the clamp.
4. Connect the ac lines to the terminal blocks of the AC source as *Figure 2-1*.
5. If you need to connect the load to the AC source, please refer to *section 2.4* for output connection.
6. Slip the safety cover over the ac input terminal strip, and secure the cover with two screws.

⚠ WARNING To protect the operators, the wire connected to the GND terminal must be connected to the earth ground. Under no circumstances shall this AC source be operated without an adequate ground connection.

Installation of the power cord must be done by a professional and in accordance with local electrical codes.

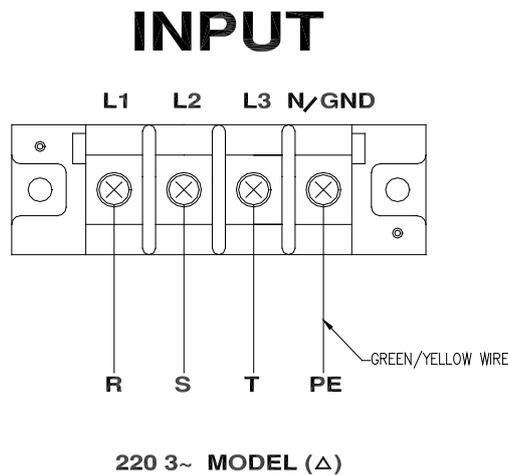


Figure 2-1-a 6460/6463/6490 220 3~Δ Input Connection

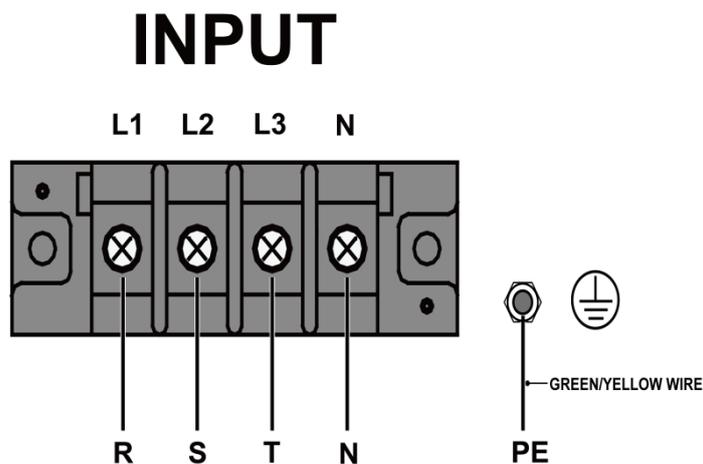


Figure 2-1-b 6460/6463/6490 380 3~Y Input Connection

2.4 Output Connection

The output terminal block is located in the rear downside of the AC source. Load connection to the AC source is done at the output terminals. To meet the safety requirements the wires to the load must be sufficiently large gauges, so they will not overheat while carrying the output current. See figure 2-2 as below.

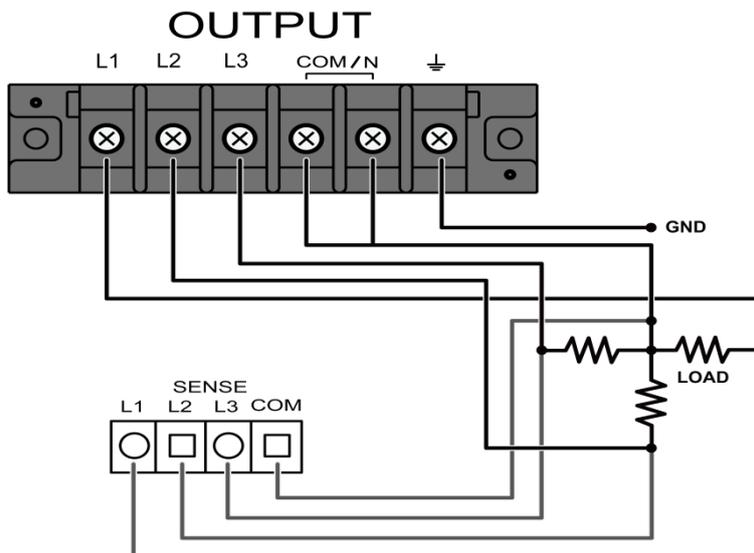


Figure 2-2-a 6463/6490 Three-Phase Output Connection

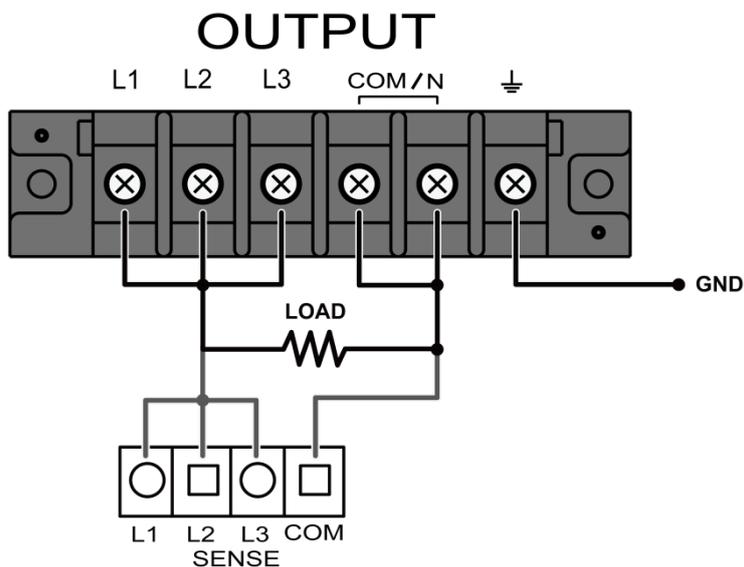


Figure 2-2-b 6463/6490 One-Phase Output Connection

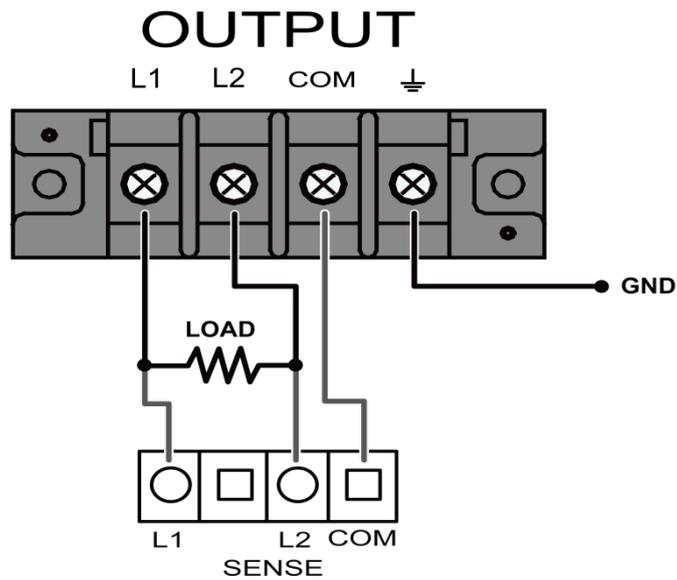


Figure 2-2-c 6460 Series Output Connection (Note: $V_{LOAD}=2 \times V_{set}$)

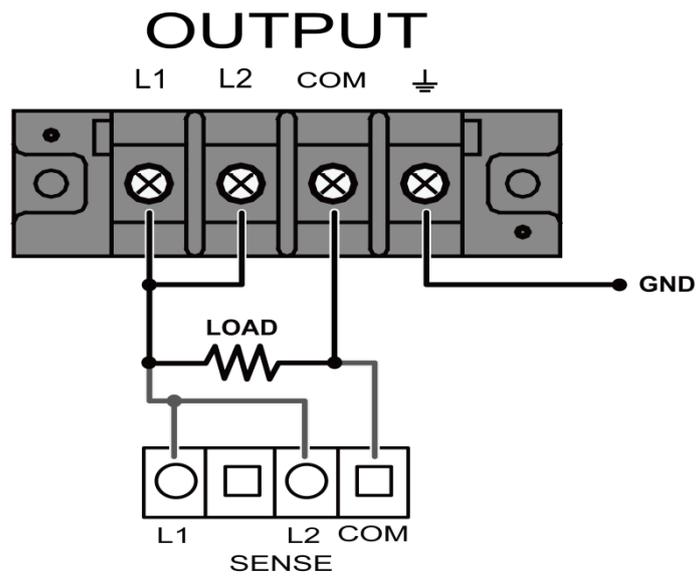


Figure 2-2-d 6460 Parallel Output Connection (Note: $V_{LOAD}=2 \times V_{set}$)

Table 2-1 The Characteristics of AWG (American Wire Gauge) Copper Wire

| AWG No. | Current ¹ | AWG No. | Current ¹ |
|---------|----------------------|---------|----------------------|
| 14 | 25 A | 8 | 60 A |
| 12 | 30 A | 6 | 80 A |
| 10 | 40 A | 4 | 105 A |

1. Current is based on the ambient temperature of 30°C with the conductor rates at 60°C.

2.5 Remote Sense Connection

The remote sense function of the AC source monitors the voltage at the load instead at the output terminal of the AC source for 6460 series mode and 6463/6490 3-phase mode. It ensures the delivery of accurate voltage as programmed at the load by automatically compensating the output voltage drop over the connecting cable. The user has to set Remote Sense ON so as to enable this function.

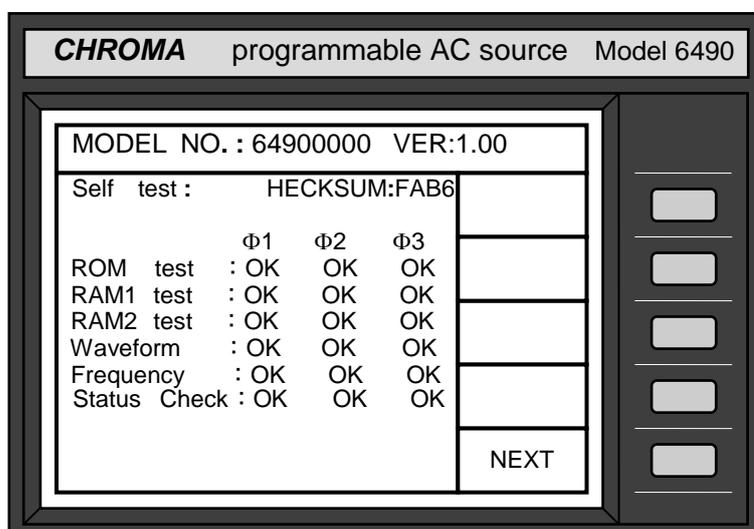
Connect the sensing leads from the “Ø1”, “Ø2”, “Ø3” and “COM” terminals on the remote sense to the load as shown in *Figure 2-2* (on the previous page). Because the sensing leads carry only a few milliamperes, the wires for sensing are much lighter than the load leads. The sensing leads are part of the feedback path of the AC source, so they must be kept at a low resistance in order to maintain the best performance. Connect the sensing leads carefully so that they will not be open-circuited. If the sensing leads are left unconnected or become open-circuited during operation, the AC source will disable the output, and display “OPEN INT”. The sensing leads must be a twisted pair to minimize the pickup of external noise. The sensing leads need to be connected to the load as close as possible. The user must press **ENTER** over two seconds to reset the AC source.

2.6 The Procedures of Power-on

⚠ WARNING 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 in the protective earth grounding will cause a potential shock hazard that might injure a person.

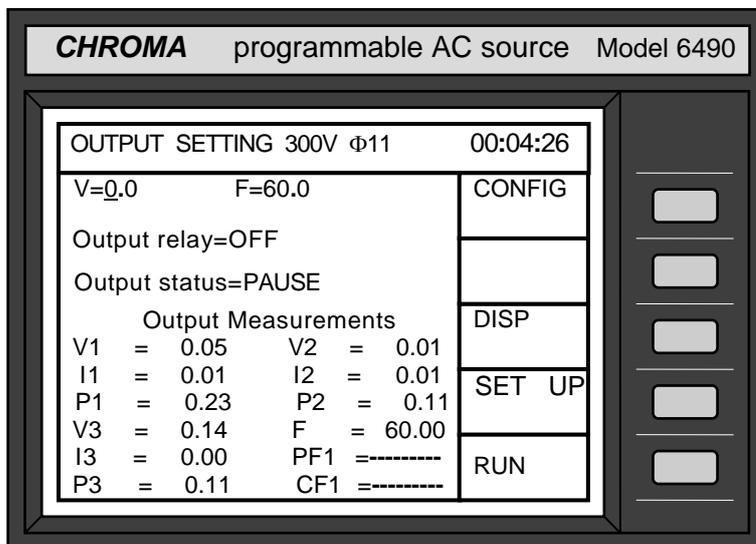
Apply the line power, and turn on the power switch on the front panel. No load shall be connected to the output terminal block. The AC source will do a series of self-tests every time the power switch is turned on.

After the routines of the self-test are done, the display will show an “OK” at the right side of each test item indicating that the item is no problem as follows:



If any failure is detected on a certain item, an “NG” will be shown at the right side of that item,

and the sound of “beep” will be heard. It takes about eight seconds to complete the routines of the self-test. If no error is found, the LCD will display as follows:



The following table shows all the error messages and recommended actions:

| Item | Error Message | Description | Action |
|------|-------------------|--|--|
| 1 | Rom test NG | System memory test fails. | Consult your dealer for assistance. |
| 2 | Waveform test NG | Waveform circuit test fails. | Consult your dealer for assistance. |
| 3 | Frequency test NG | Frequency test fails. | Consult your dealer for assistance. |
| 4 | RAM1/RAM2 test NG | Battery back-up memory test fails, or memory is bad. | Press 0 , 8 simultaneously to initialize memory. |
| 5 | Status Check NG | The NG phase interface test fails. | Consult your dealer for assistance. |

Notice

If you initialize memory, all of the saved data may be initialized, therefore you must check the saved data before doing so.

3. Local Operation

3.1 Introduction

The AC source can be configured to operate in local or remote mode. The operation in remote mode through a remote GPIB controller or RS-232C will be described in Section Six. In this section the operation in local mode through the keypad on the front panel for data entry and test is going to be described. The AC source is configured for local operation when it is turned on.

3.2 Operation through Keypad

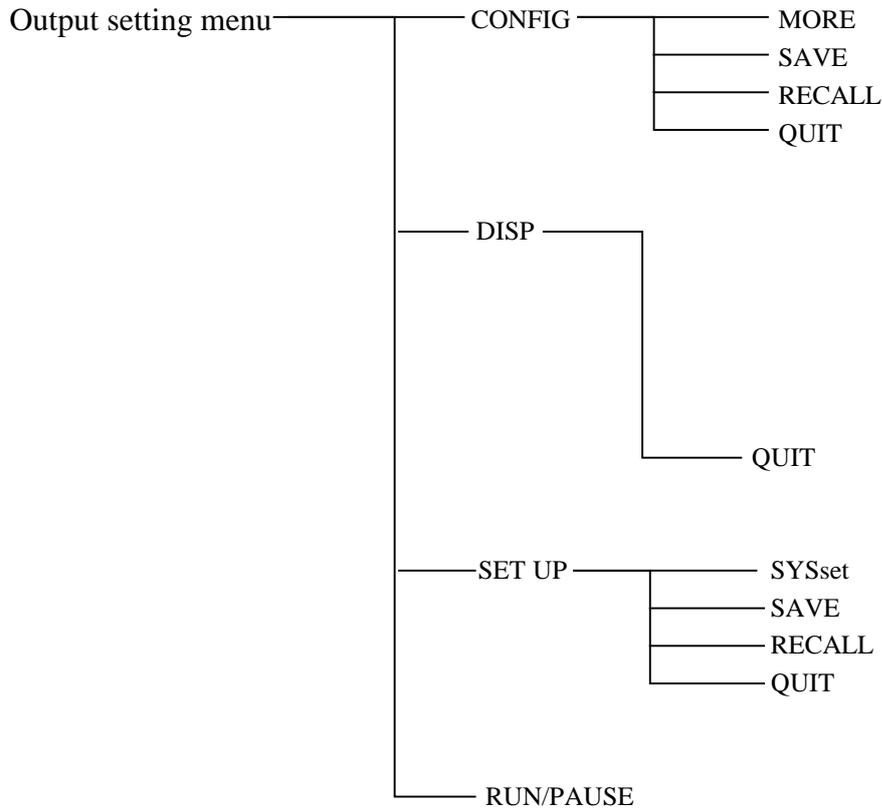
3.2.1 Introduction

The AC source provides the user-friendly programming interface using the keypad on the front panel to the user. Each display of the LCD on the AC source, which represents an operational menu, is divided into three zones.

1. **Headline:** It displays characters in reverse video on the first row of the LCD. This line provides information including current operation function, output parameters, and the total operation time after power-on.
2. **Command zone:** The farthest right column of the LCD is divided into five blocks. Each block represents a soft key for a minor function, which can be executed by pressing the key next to it. Hence, all the command sets are structured as a command tree. Each node of the command tree presents an operational menu. Also, on each node the LCD always provides the user with five choices to let him enter into other nodes, or quit from the current node.

Sample nodes (operational menu) and the command tree are shown below:

The command tree:



3. Parameters zone: The remaining area offers information which guides the user to program the AC source, to view the current status, to collect measurement results, etc.

3.2.2 Data Entry

Before describing each menu, the operations common in the parameters zone will be explained below:

Movement of Cursor

Use any of the cursor moving keys: \uparrow , \downarrow , \leftarrow , \rightarrow to move the cursor to the desired parameter for programming.

There are two ways for the user to set the parameters. One is in normal mode, and another in editing mode. The following example is how to set output voltage.

Normal Mode

- (1) Press the desired numeric keys of **1**, **3**, **5**, **.**, **2**, **ENTER** to set V=135.2V.
- (2) Press **▲** or **▼** key repeatedly, or keep pressing any of them until the desired value, V=135.2V, is shown on the LCD. Then, press **ENTER** to confirm. Increase or decrease value is done through the use of the farthest right digit.

Notice

If a parameter is modified, the user has to press **ENTER** to update the current data and save them into memory, otherwise the old data will remain when he exits from the machine.

Editing Mode

In editing mode the user can set parameters immediately without pressing **ENTER** to confirm.

The mode only allows the user to set V or F parameter. When the user moves the cursor to V parameter, and presses **Edit** to enter into the editing mode, the cursor will show as right:

Display of Cursor

| | |
|----------|---------|
| V=135.2_ | F= 60.0 |
|----------|---------|

Set the output voltage as 132.2V as follows:

Move the cursor to the position of digit 5 using **←**, and press **2** to set V=132_.2. Press **Edit** to enter into editing mode. Editing mode is useful when you want to change V or F parameter only one digit, or to set output V or F in step change. In this mode the user can increase or decrease the value of current position by pressing **▲**, **▼** or PRG too. Press **Edit** again to quit from editing mode.

3.2.3 Output Setting

The Output Setting on the screen is the main operation menu in the AC source, which accepts AC output parameters, including V, F Sync. source, etc. In this menu the user can activate the AC source by pressing the soft key of **RUN**, and obtain the measured results at the terminals of the devices under test.

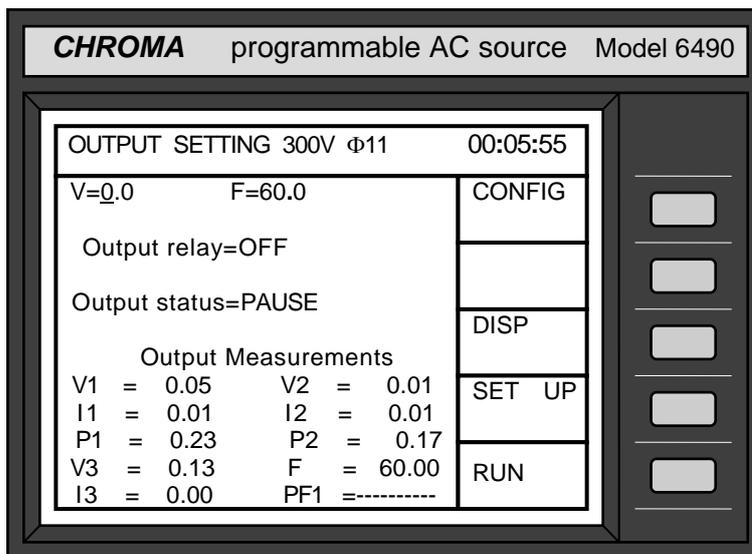
3.2.3.1 Setting Output Voltage and Frequency

Notice

The maximum output voltage of ONE power stage is limited by the peak value of the waveform, which is about 425 V_{peak}. 6463, 6490 have three power stages that can be selected in three phases or one phase (parallel). 6460 has two power stages that can be selected in series or parallel. The output is programmed in units of RMS volts. For a sine wave, the maximum AC voltage of ONE power stage that can be programmed is 300 V. So, for 6463, 6490 the max. Line to Line voltage is 519 V_{rms} in 3-phase mode, and 300 V_{rms} in 1-phase mode. For 6460 the max. voltage is 300 V_{rms} in parallel mode, 500 V_{rms} in series mode. The set voltage that we program here is just for each power stage. If we want to get 400 V_{rms} output of 6460 in series mode, we have to program 200 V on the display. For other waveforms, the max. voltage may be different.

When you turn on the AC source, the state of default output is set in the Configure menu of Power on output status. Set the output as V=135.2 V_{rms}, F=50.0 Hz as follows:

1. After you have powered on the AC source, and accomplished the self-test (or exited from any other menu by pressing **QUIT**), the LCD will display a main operational picture on the screen as follows (on the next page):



The line where the cursor stays indicates that the AC source is waiting for the input of the voltage value.

Display of Cursor

V= _ 0.0

2. Input the value of V as 135.2 by pressing **1**, **3**, **5**, **.**, **2**, **ENTER** to set voltage of 135.2 V_{rms}, or using data entry in section 3.2.2.

V=135.2 F= _ 60.00

3. Move the cursor to set frequency by inputting the value of F as 50 Hz, and pressing **5**, **0**, **ENTER**.

V= 135.2 F= 50.00



Notice

Voltage ranges from 0 to 300 V in step of 0.1 V. Frequency ranges from 45 to 1000 Hz in step of 0.01/0.1Hz.

3.2.3.2 The Setting of Output Relay

There is a relay on the output of the AC source for the connection with a load. When output relay is "ON", it means that the output relay is closed in spite that the output status of the AC source is in **QUIT** mode. When output relay is "OFF", it means that the output relay is closed only as the output status is in **RUN** mode. If the output status is in **QUIT** mode, the output relay will be open.

To set the output relay as ON as follows:

1. Move the cursor to the command of output relay.
2. Press **▲**, **ENTER** to set output relay ON. A click sound will be produced from the AC source when output relay is activated.

Output relay=OFF

Output relay=ON



Notice

Before powering off, please confirm if the AC SOURCE is outputting voltage. For ensure the life of the AC SOURCE, it powered off under outputting status is prohibited strongly.

3.2.3.3 The Output Status

There are two statuses of output. One is PAUSE, and another is RUN.

PAUSE: It means the output of the AC source is inactive.

RUN : It means the output of the AC source is active according to the user's set parameters.

3.2.3.4 The Programming of 3-Phase Unbalanced Voltage

Only for the 3-phase mode in 6463 and 6490, you can program the 3-phase output with different voltage:

1. Move the cursor to the command of phase select.
2. Press **▲** or **▼** to set $\emptyset 1$, and press **ENTER**.
3. Set the voltage for $\emptyset 1$.

phase select = $\emptyset 1$

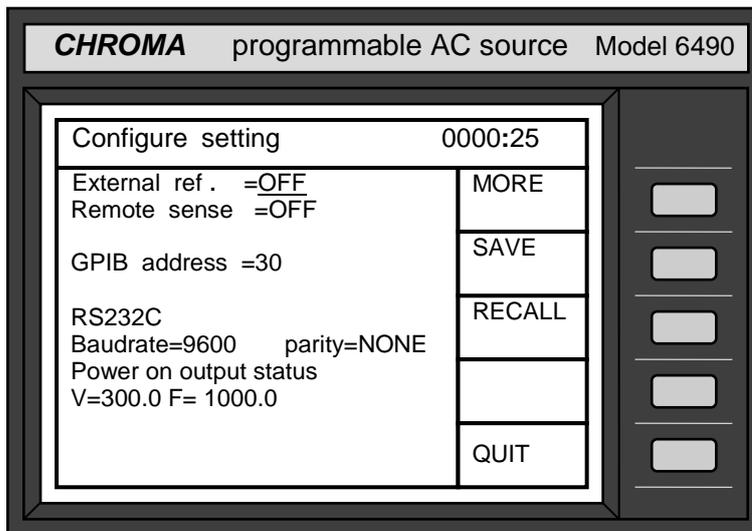
4. Repeat 1, 2, 3 for $\emptyset 2$ and $\emptyset 3$ with the set voltage you desire. Then, press **RUN**, you will get the different voltage as you program at the output.

5. If you choose Ø1+Ø2+Ø3, the programmed voltage will be for all three phases.

3.2.4 The Setting of Configuration

The AC source provides the user with a lot of useful features such as Remote sensing, External reference, etc. To use these powerful features the user must program relevant parameters according to the needs of application using the configuration setup.

Press the soft key, **CONF**, the LCD displays the following picture:



3.2.4.1 External Reference

The AC source allows the user to make use of the controlled signal from external devices for the setting of its output. The BNC connector of the external reference on the rear panel lets the user apply DC signal to the AC source for the setting of output voltage. The output voltage (V_{out}) responses linearly proportional to the controlled DC level with voltage ranging from 0 to 10 V. V_{out} can be calculated using the following formula:

$$V_{out} = V_{control} / 10 V \times V \text{ range.}$$

To set V_{out} to 60Vrms:

1. Select range = 300V in setup menu, apply external DC = 2V, and V_{out} = 60Vrms.
2. Select range = 150V in setup menu, apply external DC = 4V, and V_{out} =60Vrms.

The procedures of setup are shown below:

1. Move the cursor to the command of External ref.
2. Press **▲**, **ENTER** to change the option from OFF to ON.

External ref. =OFF

External ref. =ON

Notice

When external ref. is set as ON, the output voltage (Vout) will respond to the external control DC voltage level. The user cannot control Vout amplitude through the keypad on the front panel until external ref. is set as OFF again. However, the user can still program and output other parameters.

3.2.4.2 Remote Sense

Remote sensing is to eliminate voltage drop on the connection cables from the output terminal of the AC source to that of the load. For the details of wire connection please refer to *section 2.5*. The procedures of setup are shown below:

1. Move the cursor to the command of Remote Sense.
2. Press **▲**, **ENTER** to change the option from OFF to ON.

Remote Sense =OFF

Remote Sense =ON

3.2.4.3 GPIB Address

The AC source offers the mode of remote operation too. For details please refer to *Chapter 5*. Prior to remote operation the user has to set the GPIB address 10 as follows:

1. Move the cursor to the command line of GPIB address.
2. Press **1**, **0**, **ENTER** to set address 10.

GPIB address =30

GPIB address =10

Notice

Addressing space ranges from 0 to 30.

3.2.4.4 The Setup of RS-232C

The AC source offers another remote operation through the RS-232C bus. Communication protocol is set as follows:

To set baud rate=19200, parity=ODD.

1. Move the cursor to the command line of Baudrate.
2. Press **▲**, **▼** or turn RPG to select 19200, then press **ENTER**.

Baudrate=4800 Parity=EVENBaudrate=19200 Parity=EVEN

- The cursor moves automatically to the setting position of "parity".

Press ,  or turn RPG to select "ODD", then press .

Baudrate=19200 Parity=ODD

 **Notice**

The options of baud rate are 2400/4800/9600/19200. The options of parity are EVEN/ODD/NONE.

3.2.4.5 The Saving

To save all of the system data as follows:

- Press , and the LCD displays as right.

Save to group 0

- Press the numbers from 0 to 2 on the numeric keypad to select a desired memory group.
- Press  to confirm it.

 **Notice**

- Selection of memory group is programmable by pressing the numeric keypad only. Other methods, including the turning of rotary knob and the pressing of  or , are invalid when the user tries to program a memory group to be "Saved" or "Recalled".
- The AC source provides three memory groups: 0, 1, and 2. The memory group 0 keeps power-on defaults. The setups saved into the memory group 0 will be recalled automatically when the AC source is powered on again while those saved into other memory groups must be recalled manually.

3.2.4.6 The Recalling

To recall the system data as follows:

- Press , and the LCD displays as right.
- Press the numeric keypad to select a desired memory group.
- Press  to confirm it.

Recall from group 0

3.2.4.7 More

Press the soft key of  to enter into another display to select output phase and the waveform.

3.2.4.7.1 The Selection of Phase Status

In 6460 there are two modes, “parallel” and “series”, for choice. In 6463, 6490 there are two modes, “one phase” and “three phase”, for choice too. If you choose “three phase” and press **ENTER**, there will be $\varnothing 2=120.0$, $\varnothing 3=240.0$ appearing at the downside of the display. They are the phase shift of $\varnothing 2$ and $\varnothing 3$ reference to $\varnothing 1$, and can be programmed as you like.

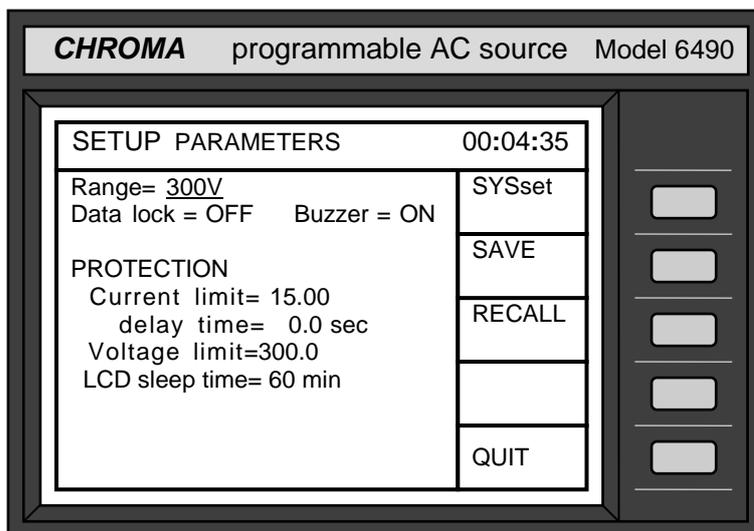
Note You can easily verify the mode you are using from the headline of the output main menu.

$\varnothing 13$: “series” mode for 6460 and “3-phase” mode for 6463, 6490.

$\varnothing 11$: “parallel” mode for 6460 and “1-phase” mode for 6463, 6490.

3.2.5 The Setting of Setup

The operational menu of “SET UP” manages the setups for V full range, waveform, data lock, protections, etc. Press **SET UP** to enter into the menu of “SET UP”, and the LCD will display as follows:



3.2.5.1 The Output Range

The AC source supplies full range of output voltage with two options of 150 V or 300 V.

To set the range of output voltage as 150 as follows:

1. Move the cursor to the command line of Range.
2. Press **▲** or **▼** to change the option from “300” to “150”, then press **ENTER**.

Range = 300

Range = 150

Notice

The AC source will set output voltage as 0 V first in order to eliminate voltage spike when range changes. Then, it will set output voltage as set value. It may cause UUT to shut down or get bad if the output is

active, and range changes.

3.2.5.2 The Data Lock

The AC source allows the user to lock data entries, so the pre-defined parameters can be protected from being modified by an unauthorized person.

The procedures for the setting of data lock are shown below:

1. Move the cursor to the command line of "Data lock".

| |
|------------------------------------|
| Data lock = <u>OFF</u> Buzzer = ON |
|------------------------------------|

2. Press **▲**, **ENTER** to change the option from OFF to ON.

| |
|-----------------------------------|
| Data lock = ON Buzzer = <u>ON</u> |
|-----------------------------------|



The user must select OFF to unlock.

3.2.5.3 The Setup of Buzzer

The buzzer of the AC source beeps when the user presses the keypad on the front panel, or turns the PRG knob. If the user does not need it, turn it off.

To turn off the buzzer as follows:

1. Move the cursor to the command line of "Buzzer=".

| |
|------------------------------------|
| Data lock = off Buzzer = <u>ON</u> |
|------------------------------------|

2. Press **▲**, **ENTER** to change the option from ON to OFF.

| |
|------------------------------|
| Data lock = off Buzzer = OFF |
|------------------------------|

3.2.5.4 Protection

Limitation of output RMS current, output voltage, and delay time are the parameters for triggering overload protection. The discussion of protection/limitation in this subsection is about user-programmable protection, not hardware protection.

The procedures for setting Current limit = 20A, Delay time = 1 sec., and Voltage limit = 250V are described below:

1. Move the cursor to the command line of "Current limit=".

| |
|-----------------------|
| Current limit= _15.00 |
|-----------------------|

2. Press **2**, **0**, **ENTER** to change the value to "20.00".

| |
|---------------------|
| Current limit=20.00 |
|---------------------|

3. The cursor moves to the command line of "delay time=" automatically.

| |
|----------------------|
| delay time= _0.0 sec |
|----------------------|

4. Press **[1]**, **[ENTER]** to change the value to "1.0".

```
delay time= 1.0 sec
```

5. The cursor moves to the command line of "Voltage limit=" automatically.

```
Voltage limit = 150.0
```

6. Press **[2]**, **[5]**, **[0]**, **[ENTER]** to change the value to "250.0".

```
Voltage limit =250.0
```

Notice

1. Delay time is valid for eliminating transient current spike, which is useless in voltage protection.
2. Current limit ranges from 0 to 100 in step of 0.01 A.
Delay time ranges from 0 to 100 in step of 0.1 sec.
Voltage limit ranges from 0 to 300 in step of 0.1 V.
3. The output of the AC source will be disabled when protection is active, and will remain so even the condition is released. The user has to press **[ENTER]** for over two seconds to reset the AC source.

3.2.5.5 The Saving/Recalling

Please refer to 3.2.4.5 and 3.2.4.6 for related information.

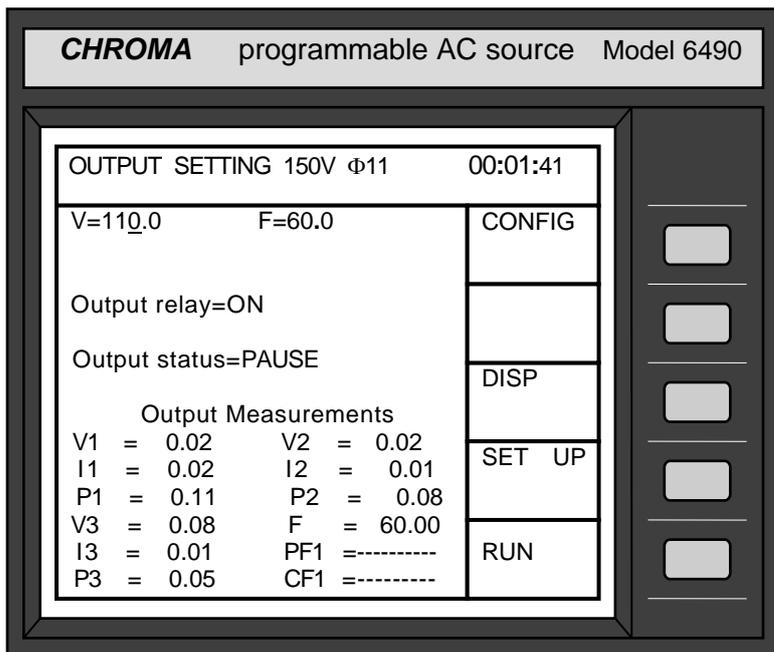
3.2.5.6 The SYSsetting

This function is reserved for maintenance and factory testing only.

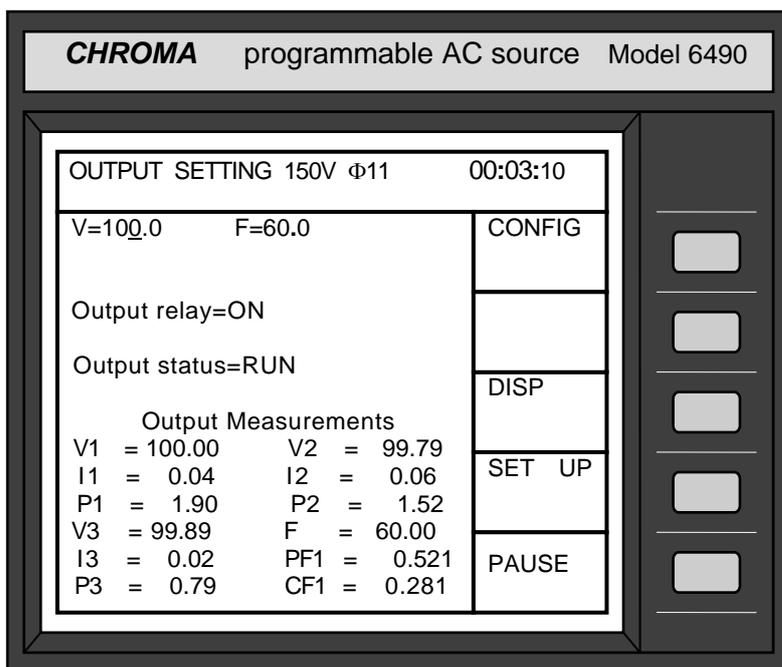
3.3 Applications

3.3.1 The Execution of Output

In the main operational menu of output, the user can press the soft key **[RUN]** to enable the execution of output. When the user presses **[RUN]**, the LCD will change from "Output status=PAUSE" to "Output status=RUN", and the command string of the original "RUN" will change to "PAUSE" (Push the soft key **[PAUSE]** to disable output when output is in "RUN"). The following example of LCD indicates the states when the user toggles the output between "RUN" and "PAUSE" by the soft key. If the output is inactive, the LCD will show as follows:



Press **RUN** to enable the active output, and the LCD will show as follows:



Notice

The user may observe the measured values of the measurable items under Output Measurements on the lower part of the LCD. For detailed description of the measurement please refer to *section 3.4*.

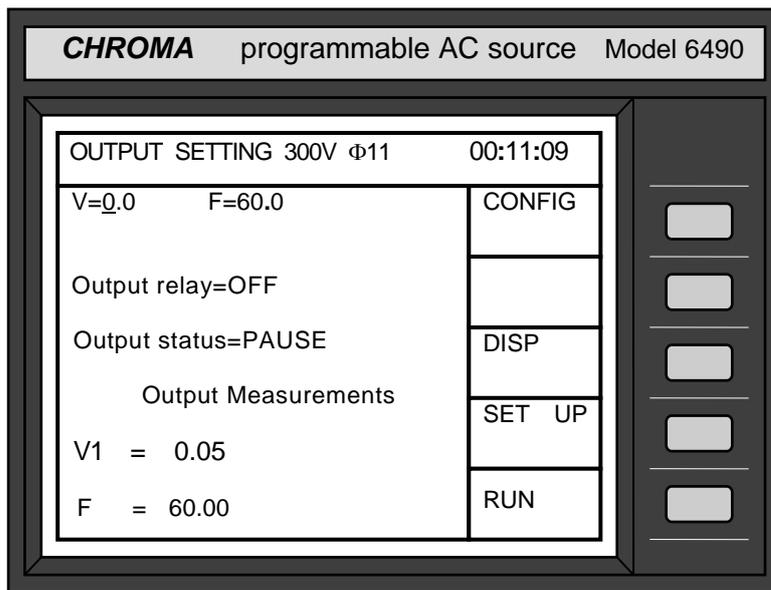
3.4 Measurement

The AC source can measure the actual performance of a load connected to it without using an extra measuring instrument. When the AC source is active, it measures the V, I, F, P, etc. of

a load of each phase. The user can select the measurement point at the connector of a load (remote sense= ON), or at the output connector of the AC source itself.

3.4.1 The Selection of Measurement Items

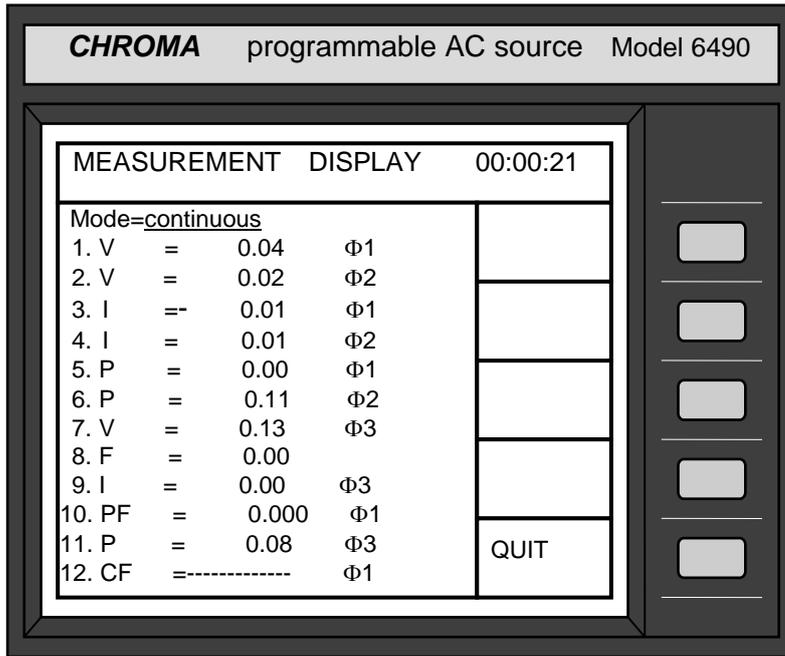
The AC source can display concurrently up to 7 measurable readings, including V, P, I, CF, PF, F, Ptot. The user can select different measurement functions to display the measured readings. If the user selects less than three measurement functions, the LCD will display the measurement in enlarged characters as follows (The lower half of the main operational menu is the display area of measurement):



When the output parameters for measurement are more than three, the LCD will display in normal characters.

The procedures for selecting the measurement functions are described below:

1. Enter into the measurement display menu by pressing the soft key **DISP** in the main operation menu. The LCD displays as follows:

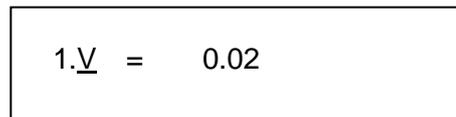


(It is the default setting from the factory for all the measurement items.)

2. Display the readings in a continuous way, or display a single measurement per trigger by turning rotary knob, or pressing or key (Leave “continuous” unchanged).

Note | If the user selects “single”, he may use **TRIG** for measurement by manual trigger.

3. Move the cursor to the first display item.
Number: 1 in front of V means the display position of measurement function.



4. Turn the rotary knob clockwise, or press and the measurement functions will change one by one in the following order:

V => P => I => CF => PF => F => Ptot => empty => (return to V)

Note | 1. Turn the rotary knob counterclockwise or press , the item will appear in reversely order.
2. The option “empty” means that nothing is displayed for a corresponding item.

5. Select a desired measurement function, and press **ENTER** to confirm. The cursor moves to the second column automatically.
6. You can select the phase $\emptyset 1$, $\emptyset 2$ (or $\emptyset 3$ for 6463, 6490) by turning the rotary knob and pressing **ENTER** to confirm. The cursor moves to the next item of the first column. When you return to the main menu, these measurement items will be displayed on the lower half of the screen as shown by the above sample.

Note | If the user selects more than three items, the odd items will be displayed on the left column, and the even items on the right one. If the selected items are less than or equal to three, they will be listed with only one column in enlarged characters.

7. Repeat step 4, 5, and 6 for the remaining items.

3.4.2 Measurement Functions

The AC source offers 7 measurement functions to the user. All the functions can be specified to display in the main operational menu as stated in the previous subsection. The definitions of the functions are listed in the following table:

Table 3-1 Available Measurement Functions

| Function | Definition |
|----------|--|
| V | It is the measurement readings of Voltage in Volts. (true RMS measurement) |
| F | It is the measurement readings of Frequency in Hertz. |
| I | It is the measurement readings of Current in Amperes. (true RMS measurement) |
| P | It is the true Power measurement in Watts. |
| CF | It is the Crest Factor, and its calculation formula = I_{peak}/I_{rms} . |
| PF | It is the Power Factor, and its calculation formula = true power/ ($V_{rms} \times I_{rms}$) |
| Ptot | It is the sum of the power of all phases = $P_1+P_2(+P_3)$ |

3.5 Protection

The AC source provides protection for software and hardware. Protection for software is listed below:

| Protection | Description |
|---------------------|---|
| Current | When current is over the limit, protection is given. |
| Power | When power is over the limit, protection is given. |
| Voltage Limit | The user cannot program the voltage more than the set voltage limit. |
| Voltage Range Error | During the operation of the AC source, this message will be displayed when the set voltage is beyond the full scale of the current voltage range. |

Protection for hardware is listed on the next page too.

| Protection | Description |
|------------|---|
| PFO INT | It is power failure protection, and means that the voltage of the power supply is lower than specification. |
| FAN INT | It is fan failure protection, and means that the cooling fan malfunctions. |
| OPP INT | It is over power protection, and means that the output stage is over the power specification. |
| OCP INT | It is over current protection, and means that the output stage is over the current specification. |
| SHT INT | It is short protection, and means that the output terminals are shorted. |
| INP INT | It is power failure protection, and means that the voltage of the input |

| | | |
|-------|-----|--|
| | | power supply is lower than specification. |
| OTP | INT | It is over temperature protection, and will be enabled when the internal temperature of the AC source is too high. |
| OPEN | INT | It is feedback open protection. |
| S.OCP | INT | It is over current protection, and means that the output stage is over the current limit user programs. |
| S.OPP | INT | It is over power protection, and means that the output stage is over the power specification which is checked by software. |
| NP | INT | It is negative power protection, and means that the output stage has negative power. |
| dV | INT | The protection happens when there is a large difference between the set voltage and the measured one. |

If any output protection mentioned above is triggered to hold normal output, please remove the errors, then, press **ENTER**, and hold the key for two seconds to unlock the output protection so as to resume the normal operation.

4. Theory of Operation

4.1 General Information

The AC source consists of two (6460) or three (6463/6490) power stages, and each stage has 13 print circuit boards and other components. Each of the PCBs has its specific function that will be described in the following subsection.

4.2 Description of Overall System

Figure 4-1 (on page 4-2) shows the overall system of each power stage. Main power flows through the A/D, D/D, D/A power stage converter. The A/D power stage is designated as I board, and generates DC voltage from the line input. The DC voltage of A/D output is applied to the input of D/D power stage. The G board of D/D stage takes power from the A/D output. It generates two isolated DC outputs for D/A power stage. The H board of D/A inverter generates AC output through full bridge controlled by C board to O board. The D/A power stage is through O board relays in parallel or series control to obtain more current and higher voltage.

A board is identified as CPU. The CPU of the AC source is used to perform remote control through GPIB, RS-232C or EXT VREF interface on Optional board, to control output frequency and voltage through BS and C boards, to measure voltage, current and power through BM board, to display message, to scan front panel key through LCD module and K board, and to monitor all interrupts.

BM board is identified as measurement unit. All measurement functions are done here.

BS board is identified as waveform generator. It generates output waveforms which act as the reference input of C board.

C board is identified as controller of DC to AC (H board). It controls DC to AC power stage in order to get low distorted waveform output.

K board is identified as keyboard which includes RPG (Rotary Pulse Generator). It is an interface between the user and the instrument when the latter is used in local operation.

Extended and Optional boards are identified as input/output signals which include GPIB, RS-232C, EXT VREF, printer and other I/O control signals. Optional board is on Extended board.

M1 board is identified as mother board which includes system power supply, fan control circuit, and interconnection of A, BM, BS, C boards.

M2 board is simply an interconnection of M1, Extended, and O boards.

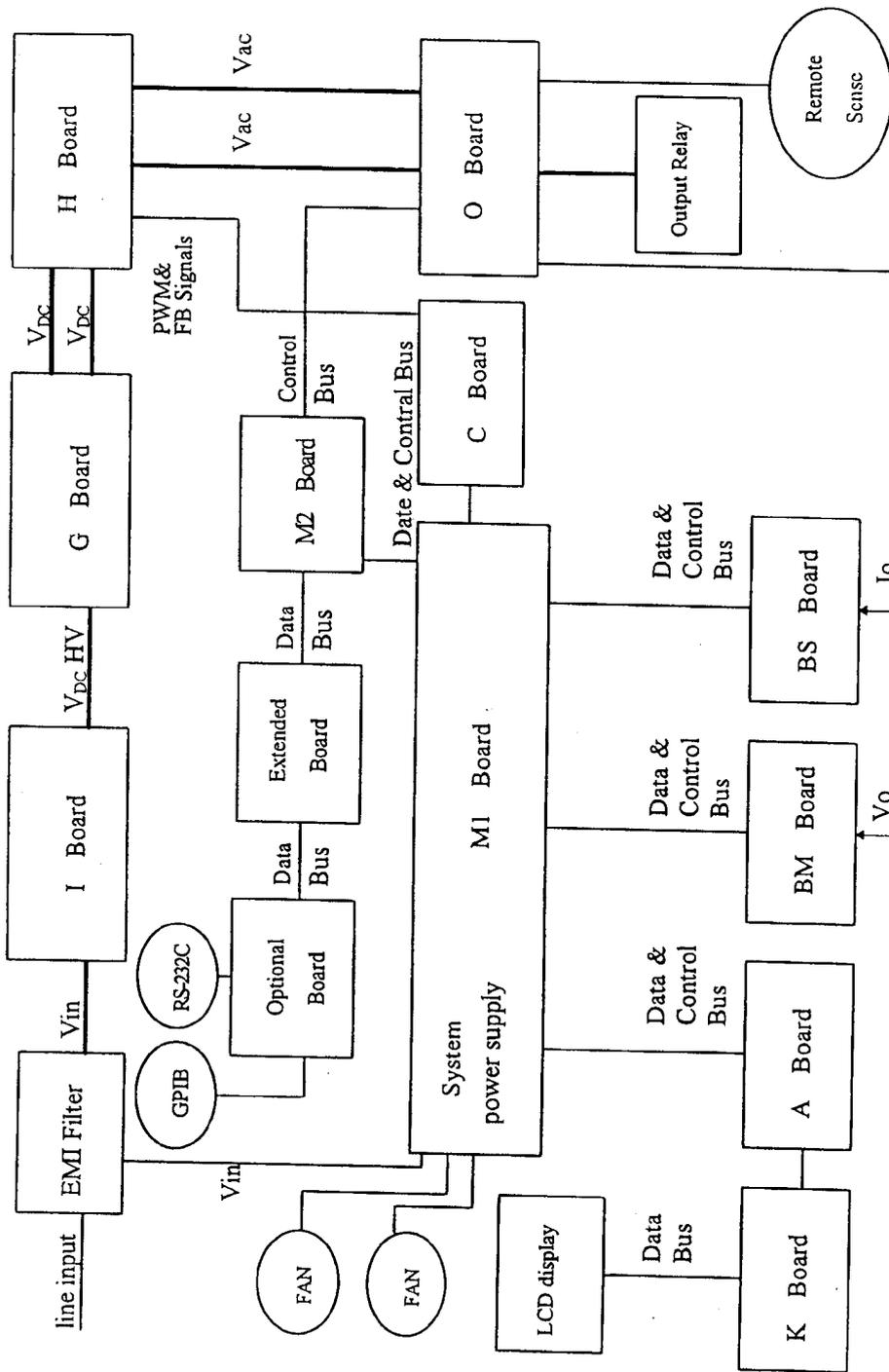


Figure 4-1 Block Diagram of Each Power Stage

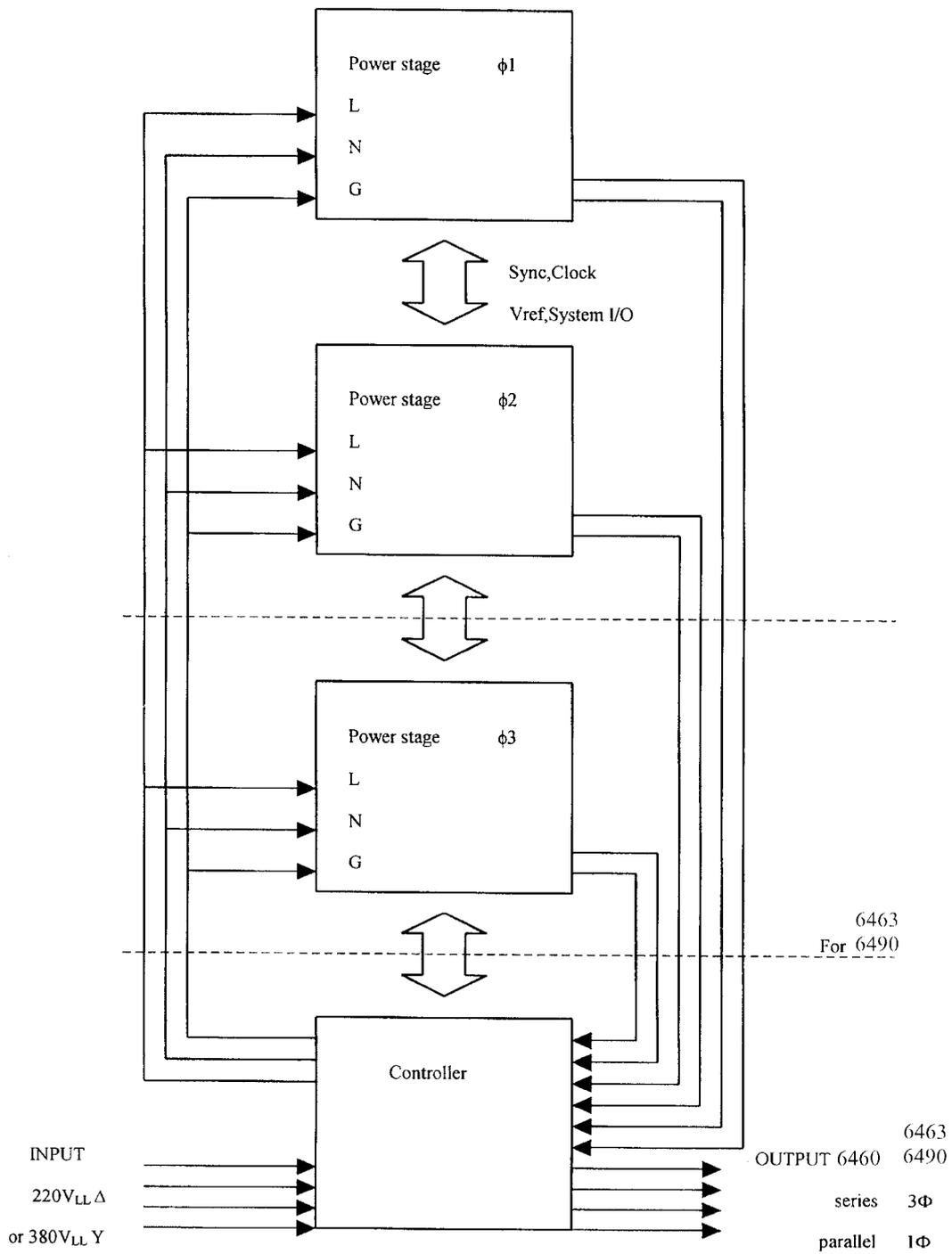


Figure 4-2 System Block Diagram

5. Remote Operation

5.1 General Information

The AC source can be controlled remotely through the GPIB or the RS-232C port. The GPIB port is mostly used, but the RS-232C port is helpful too.

Technically speaking, the GPIB interface is quite different from the RS-232C interface. The GPIB interface is an 8-bit parallel data bus owning a host of bus commands for synchronization, and up to one Megabyte transfer rate. The RS-232C interface, a series bus with a few handshake lines for synchronization, is less capable, so its requirement is not so much, and the user can write a simple program to do basic remote control easily.

5.1.1 Setting the GPIB Address and RS-232C Parameters

The AC source is shipped with the GPIB address which is set at 30. The address can be only changed from the front panel by pressing the soft key **CONFIG** in the “Configure setting” menu. This menu is also used to select the RS-232C interface, and specify the parameters of RS-232C such as baud rate and parity.

Set the GPIB address as follows:

1. Press **CONFIG** to enter into the “Configure setting” menu.
2. Move the cursor to the line of GPIB address.
3. Enter the new address from the numeric keys such as **5**, **ENTER**, and the GPIB address will change to 5.

Display of Cursor

GPIB address = 30

GPIB address = 5

Set the RS-232C interface as follows:

1. Press **CONFIG** to enter into the “Configure setting” menu.
2. Move the cursor to RS-232C parameters of baud rate.
3. Select baud rate by pressing **▲** or **▼** key then press **ENTER**.
4. Move the cursor to the line of parity, and select parity as you select baud rate.

Baudrate = 4800 Parity=EVEN

5.1.2 Wire Connection of RS-232C

The AC source is shipped with the baud rate which is set at 9600, and with parity which is set as None. For RS-232C interface, only the signals of TxD, RxD, DTR, and CTS are used for its transfer of data. The RS-232C connector is a 9-pin D subminiature female connector. The following table describes the pins and signals of RS-232C connector.

| Pin No. | Input/Output | Description |
|---------|--------------|---------------|
| 1 | --- | No connection |
| 2 | OUTPUT | TxD |
| 3 | INPUT | RxD |
| 4 | INPUT | DSR |
| 5 | --- | GND |
| 6 | OUTPUT | DTR |
| 7 | INPUT | CTS |
| 8 | OUTPUT | RTS |
| 9 | --- | No connection |

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

| IBM PC | | AC source |
|---------|--------|-----------|
| 1 (DCD) | X | |
| 2 (Rx) | <----- | 2 (Tx) |
| 3 (Tx) | -----> | 3 (Rx) |
| 4 (DTR) | -----> | 7 (CTS) |
| 5 GND | ----- | 5 GND |
| 6 (DSR) | X | |
| 7 (RTS) | X | |
| 8 (CTS) | <----- | 6 (DTR) |
| 9 (RI) | X | |

DTR of the AC source is inactive if receiver's buffer is full. It means that the AC source will not receive any data until DTR is active. Similarly, if CTS of the AC source is inactive, data will not be sent to the computer.

5.2 The GPIB Capability of the AC Source

| GPIB Capability | Description | Interface Functions |
|-----------------|--|---------------------|
| Talker/Listener | Commands and response messages can be sent and received over the GPIB bus. Status information can be read using a series poll. | AH1, SH1, T6, L4 |
| Service Request | The AC source sets the SRQ line true if there is an enabled service request condition. | SR1 |
| Remote/Local | The AC source powers up in local state. In local state, the front panel is operative, and the AC source responds to the commands from GPIB. In remote state, all front panel keys except the local key are disabled. Press local key to return the AC source to local state. Local key can be disabled | RL1 |

| | | |
|--|---|--|
| | using local lockout so that only the controller or the power switch can return the AC source to local mode. | |
|--|---|--|

5.3 Introduction to Programming

All commands and response messages are transferred in form of ASCII codes. The response messages must be read completely before a new command is sent, otherwise the remaining response messages will be lost, and a query interrupt error will occur.

5.3.1 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 more times. |

5.3.2 Numerical Data Formats

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

Numerical Data Formats

| Symbol | Description | Example |
|--------|--|------------|
| NR1 | It is a digit with no decimal point. The decimal is assumed to be at 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 |

5.3.3 Boolean Data Format

The Boolean parameter <Boolean> takes only the form ON|OFF.

5.3.4 Character Data Format

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

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

5.3.5 Basic Definition

Command Tree Table:

The commands of the AC source are based on a hierarchical structure, also known as a tree system. In order to obtain a particular command, the full path to that command must be specified. 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, below the parent node.

Program Headers:

Program headers are key words that identify the command. They follow the syntax described in *subsection 7.6* of IEEE 488.2. The AC source accepts characters in both upper and lower case without distinguishing the difference. Program headers consist of two distinctive types, common command headers and instrument-controlled headers.

Common Command and Query Headers:

The syntax of common command and query headers is described in IEEE 488.2. It is used together with the IEEE 488.2-defined common commands and queries. The commands with a leading “*” are common commands.

Instrument-Controlled Headers:

Instrument-controlled headers are used for all other instrument commands. Each of them has a long form and a short form. The AC source only accepts the exact short and long forms. A special notation will be taken to differentiate the short form header from the long one of the same header in this subsection. The short forms of the header are shown in characters of upper case, whereas the rest of the header are shown in those of lower case.

Program Header Separator (:):

If a command has more than one header, the user must separate them with a colon (FETC:CURR FUNC:SHAP). Data must be separated from program header by one space at least.

Program Message:

Program message consists of a sequence of zero or more elements of program message unit that is separated by separator elements of program message unit.

Program Message Unit:

Program message unit represents a single command, programming data, or query.

Example : VOLT?, OUTPut ON.

Program Message Unit Separator (;):

The separator (semicolon ;) separates the program message unit elements from one another

in a program message.

Example : VOLT 110 ; FREQ 120<PMT>

Program Message Terminator (<PMT>):

A program message terminator represents the end of a 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.

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

5.4 Traversal of the Command Tree

Multiple program message unit elements can be sent in a program message. The first command is always referred to the root node. Subsequent commands are referred to the same tree level as the previous command in a program message. A colon preceding a program message unit changes the header path to the root level.

Example :

| | |
|---|--|
| OUTPut : PROTection : DELAY 1 | All colons are header separators. |
| : OUTPut : PROTection : DELAY 1 | Only the first colon is a specific root. |
| OUTPut : PROTection : DELAY 1; : VOLT 100 | Only the third colon is a specific root. |

5.5 Execution Order

The AC source executes program messages by the order received. Program message units except coupled commands are executed in order of reception. The execution of coupled commands is deferred until program message terminator is received. A coupled command sets parameters which are affected by the setting of other commands. Problems may arise, because the prior state of the AC source will affect the response of a coupled parameter to its programming.

For example, assume that the current output voltage range is LOW, a new state is desired with output voltage range HIGH, and amplify 220 Volt. If the commands

```
VOLTage 220<PMT>
RANGe HIGH<PMT>
```

are sent, data out of range error will be produced. Reversing the order, or sending the commands in one program message can avoid such kind of error. For the above example, the program message

```
VOLTage 220 ; RANGe HIGH<PMT>
```

can be sent without error.

The following commands are coupled : VOLTage, : RANGe.

5.6 The Commands of the AC Source

This subsection is going to talk about the syntax and parameters for all commands of the AC source. The examples given for each command are generic.

| | |
|--------------|---|
| Syntax Forms | Definitions of syntax are in long form headers, whereas only short form headers appear in examples. |
| Parameters | Most commands require a parameter, and all queries return a parameter. |
| Models | 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. |

5.6.1 Common Command Dictionary

Common commands begin with a “ * ”, and consist of three letters and/or one “ ? ” (query). Common commands and queries are listed alphabetically.

*CLS, Clear Status Command

Description: This command clears all Event registers summarized in the status byte (Standard Event status register, Questionable Status Event register), and clears the error queue. If the *CLS command immediately follows a program message terminator, the output queue and the MAV bit are also cleared.

Syntax: *CLS

Parameters: None

*ESE<n> Standard event status enabled

This command programs the Standard Event register bits. If one or more of the enabled events of the Standard Event register is set, the ESB of Status Byte Register is set too.

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 | | | | | DDE = Device-dependent error | | | |
| EXE = Execution error | | | | OPC = Operation complete | | | | |
| PON = Power-on | | | QYE = Query error | | | | | |

*ESE? Return standard event status enabled

The query reads the Standard Event Status Event register.

***IDN?** Return the AC source identification

Return Parameter Chroma ATE 6490, 1234, 2.01
 Chroma ATE : Company name
 6490 : Model name
 1234 : Serial number
 2.01 : Firmware version number

***OPC?**, Operation Complete Query; this query returns an ASCII "1" when all pending operations are completed.

***RCL<n>** Restore the values of the specific group which is previously stored in memory.

Parameter 0 - 2

***RST** This command resets the ac source to the following states:

| Item | Value |
|----------------------|-------|
| OUTPUT :STATE | OFF |
| FREQ | 60.0 |
| VOLT | 0.0 |
| CURR:LIMIT | 15.0 |
| VOLT:LIMIT | 300.0 |
| INST:COUP | ALL |
| INST:NSEL | 1 |

***SAV<n>** Save the values into the specific group in memory.

***STB?**, This query returns the Status Byte register (STB). The status byte can be read with either a serial poll or the *STB? Common query. If it is read with a serial poll, the RQS bit is sent for the bit 6 position and then cleared. If it is read with *STB?, MSS bit is sent but not cleared.

Bit configuration of Status Byte Register

| Bit position | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-------------------|------|-----|-----|-----|------|-----|-----|-----|
| Condition | OPER | MSS | ESB | MAV | QUES | --- | --- | --- |
| | | RQS | | | | | | |
| Bit Weight | 128 | 64 | 32 | 16 | 8 | | | |

RQS: Request service bit
 MSS: Master status summary bit
 ESB: Event status summary bit
 MAV: Message available summary bit
 QUES: Questionable status summary bit
 OPER: Operation status summary bit

***SRE** This command sets the content of the Service Request Enable register (SRE), which determines which events of the Status Byte Register (STB) are allowed to set the Master Status Summary (MSS) bit and the Request for Service Summary (RQS) bit. If a bit is 1 in SRE and its associated event bit in STB transitions to true, bit 6 of STB is then set true.

Query Syntax: *SRE?

***TST?, Self-Test Query**

This query causes an internal self-test and reports result.
 Return parameters <NR2>

5.6.2 Instrument Command Dictionary

The commands are listed in alphabetical order. Commands followed by question marks (?) take only the query forms. When commands take both the command and query forms, they are noted in the syntax descriptions.

FETCh | MEASure

[: SCALar]

: CURRent

: AC?

: CRESfactor?

Query AC rms current

Query current crest factor

This command lets the user get measurement data from the AC source. Two measurement commands are available: MEASure and FETCh. MEASure triggers the acquisition of new data before returning data. FETCh returns the previously acquired data from measurement buffer. Individual outputs of a multi-phase source are specified by the setting of INSTRument : NSELect command.

FETCh [: SCALar] : CURRent : AC?

MEASure [: SCALar] : CURRent : AC?

Return parameters <NR2>

These queries return the rms current which is being output at the output terminal.

FETCh [: SCALar] : CURRent : CRESfactor?

MEASure [: SCALar] : CURRent : CRESfactor?

Return parameters <NR2>

These queries return the output current crest factor. It is the ratio of peak output current to rms output current.

FETCh | MEASure

[: SCALar]

: FREQuency?

Query the output frequency

FETCh [: SCALar] : FREQuency?

MEASure [: SCALar] : FREQuency?

Return parameters <NR2>

These queries return the output frequency in Hertz.

FETCh | MEASure

[: SCALar]

```

: POWer
  : AC
    [ : REAL] ?           Query real power
    : PFACTOR?           Query power factor
    : TOTAl?             Query total power

```

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

Return parameters <NR2>

These queries return the true power which is being output at output terminals in watts.

FETCh [: SCALAr] : POWer : AC : PFACTOR?
MEASure [: SCALAr] : POWer : AC : PFACTOR?

Return parameters <NR2>

These queries return the power factor which is being output at output terminals. Power factor is computed as:

PF = TRUE POWER / APPARENT POWER

FETCh [: SCALAr] : POWer : AC : TOTAl?
MEASure [: SCALAr] : POWer : AC : TOTAl?

Return parameters <NR2>

Model 6460/6463/6490 only.

These queries return the total true power which is being output at output terminals in watts.

```

FETCh | MEASure
  [ : SCALAr]
    : VOLTage
      : AC?           Query the output voltage

```

Return parameters <NR2>

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

These queries return the ac rms voltage which is being output at the output terminals.

```

INSTrument
  : COUPlE ALL | NONE           Set coupled phases for programming
  : NSElect <n>                 Select output phase to program
  : SElect <OUTPut>

```

Model 6463/6490 only.

INSTrument : COUPlE ALL | NONE

Query syntax INSTrument : COUPlE?
Return parameters ALL | NONE

In a multi-phase power source it is convenient to set parameters of all phases simultaneously with one programmed command. When **INST : COUP ALL** command is programmed, a command will be sent to the AC source, and to all phases in the end. **INST : COUP NONE** command cancels **COUP ALL** command. This command only affects set voltage.

This command has no effect on queries and can set parameters only.

INSTrument : NSElect 1| 2| 3
INSTrument : SElect OUTPut1| OUTPut2| OUTPut3
 Query syntax INSTrument : NSElect?
 Return parameters 1| 2| 3

This command sets individual outputs in a multi-phase model for subsequent commands or queries. If **INST : COUP NONE** is programmed, the phase-selective commands are sent to the particular output phase set by **INSTrument : NSElect** command. If **INST : COUP ALL** is programmed, all commands are sent to all output phases. This command affects set voltage and queries Measurement data. For example, if "**INST : COUP ALL** " and "**INST : NSEL 2**" and "**Meas : V?**" are programmed, the AC source will return Ø2's measured voltage. **INST : NSEL** selects phase by its number, and **INST : SEL** refers to it by its name.

ORELAY ON | OFF Set output relay on (closed) or off (open)

This command sets output relay on/off.

ON sets the output relay of the AC source on (closed).
OFF sets the output relay of the AC source off (open).

OUTPut
 [: STATE] <bool> Enable/disable the output of the AC source
 : PROTection
 : CLear Reset protection status
 : DELay <n> Set the delay time of protection

OUTPut [: STATE] ON | OFF

Query syntax OUTPut?
 Return parameters ON | OFF

This command enables or disables the output of the AC source. Disable output is to set an output voltage amplitude at 0 Volt.

OUTPut : PROTection : CLear

This command clears the latch that disables the output when an overcurrent (OC), overtemperature (OT) or overpower (OP) is detected. All conditions which have generated the fault must be removed before the latch is cleared.

OUTPut : PROTection : DELay <NR2>

Query syntax OUTPut : PROTection : DELay?
 Parameter 0.0 to 100.0
 Return parameters <NR2>

This command sets delay time when software protection occurs. The time unit is 0.1 second.

RANGe HIGH | LOW Set output voltage range

This command sets the output voltage range of the AC source.

HIGH sets the AC source at 300V (high) range.

LOW sets the AC source at 150V (low) range.

[SOURce :]
 CURRent
 :LIMit
 [: AMPLitude] <NR2>

[SOURce :] CURRent : LIMit [: AMPLitude] <NR2>

Query syntax **[SOURce :] CURRent : LIMit [: AMPLitude]?**
 Parameter 0.0 to 100.0
 Return parameters <NR2>

This command sets the voltage limit of the AC source. The unit is 0.1 ampere.

[SOURce :]
 VOLTage
 [: LEVel]
 [: IMMEDIATE]
 [: AMPLitude] <n> Set the rms voltage amplitude

[SOURce :] VOLTage [: LEVel] [: IMMEDIATE] [: AMPLitude] <NR2>

Query syntax VOLTage [: LEVel] [: IMMEDIATE] [: AMPLitude]?
 Return parameters <NR2>

This command sets the rms output voltage level of the AC source.

[SOURce :] VOLTage : LIMit : AC <NR2>

Query syntax **[SOURce :] VOLTage : LIMit : AC?**
 Parameter 0.0 to 300.0
 Return parameters <NR2>

This command sets the voltage limit of the AC source. The unit is 0.1 volt.

SYSTEM

: ERRor? Query the error string
 Response error string :
 No Error Data Format Error Data Range Error
 Too Many Errors Execution Error

TRACe | DATA
 [: DATA] <US1, . . . , US6>, <D1, D2. . . > Assign value to a waveform

SYSTEM : LOCAL

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.

SYSTem : REMote

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 Local key.

SYSTem : RWLock

This command can only be used under the control of RS-232C. If SYST : RWL is programmed, the AC source will be set in the Remote-Lockout state, and front panel will be disabled without exception.

STATus:OPERation?

This query returns the content of the Operation Event register. The Operation Event register is cleared when read or by the common command *CLS.

STATus:OPERation:CONDition?

Return the content of Operation Condition register. The Condition register reflects the TRUE or FALSE state of Operation status.

STATus:OPERation:ENABLE

This command sets the enable mask, which allows true conditions in the Operation Event register to be reported in the Operation summary bit (OPER) of the Status Byte register.

Parameters: 0 to 32727

| | | | | | | | | | | | | | | |
|---------------------|-------|------|------|-----------|-----------|-----|-----|-----|-----|-----|-----|-----|------|-----|
| Bit Position | 15-13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Condition | ---- | NP | DV | S.OP P | S.OC P | --- | FAN | OPP | OCP | SHT | OTP | INP | OPEN | PFO |
| Bit Weight | | 4096 | 2048 | 1024 | 512 | | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |

Bit configuration of Questionable status register

STATus:QUESTIONable:EVENT?

This query returns the content of the Questionable Event register. The Event register latches events that are passed by Questionable PTR and/or NTR filter. It is cleared when read or by the common command *CLS.

STATus:QUESTIONable:CONDition?

Return the content of the Questionable Condition register. The Condition register reflects the TRUE or FALSE state of Questionable status.

STATus:QUESTIONable:ENABLE

This command sets the enable mask which allows true conditions in the Questionable Event register to be reported in the Questionable summary (QUES) bit of the Status Byte register.

STATus:QUESTIONable:NTRansition

STATus:QUESTIONable:PTRansition

These commands set the content of the Questionable NTR (negative transition 1-to-0) and PTR (positive transition 0-to-1) registers. These registers determine what type of transition in the Condition register shall set the corresponding bit in the Event register.

5.7 Command Summary

Common Commands

| | |
|----------|---|
| * CLS | Clear status |
| * OPC? | Return 1 |
| * ESE<n> | Standard event status enable |
| * ESE? | Return standard event status enable |
| * IDN? | Return the AC source identification |
| * RLC<n> | Recall the AC source file |
| * RST | Reset AC source |
| * SAV<n> | Save the AC source status |
| * STB? | Return Status Byte |
| * SRE | Set the Service Request Enable register |
| * SRE? | Query the Service Request Enable register |

Instrument Commands

FETCh | MEASure

```

[: SCALar]
    : CURRent
        : AC?
        : CRESfactor?

```

FETCh | MEASure

```

[: SCALar]
    : FREQuency?

```

FETCh | MEASure

```

[: SCALar]
    : POWer
        : AC
            [ : REAL] ?
            : PFACTOR?
            : TOTal?

```

FETCh | MEASure

```

[: SCALar]
    : VOLTage
        : AC?

```

INSTrument

```

    : COUPlE ALL | NONE
    : NSElect <n>
    : SElect <OUTPut>

```

ORELay ON | OFF

OUTPut

```

[: STATe] <bool>
: PROTection
    : CLear
    : DELay <n>

```

RANGe HIGH | LOW

[SOURce :]
 CURRent
 [: LEVel]
 [: IMMEDIATE]
 [: AMPLitude] <n>

[SOURce :]
 CURRent
 :LIMit
 [: AMPLitude] <n>

[SOURce :]
 FREQuency
 [: CW | : IMMEDIATE] <n>

[SOURce :]
 VOLTage
 [: LEVel]
 [: IMMEDIATE]
 [: AMPLitude] <n>

[SOURce :]
 VOLTage
 :LIMit
 : AC

SYSTEM
 : ERRor?
 [: IMMEDIATE]

SYSTEM
 : VERSion?
 : LOCAl
 : REMote
 : RWLock

| | |
|--------------------|--|
| STATus | |
| :OPERation | |
| [:EVENT]? | Return the content of the event register |
| :CONDition? | Return the content of the condition register |
| :ENABle <NRf> | Set the enable register |
| :QUESTionable | |
| [:EVENT]? | Return the content of the event register |
| :CONDition? | Return the content of the condition register |
| :ENABle <NRf> | Set the enable register |
| :NTRansition <NRf> | Set the negative transition filter |
| :PTRansition <NRf> | Set the positive transition filter |

Appendix A Pin Assignment of User Interface

25-Pin D-Type Male Connector:

| Pin No. | Signal | Pin No. | Signal | Description |
|---------|-------------|---------|---------------------------|---------------|
| 1 | GND | 14 | System Used | |
| 2 | GND | 15 | System Used | |
| 3 | GND | 16 | System Used | |
| 4 | GND | 17 | System Used | |
| 5 | GND | 18 | System Used | |
| 6 | GND | 19 | System Used | |
| 7 | GND | 20 | System Used | |
| 8 | GND | 21 | System Used | |
| 9 | GND | 22 | ----- | |
| 10 | GND | 23 | $\overline{\text{TRIG}}$ | Trigger |
| 11 | GND | 24 | $\overline{\text{TRANS}}$ | Transient |
| 12 | System Used | 25 | AC ON | Output enable |
| 13 | System Used | | | |

Appendix B Pin Assignment of TTL I/O

9-Pin D-Type Female Connector:

| Pin No. | Signal | Direction | Pin No. | Signal | Direction |
|---------|--------|---------------|---------|--------|-----------|
| 1 | TRANS | Transient | 6 | GND | |
| 2 | AC ON | Output enable | 7 | GND | |
| 3 | TRIG | Trigger | 8 | GND | |
| 4 | ----- | | 9 | GND | |
| 5 | ----- | | | | |



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