# Lx \Ls Series II AC Power Source User Manual 

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## Important Safety Instructions

Before applying power to the system, verify that your product is configured properly for your particular application.


WARNING

Hazardous voltages may be present when covers are removed. Qualified personnel must use extreme caution when servicing this equipment.
Circuit boards, test points, and output voltages also may be floating above (below) chassis ground.


The equipment used contains ESD sensitive ports. When installing equipment, follow ESD Safety Procedures. Electrostatic discharges might cause damage to the equipment.

Only qualified personnel who deal with attendant hazards in power supplies, are allowed to perform installation and servicing.
Ensure that the AC power line ground is connected properly to the Power Rack input connector or chassis. Similarly, other power ground lines including those to application and maintenance equipment must be grounded properly for both personnel and equipment safety.
Always ensure that facility AC input power is de-energized prior to connecting or disconnecting any cable.
In normal operation, the operator does not have access to hazardous voltages within the chassis. However, depending on the user's application configuration, HIGH VOLTAGES HAZARDOUS TO HUMAN SAFETY may be normally generated on the output terminals. The customer/user must ensure that the output power lines are labeled properly as to the safety hazards and that any inadvertent contact with hazardous voltages is eliminated.
Guard against risks of electrical shock during open cover checks by not touching any portion of the electrical circuits. Even when power is off, capacitors may retain an electrical charge. Use safety glasses during open cover checks to avoid personal injury by any sudden component failure.
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## SAFETY SYMBOLS



Off (Supply)

Standby (Supply)

On (Supply)


Protective Conductor Terminal


Fuse


CAUTION
Refer to Accompanying Documents
$\overline{\text { =- }}$ Direct Current (DC)
~ Alternating Current (AC)
$3 \sim$ Three-Phase Alternating Current


Earth (Ground) Terminal

Chassis Ground

# Product Family: Lx \Ls Series II 

## Warranty Period: One Year

## WARRANTY TERMS

AMETEK Programmable Power, Inc. ("AMETEK"), provides this written warranty covering the Product stated above, and if the Buyer discovers and notifies AMETEK in writing of any defect in material or workmanship within the applicable warranty period stated above, then AMETEK may, at its option: repair or replace the Product; or issue a credit note for the defective Product; or provide the Buyer with replacement parts for the Product.
The Buyer will, at its expense, return the defective Product or parts thereof to AMETEK in accordance with the return procedure specified below. AMETEK will, at its expense, deliver the repaired or replaced Product or parts to the Buyer. Any warranty of AMETEK will not apply if the Buyer is in default under the Purchase Order Agreement or where the Product or any part thereof:

- is damaged by misuse, accident, negligence or failure to maintain the same as specified or required by AMETEK;
- is damaged by modifications, alterations or attachments thereto which are not authorized by AMETEK;
- is installed or operated contrary to the instructions of AMETEK;
- is opened, modified or disassembled in any way without AMETEK's consent; or
- is used in combination with items, articles or materials not authorized by AMETEK.

The Buyer may not assert any claim that the Products are not in conformity with any warranty until the Buyer has made all payments to AMETEK provided for in the Purchase Order Agreement.

## PRODUCT RETURN PROCEDURE

1. Request a Return Material Authorization (RMA) number from the repair facility (must be done in the country in which it was purchased):

- In the USA, contact the AMETEK Repair Department prior to the return of the product to AMETEK for repair:
Telephone: 800-733-5427, ext. 2295 or ext. 2463 (toll free North America) 858-450-0085, ext. 2295 or ext. 2463 (direct)
- Outside the United States, contact the nearest Authorized Service Center (ASC). A full listing can be found either through your local distributor or our website, www.programmablepower.com, by clicking Support and going to the Service Centers tab.

2. When requesting an RMA, have the following information ready:

- Model number
- Serial number
- Description of the problem

NOTE: Unauthorized returns will not be accepted and will be returned at the shipper's expense.
NOTE: A returned product found upon inspection by AMETEK, to be in specification is subject to an evaluation fee and applicable freight charges.

Refers to:
Lx Series AC Power Source/Analyzers - Series II
Ls Series AC Power Sources - Series II

## Models:

Single chassis: $\quad 3000 \mathrm{Lx}, 4500 \mathrm{Lx}, 6000 \mathrm{Lx}$
Multiple chassis: $\quad 9000 \mathrm{Lx} / 2,12000 \mathrm{Lx} / 2,13500 \mathrm{Lx} / 3,18000 \mathrm{Lx} / 3$

Single chassis: $\quad 3000 \mathrm{Ls}, 4500 \mathrm{Ls}$, 6000Ls
Multiple chassis: $\quad 9000 \mathrm{Ls} / 2,12000 \mathrm{Ls} / 2,13500 \mathrm{Ls} / 3,18000 \mathrm{Ls} / 3$
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## 1. Introduction

This instruction manual (P/N 7004-980) contains information on the installation, operation, calibration and maintenance of the Lx Series II and Ls Series II AC power sources. The Series II versions of the Lx and Ls Series are backward compatible with the Series I models. The User Manual for Series I models is CI P/N 7004-960 and is available for download at www.programmablepower.com.

Series II models are different from the original Lx/Ls Series in the following areas:

- Standard USB interface has been added.
- Optional Ethernet LAN interface has been added. (Option -LAN).
- The front panel graphic design has been enhanced for a more pleasing look.
- The Output D and E terminal block is no longer installed on the standard Lx and Ls units unless the auxiliary output option -AX is installed. This makes the standard output terminal block more easily accessible.

No other functional differences exist between the Series I and Series II AC power sources. The RS232C interface is still available in addition to the USB interface.

### 1.1 General Description

The Lx Series of AC Power Source is a family of high efficiency, rack mountable, AC Power Source/Analyzer combinations that provide a precise output with low distortion and advanced measurements. Standard output voltage ranges are 150 Vac and 300 Vac RMS. The Lx Series can operate in either single or three-phase mode.
The Ls Series of AC Power Source is a family of high efficiency, rack mountable, AC Power Sources that provide a precise output with low distortion. Standard output voltage ranges are 135 Vac and 270 Vac RMS. The Ls Series is available in either single ( -1 ) or three-phase mode (3). A -MODE option is available on -3 Ls models.

For power levels above 4500 VA, two or more Lx or Ls series units can be combined using the system interface in a parallel mode of operation. These multi chassis systems consist of one master unit with controller and one or two auxiliary units without controllers. Only the master unit has a front panel keyboard and display.

Read the installation instructions carefully before attempting to install and operate the Lx / Ls Series power systems.

### 1.2 Lx Series and Ls Series Differences

The Lx Series and Ls Series of AC power sources are both based on the same AC power source hardware platform and share many common components. The differences are primarily in configuration and options. This manual covers both models for Series II. Some menus and screen shown in this manual may not apply to Ls Series AC sources without the -ADV option and / or -MODE option. See section 1 for difference between Series I and Series II models. This manual is provided for Series II models.

### 1.2.1 Firmware differences

The Lx Series is fully featured and supports all commands listed in the programming manual.
The Ls Series provides most basic functions in its standard configurations. More advanced features can be added by specifying the -ADV (advanced) option. If the -ADV option is installed, all commands listed in this programming manual are supported. If not, commands related to arbitrary waveforms and harmonic analysis measurements are not supported and will generate a "-113 Syntax Error" message.

### 1.2.2 Hardware differences

In addition to the firmware differences described, the following hardware differences exist between the standard Lx Ac source and the Ls AC source.

- Lx has a $150 \mathrm{~V} / 300 \mathrm{~V}$ rms output range pair. Optional ranges of $135 / 270$ (-HV option) and 200/400 (-EHV option) are available at time of order.
- Ls has a $135 \mathrm{~V} / 270 \mathrm{~V}$ rms output range pair. Optional ranges of 156/312 (-HV option) and 200/400 (-EHV option) are available at time of order.
- The Lx rear panel connector labeling is compliant with the California Instruments iL Series which it replaces and the HP/Agilent model 6834B.
- The Ls rear panel connector labeling is compliant with the California Instruments L Series.
- The Lx Series II comes standard with GPIB, USB and RS232C interfaces. An optional LAN interface (-LAN) is available.
- The Ls Series II comes standard with USB and RS232C, An optional GPIB interface (GPIB option) and LAN interface (-LAN) is available.
Note: All interfaces use the SCPI command syntax as described in the programming manual.
- The Lx Series provides both three phase and single-phase output modes, which can be selected from the front panel or over the bus.
- The Ls Series provides either three phase ( -3 models) or single phase ( -1 models). Three-phase Ls Series sources may optionally be equipped with the -MODE option, which provides the same phase mode switching as the Lx Series.
- The Lx Series ships with a more advanced keyboard (P/N 6005-702-1), which includes a numeric data entry pad. This same keyboard is available as an option on the Ls Series (Option -KP). Customers that prefer the simplified keyboard with dual shuttles (P/N 7004-709-1) can order this on the Lx Series as option -RP.


### 1.3 Manual organization and format

All user documentation for California Instruments power sources is provided on CDROM in electronic format. (Adobe Portable Document Format) The required Adobe PDF viewer is supplied on the same CDROM. This manual may be printed for personal use if a hardcopy is desired. To request a hardcopy from AMETEK programmable power, contact customer service at service@programmablepower.com. There will be an additional charge for printed manuals.
This manual contains sections on installation, normal use, maintenance and calibration. The Lx Series II is equipped with GPIB, USB and RS232C interfaces. The Ls Series II is equipped with USB and RS232C interfaces. An optional GPIB and/or LAN interface can be specified at the time of order. Refer to the Lx / Ls Series Programming manual for information on using the remote control interface and command syntax. The programming manual (P/N 7004-981) is provided on the same CDROM as this user manual.
AMETEK may make updated versions of this manual available from time to time in electronic format through it's website. To obtain an updated manual revision if available, check the AMETEK Programmable Power website Manual download page at www.programmablepower.com.

## 2. Specifications

Specifications shown are valid over an ambient temperature range of $25 \pm 5^{\circ} \mathrm{C}$ and apply after a 30 minute warm-up time. Unless otherwise noted, all specifications are per phase for sine wave output into a resistive load. For three phase configurations or mode of operation, all specifications are for Line to Neutral (L-N) and phase angle specifications are valid under balanced load conditions only.

Specifications for Ls models are identical to those for the Lx except where noted.

### 2.1 Electrical

### 2.1.1 Input

| Parameter | Specification |
| :---: | :---: |
| Line Voltage: (3 phase, 3 wire + ground (PE)) |  |
| Line VA: (total) | $3000 \mathrm{Lx} / \mathrm{Ls}$ $5900 \mathrm{VA} / 4100 \mathrm{~W}$ <br> $4500 \mathrm{Lx} / \mathrm{Ls}$ $8900 \mathrm{VA} / 5900 \mathrm{~W}(\times 2$ for $9000 \mathrm{Lx} / 2, \times 3$ for $13500 \mathrm{Lx} / 3)$ <br> $6000 \mathrm{Lx} / \mathrm{Ls}$ $11900 \mathrm{VA} / 7900 \mathrm{~W}(\times 2$ for $12000 \mathrm{Lx} / 2, \times 3$ for $18000 \mathrm{Lx} / 3$ |
| Line Current: (per phase) |  |
|  |  |

[^0]| Parameter | Specification |
| :---: | :---: |
| Line Frequency: | $47-440 \mathrm{~Hz}$ |
| Efficiency: | 75 \% (typical) depending on line and load |
| Power Factor: | 0.65 (typical) |
| Inrush Current: | 50 Apk @ 253VLL per chassis Note: Each Lx chassis requires <br> $83 A_{p k} @ 400$ V LL per chassis $^{\text {its own AC service. }}$  |
| Hold-Up Time: | $>10 \mathrm{~ms}$ |
| Isolation Voltage: | 1350 VAC input to chassis / input to output (208 V input models) 1900 VDC input to chassis / input to output ( 208 V input models) <br> 2200 VAC input to chassis / input to output ( 400 V input models) 3100 VDC input to chassis / input to output ( 400 V input models) |

### 2.1.2 Output

| Output Parameter | Specification |
| :--- | :--- |
| Modes |  |
| Voltage: |  |


| Ranges (L-N): | Lx Series | Ls Series |
| :---: | :---: | :---: |
| Low range | 0-150 Vrms | 0-135 Vrms |
| High range | 0-300 Vrms | 0-270 Vrms |
| Resolution: | 0.1 V | 0.1 V |
| Programming Accuracy: | $\pm(0.05 \%+0.25 \mathrm{~V})$ from 5 V to FS. |  |
| Distortion THD': | Standard:$<1 \%$$<1 \%+1 \% / k H z \quad[45-1000 \mathrm{~Hz}]$(harmonics and noise to 300 kHz )With -HF and -LKM option: |  |


|  | $\begin{aligned} & <2 \%+1 \% / \mathrm{kHz} \quad[>1000 \mathrm{~Hz}] \\ & \text { (harmonics and noise to } 300 \mathrm{kHz} \text { ) } \end{aligned}$ |
| :---: | :---: |
| Load Regulation: ALC mode ON | 0.1 \% FS |
| External Sense | Up to $10 \%$ of programmed value can be dropped across each load lead Fout $<400 \mathrm{~Hz}$. Up $2.5 \%$ of programmed value can be dropped across each load lead Fout > 400 Hz . Internal or External sense selectable. |
| Line Regulation: | 0.02\% for 10\% input line change |
| Stability: | $\pm 0.05 \%$ FS, 24 hours, constant line, load and temperature, ALC on. |
| Temp Coefficient: | $\pm 0.05 \mathrm{~V} /{ }^{\circ} \mathrm{C}$ |
| DC Offset Voltage: | 0.0 V |
| Output Noise: ( 20 kHz to 1 MHz ) | $<100 \mathrm{mV}_{\text {RMS }}$ typical |
| Output Coupling | Transformer coupled |
| Output Impedance (Z) | Z = Vrange * 0.001 / I_load |

Power - Lx Series (total power for all phases, either range, at full scale voltage)

|  | $35^{\circ} \mathrm{C}$ Ambient |  |  | $50^{\circ} \mathrm{C}$ Ambient |  |  |
| ---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Model | $\mathbf{3 0 0 0 L x}$ | $\mathbf{4 5 0 0 L x}$ | $\mathbf{6 0 0 0 L x}$ | $\mathbf{3 0 0 0 L x}$ | 4500 Lx | 6000 Lx |
| Single Phase Mode | 3 KVA | 4.5 KVA | 5.76 KVA | 3 KVA | 4 KVA | 5 KVA |
| Three Phase Mode (per <br> phase) | 1 KVA | 1.5 KVA | 1.9 KVA | 1 KVA | 1.35 KVA | 1.7 KVA |
| Model |  | $\mathbf{9 0 0 0 L x / 2}$ | $\mathbf{1 2 0 0 0 \mathrm { Lx } / \mathbf { 2 }}$ |  | $\mathbf{9 0 0 0 L x / 2}$ | $\mathbf{1 2 0 0 0 \mathrm { Lx } / \mathbf { 2 }}$ |
| Single Phase Mode |  | 9 KVA | 11.5 KVA |  | 8 KVA | 10 KVA |
| Three Phase Mode (per |  | 3 KVA | 3.8 KVA |  | $\mathbf{2 . 7 ~ K V A}$ | 3.3 KVA |

[^1]| Output Parameter | Specification |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| phase) |  |  |  |  |  |  |
| Model |  | 13500Lx/3 | 18000Lx/3 |  | 13500Lx/3 | 18000Lx/3 |
| Single Phase Mode |  | 13.5 KVA | 5.76 KVA |  | 12 KVA | 15 KVA |
| Three Phase Mode (per phase) |  | 4.5 KVA | 17.3 KVA |  | 4 KVA | 5 KVA |
| Power - Ls Series (total power for all phases, either range, at full scale voltage) |  |  |  |  |  |  |
|  | $35^{\circ} \mathrm{C}$ Ambient |  |  | $50^{\circ} \mathrm{C}$ Ambient |  |  |
| Model | 3000Ls | 4500Ls | 6000Ls | 3000Ls | 4500Ls | 6000Ls |
| Single Phase Mode | 3 KVA | 4.5 KVA | 6 KVA | 3 KVA | 4 KVA | 5 KVA |
| Three Phase Mode (per phase) | 1 KVA | 1.5 KVA | 2 KVA | 1 KVA | 1.35 KVA | 1.7 KVA |
| Model |  | 9000Ls/2 | 12000Ls/2 |  | 9000Ls/2 | 12000Ls/2 |
| Single Phase Mode |  | 9 KVA | 12 KVA |  | 8 KVA | 10 KVA |
| Three Phase Mode (per phase) |  | 3 KVA | 4 KVA |  | 2.7 KVA | 3.3 KVA |
| Model |  | 13500Ls/3 | 18000Ls/3 |  | 13500Ls/3 | 18000Ls/3 |
| Single Phase Mode |  | 13.5 KVA | 6 KVA |  | 12 KVA | 15 KVA |
| Three Phase Mode (per phase) |  | 4.5 KVA | 18 KVA |  | 4 KVA | 5 KVA |
| Maximum Current at Full Power - Lx Series |  |  |  |  |  |  |
| Note: Current, maximum amps per phase available at on low voltage range. 3000Lx and 4500Lx operate in constant power mode up to currents shown at reduced voltage. See Figure 2-1. For $9000 \mathrm{Lx} / 2$ and $12000 \mathrm{Lx} / 2$, currents are 2 x 4500 Lx and 6000Lx. For $13500 \mathrm{Lx} / 3$ and $18000 \mathrm{Lx} / 3$, currents are $3 \times 4500 \mathrm{Lx}$ and 6000Lx |  |  |  |  |  |  |
| Model <br> Single Phase Mode: Max. RMS, low Vrange <br> Three Phase Mode: Max. RMS, low Vrange per phase |  | OLX | 4500Lx |  | 6000Lx |  |
|  |  | . 4 A | 38.4 A |  | 38.4 A |  |
|  |  | . 8 A | 12.8 A |  | 12.8 A |  |
| Note: Current derates linearly from 50\% of voltage range to $20 \%$ of specified current at $10 \%$ voltage range. <br> Current in High voltage range is reduced by a factor of 2. <br> Note: For 9000Lx/2 and 12000Lx/2, currents are $2 \times 4500 L x$ and 6000Lx. <br> For $13500 \mathrm{Lx} / 3$ and $18000 \mathrm{Lx} / 3$, currents are $3 \times 4500 \mathrm{Lx}$ and 6000Lx |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| Maximum Current at Full Power - Ls Series |  |  |  |  |  |  |
| Note: Current, maximum amps per phase available at on low voltage range. 3000Ls and 4500Ls operate in constant power mode up to currents shown at reduced voltage. See Figure 2-1. For $9000 \mathrm{Ls} / 2$ and $12000 \mathrm{Ls} / 2$, currents are $2 \times 4500 \mathrm{Ls}$ and 6000Ls. For $13500 \mathrm{Ls} / 3$ and $18000 \mathrm{Ls} / 3$, currents are $3 \times 4500 \mathrm{Ls}$ and 6000Ls |  |  |  |  |  |  |
| Model <br> Single Phase Mode: <br> Max. RMS, low Vrange |  | OLs | 4500Ls |  | 6000Ls |  |
|  | 44.4 A |  | 44.4 A |  | 44.4 A |  |


| Output Parameter | Specification |  |  |
| :---: | :---: | :---: | :---: |
| Three Phase Mode: Max. RMS, low Vrange per phase | 14.8 A | 14.8 A | 14.8 A |
| Note: Current derates linearly from $50 \%$ of voltage range to $20 \%$ of specified current at $10 \%$ of voltage range. <br> Current in High voltage range is reduced by a factor of 2. |  |  |  |
| Maximum Current at Full Scale Voltage - Lx Series |  |  |  |
| Model <br> Single Phase Mode: Max. RMS, low Vrange | 3000Lx | 4500Lx | 6000Lx |
|  | 20 A | 30 A | 38.4 A |
| Three Phase Mode: Max. RMS, low Vrange per phase | 6.67 A | 10 A | 12.8 A |
| Current Limit mode |  | ble, CC or CV m |  |
| Maximum Current at Full Scale Voltage - Ls Series |  |  |  |
| Model <br> Single Phase Mode: Max. RMS, low Vrange <br> Three Phase Mode: Max. RMS, low Vrange per phase | 3000Ls | 4500Ls | 6000Ls |
|  | 22.2 A | 33.3 A | 44.4 A |
|  | 7.4 A | 11.1 A | 14.8 A |
| Current Limit mode |  | ble, CC or CV m |  |
| Repetitive Peak Current |  |  |  |
| Model <br> Max. Peak Current: | 3000Lx / Ls | 500Lx / Ls | 6000Lx / Ls |
|  | $6 \times$ RMS current at FS | S current at FS | $3 \times$ RMS current at FS |
| Note: For 9000Lx / Ls /2 and 12000Lx / Ls /2, currents are $2 \times 4500 \mathrm{Lx} / \mathrm{Ls}$ and 6000Lx/Ls. For $13500 \mathrm{Lx} / \mathrm{Ls} / 3$ and $18000 \mathrm{Lx} / \mathrm{Ls} / 3$, currents are $3 \times 4500 \mathrm{Lx} / \mathrm{Ls}$ and $6000 \mathrm{Lx} / \mathrm{Ls}$ |  |  |  |
| Frequency |  |  |  |
| Range: | $45 \mathrm{~Hz}-1000 \mathrm{~Hz}$ |  |  |
| Supplemental | Operation from 17 to 45 Hz is available at reduced output voltage. Vout max $=100$ \% * F $/ 45$ for F < 45Hz. See chart Figure 2-7 for Voltage/Frequency rating. |  |  |
| Resolution ${ }^{\text {' }}$ | 0.01 Hz $[<81.91 \mathrm{~Hz}]$ <br> 0.1 Hz $[>82.0$ to 819.1 Hz$]$ <br> $1 \mathrm{~Hz}^{2}$ $[>819 \mathrm{~Hz}]$ |  |  |
| Accuracy: | $\pm 0.025$ \% |  |  |
| Temp. Coefficient | $\pm 5 \mathrm{ppm}$ of value $/{ }^{\circ} \mathrm{C}$ |  |  |
| Stability: | $\pm 15 \mathrm{ppm}$ of value |  |  |

[^2]| Output Parameter | Specification |
| :---: | :---: |
| Phase (3 phase mode) |  |
| Range: | Phase $\mathrm{B} / \mathrm{C}$ relative to phase A 0.0 to $360.0^{\circ}$ |
| Resolution: | $\begin{aligned} & 0.1^{\circ}<819.1 \mathrm{~Hz} \\ & 0.5^{\circ}>819.1 \mathrm{~Hz} \end{aligned}$ |
| Accuracy: | $<1^{\circ}$ $[45 \mathrm{~Hz}-1000 \mathrm{~Hz}]$ <br> $<1^{\circ}+1^{\circ} / \mathrm{kHz}$ $[>1000 \mathrm{~Hz}]$ <br> Note: Specification valid under balanced load conditions.  |

Note: All output specifications apply below the Current / Voltage rating line shown in the V/I rating charts of section 2.1.2.1 for Lx Series and section 2.1.2.2 for Ls Series. Data is shown for 3-phase mode, low voltage range. For 1-phase mode, multiply current by 3. For high voltage range, divide current by 2 and multiply voltage by 2.
2.1.2.1 Voltage versus Current Rating Charts - Lx Series


Figure 2-1: 3000Lx Voltage / Current Rating Chart for 150V AC Range in 3 phase mode.


Figure 2-2: 4500Lx Voltage / Current Rating Chart for 150V AC Range in 3 phase mode.


Figure 2-3: 6000Lx Voltage / Current Rating Chart for 150V AC Range in 3 phase mode.


Figure 2-4: 3000Ls Voltage / Current Rating Chart for 135V AC Range in 3 phase mode.


Figure 2-5: 4500Ls Voltage / Current Rating Chart for 135V AC Range in 3 phase mode.


Figure 2-6: 6000Ls Voltage / Current Rating Chart for 135V AC Range in 3 phase mode.

### 2.1.2.3 Frequency versus Voltage Rating Chart

Vout max.
in \% FS


Figure 2-7: Voltage / Frequency Rating.

### 2.1.3 AC Measurements

Measurement specifications apply to single chassis Lx / Ls Series AC source in single or threephase mode. See notes for other models and configurations.

| Parameter | Range | Accuracy ( $\pm$ ) |  | Resolution |
| :---: | :---: | :---: | :---: | :---: |
|  |  | 1 Phase Mode | 3 Phase Mode |  |
| Frequency ${ }^{1}$ | $45.00-1000.0 \mathrm{~Hz}$ | $0.1 \% \pm 1$ digit |  | $\begin{aligned} & \hline 0.01 \mathrm{~Hz} \text { to } 81.91 \mathrm{~Hz} \\ & 0.1 \mathrm{~Hz} \text { to } 819.1 \mathrm{~Hz} \\ & 1 \mathrm{~Hz}>819.1 \mathrm{~Hz} \\ & \hline \end{aligned}$ |
| Phase | $\begin{aligned} & 45.00-100.0 \mathrm{~Hz} \\ & 100.0-1000 \mathrm{~Hz} \end{aligned}$ | $\begin{gathered} 0.5^{\circ} \\ 2^{\circ} \end{gathered}$ |  | 0. $1^{\circ}$ |
| RMS Voltage | 0-400 Volts | 0.05\% + 0.25V |  | 0.01 Volt |
| RMS Current | 0-50 Amps | 0.1\% + 0.15A | 0.1\% + 0.05A | 0.001 Amp |
| Peak Current | 0-150 Amps | 0.2\% + 0.5A | 0.1\% + 0.15A | 0.001 Amp |
| Crest Factor | 1.00-10.00 | 1.5 \% | 1.5 \% | 0.01 |
| VA Power | 0-6 KVA | 0.15\% + 9 VA | 0.15\% + 3 VA | 1 VA |
| Real Power | 0-6 KW | 0.15\% + 9 W | 0.15\% + 3 W | 1 W |
| Power Factor | 0.00-1.00 | 0.03 | 0.01 | 0.01 |

Note: Accuracy specifications are valid above 100 counts. For multi-chassis configurations, Current and Power range and accuracy specifications are times the number of chassis.
Note: Frequency measurement specification valid for output > 20 Vrms.
Note: Crest Factor accuracy applies for Irms > 50\% of max.
Note: Power Factor accuracy applies for PF > 0.5 and VA >50\% of max.

### 2.1.4 Harmonic Measurements

Harmonic measurement specifications apply to Lx Series or Ls Series -3 with -ADV option AC sources in three-phase mode. See notes for single-phase mode or Ls -1 with -ADV option.

| Parameter | Range | Accuracy ( $\pm$ ) | Resolution |
| :--- | :--- | :--- | :--- |
| Frequency fundamental | $45.00-81.91 \mathrm{~Hz}$ <br> $82.0-819.1 \mathrm{~Hz}$ <br> $>819.1 \mathrm{~Hz}$ | $0.1 \% \pm 1$ digit | 0.01 Hz <br> 0.1 Hz <br> 1 Hz |
| Frequency harmonics | $45.00 \mathrm{~Hz}-16 \mathrm{kHz}$ | $0.1 \%+2$ digits | 0.1 Hz |
| Voltage |  |  |  |
| Fundamental <br> Harmonic 2-50 | $0-400 \mathrm{Volts}$ | $0.05 \%+0.25 \mathrm{~V}$ | 0.01 V |
| Current <br> Fundamental <br> Harmonic 2-50 | $0-20 \mathrm{Amps}$ | $0.1 \%+0.1 \% / \mathrm{kHz}+0.25$ | 0.01 V |
|  |  | $0.1 \%+0.05 \mathrm{~A}$ | 0.01 A |

Note: Current range and accuracy specifications are times three in single-phase mode. For multichassis configurations, current accuracy specifications are times the number of chassis. The harmonic measurement bandwith increases to 48 Khz in single-phase mode.

[^3]
### 2.1.5 System Specification

| Parameter | Specification |
| :--- | :--- |
| Trigger Input: | External trigger source input. Requires TTL level input signal. Triggers <br> on negative edge. Response time $80-100 \mu \mathrm{~s}$. |
| Non volatile memory <br> storage: | 16 complete instrument setups and transient lists, 100 events per list. <br> 50 User defined waveforms. |
| Waveforms | Lx Series: Sine, square, clipped, user defined <br> Ls Series standard: Sine, square, clipped <br> Ls Series w -ADV option: Sine, square, clipped, user defined |
| Transients | Voltage: drop, step, sag, surge, sweep <br> Frequency: step, sag, surge, sweep <br> Voltage and Frequency: step, sweep |
| Current Limit Modes: | Two selectable modes of operation: <br> $1 . \quad$ Constant current mode (voltage folds back with automatic recovery) <br> $2 . \quad$ Constant voltage mode with trip-off (Relays open). |
| Interfaces | IEEE-488 <br> (Requires -GPIB option <br> on Ls Series) |
| LAN / Ethernet | AH1, DC1, DT1, L3, RL2, SH1, SR1, T6 <br> IEEE 488.2 and SCPI <br> Response time is 10 ms (typical) |
| (-LAN Option) | RJ45 Connector, 10BaseT, 100BaseT or 1000BaseT, <br> Data transfer rate: 460,800 bps <br> Protocol: TCP/IP. <br> Note: If -LAN is installed, RS232C interface is disabled. |
| RS232C | Baud rates, 9600, 19200, 38400, 57600 and 115200 <br> Data bits: 8, Start bits: 1, Stop bits: 1, Parity: None <br> Syntax: SCPI <br> Response time is 10 ms (typical @ 115200 baud) |
|  | Standard USB 2.0 peripheral. <br> Data transfer rate: 460,800 bps <br> Syntax: SCPI <br> Note: Use of the USB port to control more than one power <br> source from a single PC is not recommended, as communication <br> may not be reliable. Use GPIB interface for multiple power source <br> control. |

### 2.1.6 Unit Protection

| Parameter | Specification |
| :--- | :--- |
| Input Over current: | Input Circuit breaker. This breaker protects the equipment only and is <br> not a branch protection device. AC input connection should be make <br> using a suitable branch protection device per local electrical code. |
| Input Over voltage <br> Transients: | Surge protection to withstand EN50082-1 (IEC 801-4, 5) levels. |
| Output Over current: | Adjustable level constant current mode with programmable set point. |
| Output Short Circuit: | Peak and RMS current limit. |


| Parameter | Specification |
| :--- | :--- |
| Over temperature: | Automatic shutdown. |

### 2.2 Mechanical

| Parameter | Specification |
| :---: | :---: |
| Dimensions: | Height: 10.5 inches $(26.7 \mathrm{~cm})$ 3000Lx, 4500Lx. 6000Lx <br>  21 inches $(53.4 \mathrm{~cm})$ 9000Lx/2, 12000Lx/2 <br>  31.5 inches $(80.1 \mathrm{~cm})$ 13500Lx, 18000Lx/3 <br> Depth: 23 inches $(58.4 \mathrm{~cm})$  <br> Width: 19 inches $(48.3 \mathrm{~cm})$  <br> All dimensions are per chassis. For $/ 2$ or $/ 3$ model configurations,   <br> multiply height by 2 or 3 for total height. Width includes integrated front   <br> panel rack mount ears.   |
| Equipment Rack depth requirement | 25 inches (63.5 cm) |
| Unit Weight: Per chassis | Net: $\quad 175 \mathrm{lbs} / 79.4 \mathrm{Kg}$ approximately Shipping: $\quad 210 \mathrm{lbs} / 95.3 \mathrm{Kg}$ approximately All weights are per chassis. For $/ 2$ or $/ 3$ model configurations, each chassis is packaged individually. |
| Material: | Steel chassis with aluminum top cover |
| Finish: | Anodized external surfaces. Front panel color medium gray. |
| Cooling: | Fan cooled with air intake on the sides and exhaust to the rear. Variable speed fan control. |
| Acoustic Noise (Supplemental specification) | Measured at 1 m distance:   <br> Fan speed: Low power mode Full power mode <br> Front of unit: 47 dBA 50 dBA <br> Rear of unit: 62 dBA 67 dBA |
| Internal Construction: | Modular sub assemblies. |
| Rear Panel Connections: | (See section 3 for description of connections) <br> - AC input wiring <br> - AC output wiring <br> - External sense terminal block (Remote voltage sense) <br> - System interface (2x) <br> - GPIB (std Lx, option on Ls), USB, LAN (option) and RS232C <br> - Trigger In and Out SMA's (Master Lx chassis only) |

### 2.3 Environmental

| Parameter | Specification |
| :--- | :--- |
| Operating Temp: | $0^{\circ}$ to $+35^{\circ} \mathrm{C}$, full power, $0^{\circ}$ to $+50^{\circ} \mathrm{C}$, reduced power <br> $+32^{\circ}$ to $+95^{\circ} \mathrm{F}$, full power, $+32^{\circ}$ to $+122^{\circ} \mathrm{F}$, reduced power. |
| Storage Temp: | $-40^{\circ}$ to $+85^{\circ} \mathrm{C}$. <br> $-40^{\circ}$ to $+185^{\circ} \mathrm{F}$. <br> Altitude:$<2000$ meters <br> $<6000$ feet |


| Parameter | Specification |
| :--- | :--- |
| Relative Humidity: | $0-95 \%$ RAH, non-condensing maximum for temperatures up to $31^{\circ} \mathrm{C}$ <br> decreasing linearly to $50 \%$ at $40^{\circ} \mathrm{C}$. |
|  | Indoor Use Only |
| Vibration: | Designed to meet NSTA project 1A transportation levels. |
| Shock: | Designed to meet NSTA project 1A transportation levels. |

### 2.4 Front Panel Controls

| Controls: | Shuttle knobs: Voltage and Frequency shuttle knobs may be used to adjust voltage and <br> frequency for selected phase or all three phases while in the SET menu. <br> In all other menu's, the shuttles may be used to change parameter <br> values and settings. <br> Up/down arrow keys: A set of up and down arrow keys is used to move the cursor position in <br> all menus. This allows quick selection of the desired function or <br> parameter. <br> Function keys: Set key will show output voltage and frequency setting. <br> Meas key displays the measurement screens. Measure key will display <br> measurement values for selected phase or phase A if all three phases <br> are selected. <br> Menu key selects main menu. <br> Enter key is used to confirm selections. <br> Back key is used to back up to previous screen. <br> Output on/off key for output relay control. <br> Phase key toggles between phase A, B, C or all phases selection. <br> Displays: LCD graphics display: <br> Status indicators: <br> Large high contrast backlit LCD display. An adjustable viewing angle <br> makes it easy to read from all practical locations. <br> Large and bright status indicators inform the user of important power <br> source conditions. <br> The Remote lamp informs the user that the unit is under remote control. <br> The Overload lamp indicates that excessive current is being drawn at <br> the output. <br> The Over temperature lamp illuminates when internal heat sink <br> temperatures are too high. <br> The Hi Range indicator is lit any time the unit is switched to the high <br> voltage range. <br> The Output On/Off indicator is on when the power source output relays <br> are closed. <br> The Phase A, B and C indicators are lit when the relevant phase is <br> selected with the Phase key.  |
| :--- | :--- |

### 2.5 Special Features

## Controller Features

| Mode: | Switches between 1 and 3 phase outputs. |
| :--- | :--- |
| Parallel Operation: | 9000Lx/2 and 13500Lx/2 systems use two or three 4500Lx chassis in <br> parallel operation. The two or three chassis must be connected using the <br> system interface cable supplied with the system. <br> $12000 \mathrm{Lx} / 3$ and 18000Lx/3 systems use two or three 6000Lx chassis in <br> parallel operation. The two or three chassis must be connected using the <br> system interface cable supplied with the system |
| Controller: | Programmable controller front panel assembly. |
| Output Relay: | Standard output relay feature to isolate power source from the load. |
| Output On/Off: | The output relay can be used to quickly disconnect the load. A yellow <br> status indicator displays the status of the output relay. |
| External Trigger Output <br> or Function Strobe | An external TTL output is available which may be used to trigger other <br> equipment. The TTL output can be controlled by the transient <br> programming system. This requires the trigger mode to be set to EXT <br> (factory default). This can only be done over the bus using the <br> OUTP:TTLT:MODE TRIG command. This mode is compatible with the <br> Agilent HP6834B. <br> It can also be configured to generate an output pulse any time the <br> voltage, frequency, current limit or phase programming is updated. This <br> requires the trigger mode to be set to FSTR. This can only be done over <br> the bus using the OUTP:TTLT:MODE FSTR command. This mode is <br> compatible with the CI L Series. <br> The Trigger Output (Trig Out1) / function strobe is an active low ${ }^{1}$ TTL |
| signal with a duration of no less than 400 usec. |  |

1 Note: Early production models may have an active high Trig Out1 polarity.

### 2.6 Available Options - Lx Series

## Output Options

| - AX | Auxiliary outputs, 5 VAC and 26 VAC, 400 Hz. (Output D and E) |
| :---: | :--- |
| - HV | $135 / 270$ V range output |
| - EHV | $200 / 400$ V range output |
| - HF | High frequency option. Increases output frequency to 5000 Hz (single <br> chassis configurations) or 2000 Hz (multi-chassis models). |
| -LF | Low frequency option. Limits maximum output frequency to 500 Hz. |
| Firmware Options | RTCA/DO-160D test firmware. <br> Includes RCTA-DO160D, section 16, Change \#2 and EURO/CAE-14D <br> AC tests only. |
| -160 | Mil Std 704 test firmware - MIL704 <br> Includes AC tests for Revisions D and E |
| -704 | Mil Std 704 test firmware - MS704 <br> Includes AC tests for Revisions A through F |
| $-704 F$ | Airbus ABD0100.1.8 Tests. - ABD <br> Includes tables A, B and C. <br> This option can only be used with the provided LxGui Windows software. |
| -ABD | Airbus AMD234 Tests. - AMD <br> This option can only be used with the provided LxGui Windows software. |
| -AMD | Boeing 787B3-0147 Tests. - B787 <br> This option can only be used with the provided LxGui Windows software. |
| -B787 |  |

Misc. Options

| -EXS | External Sync (see Notes) |
| :--- | :--- |
| -L22 | Locking Knobs. Shaft lock screws replace knobs to prevent turning of <br> Voltage and Frequency shuttles. |
| -LAN | Ethernet LAN interface connection. RJ45 connector. <br> Note: When installed, RS232C interface is disabled. |
| -LKM | Clock and Lock Master. Enables synchronizing outputs of two Lx AC <br> sources, one acts as master. <br> This mode supports a frequency range of 45 to 819 Hz on standard <br> Lx/Ls models. See section 3.9. |
| -LKS | Clock and Lock Auxiliary. See -LKM for details. (see Notes) See section <br> 3.9. |
| -LNS | Line Sync (see Notes) |
| -MB | Multi-box option. Provides additional controller(s) on 9000Lx/2, <br> 12000 Lx/2, 13500Lx/3 or 18000Lx/3 configurations allowing system to be <br> separated into individual functional units. |
| -RMS | Set of 2 Rack mount slides. (Left and Right) Recommended to mount Lx <br> Chassis in 19 inch instrument cabinet. |
| -RP | Replaces standard Lx numeric keypad keyboard/display with Ls type <br> dual shuttle knob style keyboard/display. |
| -RPV | Remote programming voltage. DC voltage input 0 to +10 VDC for 0 to <br> full-scale output voltage programming. |


| Notes: | External Trigger input is standard. <br> Line sync and External sync are mutually exclusive. <br> External Trigger input and External sync are mutually exclusive. <br> Units with -LKS (auxiliary) cannot have Line Sync or External Sync. |
| :--- | :--- |

### 2.6.1 -HV Option Lx Series - Supplemental Specifications

Specifications for Lx units with -HV voltage range option installed are same as standard Lx unit except where noted below.

| Voltage: |  |  |  |
| :---: | :---: | :---: | :---: |
| Ranges (L-N): |  |  |  |
| Low range | 0-135 Vrms |  |  |
| High range | 0-270 Vrms |  |  |
| Maximum Current at Full Power |  |  |  |
| Note: Current, maximum amps per phase available at on low voltage range. 3000Lx and 4500Lx operate in constant power mode up to currents shown at reduced voltage. See Figure 2-1. For $9000 \mathrm{Lx} / 2$ and $12000 \mathrm{Lx} / 2$, currents are 2 x 4500 Lx and 6000Lx. For $13500 \mathrm{Lx} / 3$ and $18000 \mathrm{Lx} / 3$, currents are $3 \times 4500 \mathrm{Lx}$ and 6000Lx |  |  |  |
| Model | 3000Lx-HV | 4500Lx-HV | 6000Lx-HV |
| Single Phase Mode: Max. RMS, low Vrange | 44.4 A | 44.4 A | 44.4 A |
| Three Phase Mode: Max. RMS, low Vrange per phase | 14.8 A | 14.8 A | 14.8 A |
| Note: Current derates linearly from 50\% of voltage range to $20 \%$ of specified current at $10 \%$ voltage range. <br> Current in High voltage range is reduced by a factor of 2. <br> Note: For 9000Lx/2-HV and 12000Lx/2-HV, currents are $2 \times 4500 L x-H V$ and 6000Lx-HV. For $13500 \mathrm{Lx} / 3-\mathrm{HV}$ and $18000 \mathrm{Lx} / 3-\mathrm{HV}$, currents are $3 \times 4500 \mathrm{Lx}-\mathrm{HV}$ and 6000Lx-HV |  |  |  |
| Maximum Current at Full Scale Voltage |  |  |  |
| Model | 3000Lx-HV | 4500Lx-HV | 6000Lx-HV |
| Single Phase Mode: Max. RMS, low Vrange | 22.2 A | 33.3 A | 44.4 A |
| Three Phase Mode: Max. RMS, low Vrange per phase | 7.4 A | 11.1 A | 14.8 A |

### 2.6.2 -EHV Option Lx Series - Supplemental Specifications

Specifications for Lx units with -EHV voltage range option installed are same as standard Lx unit except where noted below.

| Voltage: |  |  |  |
| :---: | :---: | :---: | :---: |
| Ranges (L-N): |  |  |  |
| Low range | 0-200 Vrms |  |  |
| High range | 0-400 Vrms |  |  |
| Maximum Current at Full Power |  |  |  |
| Note: Current, maximum amps per phase available at on low voltage range. 3000Lx and 4500Lx operate in constant power mode up to currents shown at reduced voltage. See Figure 2-1. For $9000 \mathrm{Lx} / 2$ and $12000 \mathrm{Lx} / 2$, currents are $2 \times 4500 \mathrm{Lx}$ and 6000Lx. For $13500 \mathrm{Lx} / 3$ and $18000 \mathrm{Lx} / 3$, currents are $3 \times 4500 \mathrm{Lx}$ and 6000Lx |  |  |  |
| Model | 3000Lx-EHV | 4500Lx-EHV | 6000Lx-EHV |
| Single Phase Mode: Max. RMS, low Vrange | 30.0 A | 30.0 A | 30.0 A |
| Three Phase Mode: Max. RMS, low Vrange per phase | 10.0 A | 10.0 A | 10.0 A |
| Note: Current derates linearly from $50 \%$ of voltage range to $20 \%$ of specified current at $10 \%$ of voltage range. <br> Current in High voltage range is reduced by a factor of 2. <br> Note: For 9000Lx/2-EHV and 12000Lx/2-EHV, currents are $2 \times 4500 L x-E H V$ and 6000Lx-EHV. For $13500 \mathrm{Lx} / 3-E H V$ and $18000 \mathrm{Lx} / 3-\mathrm{EHV}$, currents are $3 \times 4500 \mathrm{Lx}-\mathrm{EHV}$ and $6000 \mathrm{Lx}-\mathrm{EHV}$ |  |  |  |
| Maximum Current at Full Scale Voltage |  |  |  |
| Model | 3000Lx-EHV | 4500Lx-EHV | 6000Lx-EHV |
| Single Phase Mode: Max. RMS, low Vrange <br> Three Phase Mode: Max. RMS, low Vrange per phase | 15.0 A | 22.5 A | 30.0 A |
|  | 5.0 A | 7.5 A | 10.0 A |

### 2.6.3 -HF Option Lx Series - Supplemental Specifications

Specification for Lx units with -HF frequency range option installed are same as standard Lx unit except where noted below.

| Frequency Range |  |  |
| :---: | :---: | :---: |
| Model | $\underset{\mathrm{HF}}{\text { 3000Lx-HF, 4500Lx-HF, 6000Lx- }}$ | 9000Lx/2-HF, 13500Lx/3-HF 12000Lx/3-HF, 18000Lx/3-HF |
| Three phase mode | $45 \mathrm{~Hz}-5000 \mathrm{~Hz}$ | $\begin{gathered} 45 \mathrm{~Hz}-2000 \mathrm{~Hz} \\ 2000-5000 \mathrm{~Hz} \text { (see Note) } \end{gathered}$ |
| Single phase mode | $45 \mathrm{~Hz}-5000 \mathrm{~Hz}$ | $\begin{gathered} 45 \mathrm{~Hz}-2000 \mathrm{~Hz} \\ 2000-5000 \mathrm{~Hz} \text { (see Note) } \end{gathered}$ |
| Note: On multi box systems -HF frequency limit is set to 5000 Hz but performance to specification is guaranteed only to 2000 Hz . Above 2000 Hz , full power may not be available due to amplifier unbalance. Current measurements accuracy is affected by system interface cable cross talk above 2000 Hz . |  |  |
| Output |  |  |
| Programming Accuracy: | $\begin{array}{rr}  & <1000 \mathrm{~Hz} \\ >1000 \mathrm{~Hz} & \pm(0 \\ >0.1 \%+ \end{array}$ | +0.25 V ) from 5 V to FS. <br> $/ \mathrm{KHz}+0.3 \mathrm{~V}$ ) from 5 V to FS |
| Output Noise: ( 20 kHz to 1 MHz ) | $<250 \mathrm{mV}$ RMS typical |  |

For output frequencies up to 1000 Hz , refer to standard measurement specifications. For output frequencies above 1000 Hz , see table below.

| Parameter | Range | Accuracy ( $\pm$ ) |  | Resolution |
| :---: | :---: | :---: | :---: | :---: |
|  |  | 1 Phase Mode | 3 Phase Mode |  |
| Frequency ${ }^{1}$ | $45.00-5000.0 \mathrm{~Hz}$ | $0.1 \% \pm 1$ digit |  | 0.01 Hz to 81.91 Hz 0.1 Hz to 819.1 Hz $1 \mathrm{~Hz}>819.1 \mathrm{~Hz}$ |
| Phase | $\begin{aligned} & 45.00-100.0 \mathrm{~Hz} \\ & 100.0-2000 \mathrm{~Hz} \\ & >2000 \mathrm{~Hz} \end{aligned}$ | $\begin{gathered} \hline 0.5^{\circ} \\ 2^{\circ} \\ 5^{\circ} \end{gathered}$ |  | 0. $1^{\circ}$ |
| RMS Voltage | $\begin{aligned} & 0-400 \text { Volts } \\ & <1000 \mathrm{~Hz} \\ & >1000 \mathrm{~Hz} \end{aligned}$ | $\begin{gathered} 0.05 \%+0.25 \mathrm{~V} \\ 0.1 \%+0.1 \% / \mathrm{KHz}+0.3 \mathrm{~V} \end{gathered}$ |  | 0.01 Volt |
| RMS Current | 0-50 Amps | 0.5\% + 0.15A | $0.5 \%+0.05 \mathrm{~A}$ | 0.001 Amp |
| Peak Current | 0-150 Amps | 0.5\% + 0.5A | 0.5\% + 0.15A | 0.001 Amp |
| Crest Factor | 1.00-10.00 | 1.5 \% | 1.5 \% | 0.01 |
| VA Power | 0-6 KVA | 0.5\% + 9 VA | $0.5 \%+3 \mathrm{VA}$ | 1 VA |
| Real Power | 0-6 KW | 0.5\% + 9 W | 0.5\% + 3 W | 1 W |
| Power Factor | 0.00-1.00 | 0.03 | 0.01 | 0.01 |

[^4]Note: Accuracy specifications are valid above 100 counts. For multi-chassis configurations, Current and Power range and accuracy specifications are times the number of chassis.
Note: Frequency measurement specification valid for output > 20 Vrms.
Note: Crest Factor accuracy applies for Irms > 50\% of max.
Note: Power factor accuracy applies for PF > 0.5 and VA > $50 \%$ of max.

### 2.6.4 -AX Option Lx Series - Supplemental Specifications

Specifications for -AX auxiliary output voltage option on the Lx units are listed below. This output is available on the Phase D and E terminal strip. There is no external sense connection for the AX outputs. Sense is internal only. Specifications apply for programmed frequency range of 360 Hz to 440 Hz .

| Parameter | Supplemental Specification |
| ---: | :--- |
| Phase D Output |  |
| Voltage | $26.0 \mathrm{Vrms} \pm 0.52 \mathrm{~V}$ |
| Voltage Distortion | $<1.0 \% \mathrm{THD}$ |
| Max. Current | 3.0 Arms |
| Frequency range: | $360-440 \mathrm{~Hz}$, locked to programmed frequency. <br> If programmed exceeds 819 Hz, -AX outputs will turn off. |
| Phase error to phase 1 | $<3.0^{\circ}$ |
| Phase E Output |  |
| Voad Regulation | $<1.5 \%$ |
| Max. Current | 1.0 Arms |
| Frequency range: | $360-440 \mathrm{~Hz}$, locked to programmed frequency. <br> If programmed exceeds 819 Hz, -AX outputs will turn off. |
| Phase error to phase 1 | $<3.0^{\circ}$ |
|  |  |

### 2.6.5 -LKM and -LKS Options Lx Series - Supplemental Specifications

The Clock and Lock option enables two independent Ls/Lx power systems to be phase synchronized to each other. One system (-LKM) acts as the master, the other(s) (-LKS) as auxiliaries. The -LKS unit is synced to the -LKM unit. Refer to section 3.9 for details on Clock and Lock mode. Note that the maximum number of auxiliary units (-LKS) per master (-LKM) is one. No T connectors are allowed to increase the number of auxiliary units as this may cause reflections on the clock and lock signals.
The following supplemental specifications apply when the Lx is configured with the Clock and Lock option. (-LKM or -LKS).

| Parameter | Supplemental Specification |  |
| :---: | :---: | :---: |
| Voltage |  |  |
| Voltage Distortion | Standard: <br> With -HF option: | standard specifications apply. $\begin{aligned} & <2 \% \\ & <2 \%+1 \% / k H z \quad[45-1000 \mathrm{~Hz}] \\ & \text { (harmonics and noise to } 300 \mathrm{kHz} \text { ) } \\ & \hline \end{aligned}$ |
| Frequency |  |  |
| Range | Standard Lx: With -HF option: | $\begin{aligned} & 45-819 \mathrm{~Hz} \\ & 45-5000 \mathrm{~Hz} . \end{aligned}$ |
| Resolution | Standard Lx: | 0.1 Hz |


| Parameter | Supplemental Specification |
| :---: | :---: |
|  | With -HF option: 1 Hz |
| Accuracy | $\pm 0.025 \%$ |
| Phase |  |
| Phase Resolution | $\begin{array}{ll}\text { Standard: } & \text { standard specifications apply. } \\ \text { With -HF option: } & 0.5^{\circ}\end{array}$ |
| Phase Accuracy | $\begin{array}{lr}\text { Standard: } & \text { standard specifications apply. } \\ \text { With -HF option: } \quad<2^{\circ}+1^{\circ} / \mathrm{kHz} \\ \text { Note: Specification valid under equal load conditions. }\end{array}$ |

### 2.6.6 -EXS Option Lx Series - Supplemental Specifications

The -EXS (External Sync) option allows the output frequency of the AC source to be synchronized to an external TTL level clock signal. Note that some implementation changes were made starting with firmware revision 1.50 as indicated below.
The following supplemental specifications apply when the Lx is configured with the external sync option. (EXS).

| Parameter | Supplemental Specification |
| :---: | :---: |
| Input |  |
| Voltage Input | TTL Level square wave. |
| Impedance | 10 KOhm. |
| Frequency |  |
| Range | Same as internal clock mode. See configuration limits. |
| Max Sync Input Slew Rate | Units with firmware revision less than 1.5: $<80 \mathrm{~Hz} / \mathrm{sec}$. Units with firmware revision 1.5 or higher: $<250 \mathrm{~Hz} / \mathrm{sec}$ |
| Max Sync Step | Units with firmware revision less than 1.5: $<20 \mathrm{~Hz}$. Units with firmware revision 1.5 or higher: < 200 Hz |
| Errors <br> Error 804 External Sync Error | Following conditions will result in Error 804: <br> 1. Loss of sync input signal <br> 2. Sudden changes in sync input frequency (see max. sync step). <br> 3. Fast changes in sync input frequency (see max sync slew rate). <br> Response time to detect sync fault is 400 msec . If a sync error occurs, the output relay will be opened. Units with firmware revision less than 1.5 will remain in External sync mode. Units with firmware revision 1.5 or higher will revert back to Internal Sync mode. |
| Mode Selection | Units with firmware revision less than 1.5: <br> When switching between INT and EXT sync mode, the output of the AC source will be dropped momentarily. <br> Units with firmware revision 1.5 or higher: <br> When switching form INT to EXT sync mode, the internal frequency is set to the detected ext sync frequency first, then the mode is switched to external sync. This sync process takes about 200 msec so there will be this much delay between receiving the EXT sync command and the actual change of sync mode. The output does not drop out during this time. |
| Restrictions | Frequency cannot be programmed in external sync mode. Frequency transient list system is not available in sync mode. Transient list dwell times are not correlated to external sync but based on internal timebase. <br> Units with firmware revision 1.5 or higher: <br> When switching from INT to EXT sync mode, the difference between the internal frequency present at the time and the external sync frequency may |


| Parameter | Supplemental Specification |
| :--- | :--- |
|  | not exceed 200 Hz. |

### 2.7 Available Options - Ls Series

| Output Options |  |
| :---: | :---: |
| -AX | Auxiliary outputs, 5 VAC and $26 \mathrm{VAC}, 400 \mathrm{~Hz}$. (Output D and E) |
| - HV | 156 / 312 V range output |
| - EHV | 200 / 400 V range output |
| -HF | High frequency option. Increases output frequency to 5000 Hz (single chassis configurations) or 2000 Hz (multi-chassis models). |
| -LF | Low frequency option. Limits maximum output frequency to 500 Hz . |
| -MODE | Adds single phase and three phase mode switching capability to -3 LS models. Not available on -1 models. |
| Firmware Options |  |
| -160 | RTCA/DO-160D test firmware. <br> Includes RCTA-DO160D, section 16, Change \#2 and EURO/CAE-14D $A C$ tests only. |
| -704 | Mil Std 704 test firmware - MIL704 Includes AC tests for Revisions D and E |
| - 704F | Mil Std 704 test firmware - MS704 Includes AC tests for Revisions A through F |
| -ABD | Airbus ABD0100.1.8 Tests. - ABD <br> Includes tables A, B and C. <br> This option can only be used with the provided LxGui Windows software. |
| -AMD | Airbus AMD234 Tests. - AMD <br> This option can only be used with the provided LxGui Windows software. |
| -B787 | Boeing 787B3-0147 Tests. - B787 <br> This option can only be used with the provided LxGui Windows software. |
| Misc. Options |  |
| -ADV | Advanced features package. Adds arbitrary waveform generation and harmonic analysis measurements. For specifications, see Lx Series. |
| -EXS | External Sync (see Notes) |
| -GPIB | GPIB interface. Also adds APE command language support for backward compatibility with L Series. See Lx/Ls Programming Manual P/N 7004-981 for detail on APE command language. As of firmware revision 1.61, the ABLE (Atlas Based Language Extension) command syntax is supported as well with the -GPIB option. For details on using SCPI, APE or ABLE programming language, refer to the Lx/Ls Series Programming Manual (P/N 7004-981). |
| -KP | Replaces standard Ls dual shuttle knob keyboard/display with Lx type numeric keypad style keyboard/display. |
| -L22 | Locking Knobs. Shaft lock screws replace knobs to prevent turning of Voltage and Frequency shuttles. |
| -LAN | Ethernet LAN interface connection. RJ45 connector. Note: When installed, RS232C interface is disabled. |
| -LKM | Clock and Lock Master. Enables synchronizing outputs of two Lx AC sources, one acts as master. <br> This mode supports a frequency range of 45 to 819 Hz on standard Lx/Ls models. See section 3.9. |


| -LKS | Clock and Lock Auxiliary. See -LKM for details. (See Notes, see section <br> 3.9.$)$ |
| :---: | :--- |
| -LNS | Line Sync (see Notes) |
| -MB | Multi-box option. Provides additional controller(s) on 9000Ls/2, <br> $12000 \mathrm{Ls} / 2,13500 \mathrm{Ls} / 3$ or 18000Ls/3 configurations allowing system to <br> be separated into individual functional units. |
| -RMS | Set of 2 Rack mount slides. (Left and Right) Recommended to mount Lx <br> Chassis in 19-inch instrument cabinet. |
| -RPV | Remote programming voltage. DC voltage input 0 to +10 VDC for 0 to <br> full-scale output voltage programming. |
| Notes: | External Trigger input is standard. <br> Line sync and External sync are mutually exclusive. <br> External Trigger input and External sync are mutually exclusive. <br> Units with -LKS (auxiliary) cannot have Line Sync or External Sync. |

### 2.7.1 -HV Option Ls Series - Supplemental Specifications

Specifications for Ls units with -HV voltage range option installed are same as standard Ls unit except where noted below.

| Voltage: |  |  |  |
| :---: | :---: | :---: | :---: |
| Ranges (L-N): |  |  |  |
| Low range | 0-156 Vrms |  |  |
| High range | 0-312 Vrms |  |  |
| Maximum Current at Full Power |  |  |  |
| Note: Current, maximum amps per phase available at on low voltage range. 3000Ls and 4500Ls operate in constant power mode up to currents shown at reduced voltage. See Figure 2-1. For $9000 \mathrm{Ls} / 2$ and $12000 \mathrm{Ls} / 2$, currents are $2 \times 4500 \mathrm{Ls}$ and 6000Ls. For $13500 \mathrm{Ls} / 3$ and $18000 \mathrm{Ls} / 3$, currents are $3 \times 4500 \mathrm{Ls}$ and 6000Ls |  |  |  |
| Model | 3000Ls-HV | 4500Ls-HV | 6000Ls-HV |
| Single Phase Mode: Max. RMS, low Vrange | 38.4 A | 38.4 A | 38.4 A |
| Three Phase Mode: Max. RMS, low Vrange per phase | 12.8 A | 12.8 A | 12.8 A |
| Note: Current derates linearly from $50 \%$ of voltage range to $20 \%$ of specified current at $10 \%$ voltage range. <br> Current in High voltage range is reduced by a factor of 2. <br> Note: For 9000Ls/2-HV and 12000Ls/2-HV, currents are $2 \times 4500$ Ls-HV and 6000Ls-HV. For $13500 \mathrm{Ls} / 3-H V$ and $18000 \mathrm{Ls} / 3-H V$, currents are $3 \times 4500 \mathrm{Ls}-H V$ and $6000 \mathrm{Ls}-\mathrm{HV}$ |  |  |  |
| Maximum Current at Full Scale Voltage |  |  |  |
| Model | 3000Ls-HV | 4500Ls-HV | 6000Ls-HV |
| Single Phase Mode: Max. RMS, low Vrange | 19.2 A | 28.8 A | 38.4 A |
| Three Phase Mode: Max. RMS, low Vrange per phase | 6.4 A | 9.6 A | 12.8 A |

### 2.7.2 EHV Option Ls Series -Supplemental Specifications

Specifications for Ls units with -EHV voltage range option installed are same the Lx with -EHV option. See paragraph 2.6.2.

### 2.7.3 -HF Option Supplemental Specifications

Specification for Ls units with -HF frequency range option installed are same as standard Ls unit except where noted below.

| Frequency Range |  |  |
| :---: | :---: | :---: |
| Model | $\begin{gathered} \hline \text { 3000Ls-HF, 4500Ls-HF } \\ \text {, 6000Ls-HF } \end{gathered}$ | $\begin{aligned} & \text { 9000Ls/2-HF, 13500Ls/3-HF } \\ & \text { 12000Ls/3-HF, 18000Ls/3-HF } \end{aligned}$ |
| Three phase mode | $45 \mathrm{~Hz}-5000 \mathrm{~Hz}$ | $45 \mathrm{~Hz}-2000^{1} \mathrm{~Hz}$ |
| Single phase mode | $45 \mathrm{~Hz}-5000 \mathrm{~Hz}$ | $45 \mathrm{~Hz}-2000{ }^{1} \mathrm{~Hz}$ |
| Output |  |  |
| Programming Accuracy: | $\begin{array}{cc}  & <1000 \mathrm{~Hz} \\ >1000 \mathrm{~Hz} & \pm(0 . \end{array}$ | 0.25 V ) from 5 V to FS . <br> / $\mathrm{KHz}+0.3 \mathrm{~V}$ ) from 5 V to FS |
| Output Noise: ( 20 kHz to 1 MHz ) | < 250 mV RMS typical |  |

For output frequencies up to 1000 Hz , refer to standard measurement specifications. For output frequencies above 1000 Hz , see table below.

| Parameter | Range | Accuracy ( $\pm$ ) |  | Resolution |
| :---: | :---: | :---: | :---: | :---: |
|  |  | 1 Phase Mode | 3 Phase Mode |  |
| Frequency ${ }^{2}$ | $45.00-5000.0 \mathrm{~Hz}$ | $0.1 \% \pm 1$ digit |  | $\begin{aligned} & 0.01 \mathrm{~Hz} \text { to } 81.91 \mathrm{~Hz} \\ & 0.1 \mathrm{~Hz} \text { to } 819.1 \mathrm{~Hz} \\ & 1 \mathrm{~Hz}>819.1 \mathrm{~Hz} \end{aligned}$ |
| Phase | $\begin{aligned} & 45.00-100.0 \mathrm{~Hz} \\ & 100.0-2000 \mathrm{~Hz} \\ & >2000 \mathrm{~Hz} \\ & \hline \end{aligned}$ | $\begin{gathered} 0.5^{\circ} \\ 2^{\circ} \\ 5^{\circ} \\ \hline \end{gathered}$ |  | $0.1{ }^{\circ}$ |
| RMS Voltage | $\begin{aligned} & 0-400 \text { Volts } \\ & <1000 \mathrm{~Hz} \\ & >1000 \mathrm{~Hz} \end{aligned}$ | $\begin{gathered} 0.05 \%+0.25 \mathrm{~V} \\ 0.1 \%+0.1 \% / \mathrm{KHz}+0.3 \mathrm{~V} \end{gathered}$ |  | 0.01 Volt |
| RMS Current | 0-50 Amps | $0.5 \%+0.15 \mathrm{~A}$ | 0.5\% + 0.05A | 0.001 Amp |
| Peak Current | 0-150 Amps | 0.5\% + 0.5A | 0.5\% + 0.15A | 0.001 Amp |
| Crest Factor | 1.00-10.00 | 1.5 \% | 1.5 \% | 0.01 |
| VA Power | 0-6 KVA | 0.5\% + 9 VA | 0.5\% + 3 VA | 1 VA |
| Real Power | 0-6 KW | 0.5\% + 9 W | 0.5\% + 3 W | 1 W |
| Power Factor | 0.00-1.00 | 0.03 | 0.01 | 0.01 |

[^5]Note: Accuracy specifications are valid above 100 counts. For multi-chassis configurations, Current and Power range and accuracy specifications are times the number of chassis.
Note: Frequency measurement specification valid for output > 20 Vrms.
Note: Crest Factor accuracy applies for Irms > 50\% of max.
Note: Power factor accuracy applies for PF > 0.5 and VA > $50 \%$ of max.

### 2.7.4 -AX Option Ls Series - Supplemental Specifications

Specifications for -AX auxiliary output voltage option on the Ls units are listed below. This output is available on the Phase D and E terminal strip. There is no external sense connection for the AX outputs. Sense is internal only. Specifications apply for programmed frequency range of 360 Hz to 440 Hz .

| Parameter | Supplemental Specification |
| ---: | :--- |
| Phase D Output |  |
| Load Regulation | $26.0 \mathrm{Vrms} \pm 0.52 \mathrm{~V}$ |
| Voltage Distortion | $<1.5 \%$ |
| Max. Current | 3.0 Arms |
| Frequency range: | $360-440 \mathrm{~Hz}$, locked to programmed frequency. <br> If programmed frequency exceeds $819 \mathrm{~Hz},-\mathrm{AX}$ outputs will turn off. |
| Phase error to phase A | $<3.0^{\circ}$ |
| Phase E Output |  |
| Voltage | $5.0 \mathrm{Vrms} \pm 0.25 \mathrm{~V}$ |
| Megulation | $<10 \%$ |
| Frequency range: | $360-440 \mathrm{~Hz}$, locked to programmed frequency. <br> If programmed frequency exceeds $819 \mathrm{~Hz},-\mathrm{AX}$ outputs will turn off. |
| Phase error to phase A | $<3^{\circ}$ |
|  |  |

### 2.7.5 -LKM and -LKS Options Ls Series - Supplemental Specifications

The Clock and Lock option enables two independent Ls/Lx power systems to be phase synchronized to each other. One system (-LKM) acts as the master, the other(s) (-LKS) as auxiliaries. The -LKS units are synced to the -LKM unit. Refer to section 3.9 for details on Clock and Lock mode. Note that the maximum number of auxiliary units (-LKS) per master (-LKM) is one. No T connectors are allowed to increase the number of auxiliary units as this may cause reflections on the clock and lock signals.
The following supplemental specifications apply when the Ls is configured with the Clock and Lock option. (-LKM or -LKS).

| Parameter | Supplemental Specification |  |  |
| :---: | :---: | :---: | :---: |
| Voltage |  |  |  |
| Voltage Distortion | Standard: <br> With -HF option: | standard specific < 2 \% <br> $<2 \%+1 \% / k H z$ | s apply. $[45-1000 \mathrm{~Hz}]$ <br> [ $>2000 \mathrm{~Hz}$ ] |


| Parameter | Supplemental Specification |
| :---: | :---: |
|  | (harmonics and noise to 300 kHz ) |
| Frequency |  |
| Range | Standard Lx: $45-819 \mathrm{~Hz}$ <br> With -HF option: $45-5000 \mathrm{~Hz}$. |
| Resolution | Standard Lx: 0.1 Hz <br> With -HF option: 1 Hz |
| Accuracy | $\pm 0.025 \%$ |
| Phase |  |
| Phase Resolution | Standard: standard specifications apply. <br> With -HF option: $0.5^{\circ}$ |
| Phase Accuracy | Standard: standard specifications apply. <br> With -HF option: $\quad<2^{\circ}+1^{\circ} / \mathrm{kHz}$ <br> Note: Specification valid under equal load conditions. |

### 2.7.6 -EXS Option Ls Series - Supplemental Specifications

The -EXS (External Sync) option allows the output frequency of the AC source to be synchronized to an external TTL level clock signal. Note that some implementation changes were made starting with firmware revision 1.50 as indicated below.

The following supplemental specifications apply when the Ls is configured with the external sync option. (EXS).

| Parameter | Supplemental Specification |
| :---: | :---: |
| Input |  |
| Voltage Input | TTL Level square wave. |
| Impedance | 10 KOhm . |
| Frequency |  |
| Range | Same as internal clock mode. See configuration limits. |
| Max Sync Input Slew Rate | Units with firmware revision less than 1.5: $<80 \mathrm{~Hz} / \mathrm{sec}$. Units with firmware revision 1.5 or higher: < $250 \mathrm{~Hz} / \mathrm{sec}$ |
| Max Sync Step | Units with firmware revision less than 1.5: $<20 \mathrm{~Hz}$. Units with firmware revision 1.5 or higher: $<200 \mathrm{~Hz}$ |
| Errors <br> Error 804 <br> External Sync Error | Following conditions will result in Error 804: <br> 1.Loss of sync input signal <br> 2. Sudden changes in sync input frequency (see max. sync step). <br> 3. Fast changes in sync input frequency (see max sync slew rate). Response time to detect sync fault is 400 msec . If a sync error occurs, the output relay will be opened. Units with firmware revision less than 1.5 will remain in External sync mode. Units with firmware revision 1.5 or higher will revert back to Internal Sync mode. |
| Mode Selection | Units with firmware revision less than 1.5: <br> When switching between INT and EXT sync mode, the output of the AC source will be dropped momentarily. <br> Units with firmware revision 1.5 or higher: <br> When switching form INT to EXT sync mode, the internal frequency is set to the detected ext sync frequency first, then the mode is switched to external sync. This sync process takes about 200 msec so there will be this much delay between receiving the EXT sync command and the actual change of sync mode. The output does not drop out during this time. |


| Parameter | Supplemental Specification |
| :--- | :--- |
| Restrictions | Frequency cannot be programmed in external sync mode. <br> Frequency transient list system is not available in sync mode. <br> Transient list dwell times are not correlated to external sync but based on <br> internal timebase. <br> Units with firmware revision 1.5 or higher: <br> When switching from INT to EXT sync mode, the difference between the <br> internal frequency present at the time and the external sync frequency may <br> not exceed 200 Hz. |

## 3. Unpacking and Installation

### 3.1 Unpacking

Inspect the unit for any possible shipping damage immediately upon receipt. If damage is evident, notify the carrier. DO NOT return an instrument to the factory without prior approval. Do not destroy the packing container until the unit has been inspected for damage in shipment. If possible, retain the container in the event the system ever has to be returned to the factory for either repair of upgrades

WARNING: This power source weighs approximately $175 \mathrm{lbs} / 79.4 \mathrm{Kg}$ per chassis (2 chassis total) Obtain adequate help when moving or installing the unit. Make sure the cabinet and rack slides used to install the Lx or Ls Series unit(s) can support the weight of the unit(s).

### 3.2 Power Requirements

The Lx / Ls Series power Source has been designed to operate from a three-phase, three wire (Wye or Delta) AC input line. A protective earth connection is required as well. (PE).
Available three-phase input setting is 208 to $230 \mathrm{~V}_{\mathrm{LL}}$ nominal for standard Lx / Ls models, 400 $\mathrm{V}_{\mathrm{LL}}$ nominal for Lx / Ls Series with option -400 or $480 \mathrm{~V}_{\mathrm{LL}}$ nominal for Lx / Ls Series with option 480. All three phase input is three wire plus ground.

The 3000Lx/Ls model with standard 208V L-L AC input may be operated from a single phase 208-230 V L-N AC input as well. In this case, the single phase AC must be connected between TB3 L2-L3 inputs for 3000Lx or TB3 ØB - ØC inputs for 3000Ls. Note that input current will be significantly higher than for a 3 phase AC input connection so wire size and AC disconnects used must be sized accordingly.

CAUTION: Do not connect 400Vor 480V into a unit designed for 208 V use. The result could be a severely damaged unit. Always check the input rating on the model number tag before connecting AC input power. AC voltage input settings CANNOT be changed in the field.

### 3.3 Mechanical Installation

The Lx / Ls Series AC power sources can be used free standing on a solid surface or mounted in a 19 " instrument cabinet. The units are fan cooled, drawing air in from the side and exhausting at the rear. The back of each unit must be kept clear of obstruction and a 3 " clearance must be maintained to the rear. Special consideration of overall airflow characteristics and the resultant internal heat rise must be considered at all times to avoid self heating and over temperature problems.
Multi chassis configurations such as the 9000Lx/2 or 9000Ls/2 consist of two self-contained 4500 Lx or 4500 Ls power sources. They must be connected through the system interface using the supplied DB25 to DB25 cable. Output wiring from each chassis to the EUT must be of equal wire gage and length to ensure proper current sharing between units.
Note that for multi-chassis systems, it is recommended to turn the Master unit ON first and then the Auxiliary unit(s). To turn the system off, turn OFF the Auxiliary unit(s) first and then the Master unit.


Figure 3-1: Rear Panel Connector Locations - Lx Series


Figure 3-2: Rear Panel Connector Locations - Ls Series

### 3.4 AC Input Wiring - INPUT

AC input connections are to be made directly to the input fuse block of all units that make up a Lx / Ls system. The input block is located on the lower right hand corner of the back of the 4500Lx/Ls and 4500Lx/Ls-NO chassis. It is labeled "INPUT" on the Lx and "INPUT TB3" on the Ls models.
Ground (earth) wire must be connected to the chassis of the AC power system using the ground connection of the AC input fuse block. The mains source must have a current rating equal to or greater than the input fuses and the input wiring must be sized to satisfy the applicable electrical codes.

The input power cables must be large enough to handle the input current of the power source and must conform to local electrical codes. Consult a qualified electrician prior to installation. Note that all wires must be sized to accommodate the worst-case maximum current that may occur under low line conditions. Local electrical codes may also require different wire types and sizes.
Cable lengths must not exceed twenty-five (25) feet. For lengths greater than 25 feet, calculate the voltage drop from the following formula:
$2 \times$ DISTANCE X CABLE RESISTANCE PER FT. X CURRENT = VOLT DROP

Note: If possible, keep input cable lengths for Master and Auxiliary chassis equal.


CAUTION: Capacitors in the power source may hold a hazardous electrical charge even if the power source has been disconnected from the mains supply. Allow capacitors to discharge to a safe voltage before touching exposed pins of mains supply connectors.
Power modules need at least 10 Minutes to discharge to safe levels before they can be removed.

### 3.5 Output Connections

### 3.5.1 Output Wiring

The output terminal blocks for each unit are located at the rear of the unit. Three phase output connections are made to the terminal block labeled OUTPUT. For a $9000 \mathrm{Lx} / 2$ or $9000 \mathrm{Ls} / 2$ two box system, the output terminals from both the master 4500Lx or 4500Ls and Auxiliary 4500Lx or 4500Ls must be connected together. See Figure 3-3.

On Lx Series, the phase outputs are labeled ø1, ø2, ø3 and COM. (Same labeling as Hewlett Packard / Agilent HP6834 and California Instruments iL Series) The common (neutral) connection (if needed) can be made on the same terminal block labeled COM. If the power source is operated in single-phase mode, all power is available from the ø1 output connection. The neutral connection (COM) is always required for single-phase output mode on a $9000 \mathrm{Lx} / 2$ and may be used if needed for the EUT for all three-phase output modes.

On Ls Series, the phase outputs are labeled øA, øB, øC and NEUT. (Same labeling as California Instruments L Series) The neutral connection (if needed) can be made on the same terminal block labeled COM. If the power source is a single-phase model or operated in single phase mode, all power is available from the $\varnothing$ A output connection. The neutral connection (COM) is
always required for single-phase output mode on a 9000Ls/2 and may be used if needed for the EUT for all three-phase output modes.
The external sense inputs allow the power system output voltages to be monitored directly at the load and must be connected at external sense connector. The external sense wires should be run as a twisted pair for short lengths. Sense leads over three (3) feet long should be run as a twisted shielded pair.

## Note: The output of the power source is isolated from the input line and floating with respect to chassis ground. If needed, either side (HI or LO) may be grounded.

The output power cables must be large enough to prevent a total voltage drop exceeding $1 \%$ of the rated output voltage between the power source and the load. Note that wires must be sized to accommodate the maximum current that is available. This may be a function of the voltage range and phase mode of the Lx \Ls model on hand. Always use the current available on the low voltage range to size the wires.

Cable lengths must not exceed twenty-five (25) feet. For lengths greater than 25 feet, calculate the voltage drop from the following formula:
$2 \times$ DISTANCE X CABLE RESISTANCE PER FT. X CURRENT = VOLT DROP
Note: Ensure that output cable lengths from Master and Auxiliary chassis to EUT are of identical length.

### 3.5.2 Output Terminal Block - OUTPUT

Each 3000/4500/6000Lx|Ls chassis has a single AC output terminal block. For tabletop operation of a single chassis system, the output terminal block must be covered using the supplied AC Output safety cover. The terminal blocks are large enough to accommodate required wire gauge sizes. The terminal block is located in the upper left corner on the rear panel of the unit. (Looking from the back).
Multi-chassis configurations have two or more output terminal blocks, one on the master Lx \Ls chassis and one of the auxiliary Lx $\backslash$ Ls chassis.
For operation as a multi-chassis system, the outputs of all $\mathrm{Lx} \backslash$ Ls chassis' must be connected together using the additional terminal blocks provided in the Lx \Ls ship kit. Keep the wire lengths between each chassis and this common terminal block the same.
See Figure 3-3 for output wiring diagram.

| Connector | Terminal | Mode | Lx Output <br> OUTPUT | Ls Output <br> TB1 |
| :--- | :---: | :--- | :--- | :--- |
|  | 1 | 3 Phase \& 1 Phase | $\varnothing 1$ | $\varnothing A$ |
|  | 2 | 3 Phase | $\varnothing 2$ | $\varnothing B$ |
|  | 3 | 3 Phase | $\varnothing 3$ | $\varnothing B$ |
|  | 4 | Common / Neutral | COM | NEUT |

Table 3-1: Output Terminal connections.

### 3.5.3 Multi-chassis Output Wiring Diagram

Figure 3-3 shows the required output connections for a 9000Lx/2 or 9000Ls/2 two chassis system (rear-view perspective). Always turn off AC mains power to the 9000Lx/2 or 9000Ls/2 by turning off the circuit breakers on both the Master and Auxiliary 4500Lx / Ls power source before making or changing output connections. The terminal block shown to connect the outputs of both chassis together is provided in the 9000Lx/2 or 9000Ls/2 ship kit. The System Interface cable is a DB25 to DB25 M/F cable approximately 2 meters in length. (CI P/N 250778). This cable connects between the male DB25 connector on the Master unit rear panel labeled TO AUXILIARY INTERFACE and the female DB25 connector on the Auxiliary unit rear panel labeled TO MASTER INTERFACE as shown in Figure 3-3. The OUTPUT SAFETY COVER must be removed to use the System Interface and the AC Source must be installed in a cabinet with a protective rear screen or door.


Figure 3-3: 9000Lx/2 and 9000Ls/2 Output Wiring


Figure 3-4: 9000Lx/2, 9000Ls/2, 12000Lx/2 or 12000Ls/2 Wiring diagram - 3 Phase mode


Figure 3-5: $13500 \mathrm{Lx} / 2,13500 \mathrm{Ls} / 3,18000 \mathrm{Ls} / 3$ or $18000 \mathrm{Ls} / 3$ Wiring diagram - 3 Phase mode

### 3.6 Connectors - Rear Panel

A number of connectors are located along the top rear covers. These connectors are in a recessed area to protect them from shipment damage. A summary of available connectors is provided in the table below.

| Connector |  |  |
| :---: | :---: | :---: |
| Lx Series |  |  |
| AC Input (INPUT) | Function | Connects To |
| $\begin{aligned} & \text { L1 - AC in } \\ & \text { L2 - AC in } \\ & \text { L3-AC in } \\ & \text { CHASSIS - GND } \end{aligned}$ | Primary AC Power Input | 208-230 VAC nominal (Std) 400 VAC nominal (-400 option) 480 VAC nominal (-480 option) Note: For 3000Lx/Ls operated from single-phase AC input, use L2-L3. |
| AC Output (OUTPUT) | Function | Connects To |
| $\begin{aligned} & \varnothing 1 \\ & \varnothing 2 \\ & \varnothing 3 \\ & \text { COM } \end{aligned}$ | AC output | User Load |
| External Sense | Function | Table |
| $\begin{aligned} & \text { Sense } \varnothing 1, \varnothing 2, \varnothing 3 \text {, } \\ & \text { COM } \end{aligned}$ | External Sense | Table 3-7 |
| Ls Series |  |  |
| AC Input (INPUT TB3) | Function | Connects To |
| $\begin{aligned} & \varnothing A-A C \text { in } \\ & \emptyset B-A C \text { in } \\ & \emptyset C-A C \text { in } \\ & \text { CHASSIS - GND } \end{aligned}$ | Primary AC Power Input | 208-230 VAC nominal (Std) 400 VAC nominal (-400 option) 480 VAC nominal (-480 option) Note: For 3000Lx/Ls operated from single-phase $A C$ input, use ØB- $\varnothing C$. |
| AC Output (OUTPUT TB1) | Function | Connects To |
| ØA <br> ØВ <br> $\varnothing$ С <br> NEUT | AC output | User Load |
| External Sense | Function | Table |
| Sense ØA HI, ØB HI, ØC HI, NEUT | External Sense | Table 3-7 |
| Lx and Ls Series |  |  |
| Remote Control | Function | Table |
| RS232 | Serial Control Interface | Table 3-8 |
| IEEE-488 | GPIB Control Interface | See IEEE-488 standard for pin out. Optional on Ls. |
| LAN | Ethernet Interface | Optional on Lx and Ls. |
| USB | USB Control Interface |  |
| System Interface | Function | Table |
| Master | Connects to Master | DB25, MALE |
| Auxiliary | Connects to Auxiliary | DB25, FEMALE |
| Lx Series |  |  |
| Other | Function | Table |


| Connector |  |  |
| :--- | :--- | :--- |
|  | SMA Connectors | Discrete Fault Indicator |
|  | Remote Inhibit | Table 3-4 |
|  | Trigger Out1 <br> (Function Strobe) | Table 3-4 |
|  | Trigger In1 | Table 3-4 |
|  | RPV (N/A) | Table 3-4 |
| BNC Connectors | Clock | Table 3-6 -LKM / -LKS option |
|  | Lock | Table 3-6 |
| Ls Series |  |  |
| SMA Connectors | Function | Discrete Fault Indicator |
|  | J7-36+ / J7-27- <br> (Remote Shutdown) | Table 3-4 |
|  | Function Strobe | Table 3-4 |
|  | Trigger | Table 3-4 |
|  | RPV (N/A) | Table 3-4 |
| BNC Connectors | J1- Clock | Table 3-6 -LKM / -LKS option |
|  | J2 - Lock | Table 3-6 |

Table 3-2: Rear Panel Connectors

### 3.6.1 AC Input Connector - INPUT

See section 3.4 for details on connecting AC input power. Labeled INPUT on Lx models, INTPUT TB3 on Ls models.

| INPUT. | Designator <br> Lx Series | Designator <br> Ls Series | Direction | Connection <br> Description |
| :---: | :--- | :--- | :--- | :--- |
| 1 | L1 | $\varnothing A$ | Input | AC Line |
| 2 | L2 | $\varnothing$ B | Input | AC Line |
| 3 | L3 | $\varnothing C$ | Input | AC Line |
| 4 | GND | Gnd symbol |  | Chassis Ground |

Table 3-3: AC Input Terminal Block Connection Description

### 3.6.2 SMA Connectors - Lx Series

SMA connectors. Functions are called out on rear panel decal. Table 3-4 shows connections from left to right when standing at the rear of the Lx cabinet. SMA connectors are small high frequency capable coax connectors that can be screwed down securely to prevent signal loss. Adaptor for SMA to BNC conversion are readily available.
To connect these signals using more conventional BNC cables, SMA Male to BNC Female adapters may be used. These are available from www.pasternack.com , P/N PE9074.


PE9074 Adaptor.

| SMA | Description |
| :--- | :--- |


| SMA | Description |
| :---: | :--- |
| FLT | Discrete Fault Indicator output. Isolated Open Collector active high output with <br> internal pull up to +5Vdc. Can be used to signal external devices when a fault <br> condition is detected. |
| INH | Remote Inhibit. (TTL input) |
| TRIGGER <br> OUT1 | Trigger Output (TTL output). The Trigger Output (Trig Out1) is an active low TTL signal <br> with a duration of no less than 400 usec. <br> (Can be set to Function Strobe for compatibility with CI L Series) |
| TRIGGER <br> IN1 | Trigger Input (TTL input) <br> RPV / NARemote programming voltage. DC voltage input 0 to +10 VDC for 0 to full-scale output <br> voltage programming.(RPV option) |

Table 3-4: SMA Connectors - Lx Series

### 3.6.3 SMA Connectors - Ls Series

SMA connectors. Functions are called out on rear panel decal. Table 3-5 shows connections from left to right when standing at the rear of the Ls cabinet. SMA connectors are small high frequency capable coax connectors that can be screwed down securely to prevent signal loss. Adaptor for SMA to BNC conversion are readily available.

To connect these signals using more conventional BNC cables, SMA Male to BNC Female adapters may be used. These are available from www.pasternack.com , P/N PE9074.


| SMA | Description |
| :---: | :--- |
| J3 <br> DFI | Discrete Fault Indicator output. Isolated Open Collector active high output with <br> internal pull up to +5Vdc. Can be used to signal external devices when a fault <br> condition is detected. |
| J7 <br> $36 / 27$ <br> INH | Remote Shutdown. (Inhibit) Active low TTL input. Equivalent to J7-36 (+) and J7-27 (-) on <br> CI L Series. |
| J7 <br> $31 / 14$ <br> FSTB | Function Strobe The function strobe is an active low TTL signal with a duration of no <br> less than 400 usec. <br> (Can be set to Trigger Output (TTL output) for compatibility with CI iL Series) <br> Equivalent to J7-31 (+) and J7-14 (-) on CI L Series. |
| TRIG | Trigger Input (TTL input) |
| RPV / NA | Remote programming voltage. DC voltage input 0 to +10 VDC for 0 to full-scale output <br> voltage programming.(RPV option) |

Table 3-5: SMA Connectors - Ls Series

### 3.6.4 BNC Connectors (-LKM / -LKS options)

BNC connectors. Functions are called out on rear panel decal. Table 3-6 shows connections for the optional -LKM and -LKS clock and lock mode. Refer to section 3.9 for more details.

| BNC | Ls Series <br> Ref. | Description |
| :---: | :---: | :--- |
| CLOCK | J1 | Clock Option (TTL output on Master / TTL input on Auxiliary) |
| LOCK | J2 | Lock Option (TTL output on Master / TTL input on Auxiliary) |

Table 3-6: BNC Connectors

### 3.6.5 External Sense Connector - SENSE

The external sense connections for Phase 1, 2 and 3 ( $A, B$ and $C$ ) in three-phase mode and Phase $1(A)$ in single phase mode MUST be connected for correct operation. Sense connections must be made at the MASTER 4500Lx/Ls unit for a multi-box Lx/Ls system.

| Pin | Description - Lx Series | Description - Ls Series |
| :---: | :--- | :--- |
| 1 | Phase 1 sense Hi | Phase A sense Hi |
| 2 | Phase 2 sense Hi | Phase B sense Hi |
| 3 | Phase 3 sense Hi | Phase C sense Hi |
| 4 | Neutral sense | Neutral sense |
| 5 | - AX Option Phase D Hi - N/A | - AX Option Phase D Hi - N/A |
| 6 | - AX Option Phase D Lo - N/A | - AX Option Phase D Lo - N/A |

Table 3-7: External Sense Connector

### 3.6.6 RS232C Serial Interface - RS232C

A standard RS232C DB9 connector is located on the rear panel for serial control. A straight thru DB9 male to DB9 female interface cable to 9-pin PC serial port connector may be used

| Pin | Designator | Dir. | Description |
| :---: | :--- | :--- | :--- |
| 1 | Not used |  | N/C |
| 2 | TxD | Output | Transmit data |
| 3 | RxD | Input | Receive data |
| 4 | Not used |  | N/C |
| 5 | Common |  | Common |
| 6 | Not used |  | N/C |
| 7 | CTS | Input | Clear to send |
| 8 | RTS | Output | Request to send |
| 9 | Not used |  | N/C |

Table 3-8: RS232C Connector

### 3.6.7 System Interface Connectors - MASTER and AUXILIARY

WARNING: The system interface connectors are for use with AMETEK supplied cables, and only between California Instruments equipment.

A set of two System Interface connectors is located on the rear panel of each 4500Lx/Ls chassis. The system interface is used to connect the multiple 4500Lx/Ls or 6000Lx/Ls power sources in a Master/Auxiliary configuration to create a $9000 \mathrm{Lx} / \mathrm{Ls} / 2,12000 \mathrm{Lx} / \mathrm{Ls} / 2,13500 \mathrm{Lx} / \mathrm{Ls} / 3$ or $18000 \mathrm{Lx} / \mathrm{Ls} / 3 \mathrm{AC}$ power source configuration. In this configuration, only the Master power source has a built-in controller and front panel. The System Interface cable provided in the Lx or Ls Series ship kit (CI P/N 250778) MUST be used to connect both chassis as shown in Figure 3-3.

Note that no user accessible signals are provided on the System Interface connections and they should only be used for their intended purpose. To use the System Interface capability, the output safety cover has to be removed. As such, multi-chassis configurations cannot be used outside of a cabinet with proper rear screens.
Note that for multi-chassis systems, it is recommended to turn the Master unit ON first and then the Auxiliary unit(s). To turn the system off, turn OFF the Auxiliary unit(s) first and then the Master unit.

### 3.6.8 USB Interface

A standard USB Series B device connector is located on the rear panel for remote control. A standard USB cable between the AC Source and a PC or USB Hub may be used.

Note: Use of the USB port to control more than one power source from a single PC is not recommended, as communication may not be reliable. Use GPIB interface for multiple power source control.

## USB



Figure 3-6: USB Connector pin orientation.

| Pin | Name | Description |
| :--- | :--- | :--- |
| 1 | VBUS | +5 VDC |
| 2 | D- | Data - |
| 3 | D+ | Data + |
| 4 | GND | Ground |

Table 3-9: USB Connector pin out.

### 3.6.9 LAN Interface - RJ45

An optonal RJ45 Ethernet 10BaseT connector is located on the rear panel for remote control. A standard RJ45 UTP patch cord between the AC Source and a network Hub may be used to connect the AC source to a LAN. For direct connection to a PC LAN card, a crossover RJ45 cable is required. Consult your network administrator for directions on connecting the AC source to any corporate LAN.

If the -LAN Ethernet interface option is present, the MAC Address (Media Access Control) of the Ethernet port is printed on the serial tag of the power source. The serial tag is located on the rear panel of the unit.
For information on how to set up a network connection or a direct PC connection using the LAN interface, refer to the Lx/Ls Series Programming Manual P/N 7004-981 distributed in Adobe PDF format on CD ROM CIC496.


87654321
LAN

| Pin \# | Ethernet TPE <br> 10BaseT/100BastT/1000Base <br> $\mathbf{T}$ | EIA/TIA 568A | EIA/TIA 568B <br> Crossover |
| :---: | :--- | :--- | :--- |
| 1 | Transmit/Receive Data 0 + | White with green strip | White with orange stripe |
| 2 | Transmit/Receive Data 0 - | Green with white stripe or <br> solid green | Orange with white stripe or <br> solid orange |
| 3 | Transmit/Receive Data 1 + | White with orange stripe | White with green stripe |
| 4 | Transmit/Receive Data 2 + | Blue with white stripe or <br> solid blue | Blue with white stripe or <br> solid blue |
| 5 | Transmit/Receive Data 2 - | White with blue stripe | White with blue stripe |
| 6 | Transmit/Receive Data 1 - | Orange with white stripe <br> or solid orange | Green with white stripe or <br> solid |
| 7 | Transmit/Receive Data 3 + | White with brown strip or <br> solid brown | White with brown strip or <br> solid brown |
| 8 | Transmit/Receive Data 3 - | Brown with white stripe or <br> solid brown. | Brown with white stripe or <br> solid brown |

Table 3-10: RJ45 LAN Connector pin out.

### 3.7 Basic Initial Functional Test

## CAUTION: Work carefully when performing these tests; hazardous voltages are present on the input and output during this test.

Refer to Figure 3-3 for the required functional test set up. Proceed as follows to perform a basic function check of the power system:

1. Verify the correct AC line input rating on the nameplate of the Lx/Ls unit(s) and make sure the correct three-phase line voltage is wired to the input of the Lx/Ls before applying input power.
2. Connect a suitable resistive or other type load to the output of the Lx or Ls. Suggested load values for the low voltage range rounded up to the nearest 0.1 Ohm are shown in Table 3-11 for the Lx Series and Table 3-12 for the Ls Series.
For the high voltage range, the resistor values must be multiplied by four. For models with HV or -EHV voltage range option, recalculate these values by adjusting for the voltage range value. Make sure the power resistor has sufficient power dissipation capability for full load test and that the load used does not exceed the maximum power rating of the AC source. For three phase configurations, this test can be performed on one phase at a time if needed.
3. Connect an oscilloscope and DMM / voltmeter to the AC source output. Set both for AC mode.
4. If the correct voltage is present, turn on the Lx/Ls unit(s) by closing the On/Off circuit breaker on the front panel of both chassis.
5. Set the output voltage to 0 volt and close the output relay with the OUTPUT ON/OFF button. There should be little or no output although the DMM may show a noise level, especially if the DMM is in auto ranging mode.
6. Select the Set screen and use the voltage shuttle to program a small voltage ( 20 VAC ). Observe the DMM reading. The reading should track the programmed voltage.
7. Also monitor the scope. The output should be a sinusoidal voltage waveform.
8. If the output tracks, increase the voltage till you reach $80 \%$ of the voltage range or more. Check the output voltage reading and waveform.
9. Select the measurement screen by pressing the Meas button. The output voltage, current and power will be displayed. For three phase configurations, use the PHASE button to select individual phase data. If all phases are loaded equally, the same current and power should be visible for all three unless the voltages are not programmed to the same level. If only one phase is loaded, current and power will only be shown for the loaded phase.

In the unlikely event the power source does not pass the functional test, refer to the calibration procedure in Section 6 or call California Instrument's customer satisfaction department for further assistance.

| Model | 3 Phase Mode, 150 V range | 1 Phase Mode, 150 V range |
| :---: | :---: | :---: |
| 3000 Lx | 22.5 Ohm | 7.5 Ohm |
| 4500 Lx | 15 Ohm | 5.0 Ohm |
| 6000 Lx | 11.8 Ohm | 4.0 Ohm |
| 9000 Lx | 7.5 Ohm | $2,5 \mathrm{Ohm}$ |
| 12000 Lx | 5.9 Ohm | 2.0 Ohm |
| 13500 Lx | 5.0 Ohm | 1.7 Ohm |
| 18000 Lx | 4.0 Ohm | 1.4 Ohm |

Table 3-11: Full Load Resistance - Lx Series

| Model | 3 Phase Mode, 135 V range | Model | 1 Phase Mode, 135 V range |
| :---: | :---: | :---: | :---: |
| 3000Ls-3 | 18.3 Ohm | 3000Ls-1 | 6.1 Ohm |
| 4500Ls-3 | 12.2 Ohm | $4500 \mathrm{Ls}-1$ | 4.1 Ohm |
| 6000Ls-3 | 9.2 Ohm | $6000 \mathrm{Ls-1}$ | 3.1 Ohm |
| 9000Ls-3 | $6,1 \mathrm{Ohm}$ | $9000 \mathrm{Ls}-1$ | 2.1 Ohm |
| 12000Ls-3 | 4.6 Ohm | $12000 \mathrm{Ls}-1$ | 1.6 Ohm |
| 13500Ls-3 | 4.1 Ohm | 13500Ls-1 | 1.4 Ohm |
| 18000Ls-3 | 3.1 Ohm | 18000Ls-1 | 1.1 Ohm |

Table 3-12: Full Load Resistance - Ls Series

### 3.8 Multi-box Configurations (-MB Option)

Multi-box configurations are identical to a two or three box system except each chassis (box) has its own controller. When connected as a multi-chassis system through the system interface, the controller in the auxiliary chassis is disabled and the entire system is controller from the master unit. Operation is identical to a normal multi-box model. E.g. a 9000Lx/2-MB is connected and operated the same way as a $9000 \mathrm{Lx} / 2$. While a $9000 \mathrm{Lx} / 2$ will have once chassis with a blank front panel, a 9000Lx/2-MB will have a controller on both front panels of which only one is used when configured as a 9000Lx/2. The other controller will display a message indicating it is operating as an auxiliary unit ${ }^{1}$.

The benefit of the -MB option is that both units can be separated and operated independently. To so do, proceed as follows:

1. Turn off both units.
2. Disconnect the output terminals ( $1,2,3, \mathrm{COM}$ or $\mathrm{A}, \mathrm{B}, \mathrm{C}, \mathrm{NEUT})$ from each other.
3. Disconnect the system interface cable between the two (or three) units.

When powered up, each unit will power up as a stand-alone unit. Connection diagrams for a MB system are identical to those for a $9000 \mathrm{Lx} / \mathrm{Ls} / 2,12000 \mathrm{Lx} / \mathrm{Ls} / 2,13500 \mathrm{Lx} / \mathrm{Ls} / 2$ or $1800 \mathrm{Lx} / \mathrm{Ls} / 3$. See section 3.5.3, Figure 3-4 and Figure 3-5 for wiring diagrams.

### 3.8.1 Adjustment requirements

AC power sources used in a multi-box configuration must be properly adjusted for matched gain and impedance to ensure correct current sharing between paralleled amplifiers. This adjustment is done at the factory if the -MB option is specified. The -MB option must be specified at the time of system purchase.

If units have been acquired individually such as at different points in time or without the -MB configuration option specified, it may be necessary to balance the amplifiers in order for them to function at full power in a multi-box configuration. Refer to section 6.6 "Non-Routine Output Gain Calibration" and section 6.7 "Non-Routine Amplifier Gain Balance Adjustment"

### 3.8.2 Power Up and Power Down sequence.

A multi-box Lx/Ls system can be turned on in either order. Generally, it is recommended to turn on the auxiliary unit before turning on the master unit and turn off in the opposite order but no damage will occur if the order is reversed.

## Note: It is not recommended to turn off either unit without turning off the other unit and then turning it back on. This may result in miscellaneous error messages occurring on the unit that was not powered down. If one unit has been turned off, turn off all units first before turning the system back on.

If a master unit is to be used by itself, it is not sufficient to just leave the auxiliary unit off while the system interface cable remains connected. Disconnect the system interface from the back of the master unit and then turn the unit on for stand-alone use.

[^6]
### 3.9 Clock and Lock Mode (-LKM/-LKS Option)

Clock and lock mode operation of two Lx or Ls AC power sources is available only if the -LKM and -LKS options have been installed at the factory. With these options installed, it is possible to lock an auxiliary unit (-LKS) to a master unit (-LKM). The master unit controls the frequency. This configuration can be used to create multiphase power systems such as split-phase or six phases. The auxiliary unit must be set to external clock mode from the Control screen. See section 4.2.5.

Two BNC connectors are provided on the rear panel of the Lx/Ls for clock and lock mode. Both need to be connected between the master and auxiliary unit. On the master unit (-LKM), both are outputs. On the auxiliary unit (-LKS), both are inputs. Do not connect these BNC's between two master units (-LKM's) or damage to the unit could result.

## Note: $\quad$ The maximum number of auxiliary units (-LKS) per master (-LKM) is one. No T connectors are allowed to increase the number of auxiliary units as this may cause reflections on the clock and lock signals.

Refer to Figure 3-7 for the required connections between the -LKM and -LKS units. The example is shown for two units, one master, one auxiliary.

## WARNING: DO NOT CONNECT THE AC OUTPUTS OF THE -LKM AND -LKS UNITS TOGETHER. CLOCK AND LOCK OUTPUTS CANNOT BE PARALLELED TO OBTAIN HIGHER OUTPUT CURRENTS.

Do not use clock and lock mode to obtain higher power capability on the same phase(s). For higher power configurations, use the multi-chassis configuration through the system interface connection instead. Refer to section 3.5.3 for multi-chassis configuration and connection information.

The frequency of the auxiliary unit will track that of the master. The output phase angle of phase 1/A will be locked to the auxiliary unit as well. (See LKM/LKS supplemental specifications for phase accuracy). This allows split phase or six phase configurations to be created.

### 3.9.1 Configuration settings

Units configured with the -LKM option will show the Clock as INT (internal) and the mode as CLK/LOC on the CONTROL screen. Units configured with the -LKS option can be set to INT (internal) or EXT (external) clock from the CONTROL screen. The MODE setting on the CONTROL screen of the -LKS unit determines the power on state for the clock setting. When set to STAN (Stand-alone operation), the unit powers up with INT clock. When set to CLK/LOC mode, it powers up in EXT clock mode suitable to clock and lock system operation. See section 4.2.5 for details.

### 3.9.2 Frequency measurements on -LKS units

Lx or Ls models configured with the -LKS option used in a clock and lock configuration will not accurately measure frequency if the programmed frequency of the master unit (-LKM) exceeds 2000 Hz unless the frequency setting of the -LKS is set to the a value close to the programmed frequency of the -LKM master unit. Setting the -LKS programmed frequency when it is operating as a clock and lock auxiliary does not affect its actual output frequency as it is controlled by the -LKM master unit. This provides the controller with the required information to accurately measure the frequency.

### 3.9.3 Lx versus Ls Differences

The Lx and Ls Series differ in how to control the phase angle of phase 1/A. On the Ls series, setting the phase angle for phase A on the auxiliary unit will result in all three phases of the auxiliary unit shifting by the same amount. Thus, programming the auxiliary unit to $60^{\circ}$ on phase A will result in a 60 degree offset between the two phase $A$ outputs, B outputs and $C$ outputs.

On the Lx Series, programming phase 1 of the auxiliary unit does not rotate phase $B$ and $C$ on the auxiliary unit as well. There are two ways to accomplish this:

1. Program all three phases on the auxiliary unit with the same phase offset. Eg. Program phase 1 to $60^{\circ}$, phase 2 to $300^{\circ}$ and phase 3 to $180^{\circ}$.
2. Set the phase $1 / A$ offset calibration coefficient for phase $1 / A$ to the desired offset. This will rotate all three phases, similar to setting the phase A angle on the Ls Series.

This discrepancy is caused by the requirement to maintain backward compatibility with the HP6834B, which did not support Clock and Lock capability.


Figure 3-7: Clock and Lock Connections

### 3.10 Remote Control Interfaces

Setup and connection information on setting up remote control using either GPIB, RS232, USB or LAN interfaces is provided in the Lx/Ls Series II Programming Manual P/N 7004-981. This manual is distributed on the same CD ROM (P/N CIC496) as this user manual. It can also be downloaded from the AMETEK Programmable Power website (www.programmablepower.com).
Connector pin out information is provided in sections 3.6.6, 3.6.8 and 3.6.9of this manual.
Note: Use of the USB port to control more than one power source from a single PC is not recommended, as communication may not be reliable. Use GPIB interface for multiple power source control.

### 3.11 RPV Input (RPV option)

The -RPV option is factory installed only. If installed, this option disables the internal controller voltage programming reference. Instead, a user provided DC signal is used to drive all amplifiers. Note that only one RPV input is available so in three phase modes, all three outputs will track the same RPV DC input signal.
A 0 to +10 VDC signal will provide a 0 to full-scale voltage output on the selected voltage range.
To enable the RPV mode, press the MENU key until the CONTROL screen and scroll to the ALC setting entry. If the ALC is set to REG or ON, turn if OFF first. Then scroll to the VOLT REF entry. Select EXT to use the RPV (remote programming voltage).
The presence of the RPV option is indicated by the -RPV field in the model number on the serial tag. Note that the -EXT and -RPV options are mutually exclusive so only one or the other can be present.

## 4. Front Panel Operation

### 4.1 Tour of the Front Panel

Before operating the AC source using the front panel, it helps to understand the operation of the front panel controls. Specifically, the operation of the knob, keyboard and the menu layout are covered in the next few paragraphs.

### 4.1.1 Front Panel Controls and Indicators



Ls Series Keyboard / Display (or -RP option keyboard on Lx Series)


Lx Series Keyboard / Display (or -KP option keyboard on Ls Series)

The front panel can be divided in a small number of functional areas:

- Mains circuit breaker
- Keyboad/ Display panel:
- Status Indicator lights
- Shuttle knob(s) (Voltage / Frequency)
- Numeric Keypad (Lx only or Ls with -KP option)
- LCD display
- MENU and CURSOR keys


### 4.1.2 System On/Off Circuit Breaker

The circuit breaker located on the top left side of the front panel of the unit and disconnects the three phase Line input. As such, the circuit breaker acts as a power on/off switch for the Lx Series unit.

When the input current rating of the $L x / L s$ Series $A C$ power source is exceeded or an input over voltage condition occurs, the circuit breaker will trip.

Note that for multi-chassis systems, it is recommended to turn the Master unit ON first and then the Auxiliary unit(s). To turn the system off, turn OFF the Auxiliary unit(s) first and then the Master unit.

### 4.1.3 Status Indicator Lights

Eight yellow LED status indicators are located on the left hand side of the keyboard/display panel. These LED's correspond to the following conditions:

| Hi Range | The Hi Range LED is on when the high voltage output range has been selected. |
| :---: | :---: |
| Overtemp | The Overtemp LED indicates an overheating problem inside the unit. This is an abnormal condition, which will cause the unit to shut off. Check the air openings to make sure they are not blocked. |
| Overcurrent | The Overcurrent LED indicates an output overload condition. This condition can be controlled by setting the current limit value in the PROGRAM menu. Removing the load using the OUTPUT ON/OFF button will recover from an overload condition when in CV mode. |
| Remote | The Remote LED indicates that the unit is in remote control mode. If the IEEE-488 interface is used, this indicator will be lit whenever the ATN line (Attention) line is asserted by the IEEE controller. If the RS232C, USB or LAN interface is used, the REMOTE state can be enabled by the controller using the SYST:REM command. Any time the Remote LED is lit, the front panel of the power source is disabled. Note: The BACK button doubles as a GOTO LOCAL button (LOCAL) while the unit is in remote state. This allows the user to regain control of the front panel. The LOCAL button can be disabled by sending a Local Lockout bus command. This prevents unauthorized changes of settings in ATE applications. |
| Output on/off | The Output on/off LED indicates the output relay status. If the LED is off, the output relays for all output phases are open and the external sense lines are wrapped around internally. If the LED is on, the output relays are closed and the external sense lines are connected to the SENSE terminal block. |
| $\varnothing \mathrm{A}, \varnothing \mathrm{B}, \varnothing \mathrm{C}$ | The ØA, ØB, ØC LED indicates the output phase selection for either settings or measurements. Phase selection can be changed using the Phase button to the right of the MEMU keys. Pressing the Phase button repeatedly will cycle through phase $\mathrm{A}, \mathrm{B}, \mathrm{C}$ and ALL PHASES. The ØA, ØB, ØC indicators correspond to outputs $\varnothing 1, \varnothing 2$ and $\varnothing 3$ on the Lx Series rear panel and $\varnothing \mathrm{A}, \varnothing \mathrm{B}, \varnothing \mathrm{C}$ on the Ls Series rear panel respectively. If all three phase selection LED's are lit, all three phases are selected and changes made to voltage and current limit settings will apply to all three phases. <br> Note that in single phase mode, the ØA LED is always lit and the Phase button is inactive. |

### 4.1.4 The Shuttle Knob(s)



Figure 4-1: Shuttle Knob
Two different style keyboards are available for the Lx/Ls Series. The Ls Series comes standard with a dual shuttle knob keypad. All data entry is made by using these shuttle knobs. The Lx Series comes standard (as of Q1-2006) with a numeric keypad and single shuttle. Data entry can be done either through the 0-9 numeric keypad or using the single shuttle.

The shuttle knob(s) are/is located to the right of the LCD screen and are used to change setup parameters. Note that it cannot be used to move the cursor position between menu fields. Use the UP and DOWN arrow keys for this.
The shuttle knob can operate in one of two distinct modes of operation:

## MODE

IMMEDIATE mode

SET mode

## DESCRIPTION

Any time the ENTER key is pressed, the Lx/Ls Series returns to its normal mode of operation. In this mode, changes made with the shuttle knob will take immediate effect. The IMMEDIATE mode is useful for slewing output values such as voltage and frequency and observing the effect on the load.

When the Set key is pressed again while the PROGRAM screen is already displayed, changes made with the shuttle to any output parameter will not take effect until the ENTER key is pressed. In this mode, any changes made to a setup menu will have a blinking cursor to indicate the pending change condition. This mode allows changes to be made to all output parameters and executing them all at once by pressing the ENTER key.

### 4.1.5 Menu Keys

The Lx/Ls Series is operated through a series of menu's. These menus can be reached by using a number of menu keys located along the bottom of the LCD display and the UP/DOWN cursors keys. Several menus have more than two entries. Since the LCD display only has two display lines, additional entries may not be visible and can be reached only by scrolling up or down using the UP/DOWN cursor keys. The following menu keys are available:


Figure 4-2: Menu Keys

KEY
Set

Meas

Menu

Enter

Back

## DESCRIPTION

The Set key selects the output setting screen. While this screen is displayed, the voltage and frequency shuttle knobs can be used to change voltage and frequency for the selected phase(s). Additional output settings such as current limit can be reached by using the down $\mathbf{\nabla}$ cursor key.

For tests implemented in firmware such as the -160 and -704 options, the SET key can be used to skip to the next test in a test sequence.
The Meas key selects the measurement screen for the selected phase. If all three phases are selected, the measurement data for phase A will be displayed. There are no user changeable fields in the measurement screen. The voltage and frequency shuttles are active while the measurement screen is displayed. Additional measurement data can be displayed by using the up
$\mathbf{\Delta}$ and down $\boldsymbol{\nabla}$ cursor keys.
The top level menu is accessed by pressing the Menu key. Refer to section 4.2 for details on available menus.

The Enter key is used to confirm selections made in menu's or to active settings made in SET mode.
The Back key may be used to back up to the previous menu level or previously selected screen. It can also be used as a backspace key to delete the last digit entered.
For tests implemented in firmware such as the -160 and -704 options, the BACK key can be used to abort a test in progress.
If the unit is in remote mode, (Remote LED is lit), the front panel of the power source is disabled. The BACK button doubles as a GOTO LOCAL button (LOCAL) while the unit is in remote state. This allows the user to regain control of the front panel. This LOCAL button can be disabled by sending a Local Lockout bus command. This prevents unauthorized changes of settings in ATE applications.

### 4.1.6 Cursor Keys

The cursor keys can be used to scroll through a list of menu entries.:

CURSOR UP ( $\mathbf{( 1 )}$

CURSOR DOWN (V)

The UP key moves the cursor position upwards one position to the previous available cursor position. If the present cursor position is at the top of the right hand column, the cursor is moved to the bottom position of the left hand column. If the present cursor is at the top of the left hand column, the cursor is moved to the bottom of the right hand column.
The DOWN key moves the cursor position downwards one position to the next available cursor position. If the present cursor position is at the bottom of the left hand column, the cursor is moved to the top position of the right hand column. If the present cursor is at the bottom of the right hand column, the cursor is moved to the top of the left hand column.

### 4.1.7 Output on/off Key

The Output on/off key located to the left of the Menu keys may be used to control the state of the output relays. The active state is indicated by the LED directly above the on/off key. If the output relays are open (LED is off), the output is floating. The ON/OFF button provides a convenient way to disconnect the load without having to remove any wires.

### 4.1.8 Phase Key

The Phase key may be used to select the desired output phase. (ØA, ØB, ØC or $\varnothing 1, \varnothing 2, \varnothing 3)$. Pressing the Phase button repeatedly will cycle through phase A, B, C and ALL PHASES. The ØA, ØB, ØC indicators correspond to outputs $\varnothing 1, \varnothing 2$ and $\varnothing 3$ respectively.

If all three phase selection LED's are lit, all three phases are selected and changes made to voltage and current limit settings will apply to all three phases.
Note that in single-phase mode, the $\varnothing$ A LED is always lit and the Phase button is inactive.

### 4.1.9 LCD Display

The LCD display of the Lx/Ls Series power source provides information on instrument settings and also guides the user through the various menus. A sample of the measurement display screen is shown in Figure 4-3. Due to the two line ( $\times 20$ characters) display limitation of the LCD display, most menus are accessed by scrolling through two or more entries. Alternatively, the Menu key may be pressed repeatedly to access additional available menu entries.

The active cursor position is indicated by a LEFT POINTING ARROW $(\leftarrow)$ and can be moved by using the UP $(\mathbf{\Delta})$ and DOWN $(\mathbf{\nabla})$ keys located to the right of the LCD display.


Figure 4-3: Measurement Screen

### 4.2 Menu Structure

The next few pages show a map of the available menus in the Lx/Ls Series. All menus can be reached by repeatedly pressing the Menu key. Frequently used menus have a short cut key that provides direct access. Examples of such menus are Program and Measurements. In any case, there are never more than two levels of menus although some menus may be spread across more than one screen.

### 4.2.1 Power on screens

At initial power up, the Lx/Ls Series power supply will display important configuration information in a series of power on screens. These displays are only visible for a short period of time and will not re-appear until the next time the unit is turned on.

There are three screens that will appear in the same order:

1. LANetwork detection... At power up, the unit will try to detect a LAN interface. If not found, a "LAN not available" message will appear. The LAN will not be detected if:
2. No -LAN option is installed.
3. The USB port is connected to a computer.
4. The RS232 port jumper is installed.

This process may take several seconds.

```
LANEtwork
dectection...
```

2. Company and firmware information. Displays the manufacturer (Cal Inst., which is short for California Instruments and the firmware part number and revision. The firmware part number starts with CIC followed by a three-digit code and dash number. The firmware revision has a major revisions before the decimal point and a minor revision after the decimal point.

3. Model and Serial number information. The model will be a function of the configuration and will include the series designation (LX). The serial number is a 5 digit number. This number should match the model type sticker located on the back of the unit.
```
MODEL 450日LX
SERIAL #12345
```

4. Memory test result. If all internal controller memory devices pass the power-on memory test, the message "MEMORY TEST PASSED" will appear. If any part of the internal self-test fails, an error message will be displayed instead. This information may be useful when calling in for service support.


## MEMORY TEST PASSEI

Once the power on sequence is completed, the power source will always revert to the PROGRAM screen shown here.

```
vOLT
FREQ
40日.0Hz
```

The power source is now ready to be used.

### 4.2.2 Top Level Menus

The following top-level menu choices can be accessed using the Menu key:

| ENTRY | DESCRIPTION |
| :--- | :--- |
| PROGRAM | The PROGRAM menu allows primary output parameters such as <br> voltage, frequency, current limit, waveform shape and voltage <br> range to be changed. |
| CONTROL | The CONTROL menu allows secondary setting parameters such <br> as sense mode, phase mode and ALC mode to be changed. |
| MEASUREMENTS | The MEASUREMENT screen is not a menus in that no user entries <br> are required. It displays read-back data. |
| TRANSIENTS | The TRANSIENTS menu allows output transients to be <br> programmed. |
| REGISTERS | The SETUP REGISTERS menu allows complete instrument <br> settings and transient list programs to be saved to nonvolatile <br> memory. |
| CONFIGURATION | The CONFIGURATION menu allows changes to be made to <br> configuration settings such as the IEEE-488 address, RS232C or <br> USB/LAN internal baudrate, LAN settings, power on state and <br> Master/Auxiliary control mode. |
| OUTPUT CAL | The OUTPUT CAL menu provides access to the LCD viewing <br> angle and Calibration password entry. If the correct calibration <br> password is entered, additional Calibration screens can be <br> accessed. |
| MEAS CAL | The MEAS CAL menu allows for calibration of the AC source <br> measurement system. |
| APPLICATIONS | The APPLICATIONS menu provides access to the optional <br> firmware application programs that may be installed in the Lx/Ls <br> Series AC source. |


| OPTIONS | The OPTIONS menu provides access optional functions that may <br> be present on the Lx/Ls unit. |
| :--- | :--- |
| ETIME/TEMP | The ETIME/TEMP screen displays the Elapsed time (Time the unit <br> has been in operation) in hours, minutes and seconds. It also <br> displays the internal temperature of the unit in degrees Celsius. |
| LIMITS | The LIMITS screen display the hardware configuration limits of the <br> AC power source. It is for display purposes only and the user can <br> change none of these fields. |

### 4.2.3 Menu Tree



LEVEL 1

-LAN option only
(FW 1.33+)


| HostBits | 8 | $\mathrm{NC}<$ |
| :--- | :---: | :---: |
| Port No | 5025 |  |




### 4.2.4 PROGRAM Menu

VOLT
120. 004
FREQ
400.0 HZ

Figure 4-4: PROGRAM Menu
The PROGRAM menu is shown in Figure 4-4. It can be reached in one of two ways:

1. by selecting the Menu key, selecting the PROGRAM entry and pressing the Enter key.
2. by pressing the Set key.

The PROGRAM menu is used to change primary output parameters. Less frequently used parameters are located in the CONTROL menu.
The following choices are available in the PROGRAM menus:

| ENTRY | DESCRIPTION |
| :--- | :--- |
| VOLTAGE | Programs the output voltage in Vrms. The voltage can be changed <br> from 0 to its max range value as determined by the configuration <br> settings and the selected voltage range using the Voltage shuttle. |
| FREQ | Programs the output frequency The frequency can be changed from <br> its min to its max value as determined by the configuration settings <br> using the Frequency shuttle. |
| VRANGE | Selects 150V or 300V voltage range (if available). The actual range <br> values may be different depending on the configuration. The value of <br> this field can be changed with either Voltage or Frequency shuttle as <br> long as the active pointer ( $\leftarrow)$ points to the VRANGE entry. If only <br> one voltage range is available, this field cannot be changed. |
| PHASE | Selects the phase angle between the external clock and the output <br> of the AC source. If the clock source is internal, this parameter has <br> no effect. |
| FUNC | Selects the waveform for the selected phase. Available choices are <br> SINE, SQUARE and CLIPPED or any user defined waveform that <br> was downloaded to the AC source waveform memory using the |
| IEEE-488, LAN, RS232C or USB interface. |  |$|$| CLIP LEVEL |
| :--- |
| Sets the clip level for the CLIPPED sine wave in percent VTHD. The <br> range is 0 to 20 \%. |
| CURR |
| Sets the current limit value for the current detection system. When <br> the load current value exceeds the set current limit, a fault condition <br> is generated. The actual response of the AC Source to a current limit <br> fault is determined by the protection mode selected in the OL MODE <br> field. (CC = Constant Current, CV = Constant Voltage). |
| OL MODE |
| Sets the current limit over load mode. The actual response of the AC <br> Source to a current limit fault is determined by this setting. Available <br> settings are CC for Constant Current mode or CV for Constant <br> Voltage mode. In CV mode, the AC source output will trip off and |


| ENTRY | DESCRIPTION |
| :--- | :--- |
|  | stay off until re-engaged. In CC mode, the voltage will be reduced to <br> maintain the set current level. |

### 4.2.5 CONTROL Menus



Figure 4-5: CONTROL Menus
The CONTROL menu is shown in Figure $4-5$ and can be reached by selecting the Menu key, selecting the CONTROL entry using the DOWN cursor key and then pressing the Enter key.
The CONTROL menu is used to change secondary output parameters. The following choices are available in the CONTROL menus:

| ENTRY | DESCRIPTION |  |
| :---: | :---: | :---: |
| SENSE | Selects internal or external remote sense mode. If INT is selected, the voltage is sensed at the output terminal block. If EXT is selected, the voltage is sensed at the external sense connector. If external sense is selected, care must be taken to connect the external sense lines at the load. For sense leads longer than 1 meter, twisted pairs should be used. |  |
| SYNC | Selects the external sync mode if available. Default is internal sync, which means a free running time base. The timebase can be synchronized to either the AC line frequency (-LNS option) or an external sync signal (-EXS option) depending on the installed option. |  |
| CLOCK | Selects internal or external clock source. The Lx/Ls Series controller uses an open-air crystal time base with an accuracy of 100 ppm . The external clock mode is used to support the -LKS option. For use as an auxiliary unit in a clock and lock system, this field must be set to EXT. A unit with -LKS option can be used stand-alone if needed by setting the INT clock mode. |  |
|  | INT | Default, internal clock. |
|  | EXT | Auxiliary unit (-LKS) driven by master (-LKM) clock input. <br> Note: When selecting EXT mode, make sure the Clock and Lock BNC cables are connected to the Master (-LKM) unit. If not, there will be no output on the -LKS unit. See section 3.9 for connection information. |


| ENTRY | DESCRIPTION |  |
| :---: | :---: | :---: |
| MODE | Power on clock mode. The following two modes can be selected. |  |
|  | STAND | Power up in INT (internal) clock mode for standalone operation. This is the only mode for Lx/Ls unit without the -LKS option. <br> For units with the -LKM option installed, this field is fixed to CLK/LOCK. <br> For units with the -LKS option installed, this field can be changed to CLK/LOCK for use as an auxiliary unit in a clock and lock system or to STAND for use as a stand alone unit. |
|  | CLK/LOCK | Fixed on master (-LKM) unit configuration in a clock and lock system. Power up with EXT (external) clock mode on unit with -LKS option. (See OPTION menu section.). <br> Note that this field cannot be changed if the -LKM option is installed. <br> The frequency resolution below 81.9 Hz in MAST clock and lock mode is reduced to 0.1 Hz from the normal 0.01 Hz . <br> If the -HF option is installed, frequency resolution on the -LKM unit is fixed at 1 Hz . |
| ALC STATE | Sets the Auto internal meas three modes <br> In most situa optimal perfo <br> Note: The A above 5 Vrm | evel Control (ALC) mode. This mode uses the ement system to zero regulate the output. There are operation: <br> surement based output regulation. <br> regulation is enabled. AC source will continuously output but will not trip off output. (Note: This mode firmware revision 0.98 or higher). <br> regulation is enabled and output will fault (trip off) or 801 "Output Voltage fault" if regulation cannot be ned and the programmed output voltage is 10 Vrms or No error is generated for settings below 10 volt. <br> s, the ALC mode should be set to REG or ON for ance. <br> mode only functions for programmed output voltages |
| VOLT REF | Selects intern programming EXT to use the for 0 to full-sc | or external voltage programming. Select INT for voltage from the front panel or over the bus. Select RPV. The RPV input expects a 0 to +10 Vdc signal AC output voltage. |


| NO OUTP | Selects SINGLE or THREE phase mode of operation. In SINGLE <br> phase mode, all current is delivered to the $\varnothing 1$ and COM terminals of <br> the OUTPUT terminal block. <br> Note that even in SINGLE phase mode, a voltage is present at $\varnothing 2$ <br> and $\varnothing 3$ terminals. Connect only a single phase load when operating <br> in single phase mode. |
| :--- | :--- |
| ST PHASE | Selects the start phase angle for output changes made to either <br> voltage or frequency. This allows changing the output at a specific <br> phase angle. The Output on/off key also uses this phase angle <br> setting to program the output voltage up to the set level after the <br> output relay is closed. The default value for this field is RAND. To set <br> the start phase angle, set the cursor to the ST PHASE field and use <br> either shuttle knob to adjust between $\pm 360^{\circ}$. To set to RAND, use <br> the BACK key. |

### 4.2.6 MEASUREMENTS Screens

The Lx/Ls Series uses a DSP based data acquisition system to provide extensive information regarding the output of the Source. This data acquisition system digitizes the voltage and current waveforms and calculates several parameters from this digitized data. The results of these calculations are displayed in a series of measurement data screens. A total of three measurement screens are used to display all this information.


Figure 4-6: MEASUREMENT Screen
The three Measurement screens available on the Lx Series are not menus in that no changes can be made anywhere. Instead, these three screens provide load parameter readouts. The measurement screens can be reached by successively pressing the Meas key, which will toggle to all available screens. For Ls Series, only the first two screens are available unless the -ADV option is installed.

In three-phase mode, measurements are available for each phase individually. To select the desired phase, use the PHASE key to toggle through phase A, B, C, or ABC. The ABC mode displays the data for phase A only.

The following parameters are available in the measurement screens:

| ENTRY | DESCRIPTION |
| :--- | :--- |
|  | MEASUREMENTS 1 |
| VOLTAGE | This value is the true rms output voltage measured at the voltage <br> sense lines. |
| CURRENT | This value is the true rms output current drawn by the load. |
| FREQ | The output frequency is measured at the sense lines. <br> For Lx/Ls units with -LKS option, see note below. |
| POWER | This value is the real power. |
|  | This value is the apparent power. |
| VA POWER | This is the instantaneous peak current. |
| PEAK CURRENT | This readout shows the power factor of the load. |
| POWER FACTOR | This readout displays the ratio between peak current and rms <br> current. |
| CREST FACTOR | MEASUREMENTS 3 |
|  | This readout displays the total voltage distortion for the selected <br> phase. The distortion calculation is based on the H2 through H50 <br> with the RMS voltage in the denominator. Note that some definitions |
| VOLT THD |  |


| ENTRY | DESCRIPTION |
| :--- | :--- |
|  | of THD use the fundamental component (H1) of the voltage as the <br> denominator. <br> Lx/Ls units with firmware revision 0.88 or higher can be programmed <br> to use the fundamental component as the denominator. This mode <br> can only be programmed over the bus by sending the <br> "MEAS:THD:MODE FUND" command. At power up or after a reset <br> command, the mode will revert back to RMS. |
| CURR THD | This readout displays the total current distortion for the selected <br> phase. The distortion calculation is based on the H2 through H50 <br> with the RMS current in the denominator. Note that some definitions <br> of THD use the fundamental component (H1) of the current as the <br> denominator. <br> Lx/Ls units with firmware revision 0.88 or higher can be programmed <br> to use the fundamental component as the denominator. This mode <br> can only be programmed over the bus by sending the <br> "MEAS:THD:MODE FUND" command. At power up or after a reset <br> command, the mode will revert back to RMS. |
| PEAK CURR | This readout reflects the peak current value detected at the output. <br> To measure inrush current for a unit under test, open the output <br> relay and reset the peak current value using the PEAK CURR <br> RESET entry. Then program the output voltage and frequency and <br> turn on the output relay. The peak current measurement will <br> continuously track the maximum current value detected until reset. |
| PHASE | Relative voltage phase angle measurement with respect to phase A. |

## Update Program Functions from Measurement Screen

The Shuttles can be used to update voltage and frequency settings from the measurement screen. While the measurement screens is visible, the Voltage and Frequency shuttle continue to operate.

## Frequency measurements on -LKS units

Lx or Ls models configured with the -LKS option used in a clock and lock configuration will not accurately measure frequency if the programmed frequency of the master unit (-LKM) exceeds 2000 Hz unless the frequency setting of the -LKS is set to the a value close to the programmed frequency of the -LKM master unit. Setting the -LKS programmed frequency when it is operating as a clock and lock auxiliary does not affect its actual output frequency as it is controlled by the -LKM master unit. It does provide the controller with the required information to accurately measure the frequency.

### 4.2.7 TRANSIENT Menu



The transient menu is used to program and execute user-defined output sequences. These output sequences are defined as a sequential list of voltage and/or current settings that can be executed in a time controlled manner.
Each step in these lists is assigned a sequence number ranging from \#0 through \#99. The numbering determines the order in which each step is executed.

Each step can control the voltage setting, voltage slew rate, frequency setting, frequency slew rate and dwell time. The dwell time determines how long the output dwells at the current step before progressing to the next step. Dwell times can range from 1 msec up to 900000 secs.
Transient lists can be set up from the front panel or over the bus. The transient list can be saved with the rest of the front panel settings in one of the setup registers. (See Register Menu).

| ENTRY | DESCRIPTION |  |
| :---: | :---: | :---: |
| TRAN ST | Indicates the status of the transient system. Available modes of operation are: |  |
|  | IDLE | Transient system is in IDLE or inactive state. To start a transient list, press the ENTER key while on the TRAN STATE field. Note that the output must be ON to run a transient program or an error message will be displayed. |
|  | WTRIG | Transient system is armed and waiting for a trigger event. |
|  | BUSY | Transient system is active. A transient list execution is in progress. |
| COUNT | Sets the execution count for the transient system. A count of 1 indicates the transient will run 1 times. The count value can be set with either voltage or current knob while the cursor is on this field. The count range is from 1 through $2 \mathrm{E}+08$. Values below 200,000 are displayed in fixed point notation. Value higher than 200,000 are displayed as a floating point number $(2 \mathrm{E}+05)$. The display has insufficient characters to display the entire mantissa so entering values above $2 \mathrm{E}+05$ from the keyboard is not recommended. |  |
| TRIG SOURCE | Indicates the trigger source for transient system. Available trigger sources are: |  |
|  | IMM | Immediate mode. The transient is started from the front panel using the ENTER key. |


| ENTRY | DESCRIPTION |  |
| :---: | :---: | :---: |
|  | BUS | Bus mode. The transient system is started by a bus command or a group execute trigger (GET). |
|  | EXT | External mode. The transient system is started by a user-provided external TTL trigger signal on TRIGGER IN1. |
| TRAN STEP | Indicates the transient system execution mode. Available modes are: |  |
|  | AUTO | When triggered, the transient system will automatically execute each list point sequentially without waiting for a trigger between list points. This execution is paced by the dwell time set for each data point. |
|  | ONCE | When triggered, the transient system will execute the first list point and wait for a new trigger once the dwell time expires. This allows triggered execution of each step in the transient list. |
| List parameters: |  |  |
| VOLT | Step \# | Voltage set point |
| VSLEW | Step \# | Voltage slew rate in V/sec |
| FREQ | Step \# | Frequency set point |
| FSLEW | Step \# | Frequency slew rate in $\mathrm{Hz} / \mathrm{sec}$ |
| FUNC | Step \# | Waveform selection. Available choices are Sine, Square, Clipped or any of the user provided waveforms in waveform memory. |
| PAUSE | Step \# | Delay |
| CURR | Step \# | Current set point |
| PHASE | Step \# | Phase angle set point. (Not relevant for phase A if clock mode is internal.) |
| DWELL | Step \# | Dwell time in seconds. <br> Range is 0.001 to 900000 |
| TTLT | Step \# | ON: Generates an output trigger pulse at this list step. <br> OFF: No output trigger. <br> The output trigger is available on the TRIG OUT1 SMC connector on the rear panel. |

## Transient List points data entry method.

Transient list points are numbered sequentially from 0 through 99 and executed in this order. Each list point or list entry has 6 parameters as shown in the table above. To enter list point data, the right hand knob (Frequency) is used to increment or decrement the parameter value. The left-hand knob (Voltage) is used to increment or decrement the list point sequence number (\#). The sequence number can only be increased to the next available empty (new) list point.
To move to the next or previous parameter, use the UP ( $\mathbf{\Delta}$ ) or DOWN $(\boldsymbol{\nabla})$ cursor keys
The voltage and frequency slew parameters can be set to their maximum slew rates by turning the Frequency knob counter clock-wise past 0 . This will cause the slew parameter to 'wrap around' to its maximum available value.

It is not necessary to use all list points, only as many needed to accomplish the desired output sequence.

## Setting Data Values

Data values can be set for each point in a list. If all data values in a specific list are going to be the same value (e.g. the current limit parameter is set to the same value for the entire transient program), only the first data value for that parameter has to be set. Setting only the first data point will automatically repeat that value for all subsequent points in the transient list.

## Setting Slew Rates

Very often, output changes must be done as fast as the power source can make them. This means the transient list slew rate is set to its maximum value. If this is the case for all the data points in the list, it is sufficient to set just the first data point's slew rate for either voltage and/or current. Setting only the first point of any parameter in the list will automatically cause all points for that parameter to be set to the same value. This saves a lot of data entry time.

If however, one or more data points require a specific slew rate such as needed to do a ramp, all other points have to be specifically set to their required slew rates, including the maximum slew rate.

## Saving Transient Lists

Once completed, a transient sequence can be saved along with the steady state setup of the instrument by using the REGISTER, SAVE menu. Registers that may be used for this purpose are 1 through 15. It is advisable to do so, especially for longer transient lists.

### 4.2.8 REGISTERS Menu

## SAVE REG \# 1 <br> RECALL REG \#

The registers menu provides access to the non-voltage setup storage of the power source. A total of 8 front panel setups can be stored in registers numbered from 0 through 7. Each register except register 0 can hold the complete front panel setup, including the programmed transient list. This allows for quick recall of different setups and transient programs.

Register 0 is reserved to be used as the power-on setting as assigned by the user. To have the power source start in a specific setting, save the desired setting to Register 0 and assign register zero as the power-on default in the CONFIGURATION menu. Alternatively, the Lx/Ls can be set to power up with the RST factory default settings. See 4.9 for factory default settings.

| ENTRY | DESCRIPTION |  |
| :---: | :--- | :--- |
| SAVE | REG 0-7 | Saves the selected setup and transient list from <br> memory. (Setup only for Reg 0) The left knob <br> (Voltage) may be used to scroll through the <br> available list of setup register numbers. <br> Use the ENTER key to perform the save <br> operation. <br> Register 0 can be assigned as the power-on state <br> setup from the CONFIGURATION menu. A valid <br> setup must be saved in REGO to do so. |
| RECALL | REG 0-7 | Note that REGO only saves the setup, not the <br> transient list. All other registers also save the <br> transient list. |
| Recalls the selected setup and transient list to <br> memory. (Setup only for Reg 0) The left knob <br> (Voltage) may be used to scroll through the <br> available list of setup register numbers. <br> Use the ENTER key to perform the recall <br> operation. <br> Register 0 can be assigned as the power-on state <br> setup from the CONFIGURATION menu. A valid <br> setup must be saved in REGO to do so. |  |  |
|  | Note that REG0 only saves the setup, not the <br> transient list. All other registers also save the <br> transient list. |  |

### 4.2.9 CONFIGURATION Menu



The configuration menu may be used to configure various aspects of the instrument such as the serial port, IEEE-488/GPIB address and the power-on settings of the supply.

| ENTRY | DESCRIPTION |  |
| :---: | :--- | :--- |
| ADDRESS | $0-31$ | Sets the selected IEEE / GPIB bus address for the <br> optional IEEE/GIB interface. <br> Factory default is address 1. The left knob <br> (Voltage) can be used to scroll through the 0 <br> through 31 address range. Do not use address 0 as <br> this address is typically reserved for the GPIB <br> controller. |
| BAUD RATE | 9600  <br> 19200  <br> 38400  <br> 57600  <br> 115200  <br> 230400  <br> 460800 Sets the baud rate for the RS232C serial <br> communications port. The same setting applies to <br> the internal baud rate used to interface with the <br> USB and LAN interface of the power source.  <br> Factory default is 38400 baud. Available settings  <br> are 9600 through 460800 baud for RS232C.  <br> Note: For USB use, you must set the baud rate to  <br> 460800. For LAN use, any baud rate can be used  <br> but 460800 is recommended.  <br> Either shuttle knob can be used to scroll through  <br> these selections.  |  |
| POWER ON | REG0 <br> RST | Selects either non-volatile REG0 to be recalled <br> automatically at power-on or factory default (RST). <br> Factory default is RST, which recalls the factory <br> settings. |
| CONTROL | Note that to use REGO for power-on default, the <br> contents of the register must be programmed first. |  |
| See section 4.2.8. If an empty register is selected, |  |  |
| the power source will revert back to RST (factory |  |  |
| setting). |  |  |


| ENTRY | DESCRIPTION |  |
| :---: | :---: | :---: |
|  |  | unit (Master unit). The controller will be disabled and has no control over the amplifiers, the measurements or any other function. A message will be displayed at power indicating it is in Auxiliary mode. You can press any key to get in the menus but no control is possible. |
| LANGUAGE | SCPI APE ABLE | The standard bus syntax used by the Lx/Ls Series is the Standard Commands for Programmable Instruments (SCPI). <br> If an alternative syntax such as APE (Abbreviated Plain English) or ABLE (Atlas Based Language Extensions) is available, it can be selected from this menu. The APE and ABLE languages are part of the Ls Series -GPIB option. Once set, the selected language will remain in effect until changed in this menu or over the bus. |
| LANetwork ${ }^{1}$ | LAN | If the -LAN option is installed; pressing Enter while the cursor is on the LANetwork entry provides access to the LAN interface setting screens listed below. |
| $\begin{aligned} & \text { IP Addre55 NC } \\ & 255.255 .255 .255 \\ & \hline \end{aligned}$ | IP Address | Displays the IP address setting. This value can be changed by pressing the SET key and entering a new value from the keypad or using the Voltage and Frequency shuttles. Use the numeric data pad or the voltage shuttle to enter each field. To move between the four fields, use the decimal point key on the keypad or the Frequency shuttle. <br> To set a fixed IP address, press SET and enter the desired IP address. To set the unit to Dynamic Host Configuration Protocol (DHCP) mode, press SET and enter all zeros (0.0.0.0) as the IP address and cycle power two times. The obtained IP address will be displayed after the second power on. For the DHCP setting to work however, the unit MUST be connected to a network with a DHCP server. Any change to this value will NOT take effect until after power on the unit has been cycled. <br> When changing mode from static IP to DHCP, it is necessary to cycle power on the unit twice, once to change mode and again to obtain and display a new IP address from the network. |
| $\begin{array}{\|l\|} \hline \operatorname{MACAddres5} \\ 0: 20: 4 \mathrm{~A}: 9 \mathrm{~A}: 02: \mathrm{FI} \end{array}$ | MAC Address | Displays the network Media Acces Control address. This value is fixed and cannot be changed. The same MAC is normally printed on the model serial tag. The MAC address is shown as six hexadecimal numbers separated by a colon, e.g. $00: 20: 4 \mathrm{~A}: 9 \mathrm{~A}: 02:$ FD. Note that the leading ' 0 ' is |

[^7]| ENTRY | DESCRIPTION |  |
| :---: | :---: | :---: |
|  |  | never visible due to the maximum number of LCD characters per line. <br> Note: If the MAC Address displayed is corrupted or does not match the serial tag, there may have been a problem retrieving the LAN port settings. This can happen if a static IP was set that conflicts with another device on the network. To recover, turn on power to the unit while holding down the SET key. This will allow the unit to boot without attempting to collect the IP settings. You can then set the required IP values. [See IP Address above]. |
| $\begin{array}{\|l} \hline \text { GWAddress } \\ 255.255 .255 .255 \\ \hline \end{array}$ | GWAddress | Gateway address setting. A default gateway is a node (a router) on a computer network that serves as an access point to another network. <br> This value can be changed by pressing the SET key and entering a new value from the keypad or using the Voltage and Frequency shuttles. Use the numeric data pad or the Voltage shuttle to enter each field. To move between the four fields, use the decimal point key on the keypad or the Frequency shuttle. <br> Any change to this value will NOT take effect until after power on the unit has been cycled. |
|  | HostBits | Number of host bits as opposed to network bits in network mask. A CIDR class C network uses 24 network bits and 8 host bits. (Class $A=24$, Class B $=16$ ). <br> This value can be changed by pressing the SET key and entering a new value from the keypad. Any change to this value will NOT take effect until after power on the unit has been cycled. |
| Host.bits 8 <br> Port No NC | Port No | TCP remote port number. This value must be set to 5025 (SCPI) to support the built in web page. This value can be changed by pressing the SET key and entering a new value from the keypad. Any change to this value will NOT take effect until after power on the unit has been cycled. |
| $\begin{aligned} & \text { LANDefault } \\ & \text { Yes }=\text { ENT } \end{aligned}$ | LAN Default | LAN default setting can be achieve by selecting the Mac address screen and press the set key followed by the Enter key. Press the Enter key again to confirm. The IP address is set to DHCP or AUTO IP. |

### 4.2.9.1 CALIBRATION Menus



The measurement calibration menu can be used to perform routine calibration of the internal measurement system. The recommended calibration interval is 12 months. To enter the calibration screens, the calibration password must be entered first.
Note: Refer to chapter 6 for details on routine calibration procedures and equipment requirements. Do not attempt calibration without consulting the user manual.
This menu also contains the LCD viewing angle adjustment.

| ENTRY | DESCRIPTION |  |
| :--- | :--- | :--- |
| VIEW ANGLE | -10 to +10 | LCD viewing angle adjustment. |
| CAL PWORD | V range | Calibration password required to access all <br> calibration screens. The calibration password <br> is the high voltage range value. [300 ] The <br> password can be entered using the Voltage <br> shuttle followed by the ENTER key. |
| MVOLT F/S | $\pm 9999$ | Measurement Calibration Screens <br> Calibration coefficient for full-scale voltage <br> measurement. |
| MCURR F/S | $\pm 9999$ | Calibration coefficient for full-scale current <br> measurement. |
| VOLT F/S | $\pm 9999$ | Output Calibration Screens |
| CURR F/S | $\pm 9999$ | Calibration coefficient for full-scale voltage <br> output. (calibrated by measurement) |
| Calibration coefficient for full-scale current <br> ouptut. (calibrated by measurement) |  |  |

### 4.2.10 APPLICATIONS Menu

## APPLICATIONS OPTIDNS

The Applications menu provides access to application specific firmware functions if available. Note that there may be no applications installed in which case this screen will still be shown but has no function.

| MILT日4 | ON + |
| :--- | :--- |
| DOL6日 | ON |

Possible applications are DO160 and MIL704. To access either of the application screens, position the cursor on the APPLICATIONS entry and press the ENTER key. Select the desired application and press ENTER.
For information on using these applications, see sections 8 and 9 .

| MST04 | ON + |
| :--- | :--- |
| HBD | ON |

### 4.2.11 OPTIONS Menu

## APPLICATIONS OPTIONS

The Options menu provides access to available optional features. Note that there may be no options installed in which case this screen will still be shown but has no function. The option settings are protected and cannot be changed by the user. These screens are provided for information purposes only.


| ENTRY | DESCRIPTION |  |
| :--- | :--- | :--- |
| LANGUAGE | N/A | Standard SCPI command language. |
|  | ON | Ls Model may be equipped with the APE <br> (Abbreviated Plain English) and ABLE (Atleas |


| ENTRY | DESCRIPTION |  |
| :---: | :---: | :---: |
|  |  | Based Language Extensions) language options for backward compatibility with California Instrument's L Series AC power source or Elgar PIP9023 controllers. If installed, the language mode can be selected over the bus or from the CONFIGURATION screen. (see section 4.2.9). |
| ADVANCE | ON | Standard on all Lx Series models. |
|  | N/A | This feature is optional on Ls Series models. If installed, this field will display ON. If not, N/A is shown instead. |
| MODE | ON | Standard on all Lx Series models. Allows the output to be switched between single and three phase modes of operation. |
|  | N/A | This feature is optional on Ls Series models. If installed, this field will display ON. If not, N/A is shown instead. |
| CLOCK/LOC | N/A | Clock and lock is an option. If no -LKM option is installed, this field will show N/A. |
|  | MAST | -LKM Option installed. The unit can be used as a Clock and Lock system master or stand alone. |
|  | AUX | -LKS option installed. The unit can be used as a Clock and Lock system auxiliary or stand alone. |

4.2.12 Elapsed Time and Temperature Screen

| ETIME | $34: 12: 214$ |
| :--- | :--- |
| TEMF | 25.1246 C |

The Etime/Temp screen displays the elapsed time since the power source has first been turned on. This is an accumulated total time in hours, minutes and seconds.

The same screen also displays the internal temperature of the power supply.

| ENTRY | DESCRIPTION |  |
| :---: | :--- | :--- |
| ETIME | $01: 23: 45$ | The ETIME field displays the total <br> accumulated elapsed time for the instrument <br> since it's initial manufacture. This value cannot <br> be changed or reset. |


| ENTRY | DESCRIPTION |  |
| :---: | :--- | :--- |
| TEMP | $37.342^{\circ}$ | The TEMP field is not a user selectable <br> parameter but rather a read-out of the internal <br> temperature in degrees Celsius. It is provided <br> for informational purposes only. |

### 4.2.13 LIMIT Menu



The Limit menu displays the maximum available value for voltage, frequency and current range of the power supply. This screen is used for information only and contains no user changeable fields. The limit values shown cannot be changed.

| ENTRY | DESCRIPTION |  |
| :---: | :--- | :--- |
| LIM LVOLT | Low Voltage <br> Range | Displays maximum available output voltage in <br> the low voltage range. |
| HVOLT | High Voltage <br> Range | Displays maximum available output voltage in <br> the high voltage range. |
| LIM LFREQ | Low Frequency <br> Limit | Displays minimum available output frequency. |
| HFREQ | High Frequency <br> Limit | Displays maximum available output frequency |
| CURR | C range | Displays maximum available current in low <br> voltage range and single phase mode. If only 2 <br> or 3 phase mode is available, this value is the <br> maximum available current per phase. |
| PHASE (C) | Phase Setting | Displays phase angle for phase C. Valid values <br> are 120 for three phase or mode configuration, <br> 0 for single phase only configuration. Any other <br> value indicates split (2) phase configuration. |

### 4.3 Output Programming

### 4.3.1 Set the Output

Output parameters are all set from the PROGRAM screen.

1. Use the MENU key and select the PROGRAM entry.
2. Press the ENTER key to bring up the PROGRAM menu.
or
3. Use the PROG key to directly bring up the PROGRAM menu.

There are two methods for programming output parameters:
IMMEDIATE mode
SET mode

### 4.3.2 Slewing Output Values with the Knob in IMMEDIATE Mode

The default mode of operation is an immediate mode in which changes to output parameters made with the knob or the entry keypad are immediately reflected at the output.

To change the output voltage:

| UOLT | 120.0U4 |
| :---: | :---: |
| FREQ | 40 0 . 0 HZ |



1. Place the cursor on the VOLT entry
2. Rotate the shuttle knob clockwise to increase the value, counterclockwise to decrease the value or use the Keypad to enter a value and press the Enter key.
These changes take effect immediately.
To change the output frequency:

VDLT FREQ


1. Place the cursor on the FREQ entry
2. Rotate the shuttle knob clockwise to increase the value, counterclockwise to decrease the value or use the keypad to enter a value and press the Enter key.
These changes take effect immediately.

### 4.3.3 Change Output Values with the Knob in SET Mode

The SET mode of operation is a mode in which changes to output parameters made with the knob or the entry keypad do not affect the output until the Enter key is pressed. The AC source is put in this SET mode by pressing the Set key twice. A blinking cursor indicates SET mode is active.

To change the output voltage:

| $\begin{aligned} & \text { UQLT } \\ & \text { FREQ } \end{aligned}$ | $\begin{array}{r} 120.0 U 4 \\ 400.0 H Z \end{array}$ |
| :---: | :---: |



1. Press the Set key twice
2. Place the cursor on the VOLT entry
3. Rotate the Voltage knob clockwise to increase the value, counterclockwise to decrease the value
4. A blinking underline cursor will appear in the data for the VOLT field to indicate a change in settings but the output remains unchanged.
5. Place the cursor on the FREQ entry
6. Rotate the Frequency knob clockwise to increase the value, counterclockwise to decrease the value
7. A blinking underline cursor will appear in the data for the FREQ field to indicate a change in settings but the output remains unchanged.
8. Press the Enter key.

Both new voltage and frequency output values are now present at the output. The unit has returned to immediate mode of operation until the Set key is pressed again.
Note that output settings such as voltage and frequency can be changed from the measurement screen as well. If all three phases are selected, slewing the Voltage knob will change the output voltage on all three phases. If only one phase is selected, only the output of the selected phase will be affected.

### 4.4 Waveform Management

The Lx Series employs independent arbitrary waveform generators for each phase. This allows the user to create custom waveforms. In addition, three standard waveforms are always available. This chapter covers issues that relate to defining, downloading and managing custom waveforms.
Ls Series model only support arbitrary waveform generation if the -ADV option is installed. If not, you can skip forward to section 4.5 as the next sections do not apply.

### 4.4.1 Standard Waveforms

For most AC applications, a sine wave shape is used. The sine wave is one of the standard waveforms provided on all Lx Series models. This standard sine wave is always available and is the default waveform at power-on. Two more standard waveforms are available, square and clipped.


Figure 4-7: Selecting a Waveform
The square wave provides a high frequency content waveform with relative fast rise and fall times. Due to AC amplifier bandwidth limitations, the frequency content of the standard square wave has been kept within the amplifier's capabilities. As the fundamental frequency is increased, the relative contribution of higher harmonics is reduced.
The clipped sine wave may be used to simulate voltage distortion levels to the unit under test. The total harmonic distortion level may be programmed in percent using the CLIP LEV field directly below the FUNC entry.
Note that changing the distortion level of the clipped waveform forces the AC source to regenerate the clipped sine wave's data points and reload the waveform register with the newly requested data. This process requires the output to be dropped briefly. To avoid interrupting the voltage output to the unit under test, set the clip level needed before closing the output relay and do not change it while the EUT is under power. You can then toggle between the clipped sine wave and any other waveform in memory without interrupting the output.

### 4.4.2 Phase Selection



Figure 4-8: Selecting Waveforms for Single Phase or All Phases
Different waveforms may be selected for each phase. The number of custom waveforms from which to select remains 50 but each phase can be assigned a different custom or standard waveform. The specific output phase for which the wave shape is programmed is selected with the Phase key on the front panel. To select the same wave shape for all three phases in a three-
phase configuration, press the Phase key until all phase enunciators ( $\varnothing \mathrm{A}, \varnothing \mathrm{B}$ and $\varnothing \mathrm{C}$ ) are lit. Waveform selections made in this mode will apply to all three phases.

### 4.4.3 Creating Custom Waveforms

The Lx controller supports up to 50 user defined waveforms in addition to the 3 standard waveforms. Custom waveforms cannot be created from the front panel of the Lx Series. Rather, they have to be downloaded through the IEEE-488, RS232C, LAN or USB interface.

Each waveform is defined by 1024 data points. Each data point can range between -1 and +1 (floating point number). See Lx Series programming Manual (P/N 7004-961) for details on downloading waveforms.
Once downloaded, waveforms remain in non-volatile memory and will be visible in the WAVEFORMS menu for selection. The user can assign a 12 -character name to each custom waveform. Avoid using any of the standard waveform names (SINE, SQUARE or CLIPPED) as these names will not be accepted.
Waveforms may be deleted using the IEEE-488, RS232C, LAN or USB interface as well. Custom waveforms cannot be deleted from the front panel however to avoid accidental erasure.

### 4.4.4 RMS Amplitude Restrictions

The output of a sine wave may be programmed to the full rms value of the voltage range selected. If the AC source is in the 300 V range, the maximum programmable rms voltage is 300 Volt. If a custom waveform is used however, the maximum programmable rms voltage may be less than the maximum range value. The voltage range limit is based on the use of a sine wave with a 1.414 crest factor. A 300 V rms sine wave has a 424 Volt peak voltage. The AC source has a maximum peak voltage capability that is determined by the selected voltage range. If the user selects a custom waveform with a crest factor that is higher than 1.414 , the peak voltage would exceed this maximum if the rms voltage were to be programmed at 300 V rms.

The Lx Series power source automatically limits the maximum allowable programmed rms voltage of a any custom waveform by calculating the crest factor of the selected waveform and controlling the rms limit accordingly. Thus, each custom waveform may have a different maximum rms value. The controller will prevent the user from programming the rms voltage above this limit. If a value is entered in the PROGRAM menu above this value, a "Voltage peak error" message is generated.



Figure 4-9: Waveform Crest Factor Affects Max. rms Voltage
The figure shown here illustrates the relationship between the crest factor of the wave shape (or its "peakiness") and the maximum peak voltage allowed for a given voltage range. Since the peak voltage cannot exceed the AC source's capabilities, the programmable rms voltage has to be restricted, in this case to only 167.8785 volt for the waveform on the left. The sine wave on the
right can be programmed to the full 300 V rms as this still falls within the same peak voltage limitation of the AC source.

If the Lx Series is used over the bus, the ":VOLT? MAX" query command can be used to determine the maximum allowable RMS voltage for the selected waveform. Using the returned value as part of a program will prevent range errors.

### 4.4.5 Frequency Response Restrictions

The user may create a waveform that contains any number of harmonic frequencies of the fundamental. The AC Source itself however has a finite signal bandwidth and will attenuate higher frequency components of the signal. To limit the maximum frequency component of the output signal, the controller automatically applies a band-pass filter to all custom waveforms as they are downloaded. The controller implements the following process for user-defined waveforms:

Each down loaded waveform will have a computed frequency limit that is less than or equal the maximum frequency limit of the AC source. The frequency limit is a function of the harmonics content of the waveform and will follow the equation below.

$$
\mathrm{Fmax}_{\mathrm{h}}=\mathrm{Fmax} /\left(\text { level }{ }^{*} \mathrm{~h}_{\mathrm{n}}\right)
$$

If Fmaxh is below the minimum frequency limit, the waveform will be rejected at down load time and the label will be deleted from the waveform catalogue.

If the Lx Series is used over the bus, the ":FREQ? MAX" query command can be used to determine the maximum allowable fundamental frequency for the selected waveform. Using the returned value as part of a program will prevent range errors.

Limits assume a program of full-scale voltage. No adjustments for voltage setting are made below the full-scale value.

Waveform selection and frequency programming will be subject to the above limit. An error message will be generated to reflect this type of error:
"22,Waveform harmonics limit"
Transient editing will also generate the above error during keyboard entry. Remote transient entry will not check for the error until transient execution.

### 4.4.6 Switching Waveforms

Waveforms can be switched as part of the transient system. Each transient type setup menu has a FUNC field. This field allows selection of any of the standard or custom waveforms available in waveform memory. Refer to the section on transients for more details on using transient list to switch output waveforms.

### 4.5 Measurements

Standard measurements are always available through the Meas key on the front panel. These measurements are spread across multiple screens to enhance readability. Switching between these screens can be done by successively pressing the Meas button on the front panel. This will cause the screen to cycle through all available measurement screens.

### 4.5.1 Basic Measurements

The following three measurement screens are available:

| Parameter | MEASUREMENTS 1 |
| :--- | :---: |
| AC rms voltage |  |
| VOLTAGE | AC rms current |
| CURRENT | Frequency |
| FREQUENCY | Real power |
| POWER | MEASUREMENTS 2 |
| Apparent power |  |
| VA POWER | Repetitive Peak Current |
| PEAK CURR | Power factor |
| POWER FACT | Crest factor |
| CREST FACT | MEASUREMENTS 3 |
| Voltage distortion |  |
| VOLT THD | Current distortion |
| CURR THD | Highest AC current found (Track and hold) |
| PEAK CURR | Phase angle (relative to phase A (ø1) |
| PHASE |  |

Note: The V and I distortion calculations are based on H 2 through H 50 with the fundamental component (H1) in the denominator.
Measurements are always running in the background. When the user selects a measurement screen for display, the AC source first updates all the measurement parameters before displaying the requested screen. Consequently, pressing the MEAS key may not always bring up the selected screen immediately. There will be a perceptible delay. This will prevent the screen from appearing with invalid or blank readouts.
Note that all measurements are AC coupled only so any DC offset will not be reported.

### 4.5.2 Accuracy Considerations

Any measurement system has a finite accuracy specification. Measurement specifications are listed in Section 2. When using the AC source for measurement purposes, always consider these specifications when interpreting results. Measurement inaccuracies become more pronounced as the signal being measured is at the low end of the measurement range. This is particularly relevant for low current measurements. The Lx/Ls Series is a high power AC source optimized for providing and measuring high load currents. When powering low power loads, measurement inaccuracies on rms and peak current measurements will greatly affect derived measurements such as power, power factor and crest factor.

The measurement system on the Lx Series uses a digital data acquisition system with a 96 $\mathrm{Ks} / \mathrm{sec}$ sampling rate and 16 KHz bandwidth. This means that higher frequency components of the measured signal are filtered out. Any contribution to the rms value of voltage and current
above this cutoff frequency will not be reflected in the Lx Series measurements. When using an external measurement reference, this may account for discrepancies in readings.

### 4.6 Harmonic Analysis

The Lx Series controller offers advanced power analyzer measurement capabilities. These functions may be accessed from the Meas screen. The phase for which the analysis or waveform acquisition is done may be selected using the Phase key when in three-phase mode.
The controller's power analyzer performs fast Fourier transformation (FFT) on both voltage and current on each available phase. The resulting frequency spectrum can be obtained over the bus only.

The Ls Series provides this capability only if the -ADV option is present.

### 4.7 Transient Programming

### 4.7.1 Introduction

Transient programming provides a precise timing control over output voltage and frequency changes. This mode of operation can be used to test a product for susceptibility to common AC line conditions such as surges, sags, brownouts and spikes. By combining transient programming with custom waveforms, virtually any AC condition can be simulated on the output of the AC source.

The default voltage mode is FIXED which means the output voltage is constant and remains at the level set by the user. Changes made to the output voltage made from the PROGRAM menu take effect immediately. In front panel operation mode, the voltage and frequency slew rates (rate of change) are always at their maximum of $2 \mathrm{E} 5 \mathrm{~V} / \mathrm{s}$ and $2 \mathrm{E} 5 \mathrm{~Hz} / \mathrm{s}$. Slew rate programming is only possible over the IEEE-488, RS232C, LAN or USB bus. On power up, the AC source always reverts to the maximum slew rate for both voltage and frequency.

### 4.7.2 Using Transient Modes

The voltage can be programmed in the following transient operating modes:
STEP Causes the output to permanently change to its triggered value.
PULSE Causes the output to change to its triggered value for a specific time, as determined by the Pulse menu parameters.
LIST Causes the output to sequence through a number of values, as determined by points entered in the List menu.

FIXED Disables transient operation for the selected function.

### 4.7.3 Step Transients

Step transients let you specify an alternate or triggered voltage level that the AC source will apply to the output when it receives a trigger. Because the default transient voltage level is zero volts, you must first enter a triggered voltage before you can trigger the AC source to change the output amplitude. Step transients can only be programmed through the bus, not the front panel. Refer to the SCPI Programming Manual for more information about programming Step transients and triggers.

### 4.7.4 Pulse Transients

Pulse transients let you program the output to a specified value for a predetermined amount of time. At the end of the Pulse transient, the output voltage returns to its previous value.
Parameters required to set up a Pulse transient include the pulse count, pulse period, and pulse duty cycle. An example of a Pulse transient is shown in Figure 4-10. In this case, the count is 4, the pulse period is 16.6 ms or 60 Hz and the duty cycle is $33 \%$.


Figure 4-10: Pulse Transients
Note that Pulse transients can only be programmed over the bus, not the front panel. Refer to the SCPI Programming Manual for more information about programming Pulse transients and triggers.

### 4.7.5 List Transients

List transients provide the most versatile means of controlling the output in a specific manner as they allow a series of parameters to be programmed in a timed sequence. The following figure shows a voltage output generated from a list. The output shown represents three different AC voltage pulses ( 160 volts for 33 milliseconds, 120 volts for 83 milliseconds, and 80 volts for 150 milliseconds) separated by 67 millisecond, zero volt intervals.
Transient list programming is supported from the front panel and may be accessed by selecting the TRANSIENTS screen. Transient lists can also be programmed over the bus. Refer to the SCPI Programming Manual for more information about programming List transients and triggers over the bus.


Figure 4-11: List Transients
The list specifies the pulses as three voltage points (point 0, 2, and 4), each with its corresponding dwell point. The intervals are three zero-voltage points (point 1, 3, and 5) of equal intervals. The count parameter causes the list to execute twice when started by a single trigger.

### 4.7.6 Programming list transients from the front panel

The output transient system allows sequences of programmed voltage and or frequency changes to be executed in a time controlled manner. Changes can be either step changes (maximum slew rate) or ramps (specified slew rates).
The section provides some examples of programming output changes (transients). Transients are defined as a series of numbered steps in a list. The list is executed sequentially. Each step has a number of fields that can be set by the user:

Voltage, Voltage slew rate, Frequency, Frequency slew rate, Current, Function, Dwell time, Trigger out, Phase.
The voltage, current and frequency settings are the same as one would do form the setup screen using the knobs. At each step, the output will be set to the specified voltage,current and/or frequency. The rate of change for voltage and frequency is determined by the slew rate set. Current slew is fixed at MAX and cannot be programmed.
If the voltage is changed from 10 Vac to 20 Vac and the V slew is set to $100 \mathrm{~V} / \mathrm{sec}$, the voltage will ramp from 10 to 20 Vac in 100 msec . ( $20-10] / 100=0.1 \mathrm{sec}$ ). The dwell time is the time the output will remain at this setting. In this example, it should be set long enough to reach the final programmed value of 20 Vac, e.g. it should be at least 0.1 sec . If not, the voltage will never reach the final value of 20 Vac before the next step in the transient list is executed. The dwell time may be set longer than 0.1 sec in this example. If for example the dwell time is set to 1.0 sec , the voltage will ramp from 10 Vac to 20 Vac over a 0.1 sec period and then remain at 20 Vac for 0.9 sec .

Once the dwell time set for a step in the list expires, the next step is entered (if available, if not, execution stops and the output remains at the final values set in the last step of the list.)

Note that while there are parameters for both voltage and frequency level and slew rates, there is only one dwell time, which applies to each step in the transient list.
Front panel entry only supports the LIST mode of operation. For Pulse and Triggered modes, the remote control interface must be used.

When entering transient lists, each list must be entered sequentially starting with step \#0. If a list point is not yet set, the step number cannot be increased past it.
The following sample illustrates the use of transient system to program controlled output changes.


Figure 4-12: Sample Transient Output Sequence
This output can be accomplished using the following transient list.

| Step \# <br> (data point) | Volt | VSlew | Frequency | FSIew | Dwell |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 0 | 70.00 | MAX | 360.0 | MAX | 0.100 |
| 1 | 110.00 | 100.0 | 440.0 | MAX | 0.900 |
| 2 | 130.00 | MAX | 240.0 | 800.00 | 0.250 |
| 3 | 90.00 | 53.3 | 240.0 | MAX | 0.750 |
| 4 | 90.00 | MAX | 460.0 | MAX | 1.000 |
| 5 | 110.00 | MAX | 400.0 | MAX | 0.800 |
| 6 | 88.00 | MAX | 400.0 | MAX | 0.200 |
| 7 | 110.00 | MAX | 400.0 | MAX | 1.000 |

Table 4-2: Sample Transient List

### 4.7.7 Waveforms Function List

The FUNCTION field available in each transient list event setup menu may be used to dynamically switch waveforms during transient execution. This allows different waveforms to be used during transient execution. Waveforms may be switched without the output of the source being turned off. For three phase configurations, each phase has its own waveform list so different waveforms may be programmed on different phases during transient execution.

Figure 4-13 illustrates the concept of using different waveforms at different steps in a transient list. In this case, the change was programmed to occur at the zero crossing. Any phase angle can be used to start the transient execution however. To keep the phase angle synchronization, the dwell times have to be set to an integer number of periods. Over long periods of time, phase
synchronization may get lost due to timing skew between the waveform generator and the transient state machine.


Figure 4-13: Switching Waveforms in a Transient List

### 4.7.8 Transient Execution

## TRAN ST COUNT I ILE

Figure 4-14: TRANSIENT Menu
A transient list can be executed from the TRANSIENT menu. To start a transient list, position the cursor on the TRAN ST field as shown in Figure 4-14 and press the ENTER key. Transients may be aborted by pressing the ENTER key again while on the same field as the field changes to ABORT while a transient execution is in progress. For short duration transients, this will likely not be visible, as the transient will complete before the screen is updated. Longer duration transients however may be aborted in this fashion.

### 4.7.9 Saving Transient List Programs

When the AC source is turned off, the transient list that was programmed is not automatically retained. Thus, if you turn the unit off, you will loose your programmed transient list. However, transient programs may be saved in nonvolatile memory for later recall. This allows multiple transient list programs to be recalled quickly without the need to enter all parameters each time. Transient lists are stored as part of the overall instrument front panel setup in any of the available setup registers.
To save the transient list you created in the previous example, proceed as follows:

```
SAUE REG # 1
RECALL REGj ##
```

1. Press the Menu key repeatedly until the REGISTERS / CONFIGURATION menu is displayed.
2. Move the cursor to the REGISTERS entry and press the ENTER key.
3. The cursor will default to the SAVE REGISTER \# position. Enter a number from 1 through 15 and press the ENTER key. DO NOT USE REGISTER 0 (REGO) as it is reserved for poweron setting recall and does not include a transient list.
4. A message will appear indicating that the front panel settings and the transient list data have been saved in the setup register you selected.

### 4.8 Setting the Power-on Initialization Values

The power source is shipped with default factory settings when the unit is powered up. The factory settings are:

| Parameter | Factory default setting |
| :--- | :--- |
| Voltage | 0.0 Volt |
| Frequency | 60 Hz |
| Waveform | SINE |
| Current limit | Maximum available current. |
| Current Protection Mode | Constant Current mode |
| Output state | OFF |
| Phase Rotation | $\mathrm{A}=0^{\circ}, \mathrm{B}=240^{\circ}, \mathrm{C}=120^{\circ}$ |
| Local / Remote State | Local. Front panel unlocked. |

Table 4-3: Factory Default Power on Settings
It is possible to change the power on initialization values in one of two ways:

1. Using the IEEE-488, RS232C, LAN or USB bus interface.
2. Using the front panel.

To change the power on initialization values from the front panel, proceed as follows:

1. Set the AC power source output parameters from the front panel as you want to power up the unit.
2. Save this setting to setup register 0 from the REGISTERS menu.
3. Select the CONFIGURATION menu and move to the POWER ON field.
4. Change the POWER ON field to REGO.
5. This will recall the settings contained in register 0 at power up.

### 4.9 Remote Inhibit Function

The remote inhibit input on the rear panel can be used to disable the output of the AC source. This SMC input takes either a low level TTL signal or a contact closure. The mode of operation can be programmed over the remote control interface using the OUTP:RI:MODE command. See 7004-961 programming manual for details.
The following modes are supported.

| MODE | OPERATION |
| :--- | :--- |
| LATCHING | A TTL low at the RI input latches the output in the <br> protection shutdown state, which can only be cleared <br> by an OUTPut:PROTection:CLEar command or by <br> manually resetting the output. |
| LIVE | The output state follows the state of the RI input. A TTL <br> low at the RI input turns the output off; a TTL high turns <br> the output on. This mode is equivalent to using the |
| Output On/Off button on the front panel. |  |
| Default mode. This mode is active at power up. |  |$|$| OFF |
| :--- |

Table 4-4: Remote Inhibit operating modes.
The RI output state is saved as part of an instrument setup using the REGISTERS menu. It can be made part of the power on setting if needed. The default state is LIVE.

## 5. Principle of Operation

### 5.1 Overall Description

Three-phase input power is routed from the back of the cabinet to a fuse holder terminal block located in the bottom front of the unit. AC power is converted to a 300 VDC bus using a switching buck converter. The DC bus is used to power all three DC/AC invertors (amplifiers), one for each phase. The AC input converter also generates the required DC bias supply voltages to power the auxiliary circuits of the power source such as the programmable controller and keyboard display.
The output of each amplifier is fed through an output transformer which steps the output voltage to the required 150 V AC RMS or 300 V AC RMS output range. The output transformers provide the required isolation between input and output and also block any DC at the output of the power source.

The CPU controller / oscillator assembly generates the reference waveforms and provides frequency, amplitude, and current limit control. A current and voltage sense board is located at the top right of the unit above the transformers and is used to sense all output current and voltage for both control and measurement purposes. The current sensor board, in conjunction with the CPU controller, also supports the programmable RMS current limit function.

To obtain higher power levels, two 4500Lx (4500 VA) power sources are paralleled together to form a 9000 V VA three-phase AC source. This is accomplished through the system interface, which routes the required analog and digital signals from the 4500Lx master (unit with controller front panel) to the 4500 Lx auxiliary.

### 5.2 Controller Assembly

The Controller Assembly is located on the front panel the Lx/Ls master unit. The controller assembly consists of a single printed circuit board that plugs into the backplane motherboard. The controller contains the main oscillator, which generates the sine wave signal setting the frequency, amplitude and current limit level. It also senses the output voltage to provide closed loop control of the output. The controller also handles all user interface and remote control related tasks. The function of each of the two boards that make up the controller module is described in the following paragraphs.

### 5.2.1 Programmable Controller

This board assembly, A7, consists of the components for the CPU (DSP), generating all three Phase waveform signals to the power amplifier and all of the program, waveform and data memory. In addition, this board contains the circuits for all measurements. The clock and lock circuit required to support the clock and lock mode of operation of multiple Lx/Ls units is also on this board assembly.

### 5.2.2 Keyboard / Display Board

The keyboard/display assembly is assembly A9 and is mounted to the front panel. If the Lx/Ls system is used over one of the remote control interfaces, the keyboard functions can be locked out by asserting the REMOTE state. See the Lx/Ls Series Programming Manual (P/N 9003-961) for details.


## CAUTION

VOLTAGES UP TO 504 VAC AND 710 VDC ARE PRESENT IN CERTAIN SECTIONS OF THIS
POWER SOURCE. THIS EQUIPMENT GENERATES POTENTIALLY LETHAL VOLTAGES.


## DEATH

ON CONTACT MAY RESULT IF PERSONNEL FAIL TO OBSERVE SAFETY PRECAUTIONS. DO NOT TOUCH ELECTRONIC CIRCUITS WHEN POWER IS APPLIED.

## 6. Calibration

The Routine Calibration should be performed every 12 months. Non-routine Calibration is only required if a related assembly is replaced or if the periodic calibration is unsuccessful. Calibration of the Lx/Ls system can be performed from the front panel or over the bus. This section covers calibration from the front panel.

### 6.1 Recommended Calibration Equipment

Digital Multimeter:
100 mOhm Current Shunt:
10 mOhm Current Shunt:

Load Bank:

Fluke 8506A or equivalent / better. HP 34401A or equivalent / better
Isotek Model RUG-Z-R100-0.1.calibrated to $0.25 \%$ - OR -
Isotek Model RUG-Z-R010-0.1.calibrated to $0.25 \%$
(For single-phase mode or multi-chassis Lx/Ls configurations, a 10 mOhm shunt may be needed.
Various high power load resistors or a resistive load bank will be needed. (E.g. Avtron) Size of the load bank depends on model and phase mode. A load is required to perform the current measurement calibration near full scale. Current measurement calibration should be done on the lowest available voltage range.
The accuracy and value of the load resistor is not critical as long as the current drawn is sufficient to operate the AC Source in the upper current range ( $80-100 \%$ ). Suggested values of load bank settings are shown in Table 6-1 and Table 6-2.
Phase Meter Krohn-Hite Model 6620 or equivalent phase meter ( $0.01^{\circ}$ resolution, $0.02^{\circ}$ accuracy).

### 6.2 Calibration Screens

The calibration screens for output or measurement calibration can be selected from the MENU screen. (Press MENU button several times to toggle to select the CALIBRATION screen.)

To select the CALIBRATION screen press the $\uparrow$ or $\downarrow$ key several times to select PASSWORD. Then press the ENTER key. This will bring up the PASSWORD screen. To prevent unauthorized access to calibration data, a password must be entered to access any calibration screen. The calibration password is an numeric value equal to the high voltage range limit, typically 300 on a Lx Series and 270 on a Ls Series. Units with a -HV or -EHV output range option may have a different high voltage range value and corresponding calibration password. Check the serial tag label or the LIMIT screen when in doubt.

The password can be entered using the Voltage shuttle to dial in the number. The password can also be entered using the Keypad if present. Once the correct value is set, press the ENTER key. Once set, the calibration screens remain accessible until the Lx unit is powered down. If you leave the calibration screen and return, toggle the value up or down and back, followed by the ENTER key to re-engage the calibration mode.
On Lx systems or Ls systems with three-phase output capability, use the PHASE key on the front panel to select the phase to be calibrated.

To select the MEASUREMENT CALIBRATION screen, follow the same steps as outlined above but select the MEASUREMENT CAL entry instead of OUTPUT CAL. If another CALIBRATION screen has been accessed since power-up, no password is needed. Otherwise, enter the same password as indicated above.

### 6.3 Measurement Calibration

The Lx/Ls Series controller measures voltage and current by digitizing both voltage and current waveforms on each available output phase. This data is subsequently processed and use to calculate all measurement parameters such as VRMS, IRMS, Power, VA, and Frequency etc. To calibrate all measurements, only the voltage and current measurement need to be calibrated specifically. All other measurements are derived from these.
Connect the test equipment to the power source. If the power system is a master/auxiliary multibox system with one controller, the DVM for calibrating the measurement voltage should always be connected to the Remote Sense connector on the Master cabinet.

## Note: The Fluke 8506A or Agilent HP 34401A Digital Multi meter (or higher AC accuracy DMM) must be used for the following calibration. The DMM must be set to the AC HI ACCUR mode for all AC measurements.

The shunt must be connected in series with the load. Connect the load to the output. Use a 10 mOhm current shunt of sufficient power rating in series with the load to measure the AC load current.
To calibrate all measurement functions, the desired value for the measurement value of current or voltage must be entered for the corresponding calibration value. Make the indicated adjustments by typing in the desired display value. This should be the value indicated by the external DVM. If a 10 mOhm current shunt is used for current, 300 mV represents 30 amps .
The Calibration Load Table shows required load bank settings for the current measurement calibration procedure. The current should be calibrated in the lowest voltage range only. (Highest current range). The current measurement calibration must be performed for Phase A in both single and three phase mode and for phase $B$ and $C$ in three phase mode only.

| PARAMETER | POWER SYSTEM |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Model ---> | 3000Lx $1 \text { Phs }$ | 3000Lx <br> 3 Phs | 4500Lx $1 \text { Phs }$ | 4500Lx <br> 3 Phs | 6000Lx <br> 1 Phs | 6000Lx <br> 3 Phs |
| Max current, 120 V , Lo Vrange | $\begin{aligned} & 4.8 \Omega \\ & 3 \mathrm{~kW} \end{aligned}$ | $\begin{gathered} 14.4 \Omega \\ 1 \mathrm{~kW} \end{gathered}$ | $\begin{gathered} \hline 3.2 \Omega \\ 4.5 \mathrm{~kW} \end{gathered}$ | $\begin{gathered} 9.6 \Omega \\ 1.5 \mathrm{~kW} \end{gathered}$ | $\begin{aligned} & 2.4 \Omega \\ & 6 \mathrm{~kW} \end{aligned}$ | $\begin{aligned} & 7.2 \Omega \\ & 6 \mathrm{~kW} \end{aligned}$ |

Table 6-1: Calibration Load Values- Single-chassis configurations

| PARAMETER | POWER SYSTEM |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Model ---> | $\begin{gathered} 9000 \mathrm{Lx} / 2 \\ 1 \text { phs mode } \end{gathered}$ | $\begin{gathered} 9000 \mathrm{Lx} / 2 \\ 3 \text { phs mode } \end{gathered}$ | 12000Lx/2 <br> 1 phs mode | 12000Lx/2 3 phs mode |
| Max current, 120 V, Lo Vrange | $\begin{aligned} & 1.6 \Omega \\ & 9 \mathrm{~kW} \end{aligned}$ | $\begin{gathered} 4.8 \Omega \\ 3 \mathrm{~kW} \end{gathered}$ | $\begin{gathered} \hline 1.2 \Omega \\ 12 \mathrm{~kW} \end{gathered}$ | $\begin{aligned} & \hline 3.6 \Omega \\ & 4 \mathrm{~kW} \end{aligned}$ |
| Model ---> | $\begin{gathered} 13500 \mathrm{Lx} / 3 \\ 1 \text { phs mode } \end{gathered}$ | 13500Lx/3 <br> 3 phs mode | $18000 \mathrm{Lx} / 2$ <br> 1 phs mode | 18000Lx/3 3 phs mode |
| Max current, 120 V, Lo Vrange | $\begin{gathered} \hline 0.96 \Omega \\ 13.5 \mathrm{~kW} \end{gathered}$ | $\begin{gathered} \hline 3.2 \Omega \\ 4.5 \mathrm{~kW} \end{gathered}$ | $\begin{gathered} 0.8 \Omega \\ 18 \mathrm{~kW} \end{gathered}$ | $\begin{aligned} & 7.2 \Omega \\ & 6 \mathrm{~kW} \end{aligned}$ |

Table 6-2: Calibration Load Values- Multi-chassis configurations

### 6.3.1 Measurement Cal - AC

AC Volt Full-scale:

AC Current Full-scale:

Turn OFF the ALC mode first from the CONTROL menu. Program the output voltage to maximum voltage on the high voltage range and 400 Hz . Close the output relay. Go to the MEASUREMENT CALIBRATION screen. Enter the actual AC output voltage for the MVOLT FS parameter and press the ENTER key. Save this value by pressing the ENTER key.
Turn OFF the ALC mode from the CONTROL menu if it is on REG or ON setting. Calibrate the measurement current under a constant current condition or a voltage fault may be generated. Apply a load to the output. Program the output to $80 \%$ of fullscale voltage range on the low voltage range and 400 Hz . Observe the actual output current and enter this value for the MCURR FS parameter. Press the ENTER key. Save this value by pressing the ENTER key.

### 6.3.2 Single and Three Phase Modes

As indicated earlier, for 3-Phase power system, repeat the preceding steps for the Phase B and C outputs. The order in which the outputs for each phase are calibrated is not important.
Press the PHASE key to select each output to be calibrated. Monitor the output of the respective phase by moving the HI input of the Digital Multimeter and the current shunt as needed. The LO input should remain connected to the common LO of the sense connector.
The current measurement calibration for Phase A (ø1) should be done in both single and three phase modes as separate calibration coefficients apply to each phase mode. Voltage measurement calibration for phase A( $\varnothing 1$ ) can be done in either phase mode.

### 6.4 Output Calibration

The output calibration is performed automatically when the measurement calibration takes place. As such, there is no need to perform this calibration again. The output calibration coefficients may be viewed by selecting the OUTPUT CAL screen.

Output gain is set at the factory and the output calibration coefficients are pre-set. They is no need to change the factory default settings unless any of the following conditions occurs:

1. Replacement of one or more amplifiers as a result of a service action.
2. Replacement of the current limit board. (CI P/N 7004-703-1)
3. Replacement of the controller board. (CI P/N 7004-708-1)

If the output gains are found to be out of tolerance, they need to be adjusted. This requires removal of the top cover and should only be done by qualified service personnel. In that case, refer to the non-routine gain calibration section.
The factory output calibration coefficients are shown in the table below.

| Output <br> Phase | Current Limit Board <br> Adjustment Pots | OUTP CAL value |  |
| :---: | :---: | :---: | :---: |
|  |  | Standard | -HF option |
| A or 1 | R1 | 450 | 450 |
| B or 2 | R2 | 450 | 450 |
| C or 3 | R3 | 450 | 450 |

Table 6-3: Output Calibration Coefficients - Factory Defaults.

### 6.5 Phase Offset Calibration

The phase offsets for phase B and C can be calibrated using the OUTPUT CALIBRATION screen. The same calibration can be done over the IEEE-488, RS232C, LAN or USB bus if needed. Refer to the Lx/ Ls programming manual (P/N 7004-981) for command syntax on bus calibration.
Phase offset calibration requires a phase meter for reference. See section 6.1 for recommended equipment list.
For front panel calibration, proceed as follows.

1. Program the output frequency to 400 Hz .
2. Select the phase to be checked/calibrated (Phase B or C) using the PHASE key. Phase A calibration is only relevant if the Lx/Ls unit is used in External Sync, Line Sync or LKS mode. In that case, phase A offset is with respect to the external reference signal.
3. Program full-scale voltage and measure phase angle between phase $A$ and $B$ or $A$ and $C$ using a phase meter.
4. Press the MENU key several times to display OUTP CAL, then press the ENTER key.
5. Again you must enter the password, which will be the value for the highest voltage range and press ENTER.
6. Press the $\downarrow$ key to point to the PHASE OFST value. This will be the phase calibration value for the phase selected.
7. Adjust the calibration value as needed while monitoring the external phase meter reading so the output phase angle is calibrated. Press the ENTER key to save the calibration.
8. Repeat for the other phase.

### 6.6 Non-Routine Output Gain Calibration

If the Current Limit board assembly ( $\mathrm{P} / \mathrm{N} 7004-703-1$ ) is replaced in the field or one of the amplifiers has been replaced, it is necessary to check the gain of each phase and adjust as needed.

## WARNING: This requires the top cover to be removed and should be done by qualified service

 personnel only. Dangerous Voltages are present inside the AC power source.To adjust amplifier output gains, proceed as follows:

1. Turn OFF the front panel circuit breaker.
2. Loosen the top cover and slide back until the Current Limit board assembly (P/N 7004-$703-1$ ) is uncovered. This is the vertical board directly behind the CPU/Controller board. Refer to Figure 6-1.


Figure 6-1: Location of Gain pot adjustments and TP1 through TP4
3. Go to the Output Calibration screen by repeatedly pressing the MENU key until OUTP CAL is displayed.
4. Select this function by pressing the cursor until the arrow on the right side of the display point to OUTP CAL. Press the ENTER key.
5. A Calibration Password (CAL PWORD) will be required. The password will be the value of the high voltage range. Enter this value with the Front Panel encoder and press the ENTER key.
6. Select Phase A and check the output calibration coefficient setting. The value should be 450 for both standard Ls/Lx models and for Lx/Ls models with the -HF (high frequency) option. (Refer to table below). If not, adjust as needed and press the ENTER key.
7. Select Phase B and check for the correct value or set it as needed.
8. Repeat the entry for Phase C. Make sure the ENTER key is pressed each time a value has to be reset to the factory default setting to store this value
9. If three-phase mode is available, select the three-phase mode from the CONFIGURATION menu. If the Ls unit has one-phase only, adjust only phase A.
10. Select the Low Voltage range.
11. Select the SETUP screen and scroll to the ALC setting entry. Turn off the ALC mode by selecting OFF and then set the program value for the output voltage for all three phases to 115.00 volts and 400 Hz with respect to Neut (Ls) or Com (Lx).
12. Close the output relay.
13. Connect the external AC DVM to the respective output and use the adjustment indicated below so set the output voltage to $115 \pm 0.115$ volts.
14. Repeat for Phase B and $C$ as needed.
15. Open the output relays when done.

| Output Phase | Current Limit Board Adjustment Pots | OUTP CAL value |  |
| :---: | :---: | :---: | :---: |
|  |  | Standard | -HF option |
| A or 1 | R1 | 450 | 450 |
| B or 2 | R2 | 450 | 450 |
| C or 3 | R3 | 450 | 450 |

Table 6-4: Output Calibration Coefficients - Factory Defaults.

### 6.7 Non-Routine Amplifier Gain Balance Adjustment

If an amplifier has been replaced on Lx/Ls models that have single-phase mode, it will be necessary to check the amplifier gain balance and adjust it if needed. For single box Ls-3 models (no single phase mode), this adjustment is not required.

If two or more Lx/Ls units are combined into a multi-box system, the gain of all amplifiers has to be matched to each other. For systems purchased with the -MB option, this was done at the factory. For units purchased without this option, the gain balance should be checked. If units have different gains, the AC input circuit breaker of one of the units combined may trip due to bus pump up. Matching the gains of the amplifiers that are paralleled will prevent this.

This procedure requires the power sources to be connected using the system interface cable. This cable ( $\mathrm{CI} \mathrm{P} / \mathrm{N} 250778$ ) is supplied with the -MB option. If not available, it can be obtained through AMETEK Programmable Power customer service.

## WARNING: This requires the top cover to be removed and should be done by qualified service

 personnel only. Dangerous Voltages are present inside the AC power source.To adjust amplifier gain balance, proceed as follows:

1. Remove all loads from the output.
2. Program the output to the 1-phase mode and 400 Hz .
3. Program the output voltage to 100 volts on the low voltage range with ALC off.
4. Check the amplifier gain balance by measuring the circulating current between amplifiers. This current can be measured by monitoring the voltage at the test points indicated in the table below on the current limit board. All test point measurements are with respect to TP1 (common).
5. The voltage at each test point with no-load should be less than 20 millivolts. Make any correction necessary by adjusting the Amplifier Gain on each amplifier. The gain adjustment pot is indicated in the same table.
6. Check the balance at 50 Hz and again at the high frequency limit of the unit.
7. Contact AMETEK programmable power at service@programmablepower.com if the load balance exceeds 50 millivolts at the frequency extremes as the amplifier may be defective in this case.
8. Repeat for Phase B and C and A, B and C amplifiers on the auxiliary unit(s). Use the master unit's adjustment and test points for adjusting the master unit amplifiers and the auxiliary unit's adjustment and test points for adjusting the auxiliary unit amplifiers.

| Output <br> Phase | Current Limit Board <br> Test Point | Adjustment Pot R104 on <br> Amplifier assembly: |
| :---: | :---: | :---: |
| A or 1 | TP2 | Phase A (A1) |
| B or 2 | TP3 | Phase B (A2 |
| C or 3 | TP4 | Phase C (A3) |
|  | Common = TP1 |  |

Table 6-5: Amplifier balance adjustments

### 6.8 Non-Routine Amplifier Load Balance Adjustment

This procedure is required for all versions of the power source, single and multibox if an amplifier has been replaced or two or more units are combined into a multi-box system.

If this is a multi-box power system you must first check the Master source. After the Master source is checked attach the Auxiliary unit and check each amplifier by measuring the voltage at the respective test points (TP2 throug TP4) on the Current Limit board assembly (P/N 7004-7031) in the auxiliary source. Compare the voltage at each test point with that at TP2 of the Master source.

This procedure requires a load to be applied to the power source. See section
To adjust amplifier load balance, proceed as follows:

1. Connect a 10 milliohm current shunt to the Neutral or Common output terminal of the power source. Connect the AC DVM to the shunt monitor terminals.
2. Apply one terminal of the load to the other side of the current shunt. Connect the other terminal of the load to the Phase A output terminal.
3. Program the power source to the 1 -phase mode, 60 Hz and 100 Volts RMS on the low voltage range. Apply a load value that represents $80 \%$ of the maximum current allowed.
4. Close the output relay.
5. Check the voltage at TP2 of the Master power source. Record this value.
6. Check the voltages at TP3 and TP4 of each power source in the system. Verify the voltage at each test point is within $\pm 0.02$ vrms of the TP2 of the Master power source.
7. If the voltage is not within this tolerance adjust the Amplifier Regulation adjustment (R1) on the corresponding amplifier. Refer to the table below for the correct adjustment.
8. Check the Load Balance at 400 Hz and the highest frequency allowed. Make sure the voltage at the test points do not differ by more than 0.2 volts rms.

| Test Point on Current Limit Board | ADJUSTMENT <br> R1 on Amplifier |
| :---: | :---: |
| TP2 of Aux Source | Phase A (A1) |
| TP3 of Aux Source | Phase B (A2) |
| TP4 of Aux Source | Phase C (A3) |

### 6.8.1 Load Resistance for Multi Box Models

The load resistance values shown in the tables below represent approximately $80 \%$ of maximum current for the model configuration and phase mode shown in the low voltage range with 100 Vrms programmed.

| MODEL | 3-Phase <br> Load Res. | 3-Phase <br> Load Curr | 1-Phase <br> Load Res. | 1-Phase <br> Load Curr. |
| :--- | :---: | :---: | :---: | :---: |
| $6000 \mathrm{Lx} / 2$ | 10 ohms | 8 amps | 4 hms | 24 amps |
| $9000 \mathrm{Lx} / 2$ <br> $12000 \mathrm{Lx} / 2$ | 5 hms | 16 amps | 2 hms | 48 amps |
| $6000 \mathrm{Lx} / 2-\mathrm{HV}$ | 7 ohms | 10 amps |  | 2.5 ohms |
| $9000 \mathrm{Lx} / 2-\mathrm{HV}$ or <br> $12000 \mathrm{Lx} / 2-\mathrm{HV}$ | 3.5 ohms | 20 amps | 1.5 ohms | 60 amps |
| $6000 \mathrm{Lx} / 2-\mathrm{EHV}$ | 15 ohms | 7 amps |  | 4.8 ohms |
| $9000 \mathrm{Lx} / 2-\mathrm{EHV}$ or <br> $12000 \mathrm{Lx} / 2-E H V$ | 7.5 ohms | 14 amps | 2.4 ohms | 42 amps |

Lx Series - Current Measurement Calibration Currents (2 boxes)

| MODEL | 3-Phase <br> Load Res. | 3-Phase <br> Load Curr | 1-Phase <br> Load Res. | 1-Phase <br> Load Curr. |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
| $9000 \mathrm{Lx} / 3$ | 5 ohms | 16 amps |  | 2 ohms | 48 amps |
| $13500 \mathrm{Lx} / 3$ <br> $18000 \mathrm{Lx} / 3$ | 3.3 ohms | 24 amps | 1.3 hms | 72 amps |  |
| $9000 \mathrm{Lx} / 3-\mathrm{HV}$ | 3.5 ohms | 20 amps |  | 1.5 ohms | 60 amps |
| $13500 \mathrm{Lx} / 3-\mathrm{HV}$ <br> $18000 \mathrm{Lx} / 3-\mathrm{HV}$ | 2.3 hms | 30 amps | 0.83 ohms | 90 amps |  |
| $9000 \mathrm{Lx} / 3-\mathrm{EHV}$ | 7.5 ohms | 14 amps | 2.4 ohms | 42 amps |  |
| $13500 \mathrm{Lx} / 3-\mathrm{EHV}$ <br> $18000 \mathrm{Lx} / 3-E H V$ | 5 hms | 21 amps | 1.6 ohms | 63 amps |  |

Lx Series - Current Measurement Calibration Currents (3 boxes)

| MODEL | 3-Phase <br> Load Res. | 3-Phase <br> Load Curr | 1-Phase <br> Load Res. | 1-Phase <br> Load Curr. |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
| 7 ohms | 10 amps | 2.5 ohms | 30 amps |  |  |
| 6000Ls/2 <br> 12000Ls/2 | 3.5 ohms | 20 amps | 1.5 hms | 60 amps |  |
| $6000 \mathrm{Ls} / 2-\mathrm{HV}$ | 10 ohms | 8 amps |  | 4 ohms | 24 amps |
| 9000Ls/2-HV or <br> $12000 \mathrm{Ls} / 2-\mathrm{HV}$ | 5 hms | 16 amps | 2 hms | 48 amps |  |
| $6000 \mathrm{Ls} / 2-\mathrm{EHV}$ | 15 ohms | 7 amps | 4.8 ohms | 21 amps |  |
| 9000Ls/2-EHV or <br> $12000 \mathrm{Ls} / 2-E H V$ | 7.5 ohms | 14 amps | 2.4 hms | 42 amps |  |

Ls Series - Current Measurement Calibration Currents (2 boxes)

| MODEL | 3-Phase <br> Load Res. | 3-Phase <br> Load Curr | 1-Phase <br> Load Res. | 1-Phase <br> Load Curr. |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
| $9000 \mathrm{Ls} / 3$ | 3.5 ohms | 20 amps | 1.5 ohms | 60 amps |  |
| $13500 \mathrm{Ls} / 3$ <br> $18000 \mathrm{Ls} / 3$ | 2.3 ohms | 30 amps | 0.83 ohms | 90 amps |  |
| $9000 \mathrm{Ls} / 3-\mathrm{HV}$ | 5 ohms | 16 amps |  | 2 ohms | 48 amps |
| $13500 \mathrm{Ls} / 3-\mathrm{HV}$ <br> $18000 \mathrm{Ls} / 3-\mathrm{HV}$ | 3.3 ohms | 24 amps | 1.3 ohms | 72 amps |  |
| $9000 \mathrm{Ls} / 3-\mathrm{EHV}$ | 7.5 ohms | 14 amps | 2.4 ohms | 42 amps |  |
| $13500 \mathrm{Ls} / 3-\mathrm{EHV}$ <br> $18000 \mathrm{Ls} / 3-\mathrm{EHV}$ | 5 hms | 21 amps | 1.6 ohms | 63 amps |  |

Ls Series - Current Measurement Calibration Currents (3 boxes)

## 7. Service

### 7.1 Cleaning

The exterior of the power source may be cleaned with a cloth dampened with a mild detergent and wrung out. Disconnect mains power to the source before cleaning. Do not spray water or other cleaning agents directly on the power source.

### 7.2 General

This section describes the suggested maintenance and troubleshooting procedures. The troubleshooting procedure is divided into two sections. The first section deals with basic operation and connection of the equipment. The second section requires opening the unit and using LED indicators and a simple multimeter to troubleshoot the unit down to the module level. Only a qualified electronic technician should attempt this level troubleshooting.

### 7.3 Basic operation

Table 7-1: Basic Symptoms

| PARAGRAPH | PROBLEM |
| :--- | :--- |
| 7.3 .1 | Excessive Output Voltage |
| 7.3 .2 | Poor Output Voltage Regulation |
| 7.3 .3 | Overload Light On |
| 7.3 .4 | Distorted Output |
| 7.3 .5 | Unit Shuts Down After 1-2 Seconds |
| 7.3 .6 | No Output and no lights on front panel |
| 7.3 .7 | No output, but front panel controller is active. |

### 7.3.1 Excessive Output Voltage

| CAUSE | SOLUTION |
| :--- | :--- |
| External sense not connected(If used) | Connect external sense wires from TB2 on <br> rear panel to the AC power outlet TB1A <br> and TB1B |

### 7.3.2 Poor Output Voltage Regulation

| CAUSE | SOLUTION |
| :--- | :--- |
| Unit is overloaded | Remove overload |
| Unit is programmed to wrong voltage <br> range. | Select correct voltage range. |
| Input line has fallen below spec. limit. | Check input supply voltage. |

### 7.3.3 Overload Light is On

| CAUSE | SOLUTION |
| :--- | :--- |
| Unit is overloaded | Remove overload or check CL setting |
| Unit is switched to high voltage range. | Select correct voltage range. |

### 7.3.4 Distorted Output

| CAUSE | SOLUTION |
| :--- | :--- |
| Power source is grossly overloaded. | Reduce load |
| The crest factor of the load exceeds 3:1. | Reduce load current peaks by reducing <br> load. |

### 7.3.5 Unit Shuts Down after 1-2 Seconds

| CAUSE | SOLUTION |
| :--- | :--- |
| Output shorted | Remove output short |
| Output grossly overloaded. | Remove overload. |
| -400 Input module failure | Have power module serviced |
| Operating load with too high inrush or start <br> up currents. | Consult factory for application advice. |

### 7.3.6 No Output and No Lights on Front Panel

| CAUSE | SOLUTION |
| :--- | :--- |
| Input circuit breaker switched off. | Switch the breaker on. |
| No input power. | Ensure 3 phase power is present at AC <br> input terminal block |
| -400 Input Power Supply failure | Have -400 input supply serviced. |

### 7.3.7 No Output But Front Panel controller is active

| CAUSE | SOLUTION |
| :--- | :--- |
| "OUTPUT ON" button is turned off. | Press OUTPUT ON so that "ON" LED is <br> lit. |
| Current limit programmed down or to zero. | Program current limit higher. |
| Voltage programmed down or to zero. | Turn amplitude control up. |

### 7.4 Isolating amplifier failures in multi-box systems

A self test can be performed over the bus by sending the *TST? query command. The self test will run until the first error is encountered and terminate. The response to the query will either be the first error encountered or 0 is no error was found. (Selftest passed).
On multi-box model configurations such as $9000 \mathrm{Lx} / 2$ or $18000 \mathrm{Ls} / 3$, it is possible to isolate certain failures to a particular chassis. This can be done using the *TST? Self test error codes.
Note: The self test should always be run in 3 phase mode on all Lx models and Ls models with the -MODE option. If the self test is run in single phase mode, not all aspects of the Phase 2/B and $3 / \mathrm{C}$ hardware will be tested as a result. If the power source is a Ls- 1 single phase only configuration, the self test can only be run in single phase mode.
To execute a self test, the IEEE-488, RS232C, LAN or USB interface must be used. The LxGui command line can be used to send the *TST? Command. The following rules apply:

1. If a voltage error is reported on phase 1,2 or 3 , it indicates the corresponding amplifier in the Master chassis has most likely failed.
2. If a current error is reported on phase 1,2 or 3 , it indicates one of the auxiliary chassis amplifiers on the phase indicated has failed. On a 2 box configuration, there is only one auxiliary chassis. On a three box configuration, it is not possible to tell which of the two auxiliary amps have failed. They could also both have failed in this case.
To further isolate the failed amplifier in a three-box configuration, the outputs of all three chassis must be disconnected from each other. Then program each phase and close the output relay. Check the output of each chassis for the expected output voltage. The chassis with not output(s) will have the failed amplifier.

### 7.5 Advanced Troubleshooting.



WARNING: Do not connect 400-480V into the 208-240V unit, the result could be a severely damaged unit.


CAUTION: VOLTAGES UP TO 504 VAC AND 710 VDC ARE PRESENT IN CERTAIN SECTIONS OF THIS POWER SOURCE.


WARNING: THIS EQUIPMENT GENERATES POTENTIALLY LETHAL VOLTAGES. DEATH ON CONTACT MAY RESULT IF PERSONNEL FAIL TO OBSERVE SAFETY PRECAUTIONS. DO NOT TOUCH ELECTRONIC CIRCUITS WHEN POWER IS APPLIED

## Switch Off Units

Switch off each unit at the circuit breaker on the front panel as well as removing the input power from the unit.


WARNING: Wait 10 minutes for all internal capacitors to discharge.
Removing Cover
Remove the screws securing the top cover and remove it.
Initial Inspection
Make a visual inspection of the unit and ensure all the connectors are properly mated and there are no loose wires.

### 7.6 Factory Assistance

If the problem with the cabinet or one of the power modules cannot be isolated, contact the factory for assistance.

### 7.7 Fuses

See Table 7-2 for replaceable fuses and ratings for each of the sub assemblies in the Lx/Ls Power source.

### 7.8 Replaceable Parts

In order to ensure prompt, accurate service, please provide the following information, when applicable for each replacement part ordered.
a. Model number and serial number of the instrument.
b. Argantix part number for the sub-assembly where the component is located. (AMETEK PPD PART \#)
c. Component reference designator if applicable (REF \#)
d. Component description.
e. Component manufacturers (VENDOR)

All replaceable part orders should be addressed to:
AMETEK Programmable Power.
Attention: Customer Service
9250 Brown Dear Road
San Diego, California 92121
United States of America
Orders may also be placed using the following fax number: 1858458 -0267 or via email: service@programmablepower.com

| REF \# | Sub | PART \# | DESCRIPTION | MNF, P/N | QTY |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Common Assemblies |  |  |  |  |  |
| A1-2,3 |  | 4009-456-4 | Heatsink assembly (Amplifier) | Cl | 3 |
|  | A1 | 5001-725-2 | Amplifier Power board | Cl | 1 |
|  | A2 | 7004-702-1 | Amplifier Control board | Cl | 1 |
| A5 |  | 7004-700-1 | Power Mother board | Cl | 1 |
|  | F1,2,3 | 270176 | Fuse, 20A / 250V | Bussmann, ABC20 | 3 |
| A6 |  | 7004-705-1 | Control Mother board | Cl | 1 |
| A8 |  | 4009-737-1 | EMI board, 208V, 400V \& 480V | Cl | 1 |
| A9 |  | 7004-703-1 | Current Limit board | Cl | 1 |
| A12 |  | 7004-716-1 | Range Relay board | Cl | 1 |
| A13 |  | 7004-704-1 | System Interface board | Cl | 1 |
| A18 |  | 7004-401-3 | Controller Assembly | Cl | 1 |
|  | A1 | 7004-715-1 | Controller Board | Cl | 1 |
|  | A2 | 7004-709-1 | Keyboard / Display board - Rotary knobs (Std on Ls, -RP option on Lx) | Cl | 1 |
|  | A2 | 6005-702-1 | Keyboard / Display board - Decimal Keypad (Std on Lx, -KP option on Ls) | Cl | 1 |
| A19 |  | 4009-737-3 | EMI board, 400V | Cl | 1 |
| B1 |  | 241182 | Fan, 4" 24 VDC | Rotron, MD24B2 Nidec, B31257-10 EBM, 4292H | 1 |


| REF \# | Sub | PART \# | DESCRIPTION |  | MNF, P/N | QTY |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| B2 |  | 241183 | Fan, 6" 24 VDC |  | $\begin{gathered} \text { Rotron, JQ24B4 } \\ \text { NMB, 5920PL-05W- } \\ \text { B50-D00 } \\ \text { EBM, } 6424 \end{gathered}$ | 1 |
| 208 V Input Models (-208) |  |  |  |  |  |  |
| A7 |  |  | 7004-706-1 | DC Power Supply | Cl | 1 |
|  |  | F1 | 270193 | Fuse, 7A / 250V SB | LittleFuse, 313007 | 1 |
|  |  | F2 | 270174 | Fuse, 1A / 250V | Bussmann, PCC1 | 1 |
|  |  | F4 | 270230 | Polyfuse, 9A / 30V | Raychem, RUE600 | 1 |
|  |  | CB1 | 270220 | Circuit breaker, 40A, 240V | Airpax, IELK1111-31311-2-V | 1 |
| DS1 |  | 250412 |  | Lamp, neon, amber, 125V | IDI, 1050QN3 | 1 |
| C1 |  |  | 611295 | Electrolytic Cap, 3900uF, 400V | CDE, <br> 500R392T400DE2B <br> 500X442T450DF2A | 1 |
| 400 V Input Models (-400) |  |  |  |  |  |  |
| A7 |  | 7004-712-1 |  | Input Power Supply | Cl | 1 |
|  |  | F1 | 270193 | Fuse, 7A / 250V Slow Blow | LittleFuse, 313007 | 1 |
|  |  | CB1 | 270221 | Circuit breaker, 15A, 415V | $\begin{gathered} \text { Airpax, IELKK1111- } \\ 31311-1-V \end{gathered}$ | 1 |
|  |  | C27 | 611305 | Electrolytic Cap, 3900uF / 350V | $\begin{gathered} \text { CDC, } \\ 550392 \mathrm{~T} 350 \mathrm{DC2B} \end{gathered}$ | 1 |
|  |  | C17,18 | 611306 | Electrolytic Cap, 1600uF / 350V | $\begin{gathered} \text { CDC, } \\ \text { 550162T350BC2B } \end{gathered}$ | 2 |
| A16 |  | 7004-710-1 |  | Bias Startup Supply board | Cl | 1 |
| A17 |  | 7004-711-1 |  | LV Supply board | Cl | 1 |
|  |  | F1 | 270174 | Fuse, 1A / 250V | Bussmann, PCC1 | 1 |
|  |  | F4 | 270230 | Polyfuse, 9A / 30V | Raychem, RUE600 | 1 |
| DS1 |  |  | 250786 | Lamp, neon, amber, 12V | IDI, 1050N3 | 1 |


| 480 V Input Models (-480) |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| A7 |  | 7004-717-1 | Input Power Supply | Cl | 1 |
|  | F1 | 270193 | Fuse, 7A / 250V Slow Blow | LittleFuse, 313007 | 1 |
|  | CB1 | 270221 | Circuit breaker, 15A, 415V | Airpax, IELK1111- <br> 31311-1-V | 1 |
|  | C9 | 611305 | Electrolytic Cap, 3900uF / 350V | $\begin{gathered} \hline \text { CDC, } \\ \text { 550392T350DC2B } \end{gathered}$ | 1 |
|  | C3, 4 | 611464 | Electrolytic Cap, 1800uF / 400V | $\begin{gathered} \text { Nippon } \\ \text { U36D400LG182M51 } \\ \text { X105HP } \end{gathered}$ | 2 |
| A16 |  | 7004-710-2 | Bias Startup Supply board | Cl | 1 |
| A17 |  | 7004-711-2 | LV Supply board | Cl | 1 |
|  | F1 | 270174 | Fuse, 1A / 250V | Bussmann, PCC1 | 1 |
|  | F4 | 270230 | Polyfuse, 9A / 30V | Raychem, RUE600 | 1 |
| DS1 |  | 250786 | Lamp, neon, amber, 12V | IDI, 1050N3 | 1 |

Table 7-2: Replaceable Parts and Assemblies

## 8. Option -160: RTCA / DO-160D

### 8.1 General

This user manual assumes that the user is familiar with the text of the relevant DO160, section 16 test standard. No attempt is made to explain or elaborate on the actual test specification.
The RTCA/DO-160D option is capable of performing all sub-sections of RTCA/DO-160D, Section 16, RTCA/DO-160D change No2 and EUROCAE-14D / RTCA DO160D, Section 16 for the AC Source signal. A selection is made available to specify the type of standard to be applied to the EUT and the available EUT groups.
The voltage modulation tests for Airbus ABD0100.8 are supported by this option as well. The voltage modulation levels for the Airbus version are specified differently from DO160. All other tests are the same for Airbus and DO160.

Through out this document, RTCA/DO-160D change No2 will be referred to as RTCA2. Groups 1 through 3 will be used to refer to the EUROCAE-14D standard. Category A(CF), A(NF) and A(WF) will be used to refer to the RTCA2 standard.

### 8.2 Initial Setup

Nominal parameters for the AC Power source are as follows:

$$
\begin{array}{ll}
\text { Output Voltage } & 115 \mathrm{~V} \text { L-N or } 230 \mathrm{~V} \text { L-N } \\
\text { Output Frequency } & 360 \mathrm{~Hz} \text { to } 800 \mathrm{~Hz}
\end{array}
$$

Note: A setting outside these nominal values will disable the test and will prevent access to the DO160 Menu screens. To execute all tests for the 230 V L-N, the power source must be capable of programming 360 V RMS. This requires the -EHV option output range pair (200/400V). If this option is not installed, some tests will be skipped.

### 8.3 Tests Performed

### 8.3.1 NORMAL STATE

## AC Source:

1. Normal State Voltage and Frequency test
2. Voltage unbalance test
3. Waveform Distortion test
4. Voltage Modulation test
5. Frequency Modulation test
6. Momentary Power Interrupt (Under voltage) test
7. Voltage Surge (Over voltage) test
8. Frequency Transients test(Group 1 only)

Frequency Variation test (Group 2 and 3 only)

### 8.3.2 EMERGENCY TEST

## AC Source:

1. Emergency Voltage and Frequency minimum
2. Emergency Voltage and Frequency maximum
3. Voltage unbalance

### 8.3.3 ABNORMAL TEST

## AC Source:

1. Abnormal Voltage minimum
2. Abnormal Voltage maximum
3. Voltage Drop
4. Voltage Surge
5. Frequency Transients test (group 1 only)

### 8.4 Front Panel Operation -160

To perform a test from the keyboard, Press the MENU key several times until the APPLICATIONS/OPTIONS Menu appears, select the APPLICATIONS screen. The APPLICATIONS screen will appear as shown in Figure 8-1.

## MILTG4

1016日
Figure 8-1: Application Menu
Scroll to the RTCA/DO-160D entry using the up and down cursor keys. Press the ENTER key to select the RTCA/DO 160D main menu. The screen will appear as shown in Figure 8-2.

## Note: The user has to turn on the Output relay before starting a test.

## STANTARI RTCA2 GROUP <br> A(CF)

## NORMAL ST MENU EMERGENCY MENU

## ABNORMAL MENU FREUIOUS SCREEN

Figure 8-2: DO160 Main Menus
Prior to executing a test, selection of the desired test standard and group is required. Use the shuttle to select the standard and the group if applicable.

### 8.5 Normal State tests

Scroll to the NORMAL STATE entry using the up and down cursor keys. Press the ENTER key to select the NORMAL STATE screens. The screen will appear as shown in Figure 8-3.


```
FOWER INT
\#104 UOLT SURGE
```

Figure 8-3: Normal state screens

The DO160 NORMAL screens have the following tests:

```
1 VOLT FREQ MIN
2 VOLT FREQ MAX
3 VOLT UNBALANCE
4 WAVEFORM DISTORTION
5 VOLT MODULATION
6 FREQ MODULATION
7 POWER INTERRUPT
8 VOLTAGE SURGE
9 FREQ TRANSIENT (group 1/A(CF))
    FREQ VARIATION (group 2 & 3/A(NF) & A(WF))
```

The above tests can be selected by scrolling to the highlighted selection using the up and down key and the ENTER key to start the selected test. For some of these tests, numeric data entry may be required to define the test number or the modulation rate.

## VOLT FREQ MIN

| Standard/Group |  | RTCA | A(CF) | A(NF) | A(WF) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Voltage | 1 | 100 | 100 | 100 | 100 |
|  | 3 | 101.5 | 101.5 | 101.5 | 101.5 |
| Frequency |  | 380 | 390 | 360 | 360 |


| Standard/Group |  | Group1 | Group2 | Group3 |
| :---: | :---: | :---: | :---: | :---: |
| Voltage | 1 | 104 | 104 | 104 |
|  | 3 | 105.5 | 105.5 | 105.5 |
| Frequency |  | 390 | 360 | 360 |

Table 8-1: Normal Voltage and Frequency minimum

| Standard/Group |  | RTCA | A(CF) | A(NF) | A(WF) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Voltage | 1 | 122 | 122 | 122 | 122 |
|  | 3 | 120.5 | 120.5 | 120.5 | 120.5 |
| Frequency |  | 420 | 410 | 650 | 800 |


| Standard/Group |  | Group1 | Group2 | Group3 |
| :---: | :---: | :---: | :---: | :---: |
| Voltage | 1 | 122 | 122 | 122 |
|  | 3 | 120.5 | 120.5 | 120.5 |
| Frequency |  | 410 | 650 | 800 |

Table 8-2: Normal Voltage and Frequency Maximum
This test will set the voltage and frequency to levels defined by Table 8-1. The test will last for 30 minutes. The test will be repeated, except group1, using the Voltage setting from Table 8-2 and the frequency from Table 8-1. The $\leftarrow$ key (backspace) will terminate the test at any time.

## VOLT FREQ MAX

This test will set the voltage and frequency to levels defined by Table 1-2. The test will last for 30 minutes. The test will be repeated, except group1, using the Voltage setting from Table 1-1 and the frequency from Table 1-2. The unselected phases will remain at 115 volts. The $\leftarrow$ key (backspace) will terminate the test at any time.

## VOLT UNBALANCE

| Standard/Group | RTCA | A(CF) | A(NF) | A(WF) |
| :---: | :---: | :---: | :---: | :---: |
| Voltage offset | 6 | 6 | 6 | 8 |
| Frequency | 400 | $390 / 410$ | $360 / 650$ | $360 / 800$ |


| Standard/Group | Group1 | Group2 | Group3 |
| :---: | :---: | :---: | :---: |
| Voltage offset | 6 | 6 | 9 |
| Frequency | 400 | $360 / 650$ | $360 / 800$ |

Table 8-3: Normal Voltage Unbalance
This test will change the output voltage for phase $A$ and $B$ to 122 V and phase $C$ to a voltage lower by a value specified by an offset. Refer to Table 8-3 for the offset value and the Frequency. The test will repeat with the same frequency and phase $A$ and $B$ volt is set to 100 V and phase C set to a higher voltage specified by the offset value. The test will last 30 minutes. The test will be repeated for a second Frequency if applicable. The test can be terminated at any time.
The $\leftarrow$ key will terminate the test at any time.

## WAVEFORM DISTORTION

This test will generate a $5 \%$ THD voltage distortion on the output voltage waveform at the nominal voltage set. ( 115 V or 230 V ) A clipped sine wave generates the required distortion. The test will last for 30 minutes. The $\leftarrow$ key (backspace) will terminate the test at any time.

## VOLTAGE MODULATION

This test requires a numeric value entry equal to the modulation rate in Hz . This entry value must be between 1 Hz and 200 Hz . The amplitude modulation is calculated based on the modulation rate as defined in Figure 8-4. This test will last for 2 minutes.
Note that the Airbus voltage modulation test levels are specified in peak to peak voltage instead of Vrms. Table 4-4 shows the levels for the Airbus mode versus the DO160 and EUROCAE modes as implemented in Lx/Ls firmware revision 0.98. The actual requirement for Airbus ABD0100.8 is now specified in Vpeak peak instead of Vrms so the Airbus mode should not be used. Use the DO160 or EURO/CAE mode instead.

| Modulation <br> Frequency (Hz) | DO160 / EUROCAE | Modulation <br> Frequency (Hz) | AIRBUS |
| :---: | :---: | :---: | :---: |
| 1 | Volt RMS |  | Volt RMS |
| 1.7 | 0.18 | 1 | 0.5 |
| 10 | 0.18 | 1.7 | 0.5 |
| 25 | 1.24 | 10 | 3.5 |
| 70 | 1.24 | 25 | 3.5 |
| 100 | 0.18 | 70 | 0.5 |
| 200 | 0.18 | 100 | 0.5 |

Table 8-4: Airbus mode voltage modulation.

[^8]MAXIMUM MODULATION ENVELOPE COMPONENTS


FREQUENCY - Hz

Figure 8-4: Voltage Modulation - Frequency characteristics

## FREQUENCY MODULATION

This test requires a numeric value equal to the modulation rate in Hz . This value must be between 0.01 Hz and 100 Hz . The frequency modulation is calculated based on the modulation rate as defined in Figure 8-5. This test will last for a minimum of 2 minutes.


Figure 8-5: Frequency Modulation

## POWER INTERRUPT

This test requires a numeric entry value equal to the test number. The tests are grouped as follows:

- Test numbers 1 through 15 are for all Standard and Groups. See Figure 8-6 for details of the tests.
- Test numbers 16 and 17 for all equipment that does not incorporate digital circuit. Test number 16 will drop the output to zero voltage for 50 ms . Test number 17 will drop the output to zero voltage for 200 ms . Test numbers 21 through 26 are applicable for Groups 2 and 3 only for EUROCAE standard and category $A(N F)$ and $A(W F)$ for RTCA2. Output frequency will be set to the F1 value for 1 second prior to the test. The output frequency will remain set to the F2 value when the test is completed. This will allow the user to apply sequence of power interrupts. See Figure 8-7 for detail of the tests.


DO160 Table 16-1: Test conditions for equipment with digital circuits.
NOTES 1: Definitions:
T1 Power interrupt time
T2 Time it would take for the applied voltage to decay from V (nom) to zero volts.
T3 Time it would take for the applied voltage to rise from zero to $V$ (nom) volts.
V MIN The minimum level (expressed as a percentage of V NOMINAL) to which the applied voltage is permitted to decay.
2: Tolerance to T1, T2, T3 $= \pm 10 \%$
3: Test condition numbers 8 and 15 are for category $Z$, dc powered equipment only.

| Applicable Category: | A |  |  |  | A, Z |  |  | Z | A, B, Z |  |  | A, Z |  |  | Z |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Test Condition No. | 1** | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| T1 (ms) | 2** | 10 | 25 | 50 | 75 | 100 | 200 | 1000 | 10 | 25 | 50 | 75 | 100 | 200 | 1000 |
| T2 (ms) | <1 | 20* | 20 | 20 | 20 | 20 | 20 | 20 | 50* | 50* | 50 | 50 | 50 | 50 | 50 |
| T3 (ms) | <1 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| \%V Nom. <br> (V min) | 0 | 50 | 15 | 10 | 5 | 0 | 0 | 0 | 80 | 50 | 0 | 15 | 5 | 0 | 0 |

* Voltage will not reach zero in this test condition.
** Equipment performance standards may require to repeat test n$n^{\circ} 1$ with $T 1$ varying from 5 to 200 ms by step defined in the test equipment performance standards (step typically comprised between 5 ms and 20 ms depending on equipment design.

Figure 8-6: Power Interrupt


| Test no.: | $\mathbf{2 1}$ | $\mathbf{2 2}$ | $\mathbf{2 3}$ | $\mathbf{2 4}$ | $\mathbf{2 5}$ | $\mathbf{2 6}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Standard: | $\mathbf{I}$ | $\mathbf{I I}$ | III | IV | $\mathbf{V}$ | VI |
| T1 $(\mathrm{ms})$ | 50 | 50 | 100 | 100 | 200 | 200 |
| F1 $(\mathrm{Hz})$ | 360 | Fmax | 360 | Fmax | 360 | Fmax |
| F2 $(\mathrm{Hz})$ | Fmax | 360 | Fmax | 360 | Fmax | 360 |

Fmax $=650 \mathrm{~Hz}$ for Group2/A(NF)
Fmax $=800 \mathrm{~Hz}$ for Group3/A(WF)
T2 = 20 msec
$\mathrm{T} 3=5 \mathrm{msec}$
Figure 8-7: Power Interrupt for Group2/A(NF) and Group3/A(WF)

## VOLTAGE SURGE

This test requires 160 V output voltage. If the power source is set at the low voltage range, the high voltage range will be selected before the test starts. At the end of the test, the power source will be switched back to the low range automatically

|  | Voltage |  |  |  | Time |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Seq. No. | RTCA | Group 1 | Group 2 | Group 3 | ALL |
| 1 | 115 | 115 | 115 | 115 | 5 Minute |
| 2 | 160 | 160 | 160 | 170 | 30 msec |
| 3 | 115 | 115 | 115 | 115 | 5 Sec. |
| 4 | 60 | 70 | 70 | 70 | 30 msec |
| 5 | 115 | 115 | 115 | 115 | 5 Sec. |

Table 8-5: Normal VoltageSurge Sequence
The output voltage will follow the sequence in Table 8-5. The above sequence will repeat itself three times. Each repeat will start from sequence two. RTCA and Group 1 will run at 400 Hz . Group 2 and $A(N F)$ will run at 360 Hz and 650 Hz . Group 3 and $A(W F)$ will run at 360 Hz and 800 Hz . The frequency will return to the nominal setting when the test is completed. The $\leftarrow$ key (backspace) will terminate the test at any time.

FREQUENCY TRANSIENTS (Group 1 and A(CF) only)

| Seq. No | Frequency | Time |
| :---: | :---: | :---: |
| 1 | 400 | 5 Minute |
| 2 | 440 | 150 msec |
| 3 | 420 | 1.5 sec |
| 4 | 400 | 5 Sec. |
| 5 | 350 | 150 msec |
| 6 | 380 | 1.5 sec |
| 7 | 400 | 5 Sec. |

Table 8-6: Normal Frequency Transient Sequence
This test applies to Group1 and A(CF) only. The output voltage is set to Vnom (115 V) while the frequency is changed per the sequence listed in Table 8-6. The test will cycle 5 times starting from sequence 2. Steps 3 and 6 apply to A(CF) only.

FREQUENCY VARIATION (Group2 / A(NF) and Group3 / A(WF) only)

| Seq. No | Initial Frequency |  | Slew rate | Final Frequency |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Group2 | Group3 | Hz/Sec | Group2 | Group3 |
| 1 | 360 | 360 | 100 | 650 | 800 |
| 2 | 650 | 800 | 100 or 200 | 360 | 360 |
| 3 | 360 | 360 | Pause 5 sec | 360 | 360 |

Table 8-7: Normal Frequency Variation Sequence
This test will apply to Group2/A(NF) and Group3/A(WF) only. . The output voltage is set to Vnom ( 115 V ) while the frequency is set to 360 Hz for 5 minutes. The frequency is slowed per the sequence listed in Table 8-7. The test will cycle 3 times. The frequency will return to nominal after the test is completed. Slew rates of 200 Hz apply to RTCA2 only.

### 8.6 EMERGENCY TEST

From the DO160 MENU scroll to the EMERGENCY AC entry using the up and down cursor keys. Press the ENTER key to select the EMERGENCY screens. The screen will appear as shown in Figure 8-8.

## UOLT UNBALANCE FREUIOUS SCREEN

## UOLT FREQ MIN VOLT <br> FREQ MAX

Figure 8-8: Emergency Screens
The EMERGENCY SCREEN has the following tests:

```
1 VOLT FREQ MIN
2 VOLT FREQ MAX
3 VOLT UNBALANCE
```

The above tests can be selected by scrolling to the highlighted selection using the up and down key and the ENTER key to start the selected test.

## VOLT FREQ MIN

| Standard/Group |  | RTCA | A(CF) | A(NF) | A(WF) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Voltage | $1 \Phi$ | 100 | 100 | 100 | 100 |
|  | $3 \Phi$ | 101.5 | 101.5 | 101.5 | 101.5 |
| Frequency |  | 360 | 360 | 360 | 360 |


| Standard/Group |  | Group1 | Group2 | Group3 |
| :---: | :---: | :---: | :---: | :---: |
| Voltage | $1 \Phi$ | 104 | 104 | 104 |
|  | $3 \Phi$ | 105.5 | 105.5 | 105.5 |
| Frequency |  | 360 | 360 | 360 |

Table 8-8: Emergency Voltage and Frequency Minimum

| Standard/Group |  | RTCA | Group1 | Group2 | Group3 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Voltage | $1 \Phi$ | 122 | 122 | 122 | 122 |
|  | $3 \Phi$ | 120.5 | 120.5 | 120.5 | 120.5 |
| Frequency |  | 440 | 440 | 650 | 800 |


| Standard/Group |  | Group1 | Group2 | Group3 |
| :---: | :---: | :---: | :---: | :---: |
| Voltage | $1 \Phi$ | 122 | 122 | 122 |
|  | $3 \Phi$ | 120.5 | 120.5 | 120.5 |
| Frequency |  | 440 | 650 | 800 |

Table 8-9: Emergency Voltage and Frequency Maximum
This test will set the voltage and frequency to a level defined by Table 8-8. The test will last for 30 minutes. The test will be repeated using the voltage from Table 8-9 and frequency from Table 8 -8. The $\leftarrow$ key (backspace) will terminate the test at any time.

## VOLT FREQ MAX

This test will set the voltage and frequency to a level defined by Table 8-9. The test will last for 30 minutes. The test will be repeated using the voltage from Table 8-8and frequency from Table $8-9$. The $\leftarrow$ key (backspace) will terminate the test at any time.

## VOLT UNBALANCE

| Standard/Group | RTCA | A(CF) | A(NF) | A(WF) |
| :---: | :---: | :---: | :---: | :---: |
| Voltage offset | 8 | 8 | 8 | 10 |
| Frequency | 400 | $360 / 440$ | $360 / 650$ | $360 / 800$ |


| Standard/Group | Group1 | Group2 | Group3 |
| :---: | :---: | :---: | :---: |
| Voltage offset | 8 | 8 | 12 |
| Frequency | 400 | $360 / 650$ | $360 / 800$ |

Table 8-10: Emergency Voltage Unbalance
This test will change the output voltage for phase $A$ and $B$ to 122 V and phase $C$ to a voltage lower by a value specified by an offset. Refer to Table 8-10 for the offset value and the Frequency. The test will repeat with the same frequency and phase $A$ and $B$ volt is set to 100 V and phase C set to a higher voltage specified by the offset. The test will last 30 minutes. The test will be repeated for a second Frequency if applicable. The test can be terminated at any time.
The $\leftarrow$ key (backspace) will terminate the test at any time.

### 8.7 ABNORMAL TEST

From the DO160 MENU Scroll to the ABNORMAL AC entry using the up and down cursor keys. Press the ENTER key to select the ABNORMAL screens. The screen will appear as shown in Figure 8-9.

## UOLT MIN VOLT MAX

## PREUIOUS SCREEN*

## UOLT UNBALANCE FREQ TRANSIENT

```
VOLT SURGE VOLT IROF
```

Figure 8-9: Abnormal Screen
The ABNORMAL SCREEN has the following tests:
1 VOLT MAX
2 VOLTMIN
3 VOLT UNBALNCE
4 VOLT SURG
5 VOLT DROP
6 FREQ TRANSIENTS
The above test can be selected by scrolling to the highlighted selection using the up and down key and the ENTER key to start the selected test.

VOLT MAX

| Standard/Group |  | RTCA | Group1/A(CF) |  | Group2/A(NF) | Group3/A(WF) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Voltage | 1 | 97 | 97 | $104 / 100$ | 97 | 97 |
|  | 3 | 98.5 | 98.5 | $105.5 / 101.5$ | 98.5 | 98.5 |
| Frequency |  | 400 | 400 | 370 | 360 | 360 |

Table 8-11: Abnormal Voltage Minimum

| Standard/Group |  | RTCA | Group1/ACF) |  | Group2/A(NF) | Group3/A(WF) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Voltage | 1 | 134 | 134 | 122 | 134 | 134 |
|  | 3 | 132.5 | 132.5 | 120.5 | 132.5 | 132.5 |
| Frequency |  | 400 | 400 | 430 | 650 | 800 |

Table 8-12: Abnormal Voltage Maximum
This test will set the voltage and frequency to levels defined by Table 8-11 for 5 minutes. The test will be repeated for Group1and A(CF) only as indicated in Table 1-10 for voltage and Table 8-12 for frequency. All Groups will repeat the test using Table 1-10 for the voltage setting and Table 1-10 or Table 1-11for the frequency setting. The $\leftarrow$ key (backspace) will terminate the test at any time.

## VOLT MIN

This test will set the voltage and frequency to levels defined by Table 8-12 for 5 minutes. The test will be repeated for Group1 only as indicated in Table 8-12. All Groups will repeat the test using Table 8-12 for the voltage setting and Table 8-11 for the frequency setting. The $\leftarrow$ key (backspace) will terminate the test at any time.

## VOLT UNBALANCE

This test applies only to RTCA2 standard.

| Standard/Group | A(CF) | A(NF) | A(WF) |
| :---: | :---: | :---: | :---: |
| Voltage offset | 6 | 6 | 8 |
| Frequency | 400 | $360 / 650$ | $360 / 800$ |

Table 8-13: Abnormal Voltage Unbalance
This test will change the output voltage for phase $A$ and $B$ to 134 V and phase $C$ to a voltage lower by a value specified by an offset. Refer to Table 8-13 for the offset value and the Frequency. The test will repeat with the same frequency and phase $A$ and $B$ volt is set to 97 V and phase C set to a higher voltage specified by the offset. The test will last 5 minutes. The test will be repeated for a second Frequency if applicable. Additional test for $\mathrm{A}(\mathrm{CF})$ category is applied with phase A and voltage set at 122 V and phase C at 116 V . The frequency is set at 430 V . The test is repeated with the same frequency but phase A and B are set at 100 V and phase C set at 106 V . Both tests are repeated for 370 Hz . The test can be terminated at any time. The $\leftarrow$ key (backspace) will terminate the test at any time.

## VOLT UNDER

This test will drop the output voltage from 115 volts to 60 volts for 7 seconds.

## VOLT SURGE

This test requires 180 volt output voltage. If the power source is set at the low voltage range, the high voltage range will be selected before the test starts. At the end of the test the AC source will be switched back to the low range.
Note: To avoid switching to the high voltage range which provides only half the current of the low voltage range, the -EHV option range pair must be installed (200/400V).
The output voltage will surge to 180 volts for 100 ms . followed by drop to 148 volts for 1 sec before it returns to 115 volts. The $\leftarrow$ key (backspace) will terminate the test at any time.

## FREQUENCY TRANSIENTS (A(CF) only)

Test 1

| Seq. No. | Volt/Frequency | Time |
| :---: | :---: | :---: |
| 1 | $115 / 400$ | 5 minutes |
| 2 | $115 / 350$ | 5 sec. |
| 3 | $115 / 320$ | 0.2 sec. |
| 4 | $0 / 320$ | 0.2 sec. |
| 5 | $115 \mathrm{~V} / 400$ | 10 sec. |

Test 2

| Seq. No. | Volt/Frequency | Time |
| :---: | :---: | :---: |
| 1 | $115 / 400$ | 5 minutes |
| 2 | $115 / 480$ | 0.2 sec. |
| 3 | $115 / 440$ | 5 sec. |
| 4 | $0 / 440$ | 0.2 sec. |
| 5 | $115 \mathrm{~V} / 400$ | 10 sec. |

FREQUENCY TRANSIENTS (Group 1 only)

| Seq. No. | Frequency | Time |
| :---: | :---: | :---: |
| 1 | 400 | 5 minutes |
| 2 | 480 | 5 sec. |
| 3 | 400 | 10 sec. |
| 4 | 320 | 5 sec. |
| 5 | 400 | 10 sec. |

Table 8-14: Abnormal Frequency Transient
This test will set the voltage at 115 V and will remain at this voltage through out the test except for the A(CF) category. The test will cycle the frequency three times as shown in Table 8-14. Each repeat will start from sequence 2. Test1 and test2 for the $A(C F)$ category are done in succession as a single test.

## 9. Option -160: RTCA/DO-160 Rev E Tests (Software)

Use of this option requires the following:

- Lx/Ls Series ${ }^{1}$ Power Source.
-     - 160 option. Options installed are listed on unit's serial tag or shown on Configuration screen.
- Windows XP/2000 PC with RS232C, LAN or National Instruments GPIB controller interface. AMETEK recommends the use of the GPIB interface for best performance.
- LxGui Windows software revision 1.14 or higher. Provided on CI P/N CIC496 CD ROM or available for download from the AMETEK Programmable Power website.
- For specific tests, additional test equipment may be required to perform all section 16 tests.
Refer to the Avionics Software user manual (CI P/N 4994-971) for operating instructions for all GUI based test options. This manual is distributed in PFD format on the same CD as this user manual. (CI P/N CIC496).

[^9]
## 10. Option -704: MIL-STD 704 Rev D through F (MIL704 Mode)

### 10.1 General

This user manual assumes that the user is familiar with the text of the relevant MIL-STD 704, test standard. No attempt is made to explain or elaborate on the actual test specification.

The-704 option as implemented on the Lx/Ls Series only supports AC power applications. DC mode is not available on the Lx/Ls Series so no DC tests are provided in the -704 option.

The Lx/Ls supports two different implementations of the MIL-STD 704. This chapter covers the legacy implementation referred to on the menu screens as MIL704. This implementation (Option -704) pre-dates the release of the test protocol handbook that accompanied revision $F$ of the standard. To test conform the suggested test protocol, use the MS704 test mode instead. (Option -704F, Refer to Chapter 11.)

## Test Execution Considerations

Several of the MIL-STD 704 test steps take considerable time to execute. Tests in progress may be aborted by using the BACK button on the Lx/Ls front panel.

### 10.2 Initial Setup

Nominal parameters for the AC Power source are as follows:

| Output Voltage | 115 V L-N or 230 V L-N |
| :--- | :--- |
| Output Frequency | 360 Hz to 800 Hz for all revisions. <br>  <br>  <br>  <br> 60 Hz for revision F only.. |

Note: A setting outside these nominal values will disable the test and will prevent access to the 704 Menu screens or execution of any test step. To execute all tests for the 230V L-N, the power source must be capable of programming 360V RMS. This requires the -EHV option output range pair (200/400V). If this option is not installed, some tests will be skipped.

### 10.3 Test Revision

The MIL-STD 704 option is capable of performing all sub-sections of MIL-STD 704 revision D, E or $F$. A selection is made available to specify the revision of standard to be applied to the EUT. The MIL704 option defaults to Revision E.

### 10.4 Tests Performed

### 10.4.1 STEADY STATE

AC Source:
Steady State Voltage and Frequency test
Waveform Distortion test
Voltage Modulation test
Voltage Unbalance test
Phase Unbalance test
Frequency Modulation test
Voltage Modulation test
Transient Voltage low and high test
Transient Frequency low and high test

### 10.4.2 EMERGENCY STATE

Emergency Voltage minimum and maximum test
Emergency Frequency minimum and maximum test

### 10.4.3 ABNORMAL STATE

Abnormal Voltage under
Abnormal Voltage over
Abnormal Frequency under
Abnormal Frequency under

### 10.5 Front Panel Operation MIL704

To perform a test from the keyboard, from the MENU 2 screen, select the APPLICATIONS screen. The APPLICATIONS screen will appear as shown in Figure 10-1.

## APPLICATIONS OFTIDNS

Figure 10-1: Applications Menu
Scroll to the MIL-STD-704 entry using the up and down cursor keys. Press the ENTER key to select the MIL704 main menu. One of the screens will appear as shown in.

Note: The user has to turn on the Output relay before starting a test and set the steady state setup for the test. NOM FREQ must be set to match the desired steady state frequency. All MIL704 revisions will accept 400 Hz as a nominal frequency. Revision F only will accept 60 Hz and VFREQ.

REUISION NOM FREQ 40日Hz

## NORMAL ST MENU ABNORMAL MENU

## EMERGENCY MENU FREUIOUS SCREEN

Figure 10-2: MIL 704 Menu

### 10.5.1 Revision Selection

The default Revision is E. Revisions supported is D, E and F. The Revision can be changed from the front panel. Scroll to the REVISION entry using the up and down cursor keys (Figure $10-2)$. Use the shuttle to change the selection.

### 10.5.2 Nominal Frequency Selection

Three selections are available for the nominal frequency to be used:

- 400 Hz , this selection is active in all revisions. Program frequency must be set to 400 Hz .
- VFREQ, this selection is active for revision F only. Program frequency must be set between 360 Hz and 800 Hz to run the tests.
- 60 Hz , this selection is active for revision F only. Program frequency must be set to 60 Hz to run the tests.
Note that the programmed frequency of the AC source must be the same as the selected nominal test frequency selected in the 704 screen. If not, a Setting Conflict error will be generated when attempting to run a test. The programmed frequency can only be changed from the normal setup screen. Selecting the nominal test frequency in the 704 Application screen does not change the output frequency programmed.


### 10.6 Steady State Tests

Scroll to the STEADY STATE entry using the up and down cursor keys. Press the ENTER key to select the STEADY STATE screens. The screen will appear as shown in Figure 10-3

UOLTAGE FREQUENCY

UNBALANCE PHASE IIFFERENCE

## UOLT MODULATION* FREQ MODULATION

```
HIGH UOLT TRAN LOW UOLT TRAN
```


## HIGH FREQ TRAN LOW FREQ TRAN

IISTORTION FREUIOUS SCREEN

Figure 10-3: Steady State Menu
The MIL704 Steady state screens have the following tests:

1. VOLTAGE
2. FREQUENCY
3. VOLT UNBALANCE
4. PHASE DIFFERENCE
5. VOLT MODULATION
6. FREQ MODULATION
7. VOLT TRANSIENT
8. FREQ TRANSIENT
9. DISTORTION

The above tests can be selected by scrolling to the highlighted selection using the up and down cursor keys and the ENTER key to start the selected test.

## VOLTAGE

This test will change the output voltage in the sequence shown in Table 10-1.

| SEQUENCE | VOLTAGE |  | TIME |
| :---: | :---: | :---: | :---: |
|  | 400Hz/VFREQ | $\mathbf{6 0 H z}$ only |  |
| 1 | 108 | 110 | 1 minute |
| 2 | 118 | 125 | 1 minute |
| 3 | 115 | 115 | 1 minute |

Table 10-1: Steady state voltage
The $\leftarrow$ key (backspace) will terminate the test at any time.

## FREQUENCY

This test will change the output frequency in the sequence shown in Table 10-2.

| SEQUENCE | FREQUENCY | TIME |
| :---: | :---: | :---: |


|  | $\mathbf{4 0 0 H z}$ | VFREQ | $\mathbf{6 0} \mathbf{~ H z}$ |  |
| :---: | :---: | :---: | :---: | :---: |
| 1 | 393 | 360 | 59 | 1 minute |
| 2 | 407 | 800 | 61 | 1 minute |
| 3 | 400 | SSF | 60 | 1 minute |

Table 10-2: Steady state frequency

The $\leftarrow$ key (backspace) will terminate the test at any time.

## VOLT UNBALANCE

This test will change the output voltage for the selected phase only in the following sequence:

- 112 V for 1 minute.
- 118 V for 1 minute.
- 115 V for 1 minute.

The test will be repeated on three phase systems to include all three phases if the coupling is set to all.
The $\leftarrow$ key (backspace) will terminate the test at any time.

## PHASE DIFFERENCE

This test applies to three phase systems only. The phase angle for the selected phase will change relative to phase A in the following sequence:

If phase $B$ is selected:

- $236^{\circ}$ for 1 minute.
- $244^{\circ}$ for 1 minute.
- $240^{\circ}$ for 1 minute.

If phase $C$ is selected:

- $116^{\circ}$ for 1 minute.
- $124^{\circ}$ for 1 minute.
- $120^{\circ}$ for 1 minute


## VOLTAGE MODULATION

This test will vary the output voltage by $\pm 2.5 \mathrm{~V}$ rms over a period of one second. The test will last for 2 minutes. The $\leftarrow$ key (backspace) will terminate the test at any time.

## FREQUENCY MODULATION

| REVISION | D | E | F (400Hz /VFREQ) | F (60HZ) |
| :---: | :---: | :---: | :---: | :---: |
| MODULATION | $\pm 7 \mathrm{~Hz}$ | $\pm 4 \mathrm{~Hz}$ | $\pm 4 \mathrm{~Hz}$ | $\pm 0.5 \mathrm{~Hz}$ |

Table 10-3: Frequency Modulation
This test will vary the output frequency as defined by Table 10-3 over a period of one minute. The test will last for 4 minutes. The $\leftarrow$ key (backspace) will terminate the test at any time.

## WAVEFORM DISTORTION

This test will generate a $5 \%$ THD voltage distortion on the output voltage waveform. Using a clipped sine wave causes the distortion. The test will last for 2 minutes. The $\leftarrow$ key (backspace) will terminate the test at any time.

## HIGH VOLTAGE TRANSIENT

This test will change the output voltage for the selected phase in the following sequence:

## For 400 Hz and VFREQ:

- 180 V for 10 msec .
- Linearly reduced to118V in 78 msec .
- Stay at 118 V for 87 msec before returning to 115 V .

For 60 Hz only:

- 170 V for 1.67 msec
- Linearly reduced to 130 V in 14 msec .
- Linearly reduced to 120 V in 83.3 msec .
- Stay at 120 V for 75 msec .

Note: Prior to the test, a voltage range change may take place if the power source is set for the low voltage range. This will cause the EUT to loose power momentarily. If this is not acceptable, the power source must be left in high range at all times.

After this sequence, a 5 second delay will be inserted at the nominal test voltage. The $\leftarrow$ key (backspace) will terminate the test at any time.

## LOW VOLTAGE TRANSIENT

This test will change the output voltage for the selected phase only in the following sequence:

## For 400 Hz and VFREQ:

- 80 V for 10 msec .
- Linearly increase to 108 V in 70 msec .
- Stay at 108 V for 95 msec before returning to 115 V .


## For 60Hz only:

- OV for 1.67 msec .
- Linearly increase to 70 V in 14 msec .
- Linearly increase to 105 V in 83.3 msec
- Stay at 105 V for 75 msec .

After this sequence, a 5 second delay will be inserted at the nominal test voltage. The $\leftarrow$ key (backspace) will terminate the test at any time.

## HIGH FREQUENCY TRANSIENT

This test will change the output frequency in the following sequence:

## For 400Hz and VFREQ:

- 425 Hz for 1 sec .
- 420 Hz for 4 sec .
- 410 Hz for 5 sec .
- 407 Hz for 4 sec .

For 60 Hz only:

- 61 Hz for 0.5 sec .
- 60.5 Hz for 0.5 sec .

After this sequence, a 5 second delay will be inserted at the nominal test frequency. The $\leftarrow$ key (backspace) will terminate the test at any time.

## LOW FREQUENCY TRANSIENT

This test will change the output frequency in the following sequence:

## For 400 Hz and VFREQ:

- 375 Hz for 1 sec .
- 380 Hz for 4 sec .
- 390 Hz for 5 sec .
- 393 Hz for 4 sec .

For 60Hz only:

- 59 Hz for 0.5 sec .
- 59.5 Hz for 0.5 sec .

After this sequence, a 5 second delay will be inserted at the nominal test frequency. The $\leftarrow$ key (backspace) will terminate the test at any time.

### 10.7 Emergency Test

From the MIL704 main menu (Figure 10-2) scroll to the EMERGENCY entry using the up and down cursor keys. Press the ENTER key to select the EMERGENCY screens. The screen will appear as shown in Figure 10-4.

## EMERGENCY UOLT EMERGENCY FREQ

Figure 10-4: Emergency Menu
The EMERGENCY SCREEN has the following tests:
1 VOLTAGE
2 FREQUENCY
The above tests can be selected by scrolling to the highlighted selection using the up and down key and the ENTER key to start the selected test.

## Note: These tests are only required for revision D. See steady state voltage and frequency tests for all other revisions.

## VOLTAGE

This test will change the output voltage in the following sequence:

- 104 V for 1 minute.
- 122 V for 1 minute.
- 115 V for 1 minute.

The $\leftarrow$ key (backspace) will terminate the test at any time.

## FREQUENCY

This test will change the output frequency in the following sequence:

- 360 Hz for 1 minute.
- 440 Hz for 1 minute.
- 400 Hz for 1 minute.

The $\leftarrow$ key (backspace) will terminate the test at any time.

### 10.8 Abnormal Test

From the MIL704 main menu Figure 10-2) scroll to the ABNORMAL AC entry using the up and down cursor keys. Press the ENTER key to select the ABNORMAL screens. The screen will appear as shown in Figure 10-5.

## ABN UOLT OUER ABN UOLT UNDER <br> ABN FREQ OUER ABN FREQ UNDER

Figure 10-5: Abnormal Screens
The ABNORMAL SCREEN has the following tests:

1. OVER Voltage
2. UNDER VOLTAGE
3. OVER FREQUENCY
4. UNDER FREQUENCY

The above test can be selected by scrolling to the highlighted selection using the up and down key and the ENTER key to start the selected test.

## OVER VOLTAGE

This test will change the output voltage for the selected phase in the following sequence:

## For 400Hz and VFREQ:

- 180 V for 50 msec .
- The voltage gradually decays with time to 125 volt by the following equation:
$\mathrm{V}=124.6+2.77 / \mathrm{t}$. For $0.05 \leq \mathrm{t} \leq 6.925$
- Stay at 125 V for 93 seconds before returning to 115 V .


## For 60 Hz only:

- 180 V for 3.34 msec
- The Voltage gradually decays with time to 122 volt by the following equation:

$$
V=121.7+0.583 / t \text {. For } 0.00334 \leq t \leq 1.947
$$

- Stay at 122 V for 8 seconds before returning to 115 V .

Note: Prior to the test, a voltage range change may take place if the power source is set for the low voltage range. This will cause the EUT to loose power momentarily. If this is not acceptable, the power source must be left in high range at all times.

The $\leftarrow$ key (backspace) will terminate the test at any time.

## UNDER VOLTAGE

This test will change the output voltage for the selected phase in the following sequence:

## For 400 Hz and VFREQ:

- $0 V$ for 7 seconds.
- 100 V for 93 seconds.


## For 60 Hz only

- OV for 2 seconds.
- 100 V for 8 seconds.

The $\leftarrow$ key (backspace) will terminate the test at any time.

## OVER FREQUENCY

This test will change the output frequency in the sequence shown in Table 10-4 before returning to the steady state frequency.

The $\leftarrow$ key (backspace) will terminate the test at any time.

| Revision | D |  | E |  | F |  | F 60Hz only |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | FREQ | Time | FREQ | Time | FREQ | TIME | FREQ | TIME |
| Seq1 | 480 Hz | 5 sec. | 480 Hz | 5 sec. | 480 Hz | 5 sec | 61 Hz | 7 sec |
| Seq2 | 420 Hz | 5 sec | 420 Hz | 9 sec | 420 Hz | 5 sec | 60.5 Hz | 8 sec |

Table 10-4: Abnormal Over Frequency
After this sequence, a 5 second delay will be inserted at the nominal test frequency. The $\leftarrow$ key (backspace) will terminate the test at any time.

## UNDER FREQUENCY

This test will change the output frequency in the sequence shown in Table 10-5 before returning to steady state frequency.

The $\leftarrow$ key (backspace) will terminate the test at any time.

| Revision | D |  | E |  | F |  | F 60Hz only |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | FREQ | Time | FREQ | Time | FREQ | TIME | FREQ | TIME |
| Seq1 | 0 | 5 sec. | 0 Hz | 7 sec. | 0 Hz | 7 sec | 0 Hz | 7 sec |
| Seq2 | 375 Hz | 5 sec | 380 Hz | 7 sec | 380 Hz | 3 sec | 59.5 Hz | 8 sec |

Table 10-5: Abnormal Under Frequency
After this sequence, a 5 second delay will be inserted at the nominal test frequency. The $\leftarrow$ key (backspace) will terminate the test at any time.

## 11. Option -704F: MIL-STD 704 Rev A through F (MS704 mode)

### 11.1 General

This user manual assumes that the user is familiar with the text of the relevant MIL-STD 704, test standard. No attempt is made to explain or elaborate on the actual test specification.

The-704F option as implemented on the Lx/Ls Series only supports AC power applications. DC mode is not available on the Lx/Ls Series so no DC tests are provided in the -704 option.

The Lx/Ls supports two different implementations of the MIL-STD 704. This chapter covers the implementation that follows the test protocol handbook released with revision $F$ of the standard. This mode is selected by scrolling down in the APPLICATIONS menu to the MS704 entry and pressing the ENTER key.

To test conform the legacy protocol instead, use the MIL704 mode from the APPLICATIONS screen. (Refer to Chapter 9.)

Note: The MS704 mode was added with revision 0.99 firmware. If your Lx/Ls has an older firmware revision, the -704F option will not be available but MIL704 mode will be available as long as the -704 option was purchased. Check the AMETEK programmable power website at www.programmablepower.com for available firmware upgrades.

### 11.2 Initial Setup

Nominal parameters for the AC Power source are as follows:

| Output Voltage | 115 V L-N or 230 V L-N |
| :--- | :--- |
| Output Frequency | 360 Hz to 800 Hz for all revisions. |
|  | 60 Hz for revision F only. |

Note: A setting outside these nominal values will disable the test and will prevent access to the 704 Menu screens or execution of any test step. To execute all tests for the 230 V L-N, the power source must be capable of programming 360 V RMS. This requires the -EHV option output range pair (200/400V). If this option is not installed, some tests will be skipped.

### 11.3 Test Revision

The MIL-STD 704 option is capable of performing all sub-sections of MIL-STD 704 revision A, B, C, D, E or F. A selection is made available to specify the revision of standard to be applied to the EUT.
The MIL704 option defaults to Revision E.

### 11.4 Power Group Reference

The following power groups are supported by the -704F option.

| Test Group | Description |
| :--- | :--- |
| 704F_TP_SAC | Single phase, AC mode, 400 Hz nominal frequency |
| 704F_TP_SVF | Single phase, AC mode, variable nominal frequency |
| 704F_TP_SXF | Single phase, AC mode, 60 Hz nominal frequency |
| 704F_TP_TAC | Three phase, AC mode, 400 Hz nominal frequency |
| 704F_TP_TVF | Three phase, AC mode, variable nominal frequency |

Table 11-1: DO160 Test Groups

### 11.5 Available Tests

Available tests at the Group level are shown in this section. For details on test levels and test times for various test conditions in each group, refer to section 11.7 in this manual.

### 11.5.1 Normal Operation

AC Mode:

| Test | Section |
| :--- | :---: |
| Steady State Limits for Voltage and Frequency (Includes Unbalance) | 102 |
| Voltage Phase Difference | 103 |
| Voltage Modulation | 104 |
| Frequency Modulation | 105 |
| Total Voltage Distortion | 107 |
| Normal Voltage Transient | 109 |
| Normal Frequency Transient | 110 |

### 11.5.2 Transfer Operation

AC Mode:

| Test | Section |
| :--- | :---: |
| Power Interrupt | 201 |

### 11.5.3 Abnormal Operation

AC Mode:

| Test | Section |
| :--- | :---: |
| Abnormal Limits for Voltage and Frequency | 301 |
| Abnormal Voltage Transients | 302 |
| Abnormal Frequency Transients | 303 |

### 11.5.4 Emergency Operation

AC Mode:

| Test | Section |
| :--- | :---: |
| Emergency Limits for Voltage and Frequency | 401 |

### 11.5.5 Power Failure Operation

AC Mode:

| Test | Section |
| :--- | :---: |
| Power Failure (Three Phase) | 601 |
| One Phase and Two Phase Power Failures | 602 |
| Phase Reversal | 603 |

### 11.6 Front Panel Operation MS704

This section covers operating the -704 option from the front panel keyboard. For remote control operation, refer to the Lx/Ls Series Programming Manual (P/N 7004-961).

To perform a test from the keyboard, from the MENU 2 screen, select the APPLICATIONS screen. The APPLICATIONS screen will appear as shown in Figure 11-1.

## APFLICATIONS

OFTIDNS
Figure 11-1: Applications Menu
Use the ENTER Key and scroll to the MS704 entry using the up and down cursor keys. Press the ENTER key to select the MS704 main menu. The Run/Status screen will appear shown in Figure 11-2.


Figure 11-2: MIL 704 Run/Status
Note: Prior to starting any tests, you must turn on the Output relay and set the desired steady state output settings for the test. Also select the appropriate parameters that define revision, and test type before starting the test.
The RUN field has two parameters that can be selected by the shuttle, SINGLE and CONT. Scroll to the RUN entry using the up and down cursor keys. Use the shuttle to change the selection. Use the ENTER Key to Run the test. The screen will appear as shown in Figure 11-3 while the test is running.


Figure 11-3: Mil704 Run/Status
The status line will show the type of test that is running followed by the Test condition and the remaining time to complete the test condition. Test condition may be repeated several times before moving to the next test condition. Run Single will terminate the test once the test condition is completed. Run Continuous will terminate the test only when all remaining test condition is completed.

> Note: Several of the MIL-STD 704 test steps take considerable time to execute. Tests in progress may be aborted by using the BACK button on the Lx/Ls front panel.

### 11.6.1 Revision and Group Selection

Revision and Group selection must be selected prior to running the test. Use the up and down key to access the screen as shown in Figure 11-4


Figure 11-4: Revision/Group Menu
The default Revision is E. Revisions supported are A, B, C, D, E and F. Scroll to the REVISION entry using the up and down cursor key. Use the shuttle to change the selection.

The default GROUP is TAC. Groups supported are SAC, TAC, SVF, TVF and SXF. Use the shuttle to change the group selection.

### 11.6.2 Operating Area and Test Selection

Operating area and test define the test to perform. Use the up and down key to access the screen as shown in Figure 11-5


Figure 11-5: Test selection Menu

Scroll to the OPArea (Operating Area) and or TEST entry using the up and down cursor keys. Use the shuttle to change the selection. The OPArea and Test selection offer the choices shown in Table 11-2.

| OPArea | NORMAL | TRANSFER | ABNORMAL | EMERGENCY | PFAILURE |
| :--- | :--- | :--- | :--- | :--- | :--- |
| TEST: | LIMITS | POW INT | LIMITS | LIMITS | THREE |
|  | PH DIFF |  | VTRANS |  | COMB |
|  | VOLT MOD |  | FTRANS |  | PREVERSAL |
|  | FREQ MOD |  |  |  |  |
|  | DIST TH |  |  |  |  |
|  | VTRANS |  |  |  |  |
|  | FTRANS |  |  |  |  |

Table 11-2: Test Selections

### 11.6.3 Section and Test Condition Selection

The test section and test condition of the test to be performed is selected from section and test condition entry screen. Use the up and down key to access the screen as shown in Figure 11-6.

```
SEctign
TショtCond
```



Figure 11-6: Section and Test Condition
The start and end of Test Condition will be within the tested Section.
Note: All MIL704 tests start with condition A, even if the specification specifies the start test condition as AA.

### 11.6.4 Steady State Frequency Selection

The applicable Steady State Frequency can be selected from the SSTFreq screen by rotating the shuttle. The available frequency selections will depend on the group selected. Figure 11-7 shows the steady state frequency entry. The test must be repeated for each available frequency selection to satisfy the test requirements. Table 11-3 shows the available steady state frequencies for each group.

```
SSTFreg 400.04
FREVIOUS SCREEN
```

Figure 11-7:Steady State frequency

| GROUP | Steady State Frequency in Hz |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| SAC | 400 |  |  |  |
| TAC | 400 | 360 | 600 | 800 |
| SVF | 400 | 360 | 600 | 800 |
| TVF | 60 |  |  |  |
| SXF |  |  |  |  |

Table 11-3: Steady state frequency

### 11.6.5 Test Execution

Once Power group (Section) and test step (Condition) has been selected, execution can be started by moving the cursor to the RUN/STATUS screen RUN field. Press the ENTER key to start the test.

## Note: Prior to starting any tests, you must turn on the Output relay.

The RUN field has two parameters that can be selected by the shuttle, SINGLE and CONT. Scroll to the RUN entry using the up and down cursor keys. Use the shuttle to change the selection. Use the ENTER Key to Run the test.

Several of the MIL-STD 704 test steps take considerable time to execute. Tests in progress may be aborted by using the BACK button on the Lx/Ls front panel.

### 11.7 Test Steps and Execution Times Summary

With the release of revision F and the accompanying test protocol handbook, the MIL-STD 704 has grown in scope considerably. Rather than duplicating all this information in this user manual, the user is referred to the MIL-STD 704 Specification documentation for test details on each specific test.
A summary of tests arranged by group is provided in this section. Approximate test times are shown for each tests. Where tests differ by standard revisions, separate tables are shown for revisions that differ in test levels and or execution times.

### 11.7.1 SAC Group - Singe phase 400 Hz AC tests

SAC 102 Tests - Revisions C, D, E, F

| SAC102 | Steady State Voltage and Frequency - Rev C-F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltage |  |
| A | Vnom=115V, Fnom=400 Hz - Nominal | 1800 |
| B | Vnom=115V, Flow $=393 \mathrm{~Hz}$ - Nominal | 1800 |
| C | Vnom=115V, Fhigh $=407 \mathrm{~Hz}$ - Nominal | 1800 |
|  | Low Voltage |  |
| D | Vlow $=108 \mathrm{~V}$, Fnom= 400 Hz - Low | 1800 |
| E | Vlow=108V, Flow $=393 \mathrm{~Hz}$ - Low | 1800 |
| F | Vlow=108V, Fhigh=407 Hz - Low | 1800 |
|  | High Voltage |  |
| G | Vhigh=118V, Fnom=400 Hz - High | 1800 |
| H | Vhigh=118V, Flow $=393 \mathrm{~Hz}$ - High | 1800 |
| 1 | Vhigh=118V, Fhigh=407 Hz - High | 1800 |

## SAC 102 Tests - Revision B

| SAC102 | Steady State Voltage and Frequency - Rev B |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltage |  |
| A | Vnom=115V, Fnom=400 Hz - Nominal | 1800 |
| B | Vnom=115V, Flow $=395 \mathrm{~Hz}$ - Nominal | 1800 |
| C | Vnom=115V, Fhigh $=405 \mathrm{~Hz}$ - Nominal | 1800 |
|  | Low Voltage |  |
| D | Vlow $=108 \mathrm{~V}$, Fnom= 400 Hz - Low | 1800 |
| E | Vlow=108V, Flow $=395 \mathrm{~Hz}$ - Low | 1800 |
| F | Vlow=108V, Fhigh= 405 Hz - Low | 1800 |
|  | High Voltage |  |
| G | Vhigh=118V, Fnom= 400 Hz - High | 1800 |
| H | Vhigh=118V, Flow=395 Hz- High | 1800 |
| 1 | Vhigh=118V, Fhigh= 405 Hz - High | 1800 |

## SAC 102 Tests - Revision A

| SAC102 | Steady State Voltage and Frequency - Rev A |  |
| :---: | :--- | :---: |
| Condition |  | Nominal Voltage |
|  |  | 1800 |
| A | Vnom=115V, Fnom $=400 \mathrm{~Hz}-$ Nominal | 1800 |
| B | Vnom $=115 \mathrm{~V}$, Flow $=380 \mathrm{~Hz}-$ Nominal | 1800 |
| C | Vnom $=115 \mathrm{~V}$, Fhigh $=420 \mathrm{~Hz}-$ Nominal |  |
| D |  | 1800 |
| E | Vlow $=108 \mathrm{~V}$, Fnom $=400 \mathrm{~Hz}-$ Low |  |
| F | Vlow=108V, Flow $=380 \mathrm{~Hz}$ - Low | 1800 |


| SAC102 | Steady State Voltage and Frequency - Rev A |  |
| :---: | :--- | :---: |
| Condition | High Voltage | Duration (s) |
|  | G |  |
| G | Vhigh=118V, Fnom $=400 \mathrm{~Hz}-$ High | 1800 |
| H | Vhigh $=118 \mathrm{~V}$, Flow $=380 \mathrm{~Hz}-$ High | 1800 |
| I | Vhigh=118V, Fhigh $=420 \mathrm{~Hz}-$ High | 1800 |

## SAC 103 Tests

Voltage Phase Difference tests do not apply for single-phase EUT's.
SAC 104 Tests - Revisions B, C, D, E, F

| SAC104 | Voltage Modulation Rev B - F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
| A | Vmod F $=1.0 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| B | Vmod F $=1.7 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| C | $\mathrm{Vmod} \mathrm{F}=10 \mathrm{~Hz}, \mathrm{~V}=2.5 \mathrm{Vrms}$ | 1800 |
| D | $\mathrm{Vmod} \mathrm{F}=25 \mathrm{~Hz}, \mathrm{~V}=2.5 \mathrm{Vrms}$ | 1800 |
| E | $\mathrm{Vmod} F=70 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| F | Vmod F $=100 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| G | Vmod F $=200 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |

SAC 104 Tests - Revisions A

| SAC104 | Voltage Modulation Rev A |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
| A | $\mathrm{Vmod} \mathrm{F}=1.0 \mathrm{~Hz}, \mathrm{~V}=0.5 \mathrm{Vpp}$ | 1800 |
| B | $V \mathrm{mod} \mathrm{F}=1.7 \mathrm{~Hz}, \mathrm{~V}=0.5 \mathrm{Vpp}$ | 1800 |
| C | $\mathrm{Vmod} F=10 \mathrm{~Hz}, \mathrm{~V}=3.5 \mathrm{Vpp}$ | 1800 |
| D | $\mathrm{Vmod} \mathrm{F}=25 \mathrm{~Hz}, \mathrm{~V}=3.5 \mathrm{Vpp}$ | 1800 |
| E | $\mathrm{Vmod} \mathrm{F}=70 \mathrm{~Hz}, \mathrm{~V}=0.5 \mathrm{Vpp}$ | 1800 |
| F | $\mathrm{Vmod} \mathrm{F}=100 \mathrm{~Hz}, \mathrm{~V}=0.5 \mathrm{Vpp}$ | 1800 |
| G | $\mathrm{Vmod} \mathrm{F}=200 \mathrm{~Hz}, \mathrm{~V}=0.5 \mathrm{Vpp}$ | 1800 |

SAC 105 Tests - Revisions E, F

| SAC105 | Frequency Modulation Rev E, F |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
| A | Fmod $F=1 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |
| B | Fmod $F=5 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |
| C | Fmod F $=10 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |
| D | Fmod $F=25 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |
| E | Fmod F $=100 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |

SAC 105 Tests - Revisions B, C, D

| SAC105 | Frequency Modulation Rev B, C, D |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
| A | Fmod $F=1 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $= \pm 5 \mathrm{~Hz}$ | 1800 |
| B | Fmod F $=5 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $= \pm 1.75 \mathrm{~Hz}$ | 1800 |
| C | Fmod F $=10 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $= \pm 1.20 \mathrm{~Hz}$ | 1800 |
| D | Fmod F $=25 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $= \pm 0.85 \mathrm{~Hz}$ | 1800 |
| E | Fmod F $=100 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $= \pm 0.58 \mathrm{~Hz}$ | 1800 |

SAC 105 Tests - Revisions A

| SAC105 | Frequency Modulation Rev A |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
| A | Fmod F $=1 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $= \pm 4 \mathrm{~Hz}$ | 1800 |
| B | Fmod F $=5 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $= \pm 4 \mathrm{~Hz}$ | 1800 |
| C | Fmod F $=10 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $= \pm 4 \mathrm{~Hz}$ | 1800 |
| D | Fmod F $=25 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $= \pm 4 \mathrm{~Hz}$ | 1800 |

## SAC 106 Tests

Voltage distortion spectrum test require the use of additional external equipment. In particular, a high bandwidth (100Khz) AC source, a high frequency coupling transformer and coupling network as shown in figure SAC106-1 of the Mil-Std 704 standard. For this test, the Lx/Ls Series AC source can be programmed to a steady state condition of 400 Hz and Vnominal of 115 Vrms or 230 Vrms.


Figure 11-8: Required SAC-106 Test Setup.

SAC 107 Tests - Revisions B, C, D, E, F

| SAC107 | Total Voltage Distortion Rev B,C,D,E,F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
| A | 0.05 \% VTHD | 1800 |
|  | $\mathrm{F}=100 \%$ |  |
|  | H3 = 2.75\% |  |
|  | H5 = 2.75\% |  |
|  | H7 = 1.97\% |  |
|  | H9 = 1.53\% |  |
|  | H11 = 1.25\% |  |
|  | H13 = 1.06\% |  |
|  | H15 = 0.92\% |  |

SAC 107 Tests - Revisions A

| SAC107 | Total Voltage Distortion Rev A |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
| A | 0.08 \% VTHD | 1800 |
|  | F = 100\% |  |
|  | H3 = 5.00\% |  |
|  | H5 = 4.12\% |  |
|  | H7 = 2.94\% |  |
|  | H9 = 2.29\% |  |
|  | H11 = 1.87\% |  |
|  | H13 = 1.06\% |  |
|  | H15 = 1.37\% |  |

SAC 108 Tests
SAC108 are DC offset tests and are not supported by the Lx/Ls Series AC Power sources. Contact AMETEK Programmable Power for DC Supply information. (sales@programmablepower.com )

SAC 109 Tests - Revisions B, C, D, E, F

| SAC109 | Normal Voltage Transients Rev B,C,D,E,F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Voltage |  |
| A | $140 \mathrm{Vrms}, 60 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 52 |
| B | $140 \mathrm{Vrms}, 60 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=25 \mathrm{~ms}$ | 52 |
| C | $160 \mathrm{Vrms}, 34 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 52 |
| D | $160 \mathrm{Vrms}, 34 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=25 \mathrm{~ms}$ | 52 |
| E | $180 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 52 |
| F | $180 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=77 \mathrm{~ms}$ | 52 |
| G | $180 \mathrm{Vrms}, 3 \times 10 \mathrm{msec}, 0.5 \mathrm{apart}$, tf < $1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 56 |
|  | Under Voltage |  |
| H | $90 \mathrm{Vrms}, 35 \mathrm{msec}$, tf $<1.25 \mathrm{~ms}$, tr < 1.25 ms | 52 |
| 1 | $90 \mathrm{Vrms}, 35 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=45 \mathrm{~ms}$ | 52 |
| J | $80 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 52 |
| K | $80 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=70 \mathrm{~ms}$ | 52 |
| L | $80 \mathrm{Vrms}, 3 \times 10 \mathrm{msec}, 0.5 \mathrm{sec}$ apart, $\mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 56 |
|  | Combined Transient |  |
| M | $80 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 52 |
|  | $180 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=77 \mathrm{~ms}$ |  |
|  | Repetitive Transient |  |
| N | Repeats every 500 msec |  |

SAC 109 Tests - Revisions A

| SAC109 | Normal Voltage Transients Rev A |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Voltage |  |
| A | $135 \mathrm{Vrms}, 210 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 52 |
| B | $135 \mathrm{Vrms}, 145 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=130 \mathrm{~ms}$ | 52 |
| C | $145 \mathrm{Vrms}, 130 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 52 |
| D | $145 \mathrm{Vrms}, 90 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, $\mathrm{tr}=80 \mathrm{~ms}$ | 52 |
| E | $160 \mathrm{Vrms}, 48 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, $\mathrm{tr}<1.25 \mathrm{~ms}$ | 52 |
| F | $160 \mathrm{Vrms}, 30 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, $\mathrm{tr}=40 \mathrm{~ms}$ | 52 |
| G | $160 \mathrm{Vrms}, 3 \times 25 \mathrm{msec}, 0.5 \mathrm{apart}$, tf $<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 56 |
|  | Under Voltage |  |
| H | $90 \mathrm{Vrms}, 300 \mathrm{msec}$, tf < 1.25 ms , tr $<1.25 \mathrm{~ms}$ | 52 |
| I | $90 \mathrm{Vrms}, 210 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=180 \mathrm{~ms}$ | 52 |
| J | $70 \mathrm{Vrms}, 140 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 52 |
| K | $70 \mathrm{Vrms}, 95 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=85 \mathrm{~ms}$ | 52 |
| L | $58 \mathrm{Vrms}, 48 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 56 |
| M | $58 \mathrm{Vrms}, 30 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=40 \mathrm{~ms}$ | 56 |
| N | $58 \mathrm{Vrms}, 3 \times 25 \mathrm{msec}, 0.5 \mathrm{apart}$, $\mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 56 |
|  | Combined Transient |  |
| 0 | $58 \mathrm{Vrms}, 25 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr < 1.25 ms | 52 |
|  | $160 \mathrm{Vrms}, 25 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=50 \mathrm{~ms}$ |  |
|  | Repetitive Transient |  |
| P | Repeats every 500 msec |  |

SAC 110 Tests - Revisions B, C, D, E, F

| SAC110 | Normal Frequency Transients, Rev B, C, D, E, F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Frequency |  |
| A | $410 \mathrm{~Hz}, 10 \mathrm{sec}, \mathrm{tr}=40 \mathrm{msec}, \mathrm{tf}=40 \mathrm{msec}$ | 100 |
| B | $420 \mathrm{~Hz}, 5 \mathrm{sec}, \mathrm{tr}=80 \mathrm{msec}, \mathrm{tf}=80 \mathrm{msec}$ | 80 |
| C | $425 \mathrm{~Hz}, 1 \mathrm{sec}, \mathrm{tr}=100 \mathrm{msec}, \mathrm{tf}=100 \mathrm{msec}$ | 60 |
| D | $425 \mathrm{~Hz}, 1 \mathrm{sec}, \mathrm{tr}=100 \mathrm{msec}, \mathrm{tf}=10 \mathrm{msec}$ | 100 |
|  | $420 \mathrm{~Hz}, 4 \mathrm{sec}, \mathrm{tr}=10 \mathrm{msec}, \mathrm{tf}=20 \mathrm{msec}$ |  |
|  | $410 \mathrm{~Hz}, 5 \mathrm{sec}, \mathrm{tr}=20 \mathrm{msec}, \mathrm{tf}=40 \mathrm{msec}$ |  |
|  | Under Frequency |  |
| E | $390 \mathrm{~Hz}, 10 \mathrm{sec}, \mathrm{tr}=40 \mathrm{msec}, \mathrm{tf}=40 \mathrm{msec}$ | 100 |
| F | $380 \mathrm{~Hz}, 5 \mathrm{sec}, \mathrm{tr}=80 \mathrm{msec}, \mathrm{tf}=80 \mathrm{msec}$ | 80 |
| G | $375 \mathrm{~Hz}, 1 \mathrm{sec}, \mathrm{tr}=100 \mathrm{msec}, \mathrm{tf}=100 \mathrm{msec}$ | 60 |
| H | $375 \mathrm{~Hz}, 1 \mathrm{sec}, \mathrm{tr}=100 \mathrm{msec}, \mathrm{tf}=10 \mathrm{msec}$ | 100 |
|  | $380 \mathrm{~Hz}, 4 \mathrm{sec}, \mathrm{tr}=10 \mathrm{msec}, \mathrm{tf}=20 \mathrm{msec}$ |  |
|  | $390 \mathrm{~Hz}, 5 \mathrm{sec}, \mathrm{tr}=20 \mathrm{msec}, \mathrm{tf}=40 \mathrm{msec}$ |  |
|  | Combined |  |
| 1 | $375 \mathrm{~Hz}, 1 \mathrm{sec}, \mathrm{tr}=100 \mathrm{msec}, \mathrm{tf}=100 \mathrm{msec}$ | 62 |
|  | $425 \mathrm{~Hz}, 1 \mathrm{sec}, \mathrm{tr}=100 \mathrm{msec}, \mathrm{tf}=100 \mathrm{msec}$ |  |

SAC 110 Tests - Revisions A

| SAC110 | Normal Frequency Transients, Rev A |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
|  | Over Frequency |  |
| A | $430 \mathrm{~Hz}, 0.5$ cycle, $\mathrm{tr}=120 \mathrm{msec}, \mathrm{tf}=120 \mathrm{msec}$ | 100 |
| B | $430 \mathrm{~Hz}, 0.5$ cycle, $\mathrm{tr}=300 \mathrm{msec}, \mathrm{tf}=1.2 \mathrm{sec}$ | 80 |
| C | $450 \mathrm{~Hz}, 0.5$ cycle, $\mathrm{tr}=200 \mathrm{msec}, \mathrm{tf}=200 \mathrm{msec}$ | 60 |
| D | $450 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=250 \mathrm{msec}, \mathrm{tf}=3 \mathrm{sec}$ | 100 |
| E | $370 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=120 \mathrm{msec}, \mathrm{tf}=120 \mathrm{msec}$ |  |
| F | $370 \mathrm{~Hz}, 0.5$ cycle, $\mathrm{tr}=300 \mathrm{msec}, \mathrm{tf}=1.2 \mathrm{sec} /$ | 100 |
| G | $350 \mathrm{~Hz}, 0.5$ cycle, $\mathrm{tr}=200 \mathrm{msec}, \mathrm{tf}=200 \mathrm{msec}$ | 80 |
| H | $350 \mathrm{~Hz}, 0.5$ cycle, $\mathrm{tr}=250 \mathrm{msec}, \mathrm{tf}=3 \mathrm{sec}$ | 60 |
| I | $350 \mathrm{~Hz}, 0.5$ cycle, $\mathrm{tr}=200 \mathrm{msec}, \mathrm{tf}=200 \mathrm{msec}$ | 100 |
|  | $450 \mathrm{~Hz}, 0.5$ cycle, $\mathrm{tr}=200 \mathrm{msec}, \mathrm{tf}=200 \mathrm{msec}$ | 62 |

## SAC 201 Tests - All Revisions

| SAC201 | Power Interrupt, Rev A, B, C, D, E, F |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
| A | Vnom 115V, 50 msec | 62 |
| B | Vlow $108 \mathrm{~V}, 50 \mathrm{msec}$ | 62 |
| C | Vhigh $118 \mathrm{~V}, 50 \mathrm{msec}$ | 62 |
| D | Vnom $115 \mathrm{~V}, 30 \mathrm{msec}$ | 62 |
| E | Vlow $108 \mathrm{~V}, 30 \mathrm{msec}$ | 62 |
| F | Vhigh $118 \mathrm{~V}, 30 \mathrm{msec}$ | 62 |
| G | Vnom $115 \mathrm{~V}, 10 \mathrm{msec}$ | 62 |
| H | Vlow $108 \mathrm{~V}, 10 \mathrm{msec}$ | 62 |
| J | Vhigh $118 \mathrm{~V}, 10 \mathrm{msec}$ | 62 |
| J | Vnom $115 \mathrm{~V}, 3 \times 50 \mathrm{msec}, 0.5$ sec apart | 62 |
| K | Vnom $115 \mathrm{~V}, 50 \mathrm{msec}$ | 62 |
|  | $160 \mathrm{Vrms}, 30 \mathrm{msec}, \mathrm{tr}=40 \mathrm{msec}$ |  |
| L | Vnom $115 \mathrm{~V}, 50 \mathrm{msec}$ | 62 |
|  | $70 \mathrm{Vrms}, 30 \mathrm{msec}, \mathrm{tr}=40 \mathrm{msec}$ |  |

SAC 301 Tests - Revisions C, E, F

| SAC301 | Abnormal SS Limits Volt and Freq Rev C, E, F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltag |  |
| A | Vnom 115V, Flow 380 Hz | 1800 |
| B | Vnom 115V, Fhigh 420 Hz | 1800 |
|  | Low Voltage |  |
| C | Vlow 100V, Fnom 400 Hz | 1800 |
| D | Vlow 100V, Flow 380 Hz | 1800 |
| E | Vlow 100V, Fhigh 420 Hz | 1800 |
|  | High Voltage |  |
| F | Vhigh 125V, Fnom 400 Hz | 1800 |
| G | Vhigh 125V, Flow 380 Hz | 1800 |
| H | Vhigh 125V, Fhigh 420 Hz | 1800 |

SAC 301 Tests - Revisions B, D

| SAC301 | Abnormal SS Limits Volt and Freq Rev B, D |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltage |  |
| A | Vnom 115V, Flow 375 Hz | 1800 |
| B | Vnom 115V, Fhigh 425 Hz | 1800 |
|  | Low Voltage |  |
| C | Vlow 100V, Fnom 400 Hz | 1800 |
| D | Vlow 100V, Flow 375 Hz | 1800 |
| E | Vlow 100V, Fhigh 425 Hz | 1800 |
|  | High Voltage |  |
| F | Vhigh 125V, Fnom 400 Hz | 1800 |
| G | Vhigh 125V, Flow 375 Hz | 1800 |
| H | Vhigh 125V, Fhigh 425 Hz | 1800 |

SAC 301 Tests - Revisions A

| SAC301 | Abnormal SS Limits Volt and Freq Rev A |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltage |  |
| A | Vnom 115V, Flow 370 Hz | 1800 |
| B | Vnom 115V, Fhigh 430 Hz | 1800 |
|  | Low Voltage |  |
| C | Vlow 102V, Fnom 400 Hz | 1800 |
| D | Vlow 102V, Flow 370 Hz | 1800 |
| E | Vlow 102V, Fhigh 430 Hz | 1800 |
|  | High Voltage |  |
| F | Vhigh 124V, Fnom 400 Hz | 1800 |
| G | Vhigh 124V, Flow 370 Hz | 1800 |
| H | Vhigh 124V, Fhigh 430 Hz | 1800 |

SAC 302 Tests - Revisions B, C, D, E, F

| SAC302 | Abnormal Voltage Transients. Rev B, C, D, E, F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Voltage |  |
| A | $140 \mathrm{Vrms}, 180 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 54 |
| B | $140 \mathrm{Vrms}, 180 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=87 \mathrm{~ms}$ then 135 Vrms , ramp down, $\mathrm{tr}=253 \mathrm{msec}$ then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 Vrms , ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| C | $160 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| D | $160 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=31 \mathrm{~ms}$ then 150 Vrms , ramp down, $\mathrm{tr}=71 \mathrm{msec}$ then 140 Vrms , ramp down, $\mathrm{tr}=87 \mathrm{sec}$ then 135 Vrms , ramp down, $\mathrm{tr}>253 \mathrm{sec}$. then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 V rms, ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 V rms. | 135 |
| E | $180 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| F | $180 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=11 \mathrm{~ms}$ then 170 Vrms , ramp down, $\mathrm{tr}=17 \mathrm{msec}$ then 160Vrms, ramp down, $\mathrm{tr}=31 \mathrm{msec}$ then 150Vrms, ramp down, $\mathrm{tr}=71 \mathrm{msec}$ then 140 Vrms , ramp down, $\mathrm{tr}=87 \mathrm{sec}$ then 135 Vrms , ramp down, $\mathrm{tr}>253 \mathrm{sec}$. then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 V rms, ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| G | $180 \mathrm{Vrms}, 3 \times 20 \mathrm{msec}, 0.5 \mathrm{sec}$ apart, $\mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
|  | Under Voltage |  |
| H | $85 \mathrm{Vrms}, 180 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, $\mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| I | $85 \mathrm{Vrms}, 180 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=87 \mathrm{~ms}$ then 90Vrms, ramp up, $\mathrm{tr}=253 \mathrm{msec}$ then 95 Vrms , ramp up, $\mathrm{tr}=6.41 \mathrm{sec}$ then 100 Vrms , ramp up, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| J | $66 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| K | $65 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=31 \mathrm{~ms}$ then 75 Vrms , ramp up, $\mathrm{tr}=71 \mathrm{msec}$ then 85 Vrms , ramp up, $\mathrm{tr}=87 \mathrm{msec}$ then 90 Vrms , ramp up, $\mathrm{tr}=253 \mathrm{msec}$ then 95 Vrms , ramp up, $\mathrm{tr}=6.41 \mathrm{sec}$ then 100 Vrms , ramp up, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| L | $45 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 54 |
| M | $45 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=11 \mathrm{~ms}$ then 55 Vrms , ramp up, $\mathrm{tr}=17 \mathrm{msec}$ then 65 Vrms , ramp up, $\mathrm{tr}=31 \mathrm{msec}$ then 75 Vrms , ramp up, $\mathrm{tr}=71 \mathrm{msec}$ then 85 Vrms , ramp up, $\mathrm{tr}=87 \mathrm{msec}$ then 90 Vrms , ramp up, $\mathrm{tr}=253 \mathrm{msec}$ then 95 Vrms , ramp up, $\mathrm{tr}=6.41 \mathrm{sec}$ then 100 Vrms , ramp up, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| N | $45 \mathrm{Vrms}, 3 \times 20 \mathrm{msec}, 0.5 \mathrm{sec}$ apart, tf < 1.25 ms , tr < 1.25 ms | 54 |
|  | Combined Transient |  |
| 0 | $45 \mathrm{Vrms}, 20 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ $180 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=11 \mathrm{~ms}$ then 170 Vrms , ramp down, $\mathrm{tr}=17 \mathrm{msec}$ then 160Vrms, ramp down, $\mathrm{tr}=31 \mathrm{msec}$ then 150Vrms, ramp down, $\mathrm{tr}=71 \mathrm{msec}$ then 140 Vrms , ramp down, $\mathrm{tr}=87 \mathrm{sec}$ then 135Vrms, ramp down, tr $>253 \mathrm{sec}$. then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 Vrms , ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |

## SAC 302 Tests - Revision A

| SAC302 | Abnormal Voltage Transients. Rev A |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Voltage |  |
| A | $140 \mathrm{Vrms}, 1450 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 54 |
| B | $140 \mathrm{Vrms}, 1025 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=850 \mathrm{~ms}$ | 135 |
| C | $160 \mathrm{Vrms}, 520 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 54 |
| D | $160 \mathrm{Vrms}, 390 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=250 \mathrm{~ms}$ | 135 |
| E | $180 \mathrm{Vrms}, 98 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| F | $180 \mathrm{Vrms}, 75 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=50 \mathrm{~ms}$ | 135 |
| G | $180 \mathrm{Vrms}, 3 \times 20 \mathrm{msec}, 0.5$ apart, $\mathrm{tf}<1.25 \mathrm{~ms}$, $\mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
|  | Under Voltage |  |
| H | 85 Vrms, $1450 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr < 1.25 ms | 54 |
| I | $85 \mathrm{Vrms}, 1025 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=850 \mathrm{~ms}$ | 135 |
| J | $75 \mathrm{Vrms}, 520 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| K | $75 \mathrm{Vrms}, 390 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=250 \mathrm{~ms}$ | 135 |
| L | $45 \mathrm{Vrms}, 98 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, $\mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| M | $45 \mathrm{Vrms}, 75 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=50 \mathrm{~ms}$ | 135 |
| N | $45 \mathrm{Vrms}, 3 \times 20 \mathrm{msec}, 0.5 \mathrm{apart}$, tf < 1.25 ms , tr $<1.25 \mathrm{~ms}$ | 54 |
|  | Combined Transient |  |
| O | $45 \mathrm{Vrms}, 20 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 135 |
|  | $180 \mathrm{Vrms}, 75 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=50 \mathrm{~ms}$ |  |

SAC 303 Tests - Revisions B, C, D, E, F

| SAC303 | Abnormal Frequency Transients. Rev B, C, D, E, F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Frequency |  |
| A | $480 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=160 \mathrm{msec}, \mathrm{tf}=160 \mathrm{msec}$ | 55 |
| B | $480 \mathrm{~Hz}, 4.78 \mathrm{sec}, \mathrm{tr}=160 \mathrm{msec}, \mathrm{tf}=160 \mathrm{msec}$ | 76 |
|  | Under Frequency |  |
| C | $320 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=160 \mathrm{msec}, \mathrm{tf}=160 \mathrm{msec}$ | 55 |
| D | $320 \mathrm{~Hz}, 4.78 \mathrm{sec}, \mathrm{tr}=160 \mathrm{msec}, \mathrm{tf}=160 \mathrm{msec}$ | 76 |
|  | Combined |  |
| E | $320 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=160 \mathrm{msec}, \mathrm{tf}=160 \mathrm{msec}$ | 56 |
|  | $480 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=160 \mathrm{msec}, \mathrm{tf}=160 \mathrm{msec}$ |  |

## SAC 303 Tests - Revision A

| SAC303 | Abnormal Frequency Transients. Rev A |  |
| :---: | :--- | :---: |
| Condition |  | Over Frequency |
| A | $480 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=333 \mathrm{msec}, \mathrm{tf}=60 \mathrm{msec}$ |  |
| B | $480 \mathrm{~Hz}, 6.69 \mathrm{sec}, \mathrm{tr}=333 \mathrm{msec}, \mathrm{tf}=60 \mathrm{msec}$ | 55 |
|  |  | 76 |
| C | $320 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=333 \mathrm{msec}, \mathrm{tf}=60 \mathrm{msec}$ |  |
| D | $320 \mathrm{~Hz}, 6.69 \mathrm{sec}, \mathrm{tr}=333 \mathrm{msec}, \mathrm{tf}=60 \mathrm{msec}$ | Combined |
| E |  | 55 |
|  | $320 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=333 \mathrm{msec}, \mathrm{tf}=333 \mathrm{msec}$ | 76 |
|  | $480 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=333 \mathrm{msec}, \mathrm{tf}=333 \mathrm{msec}$ | 56 |

SAC 401 Tests - Revision E, F

| SAC401 | Emergency SS Limits Volt and Freq. Rev E, F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltage |  |
| A | Vnom 115V, Flow 393 Hz | 1800 |
| B | Vnom 115V, Fhigh 407 Hz | 1800 |
| Low Voltage |  |  |
| C | Vlow 108V, Fnom 400 Hz | 1800 |
| D | Vlow 108V, Flow 393 Hz | 1800 |
| E | Vlow 108V, Fhigh 407 Hz | 1800 |
| High Voltage |  |  |
| F | Vhigh 118V, Fnom 400 Hz | 1800 |
| G | Vhigh 118V, Flow 393 Hz | 1800 |
| H | Vhigh 118V, Fhigh 407 Hz | 1800 |

SAC 401 Tests - Revision B, D

| SAC401 | Emergency SS Limits Volt and Freq. Rev B, D |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltag |  |
| A | Vnom 115V, Flow 360 Hz | 1800 |
| B | Vnom 115V, Fhigh 440 Hz | 1800 |
|  | Low Voltage |  |
| C | Vlow 102V, Fnom 400 Hz | 1800 |
| D | Vlow 102V, Flow 360 Hz | 1800 |
| E | Vlow 102V, Fhigh 440 Hz | 1800 |
|  | High Voltage |  |
| F | Vhigh 124V, Fnom 400 Hz | 1800 |
| G | Vhigh 124V, Flow 360 Hz | 1800 |
| H | Vhigh 124V, Fhigh 440 Hz | 1800 |

SAC 401 Tests - Revision A, C

| SAC401 | Emergency SS Limits Volt and Freq. Rev A, C |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltage |  |
| A | Vnom 115V, Flow 360 Hz | 1800 |
| B | Vnom 115V, Fhigh 440 Hz | 1800 |
|  | Low Voltage |  |
| C | Vlow 104V, Fnom 400 Hz | 1800 |
| D | Vlow 104V, Flow 360 Hz | 1800 |
| E | Vlow 104V, Fhigh 440 Hz | 1800 |
|  | High Voltage |  |
| F | Vhigh 122V, Fnom 400 Hz | 1800 |
| G | Vhigh 122V, Flow 360 Hz | 1800 |
| H | Vhigh 122V, Fhigh 440 Hz | 1800 |

## SAC 501 Tests

Starting operations are not applicable to AC Utilization Equipment.
SAC 601 Tests - Revision F only.

| SAC601 | Power Failure - One Phase |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
| A | 100 msec | 52 |
| B | 500 msec | 54 |
| C | 3 sec | 66 |
| D | 7 sec | 86 |

SAC 602 Tests - Revision F only.
Not applicable for single-phase EUT's.
SAC 603 Tests - Revision F only.

| SAC603 | Power Failure - Phase Reversal |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
| N/A | Use physical L-N connection reversal <br> Apply Vnom $=115 \mathrm{~V}$, Fnom $=400 \mathrm{~Hz}$ | 1800 |

### 11.7.2 TAC Group Tests

Three phase 400 Hz AC tests
TAC 102 Tests - Revisions A, B, C, D, E, F

| TAC102 | Steady State Voltage and Frequency - Rev A through F |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
|  | Balanced Voltage |  |
|  |  | Nominal Voltage |
| A | Vnom=115V, Fnom=400 Hz - Nominal | 1800 |
| B | Vnom=115V, Flow=393 Hz - Nominal | 1800 |
| C | Vnom=115V, Fhigh=407 Hz - Nominal | 1800 |
| D |  |  |
| Vlow $=108 \mathrm{~V}$, Fnom $=400 \mathrm{~Hz}-$ Low Voltage | 1800 |  |
| F | Vlow=108V, Flow=393 Hz- Low | 1800 |
| Glow=108V, Fhigh=407 Hz - Low | 1800 |  |
| H |  | 1800 |
| I | Vhigh=118V, Fnom=400 Hz - High | 1800 |
| J | Vhigh=118V, Fhigh=407 Hz - High | 1800 |
| K | Unbalanced Voltage |  |
|  | Va, Vb+3V, Vc+3V, Fnom | 1800 |

TAC 103 Tests - Revisions A, B, C, D, E, F

| TAC103 | Voltage Phase Difference - Rev A through F |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
| A | $\mathrm{A}=0, \mathrm{~B}=116, \mathrm{C}=240$ | 1800 |
| B | $\mathrm{~A}=0, \mathrm{~B}=124, \mathrm{C}=240$ | 1800 |

TAC 104 Tests - Revisions B, C, D, E, F

| TAC104 | Voltage Modulation - Rev B through F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
| A | Vmod F $=1.0 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| B | $\mathrm{Vmod} \mathrm{F}=1.7 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| C | $\mathrm{Vmod} \mathrm{F}=10 \mathrm{~Hz}, \mathrm{~V}=2.5 \mathrm{Vrms}$ | 1800 |
| D | $\mathrm{Vmod} \mathrm{F}=25 \mathrm{~Hz}$, V $=2.5 \mathrm{Vrms}$ | 1800 |
| E | $\mathrm{Vmod} \mathrm{F}=70 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| F | Vmod F $=100 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| G | Vmod F $=200 \mathrm{~Hz}$, V $=0.375 \mathrm{Vrms}$ | 1800 |

TAC 104 Tests - Revision A

| TAC104 | Voltage Modulation - Rev A |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
| A | Vmod F $=1.0 \mathrm{~Hz}, \mathrm{~V}=0.5 \mathrm{Vpp}$ | 1800 |
| B | $\mathrm{Vmod} \mathrm{F}=1.7 \mathrm{~Hz}, \mathrm{~V}=0.5 \mathrm{Vpp}$ | 1800 |
| C | $V \mathrm{mod} \mathrm{F}=10 \mathrm{~Hz}, \mathrm{~V}=3.5 \mathrm{Vpp}$ | 1800 |
| D | Vmod F $=25 \mathrm{~Hz}, \mathrm{~V}=3.5 \mathrm{Vpp}$ | 1800 |
| E | Vmod F $=70 \mathrm{~Hz}, \mathrm{~V}=0.5 \mathrm{Vpp}$ | 1800 |
| F | $\mathrm{Vmod} \mathrm{F}=100 \mathrm{~Hz}$, V $=0.5 \mathrm{Vpp}$ | 1800 |
| G | $\mathrm{Vmod} \mathrm{F}=200 \mathrm{~Hz}, \mathrm{~V}=0.5 \mathrm{Vpp}$ | 1800 |

TAC 105 Tests - Revision E, F

| TAC105 | Frequency Modulation Rev E, F |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
| $A$ | Fmod F $=1 \mathrm{~Hz} / \mathrm{sec}, F m o d ~ A m p ~$ | $4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ |
| B | Fmod F $=5 \mathrm{~Hz} / \mathrm{sec}, F m o d A m p=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |
| C | Fmod F $=10 \mathrm{~Hz} / \mathrm{sec}, F m o d A m p=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |
| $D$ | Fmod F $=25 \mathrm{~Hz} / \mathrm{sec}, F m o d A m p=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |
| E | Fmod F $=100 \mathrm{~Hz} / \mathrm{sec}, F m o d A m p=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |

TAC 105 Tests - Revision B, C, D

| TAC105 | Frequency Modulation Rev B, C, D |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
| $A$ | Fmod F $=1 \mathrm{~Hz} / \mathrm{sec}, F m o d A m p ~$ | $\pm 5 \mathrm{~Hz}$ |
| $B$ | Fmod F $=5 \mathrm{~Hz} / \mathrm{sec}, F m o d A m p= \pm 1.75 \mathrm{~Hz}$ | 1800 |
| C | Fmod F $=10 \mathrm{~Hz} / \mathrm{sec}, F m o d A m p= \pm 1.20 \mathrm{~Hz}$ | 1800 |
| $D$ | Fmod F $=25 \mathrm{~Hz} / \mathrm{sec}, F m o d A m p= \pm 0.85 \mathrm{~Hz}$ | 1800 |
| E | Fmod F $=100 \mathrm{~Hz} / \mathrm{sec}, F m o d A m p= \pm 0.58 \mathrm{~Hz}$ | 1800 |

TAC 105 Tests - Revision A

| TAC105 | Frequency Modulation Rev A |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
| A | Fmod $F=1 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $= \pm 4 \mathrm{~Hz}$ | 1800 |
| B | Fmod $F=5 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $= \pm 4 \mathrm{~Hz}$ | 1800 |
| C | Fmod $F=10 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $= \pm 4 \mathrm{~Hz}$ | 1800 |
| D | Fmod F $=25 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $= \pm 4 \mathrm{~Hz}$ | 1800 |

## TAC 106 Tests

Voltage distortion spectrum test require the use of additional external equipment. In particular, a high bandwidth (100Khz) AC source, a high frequency coupling transformer and coupling network as shown in figure TAC106-1 of the Mil-Std 704 standard. For this test, the Lx/Ls Series AC source can be programmed to a steady state condition of 400 Hz and Vnominal of 115 Vrms or 230 Vrms.

7. Coupling Transformer shown is connected in series on Phase A. Testing is repeated with Coupling Transformer connected in series on Phase B and Phase C.

Figure 11-9: Required TAC-106 Test Setup.

TAC 107 Tests - Revisions B, C, D, E, F

| TAC107 | Total Voltage Distortion Rev B,C,D,E,F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
| A | 0.05 \% VTHD | 1800 |
|  | $\mathrm{F}=100 \%$ |  |
|  | H3 $=2.75 \%$ |  |
|  | H5 = 2.75\% |  |
|  | H7 = 1.97\% |  |
|  | H9 = 1.53\% |  |
|  | H11 = 1.25\% |  |
|  | H13 = 1.06\% |  |
|  | H15 = 0.92\% |  |

TAC 107 Tests - Revisions A

| TAC107 | Total Voltage Distortion Rev A |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
| A | 0.08 \% VTHD | 1800 |
|  | $\mathrm{F}=100 \%$ |  |
|  | H3 $=5.00 \%$ |  |
|  | H5 = 4.12\% |  |
|  | H7 = 2.94\% |  |
|  | H9 = 2.29\% |  |
|  | H11 = 1.87\% |  |
|  | H13 = 1.06\% |  |
|  | H15 = 1.37\% |  |

TAC 108 Tests
TAC108 are DC offset tests and are not supported by the Lx/Ls Series AC Power sources. Contact AMETEK Programmable Power for DC Supply information. (sales@programmable.com )

TAC 109 Tests - Revisions B, C, D, E, F

| TAC109 | Normal Voltage Transients Rev B,C,D,E,F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Voltage |  |
| A | $140 \mathrm{Vrms}, 60 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr < 1.25 ms | 52 |
| B | $140 \mathrm{Vrms}, 60 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=25 \mathrm{~ms}$ | 52 |
| C | $160 \mathrm{Vrms}, 34 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 52 |
| D | $160 \mathrm{Vrms}, 34 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=25 \mathrm{~ms}$ | 52 |
| E | $180 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 52 |
| F | $180 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=77 \mathrm{~ms}$ | 52 |
| G | $180 \mathrm{Vrms}, 3 \times 10 \mathrm{msec}, 0.5 \mathrm{apart}$, $\mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 56 |
|  | Under Voltage |  |
| H | $90 \mathrm{Vrms}, 35 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, $\mathrm{tr}<1.25 \mathrm{~ms}$ | 52 |
| I | $90 \mathrm{Vrms}, 35 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=45 \mathrm{~ms}$ | 52 |
| J | $80 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, $\mathrm{tr}<1.25 \mathrm{~ms}$ | 52 |
| K | $80 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=70 \mathrm{~ms}$ | 52 |
| L | $80 \mathrm{Vrms}, 3 \times 10 \mathrm{msec}, 0.5 \mathrm{sec}$ apart, $\mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 56 |
|  | Combined Transient |  |
| M | $80 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 52 |
|  | $180 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=77 \mathrm{~ms}$ |  |
|  | Repetitive Transient |  |
| N | Repeats every 500 msec |  |

TAC 109 Tests - Revisions A

| TAC109 | Normal Voltage Transients Rev A |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Voltage |  |
| A | $135 \mathrm{Vrms}, 210 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 52 |
| B | $135 \mathrm{Vrms}, 145 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=130 \mathrm{~ms}$ | 52 |
| C | $145 \mathrm{Vrms}, 130 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 52 |
| D | $145 \mathrm{Vrms}, 90 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=80 \mathrm{~ms}$ | 52 |
| E | $160 \mathrm{Vrms}, 48 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 52 |
| F | $160 \mathrm{Vrms}, 30 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=40 \mathrm{~ms}$ | 52 |
| G | $160 \mathrm{Vrms}, 3 \times 25 \mathrm{msec}, 0.5 \mathrm{apart}$, tf $<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 56 |
|  | Under Voltage |  |
| H | $90 \mathrm{Vrms}, 300 \mathrm{msec}, \mathrm{tf}$ < 1.25 ms , tr $<1.25 \mathrm{~ms}$ | 52 |
| I | $90 \mathrm{Vrms}, 210 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=180 \mathrm{~ms}$ | 52 |
| J | $70 \mathrm{Vrms}, 140 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 52 |
| K | $70 \mathrm{Vrms}, 95 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=85 \mathrm{~ms}$ | 52 |
| L | $58 \mathrm{Vrms}, 48 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 56 |
| M | $58 \mathrm{Vrms}, 30 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=40 \mathrm{~ms}$ | 56 |
| N | $58 \mathrm{Vrms}, 3 \times 25 \mathrm{msec}, 0.5 \mathrm{apart}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 56 |
|  | Combined Transient |  |
| 0 | $58 \mathrm{Vrms}, 25 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr < 1.25 ms | 52 |
|  | $160 \mathrm{Vrms}, 25 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=50 \mathrm{~ms}$ |  |
|  | Repetitive Transient |  |
| P | Repeats every 500 msec |  |

TAC 110 Tests - Revisions B, C, D, E, F

| TAC110 | Normal Frequency Transients, Rev B, C, D, E, F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Frequency |  |
| A | $410 \mathrm{~Hz}, 10 \mathrm{sec}, \mathrm{tr}=40 \mathrm{msec}, \mathrm{tf}=40 \mathrm{msec}$ | 100 |
| B | $420 \mathrm{~Hz}, 5 \mathrm{sec}, \mathrm{tr}=80 \mathrm{msec}, \mathrm{tf}=80 \mathrm{msec}$ | 80 |
| C | $425 \mathrm{~Hz}, 1 \mathrm{sec}, \mathrm{tr}=100 \mathrm{msec}, \mathrm{tf}=100 \mathrm{msec}$ | 60 |
|  | $425 \mathrm{~Hz}, 1 \mathrm{sec}, \mathrm{tr}=100 \mathrm{msec}, \mathrm{tf}=10 \mathrm{msec}$ | 100 |
|  | $420 \mathrm{~Hz}, 4 \mathrm{sec}, \mathrm{tr}=10 \mathrm{msec}, \mathrm{tf}=20 \mathrm{msec}$ |  |
|  | $410 \mathrm{~Hz}, 5 \mathrm{sec}, \mathrm{tr}=20 \mathrm{msec}, \mathrm{tf}=40 \mathrm{msec}$ |  |
| D | Under Frequency |  |
| E | $390 \mathrm{~Hz}, 10 \mathrm{sec}, \mathrm{tr}=40 \mathrm{msec}, \mathrm{tf}=40 \mathrm{msec}$ | 100 |
| F | $380 \mathrm{~Hz}, 5 \mathrm{sec}, \mathrm{tr}=80 \mathrm{msec}, \mathrm{tf}=80 \mathrm{msec}$ | 80 |
| G | $375 \mathrm{~Hz}, 1 \mathrm{sec}, \mathrm{tr}=100 \mathrm{msec}, \mathrm{tf}=100 \mathrm{msec}$ | 60 |
| H | $375 \mathrm{~Hz}, 1 \mathrm{sec}, \mathrm{tr}=100 \mathrm{msec}, \mathrm{tf}=10 \mathrm{msec}$ | 100 |
|  | $380 \mathrm{~Hz}, 4 \mathrm{sec}, \mathrm{tr}=10 \mathrm{msec}, \mathrm{tf}=20 \mathrm{msec}$ |  |
|  | $390 \mathrm{~Hz}, 5 \mathrm{sec}, \mathrm{tr}=20 \mathrm{msec}, \mathrm{tf}=40 \mathrm{msec}$ |  |
|  | Combined |  |
| I | $375 \mathrm{~Hz}, 1 \mathrm{sec}, \mathrm{tr}=100 \mathrm{msec}, \mathrm{tf}=100 \mathrm{msec}$ | 62 |
|  | $425 \mathrm{~Hz}, 1 \mathrm{sec}, \mathrm{tr}=100 \mathrm{msec}, \mathrm{tf}=100 \mathrm{msec}$ |  |

TAC 110 Tests - Revisions A

| TAC110 | Normal Frequency Transients, Rev A |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Frequency |  |
| A | $430 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=120 \mathrm{msec}, \mathrm{tf}=120 \mathrm{msec}$ | 100 |
| B | $430 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=300 \mathrm{msec}, \mathrm{tf}=1.2 \mathrm{sec}$ | 80 |
| C | $450 \mathrm{~Hz}, 0.5$ cycle, $\mathrm{tr}=200 \mathrm{msec}, \mathrm{tf}=200 \mathrm{msec}$ | 60 |
| D | $450 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=250 \mathrm{msec}, \mathrm{tf}=3 \mathrm{sec}$ | 100 |
|  | Under Frequency |  |
| E | $370 \mathrm{~Hz}, 0.5$ cycle, $\mathrm{tr}=120 \mathrm{msec}, \mathrm{tf}=120 \mathrm{msec}$ | 100 |
| F | $370 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=300 \mathrm{msec}, \mathrm{tf}=1.2 \mathrm{sec} /$ | 80 |
| G | $350 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=200 \mathrm{msec}, \mathrm{tf}=200 \mathrm{msec}$ | 60 |
| H | $350 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=250 \mathrm{msec}, \mathrm{tf}=3 \mathrm{sec}$ | 100 |
|  | Combined |  |
| 1 | $350 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=200 \mathrm{msec}, \mathrm{tf}=200 \mathrm{msec}$ | 62 |
|  | $450 \mathrm{~Hz}, 0.5$ cycle, $\mathrm{tr}=200 \mathrm{msec}, \mathrm{tf}=200 \mathrm{msec}$ |  |

## TAC 201 Tests - All Revisions

| TAC201 | Power Interrupt, Rev A, B, C, D, E, F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
| A | Vnom 115V, 50 msec | 62 |
| B | Vlow 108V, 50 msec | 62 |
| C | Vhigh 118V, 50 msec | 62 |
| D | Vnom 115V, 30 msec | 62 |
| E | Vlow 108V, 30 msec | 62 |
| F | Vhigh 118V, 30 msec | 62 |
| G | Vnom 115V, 10 msec | 62 |
| H | Vlow 108V, 10 msec | 62 |
| I | Vhigh 118V, 10 msec | 62 |
| J | Vnom 115V, $3 \times 50 \mathrm{msec}, 0.5 \mathrm{sec}$ apart | 62 |
| K | Vnom 115V, 50 msec | 62 |
|  | $160 \mathrm{Vrms}, 30 \mathrm{msec}, \mathrm{tr}=40 \mathrm{msec}$ |  |
| L | Vnom 115V, 50 msec | 62 |
|  | $70 \mathrm{Vrms}, 30 \mathrm{msec}, \mathrm{tr}=40 \mathrm{msec}$ |  |

TAC 301 Tests - Revisions C, E, F

| TAC301 | Abnormal SS Limits Volt and Freq Rev C, E, F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltage |  |
| A | Vnom 115V, Flow 380 Hz | 1800 |
| B | Vnom 115V, Fhigh 420 Hz | 1800 |
|  | Low Voltage |  |
| C | Vlow 100V, Fnom 400 Hz | 1800 |
| D | Vlow 100V, Flow 380 Hz | 1800 |
| E | Vlow 100V, Fhigh 420 Hz | 1800 |
|  | High Voltage |  |
| F | Vhigh 125V, Fnom 400 Hz | 1800 |
| G | Vhigh 125V, Flow 380 Hz | 1800 |
| H | Vhigh 125V, Fhigh 420 Hz | 1800 |

TAC 301 Tests - Revisions B, D

| TAC301 | Abnormal SS Limits Volt and Freq Rev B, D |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltage |  |
| A | Vnom 115V, Flow 375 Hz | 1800 |
| B | Vnom 115V, Fhigh 425 Hz | 1800 |
|  | Low Voltage |  |
| C | Vlow 100V, Fnom 400 Hz | 1800 |
| D | Vlow 100V, Flow 375 Hz | 1800 |
| E | Vlow 100V, Fhigh 425 Hz | 1800 |
|  | High Voltage |  |
| F | Vhigh 125V, Fnom 400 Hz | 1800 |
| G | Vhigh 125V, Flow 375 Hz | 1800 |
| H | Vhigh 125V, Fhigh 425 Hz | 1800 |

TAC 301 Tests - Revisions A

| TAC301 | Abnormal SS Limits Volt and Freq Rev A |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltage |  |
| A | Vnom 115V, Flow 370 Hz | 1800 |
| B | Vnom 115V, Fhigh 430 Hz | 1800 |
|  | Low Voltage |  |
| C | Vlow 102V, Fnom 400 Hz | 1800 |
| D | Vlow 102V, Flow 370 Hz | 1800 |
| E | Vlow 102V, Fhigh 430 Hz | 1800 |
|  | High Voltage |  |
| F | Vhigh 124V, Fnom 400 Hz | 1800 |
| G | Vhigh 124V, Flow 370 Hz | 1800 |
| H | Vhigh 124V, Fhigh 430 Hz | 1800 |

TAC 302 Tests - Revisions B, C, D, E, F

| TAC302 | Abnormal Voltage Transients. Rev B, C, D, E, F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Voltage |  |
| A | $140 \mathrm{Vrms}, 180 \mathrm{msec}, \mathrm{tt}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| B | $140 \mathrm{Vrms}, 180 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=87 \mathrm{~ms}$ <br> then 135 Vrms , ramp down, $\mathrm{tr}=253 \mathrm{msec}$ then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 Vrms , ramp down, $\mathrm{tr}>10 \mathrm{sec}$ | 135 |
| C | $160 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| D | $160 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=31 \mathrm{~ms}$ then 150 V rms, ramp down, $\mathrm{tr}=71 \mathrm{msec}$ then 140 Vrms , ramp down, $\mathrm{tr}=87 \mathrm{sec}$ then 135 Vrms , ramp down, $\mathrm{tr}>253 \mathrm{sec}$. then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 V rms, ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| E | $180 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 54 |
| F | $180 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=11 \mathrm{~ms}$ then 170 Vrms , ramp down, $\mathrm{tr}=17 \mathrm{msec}$ then 160 Vrms , ramp down, $\mathrm{tr}=31 \mathrm{msec}$ then 150 Vrms , ramp down, $\mathrm{tr}=71 \mathrm{msec}$ then 140 Vrms , ramp down, $\mathrm{tr}=87 \mathrm{sec}$ then 135 Vrms , ramp down, $\mathrm{tr}>253 \mathrm{sec}$. then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 V rms, ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 V rms | 135 |
| G | $180 \mathrm{Vrms}, 3 \times 20 \mathrm{msec}, 0.5 \mathrm{apart}$, tif $<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 54 |
|  | Under Voltage |  |
| H | $85 \mathrm{Vrms}, 180 \mathrm{msec}$, tf $<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 54 |
| 1 | $85 \mathrm{Vrms}, 180 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=87 \mathrm{~ms}$ then 90 Vrms, ramp up, $\mathrm{tr}=253 \mathrm{msec}$ then 95 Vrms , ramp up, $\mathrm{tr}=6.41 \mathrm{sec}$ then 100 V rms, ramp up, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| J | $66 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| K | 65 V rms, $78 \mathrm{msec}, \mathrm{tt}<1.25 \mathrm{~ms}, \mathrm{tr}=31 \mathrm{~ms}$ then 75 Vrms , ramp up, $\mathrm{tr}=71 \mathrm{msec}$ then 85 Vrms , ramp up, $\mathrm{tr}=87 \mathrm{msec}$ then 90 V rms, ramp up, $\mathrm{tr}=253 \mathrm{msec}$ then 95 Vrms , ramp up, $\mathrm{tr}=6.41 \mathrm{sec}$ then 100 Vrms , ramp up, tr $>10 \mathrm{sec}$ then 115 V rms. | 135 |
| L | $45 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| M | $45 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=11 \mathrm{~ms}$ then 55 Vrms , ramp up, $\mathrm{tr}=17 \mathrm{msec}$ then 65 Vrms , ramp up, $\mathrm{tr}=31 \mathrm{msec}$ then 75 Vrms , ramp up, $\mathrm{tr}=71 \mathrm{msec}$ then 85 Vrms , ramp up, $\mathrm{tr}=87 \mathrm{msec}$ then 90 Vrms , ramp up, $\mathrm{tr}=253 \mathrm{msec}$ then 95 Vrms , ramp up, $\mathrm{tr}=6.41 \mathrm{sec}$ then 100 V rms, ramp up, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| N | $45 \mathrm{Vrms}, 3 \times 20 \mathrm{msec}, 0.5 \mathrm{apart}$, $\mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
|  | Combined Transient |  |
| 0 | $45 \mathrm{Vrms}, 20 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ $180 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=11 \mathrm{~ms}$ then 170Vrms, ramp down, $\mathrm{tr}=17 \mathrm{msec}$ then 160 Vrms , ramp down, $\mathrm{tr}=31 \mathrm{msec}$ then 150 Vrms , ramp down, $\mathrm{tr}=71 \mathrm{msec}$ then 140 Vrms , ramp down, $\mathrm{tr}=87 \mathrm{sec}$ then 135 Vrms , ramp down, $\mathrm{tr}>253 \mathrm{sec}$. then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 Vrms , ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |

TAC 302 Tests - Revision A

| TAC302 | Abnormal Voltage Transients. Rev A |  |
| :---: | :--- | :---: |
| Condition |  | Over Voltage |
|  |  | Duration (s) |
| A | $140 \mathrm{Vrms}, 1450 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| B | $140 \mathrm{Vrms}, 1025 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=850 \mathrm{~ms}$ | 135 |
| C | $160 \mathrm{Vrms}, 520 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| D | $160 \mathrm{Vrms}, 390 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=250 \mathrm{~ms}$ | 135 |
| E | $180 \mathrm{Vrms}, 98 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| F | $180 \mathrm{Vrms}, 75 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=50 \mathrm{~ms}$ | 135 |
| G | $180 \mathrm{Vrms}, 3 \times 20 \mathrm{msec}, 0.5 \mathrm{apart}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
|  |  | Under Voltage |
| H | $85 \mathrm{Vrms}, 1450 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| I | $85 \mathrm{Vrms}, 1025 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=850 \mathrm{~ms}$ | 135 |
| J | $75 \mathrm{Vrms}, 520 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| K | $75 \mathrm{Vrms}, 390 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=250 \mathrm{~ms}$ | 135 |
| L | $45 \mathrm{Vrms}, 98 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| M | $45 \mathrm{Vrms}, 75 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=50 \mathrm{~ms}$ | 135 |
| N | $45 \mathrm{Vrms}, 3 \times 20 \mathrm{msec}, 0.5 \mathrm{apart}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 54 |
| O |  | $45 \mathrm{Vrms}, 20 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ |
|  | $180 \mathrm{Vrms}, 75 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}=50 \mathrm{~ms}$ | 135 |

TAC 303 Tests - Revisions B, C, D, E, F

| TAC303 | Abnormal Frequency Transients. Rev B, C, D, E, F |  |
| :---: | :--- | :---: |
| Condition | Over Frequency | Duration (s) |
|  | Under Frequency |  |
| A | $480 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=160 \mathrm{msec}, \mathrm{tf}=160 \mathrm{msec}$ | 55 |
| B | $480 \mathrm{~Hz}, 4.78 \mathrm{sec}, \mathrm{tr}=160 \mathrm{msec}, \mathrm{tf}=160 \mathrm{msec}$ | 76 |
| C | $320 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=160 \mathrm{msec}, \mathrm{tf}=160 \mathrm{msec}$ | 55 |
| D | $320 \mathrm{~Hz}, 4.78 \mathrm{sec}, \mathrm{tr}=160 \mathrm{msec}, \mathrm{tf}=160 \mathrm{msec}$ | Combined |
| E | $320 \mathrm{~Hz}, 0.5$ cycle, $\mathrm{tr}=160 \mathrm{msec}, \mathrm{tf}=160 \mathrm{msec}$ | 76 |
|  | $480 \mathrm{~Hz}, 0.5$ cycle, $\mathrm{tr}=160 \mathrm{msec}, \mathrm{tf}=160 \mathrm{msec}$ | 56 |

TAC 303 Tests - Revision A

| TAC303 | Abnormal Frequency Transients. Rev A |  |
| :---: | :--- | :---: |
| Condition |  | Over Frequency |
| A | $480 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=333 \mathrm{msec}, \mathrm{tf}=60 \mathrm{msec}$ |  |
| B | $480 \mathrm{~Hz}, 6.69 \mathrm{sec}, \mathrm{tr}=333 \mathrm{msec}, \mathrm{tf}=60 \mathrm{msec}$ | 55 |
|  |  | Under Frequency |
| C | $320 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=333 \mathrm{msec}, \mathrm{tf}=60 \mathrm{msec}$ | 76 |
| D | $320 \mathrm{~Hz}, 6.69 \mathrm{sec}, \mathrm{tr}=333 \mathrm{msec}, \mathrm{tf}=60 \mathrm{msec}$ | 55 |
| E |  | Combined |

TAC 401 Tests - Revision E, F

| TAC401 | Emergency SS Limits Volt and Freq. Rev E, F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltag |  |
| A | Vnom 115V, Flow 393 Hz | 1800 |
| B | Vnom 115V, Fhigh 407 Hz | 1800 |
|  | Low Voltage |  |
| C | Vlow 108V, Fnom 400 Hz | 1800 |
| D | Vlow 108V, Flow 393 Hz | 1800 |
| E | Vlow 108V, Fhigh 407 Hz | 1800 |
|  | High Voltage |  |
| F | Vhigh 118V, Fnom 400 Hz | 1800 |
| G | Vhigh 118V, Flow 393 Hz | 1800 |
| H | Vhigh 118V, Fhigh 407 Hz | 1800 |

TAC 401 Tests - Revision B, D

| TAC401 | Emergency SS Limits Volt and Freq. Rev B, D |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltage |  |
| A | Vnom 115V, Flow 360 Hz | 1800 |
| B | Vnom 115V, Fhigh 440 Hz | 1800 |
|  | Low Voltage |  |
| C | Vlow 102V, Fnom 400 Hz | 1800 |
| D | Vlow 102V, Flow 360 Hz | 1800 |
| E | Vlow 102V, Fhigh 440 Hz | 1800 |
|  | High Voltage |  |
| F | Vhigh 124V, Fnom 400 Hz | 1800 |
| G | Vhigh 124V, Flow 360 Hz | 1800 |
| H | Vhigh 124V, Fhigh 440 Hz | 1800 |

TAC 401 Tests - Revision A, C

| TAC401 | Emergency SS Limits Volt and Freq. Rev A, C |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltag |  |
| A | Vnom 115V, Flow 360 Hz | 1800 |
| B | Vnom 115V, Fhigh 440 Hz | 1800 |
|  | Low Voltage |  |
| C | Vlow 104V, Fnom 400 Hz | 1800 |
| D | Vlow 104V, Flow 360 Hz | 1800 |
| E | Vlow 104V, Fhigh 440 Hz | 1800 |
|  | High Voltage |  |
| F | Vhigh 122V, Fnom 400 Hz | 1800 |
| G | Vhigh 122V, Flow 360 Hz | 1800 |
| H | Vhigh 122V, Fhigh 440 Hz | 1800 |

## TAC 501 Tests

Starting operations are not applicable to AC Utilization Equipment.
TAC 601 Tests - Revision F only.

| TAC601 | Power Failure - One Phase | Duration (s) |
| :---: | :--- | :---: |
| Condition |  | 52 |
| A | 100 msec | 54 |
| B | 500 msec | 66 |
| C | 3 sec | 86 |
| D | 7 sec |  |

TAC 602 Tests - Revision F only.

| TAC601 | Power Failure - One, Two Phase |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | One Phase |  |
| A | Phase A, 7 sec - 5 x | 86 |
| B | Phase B, 7 sec - 5 x | 86 |
| C | Phase C, 7 sec - 5x | 86 |
| D | Phase A, $30 \mathrm{~min}-1 \mathrm{x}$ | 1800 |
| E | Phase B, 30 min - 1 x | 1800 |
| F | Phase C, 30 min - 1 x | 1800 |
|  | Two Phase |  |
| G | Phase A\&B, 7 sec -5 x | 86 |
| H | Phase B\&C, $7 \mathrm{sec}-5 \mathrm{x}$ | 86 |
| I | Phase A\&B, 30 min - 1 x | 1800 |
| J | Phase B\&C, 30 min - 1 x | 1800 |

TAC 603 Tests - Revision F.

| TAC603 | Power Failure - Phase Reversal |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
| A | Phase rotation C-B-A | 1800 |
|  | Phase rotation A-B-C | 1800 |

### 11.7.3 SVF Group Tests

Three phase variable frequency AC tests.
Note: Variable frequency test are part of revision F only. There are no equivalent tests in revision A through $E$.

SVF 102 Tests - Revision F

| SVF102 | Steady State Voltage and Frequency - Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Balanced Nominal Voltage |  |
| A | Vnom, 360 Hz | 1800 |
| B | Vnom, 400 Hz | 1800 |
| C | Vnom, 600 Hz | 1800 |
| D | Vlow, 800 Hz | 1800 |
|  | Balanced Low Voltage |  |
| E | $108 \mathrm{~V}, 360 \mathrm{~Hz}$ | 1800 |
| F | $108 \mathrm{~V}, 400 \mathrm{~Hz}$ | 1800 |
| G | $108 \mathrm{~V}, 440 \mathrm{~Hz}$ | 300 |
| H | $108 \mathrm{~V}, 480 \mathrm{~Hz}$ | 300 |
| 1 | $108 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| $J$ | $108 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| K | $108 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| L | $108 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| M | $108 \mathrm{~V}, 540 \mathrm{~Hz}$ | 300 |
| N | $108 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| 0 | $108 \mathrm{~V}, 570 \mathrm{~Hz}$ | 300 |
| P | $108 \mathrm{~V}, 580 \mathrm{~Hz}$ | 300 |
| Q | $108 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| R | $108 \mathrm{~V}, 640 \mathrm{~Hz}$ | 300 |
| S | $108 \mathrm{~V}, 680 \mathrm{~Hz}$ | 300 |
| T | $108 \mathrm{~V}, 720 \mathrm{~Hz}$ | 300 |
| U | $108 \mathrm{~V}, 760 \mathrm{~Hz}$ | 300 |
| V | $108 \mathrm{~V}, 800 \mathrm{~Hz}$ | 1800 |
|  | Balanced High Voltage |  |
| W | $118 \mathrm{~V}, 360 \mathrm{~Hz}$ | 1800 |
| X | $118 \mathrm{~V}, 400 \mathrm{~Hz}$ | 1800 |
| Y | $118 \mathrm{~V}, 440 \mathrm{~Hz}$ | 300 |
| Z | $118 \mathrm{~V}, 480 \mathrm{~Hz}$ | 300 |
| AA | $118 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| BB | $118 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| CC | $118 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| DD | $118 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| EE | $118 \mathrm{~V}, 540 \mathrm{~Hz}$ | 300 |
| FF | $118 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| GG | $118 \mathrm{~V}, 570 \mathrm{~Hz}$ | 300 |
| HH | $118 \mathrm{~V}, 580 \mathrm{~Hz}$ | 300 |
| II | $118 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| JJ | $118 \mathrm{~V}, 640 \mathrm{~Hz}$ | 300 |
| KK | $118 \mathrm{~V}, 680 \mathrm{~Hz}$ | 300 |
| LL | $118 \mathrm{~V}, 720 \mathrm{~Hz}$ | 300 |
| MM | $118 \mathrm{~V}, 760 \mathrm{~Hz}$ | 300 |
| NN | $118 \mathrm{~V}, 800 \mathrm{~Hz}$ | 1800 |

## SVF 103 Tests

Voltage Phase Difference tests do not apply for single-phase EUT's.

## SVF 104 Tests - Revision F

| SVF104 | Voltage Modulation Rev F |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
|  | Run at 400, Repeat at 360, 600 and 800 Hz |  |
| A | Vmod F $=1.0 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| B | Vmod F $=1.7 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| C | Vmod F $=10 \mathrm{~Hz}, \mathrm{~V}=2.5 \mathrm{Vrms}$ | 1800 |
| D | Vmod F $=25 \mathrm{~Hz}, \mathrm{~V}=2.5 \mathrm{Vrms}$ | 1800 |
| E | Vmod F $=70 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| F | Vmod F $=100 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| G | Vmod F $=200 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |

SVF 105 Tests - Revision F

| SVF105 | Frequency Modulation Rev F |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
|  | Run at 400, Repeat at 362,600 and $798 ~ H z$ | 1800 |
| $A$ | Fmod $=1 \mathrm{~Hz} / \mathrm{sec}, F m o d ~ A m p=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |
| $B$ | Fmod F $=5 \mathrm{~Hz} / \mathrm{sec}, F m o d ~ A m p=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |
| C | Fmod $=10 \mathrm{~Hz} / \mathrm{sec}, F m o d A m p=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |
| D | Fmod F $=25 \mathrm{~Hz} / \mathrm{sec}, F m o d ~ A m p=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |

## SVF 106 Tests

Voltage distortion spectrum test require the use of additional external equipment. In particular, a high bandwidth (100Khz) AC source, a high frequency coupling transformer and coupling network as shown in figure SVF106-1 of the Mil-Std 704 standard. For this test, the Lx/Ls Series AC source can be programmed to a steady state condition of 360, 400, 600 and 800 Hz and Vnominal of 115 Vrms or 230 Vrms.


Figure 11-10: Required SVF-106 Test Setup.
SVF 107 Tests - Revision F

| SVF107 | Total Voltage Distortion Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Run at 400, Repeat at $\mathbf{3 6 0 , 6 0 0}$ and 800 Hz |  |
| A | 0.05 \% VTHD | 1800 |
|  | $\mathrm{F}=100 \%$ |  |
|  | H3 = 2.75\% |  |
|  | H5 = 2.75\% |  |
|  | H7 $=1.97 \%$ |  |
|  | H9 = 1.53\% |  |
|  | H11 = 1.25\% |  |
|  | H13 = 1.06\% |  |
|  | H15 = 0.92\% |  |

## SVF 108 Tests

SVF108 are DC offset tests and are not supported by the Lx/Ls Series AC Power sources. Contact AMETEK Programmable Power for DC Supply information.
(sales@programmablepower.com )

SVF 109 Tests - Revision F

| SVF109 | Normal Voltage Transients Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Run at 400, Repeat at 360, 600 and 800 Hz |  |
|  | Over Voltage |  |
| A | $140 \mathrm{Vrms}, 60 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 52 |
| B | $140 \mathrm{Vrms}, 60 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=25 \mathrm{~ms}$ | 52 |
| C | $160 \mathrm{Vrms}, 34 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 52 |
| D | $160 \mathrm{Vrms}, 34 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=25 \mathrm{~ms}$ | 52 |
| E | $180 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 52 |
| F | $180 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=77 \mathrm{~ms}$ | 52 |
| G | $180 \mathrm{Vrms}, 3 \times 10 \mathrm{msec}, 0.5 \mathrm{sec}$ apart, $\mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 56 |
|  | Under Voltage |  |
| H | $90 \mathrm{Vrms}, 35 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 52 |
| I | $90 \mathrm{Vrms}, 35 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=45 \mathrm{~ms}$ | 52 |
| J | $80 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 52 |
| K | $80 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=70 \mathrm{~ms}$ | 52 |
| L | $80 \mathrm{Vrms}, 3 \times 10 \mathrm{msec}, 0.5 \mathrm{apart}$, $\mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 56 |
|  | Combined Transient |  |
| M | $80 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 52 |
|  | $180 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=77 \mathrm{~ms}$ |  |
|  | Repetitive Transient |  |
| N | Repeats every 500 msec |  |

SVF 110 Tests - Revision F

| SVF110 | Normal Frequency Transients, Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Frequency |  |
| A | 360 Hz 800 Hz , ts $=1.76 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=1.76 \mathrm{sec}$ | 100 |
| B | 360 Hz 800 Hz , ts $=1.76 \mathrm{sec}$, dur $=1 \mathrm{sec}, \mathrm{tf}=1.76 \mathrm{sec}$ | 80 |
| C | 360 Hz 800 Hz , ts $=0.96 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=0.96 \mathrm{sec}$ | 60 |
| D | 360 Hz 800 Hz , ts $=0.96 \mathrm{sec}$, dur $=1 \mathrm{sec}, \mathrm{tf}=0.96 \mathrm{sec}$ | 100 |
|  | Under Frequency |  |
| E | 800 Hz 360 Hz , ts $=1.76 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=1.76 \mathrm{sec}$ | 100 |
| F | 800 Hz 360 Hz , ts $=1.76 \mathrm{sec}$, dur $=1 \mathrm{sec}, \mathrm{tf}=1.76 \mathrm{sec}$ | 80 |
| G | 800 Hz 600 Hz , ts $=0.80 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=0.80 \mathrm{sec}$ | 60 |
| H | $800 \mathrm{~Hz} 600 \mathrm{~Hz}, \mathrm{ts}=0.80 \mathrm{sec}$, dur $=1 \mathrm{sec}, \mathrm{tf}=0.80 \mathrm{sec}$ | 100 |
|  | Combined |  |
| I | 600 Hz 360 Hz , ts $=0.96 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=0.96 \mathrm{sec}$ | 62 |
|  | 600 Hz 800 Hz , ts $=0.80 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=0.80 \mathrm{sec}$ |  |

SVF 201 Tests -Revision F

| SVF201 | Power Interrupt, Rev F |  |
| :---: | :--- | :---: |
| Condition | Run at 400, Repeat at 360, 600 and $\mathbf{8 0 0} \mathrm{Hz}$ | Duration (s) |
|  | V | 62 |
| B | Vlow $115 \mathrm{~V}, 50 \mathrm{msec}, 50 \mathrm{msec}$ | 62 |
| C | Vhigh $118 \mathrm{~V}, 50 \mathrm{msec}$ | 62 |
| D | Vnom $115 \mathrm{~V}, 30 \mathrm{msec}$ | 62 |
| E | Vlow $108 \mathrm{~V}, 30 \mathrm{msec}$ | 62 |
| F | Vhigh $118 \mathrm{~V}, 30 \mathrm{msec}$ | 62 |
| G | Vnom $115 \mathrm{~V}, 10 \mathrm{msec}$ | 62 |
| H | Vlow $108 \mathrm{~V}, 10 \mathrm{msec}$ | 62 |
| I | Vhigh $118 \mathrm{~V}, 10 \mathrm{msec}$ | 62 |
| J | Vnom $115 \mathrm{~V}, 3 \times 50 \mathrm{msec}, 0.5 \mathrm{sec}$ apart | 62 |
| K | Vnom $115 \mathrm{~V}, 50 \mathrm{msec}$ | 62 |
|  | $160 \mathrm{Vrms}, 30 \mathrm{msec}, \mathrm{tr}=40 \mathrm{msec}$ | 62 |
| L | Vnom $115 \mathrm{~V}, 50 \mathrm{msec}$ | 6 |

SVF 301 Tests - Revision F

| SVF301 | Abnormal SS Limits Volt and Freq Rev F |  |  |  |  |
| :---: | :--- | :---: | :---: | :---: | :---: |
| Condition | Low Voltage | Duration (s) |  |  |  |
|  | 1800 |  |  |  |  |
| A | Vlow 100V, Fnom 400 Hz | 1800 |  |  |  |
| C | Vlow 100V, Flow 360 Hz | 1800 |  |  |  |
| D | Vlow 100V, Fhigh 600 Hz | 1800 |  |  |  |
|  | Vlow 100V, Fhigh 800 Hz |  |  |  |  |
| E | Vhigh 125V, Fnom 400 Hz | 1800 |  |  |  |
| F | Vhigh 125V, Flow 380 Hz | 1800 |  |  |  |
| G | Vhigh 125V, Fhigh 600 Hz | 1800 |  |  |  |
| H | Vhigh 125V, Fhigh 800 Hz | 1800 |  |  |  |

## SVF 302 Tests - Revision F

| SVF302 | Abnormal Voltage Transients. Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Run at 400, Repeat at 360,600 and 800 Hz |  |
|  | Over Voltage |  |
| A | $140 \mathrm{Vrms}, 180 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 52 |
| B | $140 \mathrm{Vrms}, 180 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=87 \mathrm{~ms}$ then 135 Vrms, ramp down, $\mathrm{tr}=253 \mathrm{msec}$ then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 V rms, ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 V rms. | 135 |
| C | $160 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 54 |
| D | $160 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=31 \mathrm{~ms}$ then 150 Vrms , ramp down, $\mathrm{tr}=71 \mathrm{msec}$ then 140 V rms, ramp down, $\mathrm{tr}=87 \mathrm{sec}$ then 135 Vrms , ramp down, $\mathrm{tr}>253 \mathrm{sec}$. then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 V rms, ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| E | $180 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}$, tr $<1.25 \mathrm{~ms}$ | 52 |
| F | $180 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=11 \mathrm{~ms}$ then 170 Vrms , ramp down, $\mathrm{tr}=17 \mathrm{msec}$ then 160 Vrms , ramp down, $\mathrm{tr}=31 \mathrm{msec}$ then 150 Vrms , ramp down, $\mathrm{tr}=71 \mathrm{msec}$ then 140 Vrms , ramp down, $\mathrm{tr}=87 \mathrm{sec}$ then 135 Vrms , ramp down, $\mathrm{tr}>253 \mathrm{sec}$. then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 Vrms , ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| G | $180 \mathrm{Vrms}, 3 \times 20 \mathrm{msec}, 0.5 \mathrm{sec}$ apart, tf < $0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 54 |
|  | Under Voltage |  |
| H | $85 \mathrm{Vrms}, 180 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 54 |
| I | $85 \mathrm{Vrms}, 180 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=87 \mathrm{~ms}$ then 90 Vrms , ramp up, $\mathrm{tr}=253 \mathrm{msec}$ then 95 Vrms , ramp up, $\mathrm{tr}=6.41 \mathrm{sec}$ then 100 V rms, ramp up, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| J | $66 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 54 |
| K | $65 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=31 \mathrm{~ms}$ then 75 V rms, ramp up, $\mathrm{tr}=71 \mathrm{msec}$ then 85 Vrms , ramp up, $\mathrm{tr}=87 \mathrm{msec}$ then 90 Vrms , ramp up, $\mathrm{tr}=253 \mathrm{msec}$ then 95 Vrms , ramp up, $\mathrm{tr}=6.41 \mathrm{sec}$ then 100 Vrms , ramp up, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| L | $45 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 52 |
| M | $45 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=11 \mathrm{~ms}$ then 55 V rms, ramp up, $\mathrm{tr}=17 \mathrm{msec}$ then 65 Vrms , ramp up, $\mathrm{tr}=31 \mathrm{msec}$ then 75 Vrms , ramp up, $\mathrm{tr}=71 \mathrm{msec}$ | 135 |


| SVF302 | Abnormal Voltage Transients. Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | then 85 V rms, ramp up, $\mathrm{tr}=87 \mathrm{msec}$ then 90Vrms, ramp up, $\mathrm{tr}=253 \mathrm{msec}$ then 95 Vrms , ramp up, $\mathrm{tr}=6.41 \mathrm{sec}$ then 100 V rms, ramp up, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . |  |
| N | $45 \mathrm{Vrms}, 3 \times 20 \mathrm{msec}, 0.5 \mathrm{sec}$ apart, tf $<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 58 |
|  | Combined Transient |  |
| O | $45 V \mathrm{rms}, 20 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ $180 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=11 \mathrm{~ms}$ then 170 Vrms , ramp down, $\mathrm{tr}=17 \mathrm{msec}$ then 160 Vrms , ramp down, $\mathrm{tr}=31 \mathrm{msec}$ then 150 Vrms , ramp down, $\mathrm{tr}=71 \mathrm{msec}$ then 140 Vrms , ramp down, $\mathrm{tr}=87 \mathrm{sec}$ then 135 V rms, ramp down, $\mathrm{tr}>253 \mathrm{sec}$. then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 V rms, ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |

SVF 303 Tests - Revision F

| SVF303 | Abnormal Frequency Transients. Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Frequency |  |
| A | 360 Hz 800 Hz , ts $=0.88 \mathrm{sec}, \mathrm{dur}=0.5 \mathrm{cyc}, \mathrm{tf}=0.88 \mathrm{sec}$ | 60 |
| B | 360 Hz 800 Hz , ts $=0.88 \mathrm{sec}, \mathrm{dur}=1 \mathrm{sec}, \mathrm{tf}=0.88 \mathrm{sec}$ | 65 |
| C | 360 Hz 800 Hz , ts $=0.48 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=0.48 \mathrm{sec}$ | 56 |
| D | 360 Hz 800 Hz , ts $=0.48 \mathrm{sec}$, dur $=1 \mathrm{sec}, \mathrm{tf}=0.48 \mathrm{sec}$ | 62 |
|  | Under Frequency |  |
| E | 800 Hz 360 Hz , ts $=0.88 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}$, $\mathrm{tf}=0.88 \mathrm{sec}$ | 61 |
| F | 800 Hz 360 Hz , ts $=0.88 \mathrm{sec}, \mathrm{dur}=1 \mathrm{sec}, \mathrm{tf}=0.88 \mathrm{sec}$ | 68 |
| G | 800 Hz 600 Hz , ts $=0.40 \mathrm{sec}, \mathrm{dur}=0.5 \mathrm{cyc}, \mathrm{tf}=0.40 \mathrm{sec}$ | 56 |
| H | 800 Hz 600 Hz , ts $=0.40 \mathrm{sec}$, dur $=1 \mathrm{sec}, \mathrm{tf}=0.40 \mathrm{sec}$ | 60 |
|  | Combined |  |
| 1 | 600 Hz 360 Hz , ts $=0.48 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}$, $\mathrm{tf}=0.48 \mathrm{sec}$ | 60 |
|  | 600 Hz 800 Hz , ts $=0.40 \mathrm{sec}, \mathrm{dur}=0.5 \mathrm{cyc}, \mathrm{tf}=0.40 \mathrm{sec}$ |  |

SVF 401 Tests - Revision F

| SVF401 | Emergency SS Limits Volt and Freq. Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Balanced Nominal Voltage |  |
| A | Vnom, 360 Hz | 1800 |
| B | Vnom, 400 Hz | 1800 |
| C | Vnom, 600 Hz | 1800 |
| D | Vlow, 800 Hz | 1800 |
|  | Balanced Low Voltage |  |
| E | $108 \mathrm{~V}, 360 \mathrm{~Hz}$ | 1800 |
| F | $108 \mathrm{~V}, 400 \mathrm{~Hz}$ | 1800 |
| G | $108 \mathrm{~V}, 440 \mathrm{~Hz}$ | 300 |
| H | $108 \mathrm{~V}, 480 \mathrm{~Hz}$ | 300 |
| I | $108 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| J | $108 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| K | $108 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| L | $108 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| M | $108 \mathrm{~V}, 540 \mathrm{~Hz}$ | 300 |
| N | $108 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| O | $108 \mathrm{~V}, 570 \mathrm{~Hz}$ | 300 |
| P | $108 \mathrm{~V}, 580 \mathrm{~Hz}$ | 300 |
| Q | $108 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| R | $108 \mathrm{~V}, 640 \mathrm{~Hz}$ | 300 |
| S | $108 \mathrm{~V}, 680 \mathrm{~Hz}$ | 300 |
| T | $108 \mathrm{~V}, 720 \mathrm{~Hz}$ | 300 |
| U | $108 \mathrm{~V}, 760 \mathrm{~Hz}$ | 300 |
| V | $108 \mathrm{~V}, 800 \mathrm{~Hz}$ | 1800 |
|  | Balanced High Voltage |  |
| W | $118 \mathrm{~V}, 360 \mathrm{~Hz}$ | 1800 |
| X | $118 \mathrm{~V}, 400 \mathrm{~Hz}$ | 1800 |
| Y | $118 \mathrm{~V}, 440 \mathrm{~Hz}$ | 300 |
| Z | $118 \mathrm{~V}, 480 \mathrm{~Hz}$ | 300 |
| AA | $118 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| BB | $118 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| CC | $118 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| DD | $118 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| EE | $118 \mathrm{~V}, 540 \mathrm{~Hz}$ | 300 |
| FF | $118 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| GG | $118 \mathrm{~V}, 570 \mathrm{~Hz}$ | 300 |
| HH | $118 \mathrm{~V}, 580 \mathrm{~Hz}$ | 300 |
| II | $118 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| JJ | $118 \mathrm{~V}, 640 \mathrm{~Hz}$ | 300 |
| KK | $118 \mathrm{~V}, 680 \mathrm{~Hz}$ | 300 |
| LL | $118 \mathrm{~V}, 720 \mathrm{~Hz}$ | 300 |
| MM | $118 \mathrm{~V}, 760 \mathrm{~Hz}$ | 300 |
| NN | $118 \mathrm{~V}, 800 \mathrm{~Hz}$ | 1800 |
|  | Unbalanced Nominal Voltage |  |
| N/A |  |  |

## SVF 501 Tests

Starting operations are not applicable to AC Utilization Equipment.

## SVF 601 Tests - Revision F

| SVF601 | Power Failure - One Phase |  |
| :---: | :--- | :---: |
| Condition |  |  |
|  | Run at 400, Repeat at $\mathbf{3 6 0 , 6 0 0}$ and $\mathbf{8 0 0 ~ H z}$ | Duration (s) |
| A | 100 msec | 52 |
| B | 500 msec | 54 |
| C | 3 sec | 66 |
| D | 7 sec | 86 |

SVF 602 Tests - Revision F
Not applicable for single-phase EUT's.

SVF 603 Tests - Revision F

| SVF603 | Power Failure - Phase Reversal |  |
| :---: | :--- | :---: |
| Condition | Duration (s) <br> N/AUse physical L-N connection reversal <br> Apply Vnom $=115 \mathrm{~V}$, Fnom $=400 \mathrm{~Hz}$ | 1800 |

### 11.7.4 TVF Group Tests

Three phase, variable frequency tests
Note: Variable frequency test are part of revision F only. There are no equivalent tests in revision A through $E$.

TVF 102 Tests - Revision F

| TVF102 | Steady State Voltage and Frequency - Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Balanced Nominal Voltage |  |
| A | Vnom, 360 Hz | 1800 |
| B | Vnom, 400 Hz | 1800 |
| C | Vnom, 600 Hz | 1800 |
| D | Vlow, 800 Hz | 1800 |
|  | Balanced Low Voltage |  |
| E | $108 \mathrm{~V}, 360 \mathrm{~Hz}$ | 1800 |
| F | $108 \mathrm{~V}, 400 \mathrm{~Hz}$ | 1800 |
| G | $108 \mathrm{~V}, 440 \mathrm{~Hz}$ | 300 |
| H | $108 \mathrm{~V}, 480 \mathrm{~Hz}$ | 300 |
| I | $108 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| J | $108 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| K | $108 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| L | $108 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| M | $108 \mathrm{~V}, 540 \mathrm{~Hz}$ | 300 |
| N | $108 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| 0 | $108 \mathrm{~V}, 570 \mathrm{~Hz}$ | 300 |
| P | $108 \mathrm{~V}, 580 \mathrm{~Hz}$ | 300 |
| Q | $108 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| R | $108 \mathrm{~V}, 640 \mathrm{~Hz}$ | 300 |
| S | $108 \mathrm{~V}, 680 \mathrm{~Hz}$ | 300 |
| T | $108 \mathrm{~V}, 720 \mathrm{~Hz}$ | 300 |
| U | $108 \mathrm{~V}, 760 \mathrm{~Hz}$ | 300 |
| V | $108 \mathrm{~V}, 800 \mathrm{~Hz}$ | 1800 |
|  | Balanced High Voltage |  |
| W | $118 \mathrm{~V}, 360 \mathrm{~Hz}$ | 1800 |
| X | $118 \mathrm{~V}, 400 \mathrm{~Hz}$ | 1800 |
| Y | $118 \mathrm{~V}, 440 \mathrm{~Hz}$ | 300 |
| Z | $118 \mathrm{~V}, 480 \mathrm{~Hz}$ | 300 |
| AA | $118 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| BB | $118 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| CC | $118 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| DD | $118 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| EE | $118 \mathrm{~V}, 540 \mathrm{~Hz}$ | 300 |
| FF | $118 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| GG | $118 \mathrm{~V}, 570 \mathrm{~Hz}$ | 300 |
| HH | $118 \mathrm{~V}, 580 \mathrm{~Hz}$ | 300 |
| II | $118 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| JJ | $118 \mathrm{~V}, 640 \mathrm{~Hz}$ | 300 |
| KK | $118 \mathrm{~V}, 680 \mathrm{~Hz}$ | 300 |
| LL | $118 \mathrm{~V}, 720 \mathrm{~Hz}$ | 300 |
| MM | $118 \mathrm{~V}, 760 \mathrm{~Hz}$ | 300 |
| NN | $118 \mathrm{~V}, 800 \mathrm{~Hz}$ | 1800 |
|  | Unbalanced Nominal Voltage |  |
| OO | $\mathrm{Va}=108 \mathrm{~V}, \mathrm{Vb}=111 \mathrm{~V}, \mathrm{Vc}=111 \mathrm{~V}, \mathrm{~F}=360 \mathrm{~Hz}$ | 1800 |
| PP | $\mathrm{Va}=118 \mathrm{~V}, \mathrm{Vb}=115 \mathrm{~V}, \mathrm{Vc}=115 \mathrm{~V}, \mathrm{~F}=360 \mathrm{~Hz}$ | 1800 |
| QQ | $\mathrm{Va}=108 \mathrm{~V}, \mathrm{Vb}=111 \mathrm{~V}, \mathrm{Vc}=111 \mathrm{~V}, \mathrm{~F}=800 \mathrm{~Hz}$ | 1800 |
| RR | $\mathrm{Va}=118 \mathrm{~V}, \mathrm{Vb}=115 \mathrm{~V}, \mathrm{Vc}=115 \mathrm{~V}, \mathrm{~F}=800 \mathrm{~Hz}$ | 1800 |

TVF 103 Tests - Revision F

| TVF103 | Voltage Phase Difference - Rev F |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
| A | $\mathrm{A}=0, \mathrm{~B}=116, \mathrm{C}=240$ | 1800 |
| B | $\mathrm{~A}=0, \mathrm{~B}=124, \mathrm{C}=240$ | 1800 |

TVF 104 Tests - Revision F

| TVF104 | Voltage Modulation - Rev B through F |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
|  | Run at 400, Repeat at 360,600 and 800 Hz |  |
| A | Vmod $F=1.0 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| B | Vmod F $=1.7 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| C | Vmod F $=10 \mathrm{~Hz}, \mathrm{~V}=2.5 \mathrm{Vrms}$ | 1800 |
| D | Vmod F $=25 \mathrm{~Hz}, \mathrm{~V}=2.5 \mathrm{Vrms}$ | 1800 |
| E | Vmod F $=70 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| F | Vmod F $=100 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| G | Vmod $F=200 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |

TVF 105 Tests - Revision F

| TVF105 | Frequency Modulation Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Run at 400, Repeat at 362, 600 and 798 Hz |  |
| A | Fmod F $=1 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |
| B | Fmod F $=5 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |
| C | Fmod F $=10 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |
| D | Fmod F $=25 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |
| E | Fmod F $=100 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $=4 \mathrm{~Hz} \pm 2 \mathrm{~Hz}$ | 1800 |

## TVF 106 Tests

Voltage distortion spectrum test require the use of additional external equipment. In particular, a high bandwidth (100Khz) AC source, a high frequency coupling transformer and coupling network as shown in figure TVF106-1 of the Mil-Std 704 standard. For this test, the Lx/Ls Series AC source can be programmed to a steady state condition of 360, 400, 600 and 800 Hz and Vnominal of 115 Vrms or 230 Vrms.

6. CAUTION: Verify suitability of variable frequency power source and coupling transformer for distortion spectrum testing.
7. Coupling Transformer shown is connected in series on Phase A. Testing is repeated with Coupling Transformer connected in series on Phase B and Phase C.

Figure 11-11: Required TVF-106 Test Setup.
TVF 107 Tests - Revision F

| TVF107 | Total Voltage Distortion Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Run at 400, Repeat at 360, 600 and 800 Hz |  |
| A | 0.05 \% VTHD | 1800 |
|  | $\mathrm{F}=100 \%$ |  |
|  | H3 = 2.75\% |  |
|  | H5 = 2.75\% |  |
|  | H7 $=1.97 \%$ |  |
|  | H9 = 1.53\% |  |
|  | H11 = 1.25\% |  |
|  | H13 = 1.06\% |  |
|  | H15 = 0.92\% |  |

## TVF 108 Tests

TVF108 are DC offset tests and are not supported by the Lx/Ls Series AC Power sources. Contact AMETEK Programmable Power for DC Supply information. (sales@programmablepower.com )

TVF 109 Tests - Revision F

| TVF109 | Normal Voltage Transients Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Run at 400, Repeat at 360, 600 and 800 Hz |  |
|  | Over Voltage |  |
| A | $140 \mathrm{Vrms}, 60 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 52 |
| B | $140 \mathrm{Vrms}, 60 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=25 \mathrm{~ms}$ | 52 |
| C | $160 \mathrm{Vrms}, 34 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 52 |
| D | $160 \mathrm{Vrms}, 34 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=25 \mathrm{~ms}$ | 52 |
| E | $180 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 52 |
| F | $180 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=77 \mathrm{~ms}$ | 52 |
| G | $180 \mathrm{Vrms}, 3 \times 10 \mathrm{msec}, 0.5 \mathrm{sec}$ apart, tf < $0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 56 |
|  | Under Voltage |  |
| H | $90 \mathrm{Vrms}, 35 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 52 |
| I | $90 \mathrm{Vrms}, 35 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=45 \mathrm{~ms}$ | 52 |
| J | $80 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 52 |
| K | $80 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=70 \mathrm{~ms}$ | 52 |
| L | $80 \mathrm{Vrms}, 3 \times 10 \mathrm{msec}, 0.5 \mathrm{apart}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 56 |
|  | Combined Transient |  |
| M | $80 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 52 |
|  | $180 \mathrm{Vrms}, 10 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=77 \mathrm{~ms}$ |  |
|  | Repetitive Transient |  |
| N | Repeats every 500 msec |  |

TVF 110 Tests - Revision F

| TVF110 | Normal Frequency Transients, Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Frequency |  |
| A | 360 Hz 800 Hz , ts $=1.76 \mathrm{sec}, \mathrm{dur}=0.5 \mathrm{cyc}, \mathrm{tf}=1.76 \mathrm{sec}$ | 100 |
| B | 360 Hz 800 Hz , ts $=1.76 \mathrm{sec}$, dur $=1 \mathrm{sec}, \mathrm{tf}=1.76 \mathrm{sec}$ | 80 |
| C | 360 Hz 800 Hz , ts $=0.96 \mathrm{sec}, \mathrm{dur}=0.5 \mathrm{cyc}, \mathrm{tf}=0.96 \mathrm{sec}$ | 60 |
| D | 360 Hz 800 Hz , ts $=0.96 \mathrm{sec}, \mathrm{dur}=1 \mathrm{sec}, \mathrm{tf}=0.96 \mathrm{sec}$ | 100 |
|  | Under Frequency |  |
| E | 800 Hz 360 Hz , ts $=1.76 \mathrm{sec}, \mathrm{dur}=0.5 \mathrm{cyc}, \mathrm{tf}=1.76 \mathrm{sec}$ | 100 |
| F | 800 Hz 360 Hz , ts $=1.76 \mathrm{sec}, \mathrm{dur}=1 \mathrm{sec}, \mathrm{tf}=1.76 \mathrm{sec}$ | 80 |
| G | 800 Hz 600 Hz , ts $=0.80 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=0.80 \mathrm{sec}$ | 60 |
| H | 800 Hz 600 Hz , ts $=0.80 \mathrm{sec}, \mathrm{dur}=1 \mathrm{sec}, \mathrm{tf}=0.80 \mathrm{sec}$ | 100 |
|  | Combined |  |
| I | 600 Hz 360 Hz , ts $=0.96 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}$, $\mathrm{tf}=0.96 \mathrm{sec}$ | 62 |
|  | 600 Hz 800 Hz , ts $=0.80 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=0.80 \mathrm{sec}$ |  |

TVF 201 Tests -Revision F

| TVF201 | Power Interrupt, Rev F |  |
| :---: | :--- | :---: |
| Condition | Run at 400, Repeat at $\mathbf{3 6 0}, \mathbf{6 0 0}$ and $\mathbf{8 0 0} \mathbf{~ H z}$ | Duration (s) |
| A | Vnom $115 \mathrm{~V}, 50 \mathrm{msec}$ | 62 |
| B | Vlow $108 \mathrm{~V}, 50 \mathrm{msec}$ | 62 |
| C | Vhigh $118 \mathrm{~V}, 50 \mathrm{msec}$ | 62 |
| D | Vnom $115 \mathrm{~V}, 30 \mathrm{msec}$ | 62 |
| E | Vlow $108 \mathrm{~V}, 30 \mathrm{msec}$ | 62 |
| F | Vhigh $118 \mathrm{~V}, 30 \mathrm{msec}$ | 62 |
| G | Vnom $115 \mathrm{~V}, 10 \mathrm{msec}$ | 62 |
| H | Vlow $108 \mathrm{~V}, 10 \mathrm{msec}$ | 62 |
| I | Vhigh $118 \mathrm{~V}, 10 \mathrm{msec}$ | 62 |
| J | Vnom $115 \mathrm{~V}, 3 \times 50 \mathrm{msec}, 0.5 \mathrm{sec}$ apart | 62 |
| K | Vnom $115 \mathrm{~V}, 50 \mathrm{msec}$ | 62 |
|  | $160 \mathrm{Vrms}, 30 \mathrm{msec}, \mathrm{tr}=40 \mathrm{msec}$ | 62 |
| L | Vnom $115 \mathrm{~V}, 50 \mathrm{msec}$ | 6 |

TVF 301 Tests - Revision F

| TVF301 | Abnormal SS Limits Volt and Freq Rev F |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
|  |  |  |
| A | Vlow 100V, Fnom 400 Hz | 1800 |
| B | Vlow 100V, Flow 360 Hz | 1800 |
| C | Vlow 100 V, Fhigh 600 Hz | 1800 |
| D | Vlow 100 V, Fhigh 800 Hz | 1800 |
| E |  | 1800 |
| F | Vhigh 125V, Fnom 400 Hz | 1800 |
| G | Vhigh 125V, Flow 380 Hz | 1800 |
| H | Vhigh 125 V, Fhigh 600 Hz | 1800 |

TVF 302 Tests - Revision F

| TVF302 | Abnormal Voltage Transients. Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Run at 400, Repeat at 360, 600 and 800 Hz |  |
|  | Over Voltage |  |
| A | $140 \mathrm{Vrms}, 180 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}$, tr $<0.5 \mathrm{cyc}$ | 52 |
| B | $140 \mathrm{Vrms}, 180 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=87 \mathrm{~ms}$ then 135 V rms, ramp down, $\mathrm{tr}=253 \mathrm{msec}$ then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 V rms, ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 V rms. | 135 |
| C | $160 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 54 |
| D | $160 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=31 \mathrm{~ms}$ then 150 Vrms , ramp down, $\mathrm{tr}=71 \mathrm{msec}$ then 140 Vrms , ramp down, $\mathrm{tr}=87 \mathrm{sec}$ then 135 Vrms , ramp down, $\mathrm{tr}>253 \mathrm{sec}$. then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 Vrms , ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| E | $180 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ | 52 |
| F | $180 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=11 \mathrm{~ms}$ then 170 Vrms , ramp down, $\mathrm{tr}=17 \mathrm{msec}$ then 160 Vrms , ramp down, $\mathrm{tr}=31 \mathrm{msec}$ then 150 Vrms , ramp down, $\mathrm{tr}=71 \mathrm{msec}$ then 140 Vrms, ramp down, $\mathrm{tr}=87 \mathrm{sec}$ then 135 Vrms , ramp down, $\mathrm{tr}>253 \mathrm{sec}$. then 130 Vrms , ramp down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 Vrms , ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| G | $180 \mathrm{Vrms}, 3 \times 20 \mathrm{msec}, 0.5 \mathrm{sec}$ apart, tf < 0.5 cyc , tr $<0.5$ cyc | 54 |
|  | Under Voltage |  |
| H | 85Vrms, $180 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 54 |
| I | $85 \mathrm{Vrms}, 180 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=87 \mathrm{~ms}$ then 90 Vrms , ramp up, $\mathrm{tr}=253 \mathrm{msec}$ then 95 Vrms , ramp up, $\mathrm{tr}=6.41 \mathrm{sec}$ then 100 Vrms , ramp up, tr $>10 \mathrm{sec}$ then 115 Vrms . | 135 |
| J | $66 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}$, tr $<0.5 \mathrm{cyc}$ | 54 |
| K | $65 \mathrm{Vrms}, 78 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=31 \mathrm{~ms}$ then 75 V rms, ramp up, $\mathrm{tr}=71 \mathrm{msec}$ then 85 Vrms , ramp up, $\mathrm{tr}=87 \mathrm{msec}$ then 90 Vrms , ramp up, $\mathrm{tr}=253 \mathrm{msec}$ then 95 Vrms , ramp up, $\mathrm{tr}=6.41 \mathrm{sec}$ then 100 V rms, ramp up, $\mathrm{tr}>10 \mathrm{sec}$ then 115 V rms. | 135 |
| L | $45 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}$ < 0.5 cyc , tr $<0.5 \mathrm{cyc}$ | 52 |


| TVF302 | Abnormal Voltage Transients. Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
| M | $45 \mathrm{Vrms}, 50 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=11 \mathrm{~ms}$ then 55 Vrms , ramp up, $\mathrm{tr}=17 \mathrm{msec}$ then 65 Vrms , ramp up, $\mathrm{tr}=31 \mathrm{msec}$ then 75 Vrms , ramp up, $\mathrm{tr}=71 \mathrm{msec}$ then 85 V rms, ramp up, $\mathrm{tr}=87 \mathrm{msec}$ then 90 Vrms , ramp up, $\mathrm{tr}=253 \mathrm{msec}$ then 95 Vrms , ramp up, $\mathrm{tr}=6.41 \mathrm{sec}$ then 100 Vrms , ramp up, $\mathrm{tr}>10 \mathrm{sec}$ then 115 V rms. | 135 |
| N | $45 \mathrm{Vrms}, 3 \times 20 \mathrm{msec}, 0.5 \mathrm{sec}$ apart, tf < $0.5 \mathrm{cyc}, \mathrm{tr}<0.5 \mathrm{cyc}$ | 58 |
|  | Combined Transient |  |
| O | $45 V \mathrm{rms}, 20 \mathrm{msec}, \mathrm{tf}<1.25 \mathrm{~ms}, \mathrm{tr}<1.25 \mathrm{~ms}$ $180 V \mathrm{rms}, 50 \mathrm{msec}, \mathrm{tf}<0.5 \mathrm{cyc}, \mathrm{tr}=11 \mathrm{~ms}$ then 170 Vrms , ramp down, $\mathrm{tr}=17 \mathrm{msec}$ then 160 V rms , ramp down, $\mathrm{tr}=31 \mathrm{msec}$ then 150 Vrms , ramp down, $\mathrm{tr}=71 \mathrm{msec}$ then 140 Vrms , ramp down, $\mathrm{tr}=87 \mathrm{sec}$ then 135 V rms, ramp down, $\mathrm{tr}>253 \mathrm{sec}$. then $130 \mathrm{Vrms}, \mathrm{ramp}$ down, $\mathrm{tr}=6.41 \mathrm{sec}$ then 125 V rms, ramp down, $\mathrm{tr}>10 \mathrm{sec}$ then 115 Vrms . | 135 |

## TVF 303 Tests - Revision F

| TVF303 | Abnormal Frequency Transients. Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Frequency |  |
| A | 360 Hz 800 Hz , ts $=0.88 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=0.88 \mathrm{sec}$ | 60 |
| B | 360 Hz 800 Hz , ts $=0.88 \mathrm{sec}, \mathrm{dur}=1 \mathrm{sec}, \mathrm{tf}=0.88 \mathrm{sec}$ | 65 |
| C | 360 Hz 800 Hz , ts $=0.48 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=0.48 \mathrm{sec}$ | 56 |
| D | 360 Hz 800 Hz , ts $=0.48 \mathrm{sec}, \mathrm{dur}=1 \mathrm{sec}, \mathrm{tf}=0.48 \mathrm{sec}$ | 62 |
|  | Under Frequency |  |
| E | 800 Hz 360 Hz , ts $=0.88 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=0.88 \mathrm{sec}$ | 61 |
| F | 800 Hz 360 Hz , ts $=0.88 \mathrm{sec}$, dur $=1 \mathrm{sec}, \mathrm{tf}=0.88 \mathrm{sec}$ | 68 |
| G | 800 Hz 600 Hz , ts $=0.40 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=0.40 \mathrm{sec}$ | 56 |
| H | 800 Hz 600 Hz , ts $=0.40 \mathrm{sec}$, dur $=1 \mathrm{sec}, \mathrm{tf}=0.40 \mathrm{sec}$ | 60 |
|  | Combined |  |
| I | 600 Hz 360 Hz , ts $=0.48 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=0.48 \mathrm{sec}$ | 60 |
|  | 600 Hz 800 Hz , ts $=0.40 \mathrm{sec}$, dur $=0.5 \mathrm{cyc}, \mathrm{tf}=0.40 \mathrm{sec}$ |  |

TVF 401 Tests - Revision F

| TVF401 | Emergency SS Limits Volt and Freq. Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Balanced Nominal Voltage |  |
| A | Vnom, 360 Hz | 1800 |
| B | Vnom, 400 Hz | 1800 |
| C | Vnom, 600 Hz | 1800 |
| D | Vlow, 800 Hz | 1800 |
|  | Balanced Low Voltage |  |
| E | $108 \mathrm{~V}, 360 \mathrm{~Hz}$ | 1800 |
| F | $108 \mathrm{~V}, 400 \mathrm{~Hz}$ | 1800 |
| G | $108 \mathrm{~V}, 440 \mathrm{~Hz}$ | 300 |
| H | $108 \mathrm{~V}, 480 \mathrm{~Hz}$ | 300 |
| 1 | $108 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| J | $108 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| K | $108 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| L | $108 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| M | $108 \mathrm{~V}, 540 \mathrm{~Hz}$ | 300 |
| N | $108 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| 0 | $108 \mathrm{~V}, 570 \mathrm{~Hz}$ | 300 |
| P | $108 \mathrm{~V}, 580 \mathrm{~Hz}$ | 300 |
| Q | $108 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| R | $108 \mathrm{~V}, 640 \mathrm{~Hz}$ | 300 |
| S | $108 \mathrm{~V}, 680 \mathrm{~Hz}$ | 300 |
| T | $108 \mathrm{~V}, 720 \mathrm{~Hz}$ | 300 |
| U | $108 \mathrm{~V}, 760 \mathrm{~Hz}$ | 300 |
| V | $108 \mathrm{~V}, 800 \mathrm{~Hz}$ | 1800 |
|  | Balanced High Voltage |  |
| W | $118 \mathrm{~V}, 360 \mathrm{~Hz}$ | 1800 |
| X | $118 \mathrm{~V}, 400 \mathrm{~Hz}$ | 1800 |
| Y | $118 \mathrm{~V}, 440 \mathrm{~Hz}$ | 300 |
| Z | $118 \mathrm{~V}, 480 \mathrm{~Hz}$ | 300 |
| AA | $118 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| BB | $118 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| CC | $118 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| DD | $118 \mathrm{~V}, 520 \mathrm{~Hz}$ | 300 |
| EE | $118 \mathrm{~V}, 540 \mathrm{~Hz}$ | 300 |
| FF | $118 \mathrm{~V}, 560 \mathrm{~Hz}$ | 300 |
| GG | $118 \mathrm{~V}, 570 \mathrm{~Hz}$ | 300 |
| HH | $118 \mathrm{~V}, 580 \mathrm{~Hz}$ | 300 |
| 11 | $118 \mathrm{~V}, 600 \mathrm{~Hz}$ | 1800 |
| JJ | $118 \mathrm{~V}, 640 \mathrm{~Hz}$ | 300 |
| KK | $118 \mathrm{~V}, 680 \mathrm{~Hz}$ | 300 |
| LL | $118 \mathrm{~V}, 720 \mathrm{~Hz}$ | 300 |
| MM | $118 \mathrm{~V}, 760 \mathrm{~Hz}$ | 300 |
| NN | $118 \mathrm{~V}, 800 \mathrm{~Hz}$ | 1800 |
|  | Unbalanced Nominal Voltage |  |
| 00 | $\mathrm{Va}=108 \mathrm{~V}, \mathrm{Vb}=111 \mathrm{~V}, \mathrm{Vc}=111 \mathrm{~V}, \mathrm{~F}=360 \mathrm{~Hz}$ | 1800 |
| PP | $\mathrm{Va}=118 \mathrm{~V}, \mathrm{Vb}=115 \mathrm{~V}, \mathrm{Vc}=115 \mathrm{~V}, \mathrm{~F}=360 \mathrm{~Hz}$ | 1800 |
| QQ | $\mathrm{Va}=108 \mathrm{~V}, \mathrm{Vb}=111 \mathrm{~V}, \mathrm{Vc}=111 \mathrm{~V}, \mathrm{~F}=800 \mathrm{~Hz}$ | 1800 |
| RR | $\mathrm{Va}=118 \mathrm{~V}, \mathrm{Vb}=115 \mathrm{~V}, \mathrm{Vc}=115 \mathrm{~V}, \mathrm{~F}=800 \mathrm{~Hz}$ | 1800 |

## TVF 501 Tests

Starting operations are not applicable to AC Utilization Equipment.
TVF 601 Tests - Revision F

| TVF601 | Power Failure - One Phase - Rev F |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
|  | Run at 400, Repeat at 360, $\mathbf{6 0 0}$ and $\mathbf{8 0 0} \mathbf{~ H z}$ |  |
| A | 100 msec | 52 |
| B | 500 msec | 54 |
| C | 3 sec | 66 |
| D | 7 sec | 86 |

TVF 602 Tests - Revision F

| TVF601 | Power Failure - One, Two Phase - Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Run at 400, Repeat at 360, 600 and 800 Hz |  |
|  | One Phase |  |
| A | Phase A, 7 sec - 5 x | 86 |
| B | Phase B, 7 sec - $5 x$ | 86 |
| C | Phase C, 7 sec - 5x | 86 |
| D | Phase A, $30 \mathrm{~min}-1 \mathrm{x}$ | 1800 |
| E | Phase B, 30 min - 1x | 1800 |
| F | Phase C, $30 \mathrm{~min}-1 \mathrm{x}$ | 1800 |
|  | Two Phase |  |
| G | Phase A\&B, 7 sec - 5 x | 86 |
| H | Phase B\&C, $7 \mathrm{sec}-5 \mathrm{x}$ | 86 |
| 1 | Phase A\&B, 30 min - 1 x | 1800 |
| J | Phase B\&C, 30 min - 1 x | 1800 |

TVF 603 Tests - Revision F

| TVF603 | Power Failure - Phase Reversal - Rev F |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
|  | Run at 400, Repeat at 360, 600 and 800 Hz |  |
| A | Phase rotation C-B-A | 1800 |
|  | Phase rotation A-B-C | 1800 |

### 11.7.5 SXF Group Tests

Single phase 60 Hz AC tests
Note: 60 Hz frequency tests are part of revision F only. There are no equivalent tests in revision A through E.

SXF 102 Tests - Revision F

| SXF102 | Steady State Voltage and Frequency - Rev C-F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltage |  |
| A | Vnom=115V, Fnom=60 Hz - Nominal | 1800 |
| B | Vnom=115V, Flow $=59.5 \mathrm{~Hz}$ - Nominal | 1800 |
| C | Vnom=115V, Fhigh $=60.5 \mathrm{~Hz}$ - Nominal | 1800 |
|  | Low Voltage |  |
| D | Vlow $=105 \mathrm{~V}$, Fnom=60 Hz - Low | 1800 |
| E | Vlow=105V, Flow $=59.5 \mathrm{~Hz}$ - Low | 1800 |
| F | Vlow=105V, Fhigh=60.5 Hz - Low | 1800 |
|  | High Voltage |  |
| G | Vhigh=125V, Fnom=60 Hz - High | 1800 |
| H | Vhigh=125V, Flow $=59.5 \mathrm{~Hz}$ - High | 1800 |
| I | Vhigh=125V, Fhigh=60.5 Hz - High | 1800 |

## SXF 103 Tests

Voltage Phase Difference tests do not apply for single-phase EUT's.

SXF 104 Tests - Revision F

| SXF104 | Voltage Modulation Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
| A | $\mathrm{Vmod} \mathrm{F}=1.0 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| B | $\mathrm{Vmod} F=1.5 \mathrm{~Hz}, \mathrm{~V}=2.5 \mathrm{Vrms}$ | 1800 |
| C | $\mathrm{Vmod} \mathrm{F}=4 \mathrm{~Hz}, \mathrm{~V}=2.5 \mathrm{Vrms}$ | 1800 |
| D | $\mathrm{Vmod} \mathrm{F}=10 \mathrm{~Hz}$, V $=0.375 \mathrm{Vrms}$ | 1800 |
| E | $\mathrm{Vmod} \mathrm{F}=15 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |
| F | $\mathrm{Vmod} \mathrm{F}=30 \mathrm{~Hz}, \mathrm{~V}=0.375 \mathrm{Vrms}$ | 1800 |

SXF 105 Tests - Revisions E, F

| SXF105 | Frequency Modulation Rev F | Duration (s) |
| :---: | :--- | :---: |
| Condition |  | 1800 |
| A | Fmod $F=0.1 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $=0.5 \mathrm{~Hz} \pm 0.25 \mathrm{~Hz}$ | 1800 |
| B | Fmod $F=0.5 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $=0.5 \mathrm{~Hz} \pm 0.25 \mathrm{~Hz}$ | 1800 |
| C | Fmod $F=4 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $=0.5 \mathrm{~Hz} \pm 0.25 \mathrm{~Hz}$ | 1800 |
| E | Fmod F $=25 \mathrm{~Hz} / \mathrm{sec}$, Fmod Amp $=0.5 \mathrm{~Hz} \pm 0.25 \mathrm{~Hz}$ | 1800 |

## SXF 106 Tests

Voltage distortion spectrum test require the use of additional external equipment. In particular, a high bandwidth (100Khz) AC source, a high frequency coupling transformer and coupling network as shown in figure SXF106-1 of the Mil-Std 704 standard. For this test, the Lx/Ls Series AC source can be programmed to a steady state condition of 400 Hz and Vnominal of 115 Vrms or 230 Vrms.


Figure 11-12: Required SXF-106 Test Setup.

SXF 107 Tests - Revision F

| SXF107 | Total Voltage Distortion Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
| A | 0.05 \% VTHD | 1800 |
|  | $\mathrm{F}=100 \%$ |  |
|  | H3 = 2.75\% |  |
|  | H5 = 2.75\% |  |
|  | H7 $=1.97 \%$ |  |
|  | H9 = 1.53\% |  |
|  | H11 = 1.25\% |  |
|  | H13 = 1.06\% |  |
|  | H15 = 0.92\% |  |

## SXF 108 Tests

SXF108 are DC offset tests and are not supported by the Lx/Ls Series AC Power sources. Contact AMETEK Programmable Power for DC Supply information.
(sales@programmablepower.com )

SXF 109 Tests - Revision F

| SXF109 | Normal Voltage Transients Rev F |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
|  |  |  |
| A | $152 \mathrm{Vrms}, 0.5 \mathrm{cyc}, \mathrm{tf}<\mathrm{n} / \mathrm{a}, \mathrm{tr}<\mathrm{na}$ | 52 |
| B | $130 \mathrm{Vrms}, 1.0 \mathrm{cyc}, \mathrm{tf}<8.333 \mathrm{~ms}, \mathrm{tr}<8.333 \mathrm{~ms}$ | 52 |
| C | $130 \mathrm{Vrms}, 1.0 \mathrm{cyc}, \mathrm{tf}<8.333 \mathrm{~ms}, \mathrm{tr}=250 \mathrm{~ms}$ | 52 |
| D | $130 \mathrm{Vrms}, 3 \times 1.0 \mathrm{cyc}, 0.5 \mathrm{apart}, \mathrm{tf}<8.333 \mathrm{~ms}, \mathrm{tr}<8.333 \mathrm{~ms}$ | 56 |
| E |  | Under Voltage |
| F | $71 \mathrm{Vrms}, 0.5 \mathrm{cyc}, \mathrm{tf}<\mathrm{n} / \mathrm{a}, \mathrm{tr}<\mathrm{na}$ | 5 |
| G | $70 \mathrm{Vrms}, 1.0 \mathrm{cyc}, \mathrm{tf}<8.333 \mathrm{~ms}, \mathrm{tr}<8.333 \mathrm{~ms}$ | 52 |
| H | $70 \mathrm{Vrms}, 3 \times 1.0 \mathrm{cyc}, 0.5 \mathrm{apart}, \mathrm{tf}<8.333 \mathrm{~ms}, \mathrm{tr}<8.333 \mathrm{~ms}$ | 52 |
| I |  | $70 \mathrm{Vrms}, 1.0 \mathrm{cyc}, \mathrm{tf}<8.333 \mathrm{~ms}, \mathrm{tr}<8.333 \mathrm{~ms}$ |

SXF 110 Tests - Revision F

| SXF110 | Normal Frequency Transients, Rev F |  |
| :---: | :--- | :---: |
| Condition |  | Duration (s) |
|  |  |  |
| A | $61 \mathrm{~Hz}, 0.5 \mathrm{cyc}, \mathrm{tr}=10 \mathrm{msec}, \mathrm{tf}=10 \mathrm{msec}$ | 100 |
| B | $61 \mathrm{~Hz}, 5 \mathrm{sec}, \mathrm{tr}=10 \mathrm{msec}, \mathrm{tf}=10 \mathrm{msec}$ | 80 |
| C |  | Under Frequency |
| D | $59 \mathrm{~Hz}, 0.5 \mathrm{cyc}, \mathrm{tr}=10 \mathrm{msec}, \mathrm{tf}=10 \mathrm{msec}$ | 100 |
| E | $59 \mathrm{~Hz}, 5 \mathrm{sec}, \mathrm{tr}=10 \mathrm{msec}, \mathrm{tf}=10 \mathrm{msec}$ | 80 |
|  | $59 \mathrm{~Hz}, 0.5 \mathrm{cyc}, \mathrm{tr}=10 \mathrm{msec}, \mathrm{tf}=10 \mathrm{msec}$ | 62 |

## SXF 201 Tests -Revision F

| SXF201 | Power Interrupt, Rev F | Duration (s) |
| :---: | :--- | :---: |
| Condition |  | 62 |
| A | Vnom 115V, 50 msec | 62 |
| B | Vlow $105 \mathrm{~V}, 50 \mathrm{msec}$ | 62 |
| C | Vhigh $125 \mathrm{~V}, 50 \mathrm{msec}$ | 62 |
| D | Vnom $115 \mathrm{~V}, 30 \mathrm{msec}$ | 62 |
| E | Vlow $105 \mathrm{~V}, 30 \mathrm{msec}$ | 62 |
| F | Vhigh $125 \mathrm{~V}, 30 \mathrm{msec}$ | 62 |
| G | Vnom $115 \mathrm{~V}, 10 \mathrm{msec}$ | 62 |
| H | Vlow $105 \mathrm{~V}, 10 \mathrm{msec}$ | 62 |
| J | Vhigh $125 \mathrm{~V}, 10 \mathrm{msec}$ | 62 |
| J | Vnom $115 \mathrm{~V}, 3 \times 50 \mathrm{msec}, 0.5 \mathrm{sec}$ apart | 62 |
| K | Vnom $115 \mathrm{~V}, 50 \mathrm{msec}$ |  |
|  | 130Vrms, $0.5 \mathrm{cyc}, \mathrm{tr}=250 \mathrm{msec}$ | 62 |
|  | L | Vnom $115 \mathrm{~V}, 50 \mathrm{msec}$ |

SXF 301 Tests - Revision F

| SXF301 | Abnormal SS Limits Volt and Freq Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltage |  |
| A | Vnom 115V, Flow 59.5 Hz | 1800 |
| B | Vnom 115V, Fhigh 60.5 Hz | 1800 |
|  | Low Voltage |  |
| C | Vlow 100V, Fnom 400 Hz | 1800 |
| D | Vlow 100V, Flow 380 Hz | 1800 |
| E | Vlow 100V, Fhigh 420 Hz | 1800 |
|  | High Voltage |  |
| F | Vhigh 128V, Fnom 60 Hz | 1800 |
| G | Vhigh 128V, Flow 59.5 Hz | 1800 |
| H | Vhigh 128V, Fhigh 60.5 Hz | 1800 |

SXF 302 Tests - Revision F

| SXF302 | Abnormal Voltage Transients. Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Over Voltage |  |
| A | $180 \mathrm{Vrms}, 0.5 \mathrm{cyc}, \mathrm{tf}<8.333 \mathrm{~ms}, \mathrm{tr}<8.333 \mathrm{~ms}$ | 54 |
| B | $180 \mathrm{Vrms}, 0.5 \mathrm{cyc}, \mathrm{tf}<8.333 \mathrm{~ms}, \operatorname{tr}=16.67 \mathrm{~ms}$ then 147Vrms, ramp down, $\mathrm{tr}=16.67 \mathrm{msec}$ then 140 Vrms , ramp down, $\mathrm{tr}=2.0 \mathrm{sec}$ then 115 V rms. | 135 |
| C | $160 \mathrm{Vrms}, 1.0 \mathrm{cyc}$, $\mathrm{tf}<8.333 \mathrm{~ms}$, $\mathrm{tr}<8.333 \mathrm{~ms}$ | 54 |
| D | $160 \mathrm{Vrms}, 0.5 \mathrm{cyc}, \mathrm{tf}<8.333 \mathrm{~ms}, \mathrm{tr}=16.67 \mathrm{~ms}$ then 140 Vrms , ramp down, $\mathrm{tr}=2.0 \mathrm{sec}$ then 115 V rms. | 135 |
| E | $180 \mathrm{Vrms}, 3 \times 0.5 \mathrm{cyc}, 0.5 \mathrm{sec}$ apart, $\mathrm{tf}<8.333 \mathrm{~ms}$, tr $<8.333 \mathrm{~ms}$ | 54 |
|  | Under Voltage |  |
| F | $50 \mathrm{Vrms}, 0.5 \mathrm{cyc}, \mathrm{tf}<8.333 \mathrm{~ms}$, $\mathrm{tr}<8.333 \mathrm{~ms}$ | 54 |
| G | $50 \mathrm{Vrms}, 0.5 \mathrm{cyc}, \mathrm{tf}<8.333 \mathrm{~ms}, \mathrm{tr}=16.67 \mathrm{~ms}$ then 83 Vrms , ramp up, $\mathrm{tr}=16.67 \mathrm{msec}$ then 90 Vrms , ramp up, $\mathrm{tr}=2.0 \mathrm{sec}$ then 115 V rms. | 135 |
| H | $70 \mathrm{Vrms}, 1.0 \mathrm{cyc}, \mathrm{tf}<8.333 \mathrm{~ms}$, tr $<8.333 \mathrm{~ms}$ | 54 |
| 1 | $70 \mathrm{Vrms}, 0.5 \mathrm{cyc}, \mathrm{tf}<8.333 \mathrm{~ms}, \mathrm{tr}=16.67 \mathrm{~ms}$ then 90 Vrms , up, $\mathrm{tr}=2.0 \mathrm{sec}$ then 115 V rms. | 135 |
| J | $50 \mathrm{Vrms}, 3 \times 0.5 \mathrm{cyc}, 0.5 \mathrm{sec}$ apart, tf < 8.333 ms , tr $<8.333 \mathrm{~ms}$ | 54 |
|  | Combined Transient |  |
| K | $50 \mathrm{Vrms}, 0.5 \mathrm{cyc}, \mathrm{tf}<8.333 \mathrm{~ms}$, $\mathrm{tr}<8.333 \mathrm{~ms}$ $180 \mathrm{Vrms}, 0.5 \mathrm{cyc}, \mathrm{tf}<8.333 \mathrm{~ms}, \mathrm{tr}=16.67 \mathrm{~ms}$ then 147 V rms, ramp down, $\mathrm{tr}=16.67 \mathrm{msec}$ then 140 Vrms , ramp down, $\mathrm{tr}=2.0 \mathrm{sec}$ then 115 V rms. | 135 |

SXF 303 Tests - Revision F

| SXF303 | Abnormal Frequency Transients. Rev F |  |
| :---: | :--- | :---: |
| Condition | Over Frequency | Duration (s) |
|  | $61 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=0.5 \mathrm{cyc}, \mathrm{tf}=0.5 \mathrm{cyc}$ | 55 |
| A | $61 \mathrm{~Hz}, 6.968 \mathrm{sec}, \mathrm{tr}=0.5 \mathrm{cyc}, \mathrm{tf}=0.5 \mathrm{cyc}$ | Under Frequency |
| B | $59 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=0.5 \mathrm{cyc}, \mathrm{tf}=0.5 \mathrm{cyc}$ | 76 |
| C | $59 \mathrm{~Hz}, 6.968 \mathrm{sec}, \mathrm{tr}=0.5 \mathrm{cyc}, \mathrm{tf}=0.5 \mathrm{cyc}$ | 55 |
| D | Combined |  |
| E | $59 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=0.5 \mathrm{cyc}, \mathrm{tf}=0.5 \mathrm{cyc}$ | 76 |
|  | $61 \mathrm{~Hz}, 0.5 \mathrm{cycle}, \mathrm{tr}=0.5 \mathrm{cyc}, \mathrm{tf}=0.5 \mathrm{cyc}$ | 56 |

SXF 401 Tests - Revision F

| SXF401 | Emergency SS Limits Volt and Freq. Rev F |  |
| :---: | :---: | :---: |
| Condition |  | Duration (s) |
|  | Nominal Voltage |  |
| A | Vnom=115V, Fnom=60 Hz - Nominal | 1800 |
| B | Vnom=115V, Flow $=59.5 \mathrm{~Hz}$ - Nominal | 1800 |
| C | Vnom=115V, Fhigh $=60.5 \mathrm{~Hz}$ - Nominal |  |
|  | Low Voltage |  |
| D | Vlow $=105 \mathrm{~V}$, Fnom= 60 Hz - Low | 1800 |
| E | Vlow=105V, Flow $=59.5 \mathrm{~Hz}$ - Low | 1800 |
| F | Vlow=105V, Fhigh=60.5 Hz - Low | 1800 |
|  | High Voltage |  |
| G | Vhigh=125V, Fnom=60 Hz - High | 1800 |
| H | Vhigh=125V, Flow=59.5 Hz- High | 1800 |
| 1 | Vhigh $=125 \mathrm{~V}$, Fhigh $=60.5 \mathrm{~Hz}$ - High | 1800 |

## SXF 501 Tests

Starting operations are not applicable to AC Utilization Equipment.
SXF 601 Tests - Revision F

| SXF601 | Power Failure - One Phase | Duration (s) |  |  |
| :---: | :--- | :---: | :---: | :---: |
| Condition | 52 |  |  |  |
| A | 100 msec | 54 |  |  |
| B | 500 msec | 66 |  |  |
| C | 2 sec | 6 |  |  |

## SXF 602 Tests - Revision F

Not applicable for single-phase EUT's.

## SXF 603 Tests - Revision F

| SXF603 | Power Failure - Phase Reversal | Duration (s) |
| :---: | :--- | :---: |
| Condition | Use physical L-N connection reversal <br> Apply Vnom $=115 \mathrm{~V}$, Fnom $=60 \mathrm{~Hz}$ | 1800 |
| N/A |  |  |

### 11.8 MS704 Operation Using the LxGui Software

The LxGui supplied with the Lx/Ls Series AC power sources can be used to operate the MS704 option. The LxGui detects the presence of this option and enables access to the relevant operating screens. If you are unable to access the MS704 option screens from within the LxGui, you do not have the -704F option (MS704) installed or the firmware in your unit pre-dates release of the MS704 version of this option. In that case, contact AMETEK Programmable Power for upgrade information. (sales@calist.com )
The information on use of the LxGui with the MS704 option is also contained in the on-line help file of the LxGui program.

> | Note: | $\begin{array}{l}\text { For Ls Series AC sources without the -ADV option installed, the harmonic } \\ \text { analysis and waveform acquisition functions described in this section are not } \\ \text { available. Contact sales@programmablepower.com to upgrade the Ls AC Source } \\ \text { with the -ADV option. The MIL-STD } 704 \text { stimulus can still be run however. }\end{array}$ |
| :--- | :--- |

### 11.8.1 Steady State Settings

To access the MS704 test screen, the steady state settings of the Lx/Ls AC source must meet the following conditions:

| Parameter | Setting | Notes |
| :--- | :--- | :--- |
| Output voltage for all phases: | 115 Vrms or 230 Vrms | Line to Neutral. |
| Frequency: | Between 360 and 800 Hz <br> or 60 Hz. |  |
| Phase Rotations: | $\mathrm{A}=0^{\circ}, \mathrm{B}=240^{\circ}, \mathrm{C}=120^{\circ}$ | Three phase mode only. |

If one or more conditions is not met, the MS704 screen cannot be opened but instead an error message indicated the above conditions must be met will be displayed. The state of the output relay (open or closed) is not important. If needed, the output relay will be closed when the user starts a test.

The Mil-Std 704 tests can be selected from the LxGui toolbar or menu. There is a separate toolbar button for -704 and -704 F options or an individual menu entry for each option. If the corresponding options are installed, the toolbar button and menu entry will be active.

### 11.8.2 LxGui MS704 Test Screen

The -704F option interface screen is shown below. (Figure 11-13). Settings can be made through a series of tabbed dialogs in the center of the screen. Any EUT information can be entered at the bottom. This information will be transferred to the test report.
Test execution is controlled using the Start / Abort buttons to the left. The right hand side of this window provides output monitoring for voltage (all three phases in 3 phase mode) and frequency. During a test run, this data is updated once a second. A log of readings is automatically kept.


Figure 11-13: LxGui MS704 Option Screen
All test selection and execution modes are set from this screen.

### 11.8.3 LxGui MS704 Performance Test Screen

## Note: For Ls Series AC sources without the -ADV option installed, the harmonic analysis and waveform acquisition functions described in this section are not available. Contact sales@programmablepower.com to upgrade the Ls AC Source with the -ADV option. The MIL-STD 704 stimulus can still be run however.

Revision F of the MIL-STD 704 provides additional detail on performance evaluation of the EUT after running an immunity test. This is covered in test method 101 of each of the power test groups. The Lx Series AC source and the Ls Series AC source with the -ADV option provides built-in measurement functions that can be used to evaluate EUT performance.

Note however that the maximum bandwidth requirement for current harmonic measurements of the Lx/Ls Series is limited to 48 KHz in single-phase mode and 16 KHz in three-phase range. Harmonic components that fall outside this bandwidth are not reported (value of 0.00 is returned).
The requirement for MIL-STD 704 is 150 KHz so for EUT's with high harmonic order currents, a higher bandwidth external power analyzer should be used in addition to the AC source.


Figure 11-14: LxGui MS704 Option EUT Performance Test Screen - Measurements

The EUT measurement data collected for the 101 EUT performance test is divided among four separate tabs that can be displayed by clicking on each tab at the top of the test window. Available tabs are:

| Tab | Description |
| :--- | :--- |
| Parameters | This tab displays parametric measurement data for all phases (three- <br> phase mode) or phase A only (single-phase mode). Data displayed <br> includes Frequency (Hz), Voltage RMS (V), Current RMS (A), Apparent <br> Power (VA), Inrush current (A), Power Factor and Total Current Distortion <br> (\%). The total VA for all three phases combined is shown for three phase <br> EUT's. Any unbalance between phases is calculated and displayed next <br> to the total VA readout. If the unbalance exceeds the MIL-STD 704 limit <br> of 3\%, this field will have a red background. <br> The current distortion is compared to the user specified ITHD limit value <br> shown to the right of the current distortion readout. If one of more of the <br> phase currents exceeds this limit, a Fail result will be displayed on the <br> right. The ITHD limit is set in the "MS704_Distortion_Limits.ini" text file <br> located in the LxGui application directory. (See paragraph 11.8.3.1) |
| This tab displays at least one full cycle of both the voltage and current <br> waveforms. (all waveforms are for L-N voltage and phase current). In <br> three-phase mode, the phase to be displayed can be selected by using <br> the phase selection radio buttons to the left of the graph. Only one phase <br> is displayed at a time but all three phases are always acquired at the <br> same time. The test report will include data for all three phases as well. |  |
| The Settings button can be used to change display scaling and graph |  |
| colors if needed. |  |

The EUT performance measurements are taken at the start of a test run and again after the selected test or tests have been completed. If a variable frequency test group is selected, the data will be taken at $360 \mathrm{~Hz}, 400 \mathrm{~Hz}, 600 \mathrm{~Hz}$ and 800 Hz . Data for each frequency is saved and can be recalled for display if needed by using the "File Read" button in the lower left corner of the Parameters Tab. The last measurement data taken by the LxGui program is preserved in the
application subdirectory $\backslash$ Reports as a text file named MeasData_XXX_Hz.txt where $X X X$ is either 360, 400, 600 or 800.


Figure 11-15: LxGui MS704 Option EUT Performance Test Screen - Waveforms

### 11.8.3.1 MS704 Current Harmonics Limits File

The user can define relative limits for one or more current harmonics. If set, the LxGui will compare actual harmonic current components against the user defined limits and display pass or fail in the right hand column. This data is also part of the test report. The current harmonic limits can be set by editing the "MS704_Distortion_Limits.ini" text file located in the LxGui application directory. To not set a limit for a specific harmonic component, remove its entry from the INI file or set its value to zero.
Limits can be defined for each of the five available power groups. The mapping is as follows:

| INI File Section Header | Test Group |
| :--- | :--- |
| MS704_Group_0 | TAC |
| MS704_Group_1 | TVF |
| MS704_Group_2 | SAC |
| MS704_Group_3 | SVF |
| MS704_Group_4 | SXF |

The total harmonic current distortion level ITHD is set for each group with the enrty "Ithd = nn.n" where nn.n is the limit in \%.
For individual harmonic components, use the keyword, "IHarmLimit_x" where $\mathrm{x}=1$ through 50 .
A sample "MS704_Distortion_Limits.ini" file shipped with LxGui program is shown below.

```
[MS704_Group_0]
// Const MS_TAC = 0
lthd = 12.0
1HarmLimit_3 = 65.00
IHarmLimit_5 = 4.00
IHarmLimit_7 = 3.00
[MS704_Group_1]
// Const MS_TVF = 1
lthd = 12.0
IHarmLimit_3 = 5.00
IHarmLimit_5 = 4.00
1HarmLimit_7 = 3.00
[MS704_Group_2]
// Const MS SAC = 2
lthd = 12.0
|HarmLimit_3 = 5.00
IHarmLimit_5 = 4.00
IHarmLimit_7 = 3.00
[MS704_Group_3]
// Const MS_SVF = 3
lthd = 12.0
1HarmLimit_3 = 5.00
IHarmLimit_5 = 4.00
IHarmLimit_7 = 3.00
[MS704_Group_4]
// Const MS_SXF = 4
lthd = 12.0
1HarmLimit_3 = 5.00
IHarmLimit_5 = 4.00
IHarmLimit_7 = 3.00
```

// Comments can be included for readability.
// Current Distortion Harmonics Limits by Power Group

### 11.8.4 LxGui MS704 Test Settings Screen

Before running a Mil-Std 704 immunity test, the desired test revision and Power Group must be selected from the Test Settings tab. (See Figure 11-13) Note that not all power groups are available for all revisions of the Mil-Std 704. In particular, variable frequency power groups and the 60 Hz power group were added only with revision F. Only supported power groups can be selected for a specific test revision. Others will be disabled automatically.
For variable frequency power groups in Revision F (TVF and SVF), the Nominal frequency at which to perform the test can be selected on the left hand side. Available choices are 360 Hz , $400 \mathrm{~Hz}, 600 \mathrm{~Hz}$ and 800 Hz . The Auto-cycle setting if checked will cause the selected tests to be repeated for all four frequencies. This will increase the total test time by a factor of 4.
If the AC source is in three-phase mode, the phase selection radio buttons may be used to select a specific phase or all three phases. If a specific phase is selected, the other two phases remain at the nominal programmed voltage. If the AC source is in single-phase mode or a single-phase model only, this selection will be locked on phase 1 or A.

## Note: Any Frequency tests will affect all phase output, regardless of the phase selection made by the user.

Once a test is in progress, the test selections cannot be changed and all frames in this tab are disabled. Tests can be aborted at any time using the Abort button or the Run, Stop menu.

### 11.8.5 LxGui MS704 Test Method Selections 2XX through 60X

Tests steps can be selected individually as desired. For each test method (2XX through 6XX), a separate tab is provided. Each tabs will show available test steps for the selected standard revision and power group. Test method numbers are shown for each step for reference to MilStd 704 rev F. A test method is selected by checking the check box in front of it. As each test method is selected, the total estimated execution time and expected date and time of completion is shown in the left hand yellow window. Note that several tests require the EUT to run for 30 minutes so the total test time can add up quickly.
To select all test methods on any given tab, use the Select All button at the bottom of the tab. To de-select all test methods on a tab, use the Unselect All button. These buttons work only on the displayed test method tab. Check the other tabs by clicking each one for other selections that have been made. Unless the total time in the left window shows 00:00:00, one or more test methods have been selected.

### 11.8.6 LxGui MS704 Test Execution

Each test method has several steps, generally labeled $A$ through $Z$ and $A A$ through RR. The number of test steps will differ between test methods. Execution can be done for a complete test method. In this case, all test steps will run in sequence. This is the Continuous execution mode.

Alternatively, a single test steps can be executed by selecting the Single Execution mode. In this mode, the desired test step must be selected using the drop down list in the Execution selection frame. It is the user's responsibility to select a test step that actually exists for the selected test method. It is not recommended to select more than one test method at a time when using the Single mode as different test methods may not have the same step letter.
Note that the execution times shown in the right apply to the complete test method(s) selected. They do not reflect the execution time for a single step in Single mode. Refer to section 11.7 for specific test times per step.

### 11.8.7 LxGui MS704 Observations Data Entry

Observations of EUT behavior during the test can be entered by the operator in the Observations tab. This information will be included in the test report. This is a free form text entry field.

### 11.8.8 LxGui MS704 Reports

Upon completion of a test, it is possible to print a test report. There are two report formats available. The report format must be set in the Report Setup screen available from the Options, Test Report Setup... menu in the main LxGui window. This screen also allows entry of any custom report header and footers.
The simplest form is the direct printer format, which produces a short form report with textual information only. Select "Output directly to Windows printer."
A more comprehensive report is available if a copy of MS Word (version 8.0 or higher) is installed on the PC used to run the LxGui program. When selected, the word report file name can be assigned a random number or the user can set the program to prompt for a report name each time a report is generated.
Once the MS704 screen has been opened, the report format selection cannot be changed without closed the MS704 screen first.
Word reports are saved in the ... ILxGuilReports directory and can be printed from MS Word as needed. MS704 reports which are assigned a random sequence number by the LxGui will have a "MS704_XXX_NNNNNN.doc" file name where XXX stands for the selected power group (TAC, SAV, TVF, SVF or SXF) and NNNNNN is a random sequential number.
In addition to the test reports, the LxGui program creates a tab delimited text file during MS704 execution, which logs the voltage and frequency at the AC source output every second. The file is called "MS704_Meas_Log.txt" and is saved in the Reports sub directory. This text file may be opened in Excel for charting or reporting purposes. However, each time a new test is started, the data in this file will be overwritten.

## 12. Option -ABD: Airbus ABD0100.1.8 Test (Software)

Use of this option requires the following:

- Lx or Ls Series AC power source with firmware revision 1.02 or higher.
- -ABD option. Options installed are listed on unit's serial tag.
- Windows XP/2000 PC with RS232C or National Instruments GPIB controller interface. AMETEK recommends the use of the GPIB interface for best performance.
- LxGui Windows software revision 1.11 or higher. Provided on CI P/N CIC496 CD ROM or available for download from the AMETEK Programmable Power website.
- Additional equipment will be required in order to meet all ABD directive test requirements.
Refer to the Avionics Software Test user manual (CI P/N 4994-971) for operating instructions for all GUI based test options. This manual is distributed in PFD format on the same CD as this user manual. (CI P/N CIC496).


## 13. Option -A350: Airbus A350, ABD0100.1.8 Test (Software)

Use of this option requires the following:

- Lx or Ls Series AC power source with firmware revision 1.40 or higher.
- -A350 option. Options installed are listed on unit's serial tag.
- Windows XP/2000 PC with RS232C or National Instruments GPIB controller interface. AMETEK recommends the use of the GPIB interface for best performance.
- LxGui Windows software revision 1.18.0.0 or higher. Provided on CI P/N CIC496 CD ROM or available for download from the AMETEK Programmable Power website.
- Additional equipment will be required in order to meet all ABD directive test requirements.
- Some hardware options may be required to perform certain tests.

Refer to the Avionics Software Test user manual (CI P/N 4994-971) for operating instructions for all GUI based test options. This manual is distributed in PFD format on the same CD as this user manual. (CI P/N CIC496).

## 14. Option -AMD: Airbus AMD24 Test (Software)

Use of this option requires the following:

- Lx or Ls Series AC power source with firmware revision 1.4 or higher.
- -AMD option. Options installed are listed on unit's serial tag.
- Windows XP/2000 PC with RS232C, USB, LAN or National Instruments GPIB controller interface. AMETEK recommends the use of the GPIB interface for best performance.
- LxGui Windows software revision 1.17 or higher. Provided on CI P/N CIC496 CD ROM or available for download from the AMETEK Programmable Power website.
- Additional equipment will be required in order to meet all AMD directive test requirements.
Refer to the Avionics Software Test user manual (CI P/N 4994-971) for operating instructions for all GUI based test options. This manual is distributed in PFD format on the same CD as this user manual. (CI P/N CIC496).


## 15. Option -B787: Boeing 787B3-0147 Test (Software)

Use of this option requires the following:

- Lx or Ls Series AC power source with firmware revision 1.4 or higher.
- -B787 option. Options installed are listed on unit's serial tag.
- Windows XP/2000 PC with RS232C or National Instruments GPIB controller interface. AMETEK recommends the use of the GPIB interface for best performance.
- LxGui Windows software revision 1.15 or higher. Provided on CI P/N CIC496 CD ROM or available for download from AMETEK Programmable Power website.
- Additional equipment will be required in order to meet all B787 directive test requirements.
Refer to the Avionics Software user manual (CI P/N 4994-971) for operating instructions for all GUI based test options. This manual is distributed in PFD format on the same CD as this user manual. (CI P/N CIC496).


## 16. Error Messages

Any errors that occur during operation from either the front panel or the remote control interface will result in error messages. Error messages are displayed on the LCD display. They are also stored in the error message queue from which they can be queried using the SYST:ERR? Query. The error queue has a finite depth. If more error messages are generated than can be held in the queue, a queue overflow message will be put in the last queue location. To empty the queue, use the error query until the No Error result is received.

Errors appearing on the LCD will generally remain visible until the user moves to another screen. If multiple error messages are generated in succession, only the last message will be visible as there is only space for one error message on the LCD display.
The same area of the display is also used to display status messages. While error messages always have a negative error number, status messages have a positive number.

The table below displays a list of possible error and status messages along with their possible cause and remedy.

| Number | Message String | Cause | Remedy |
| :---: | :--- | :--- | :--- |
| 0 | "No error" | No errors in queue |  |
| -100 | "Command error" | Unable to complete <br> requested operation | Unit may be in a mode inconsistent <br> with request. |
| -102 | "Syntax error" | Command syntax <br> incorrect. | Misspelled or unsupported command |
| -103 | "Invalid separator" | SCPI separator not <br> recognized | See SCPI section of programming <br> manual. |
| -104 | "Data type error" | Data type invaled. | Check command for supported data <br> types |
| -108 | "Parameter not allowed" | One or more <br> additional parameters <br> were received. | Check programming manual for <br> correct number of parameters |
| -109 | "Missing parameter" | Too few parameters <br> received for <br> requested operation | Check programming manual for <br> correct number of parameters |
| -110 | "Command header error" | Command header <br> incorrect | Check syntax of command. |
| -111 | "Header separator error" | Invalid command <br> separator used. | Use semi-colon to separate command <br> headers |
| -112 | "Program mnemonic too | Syntax error | Check programming manual for <br> correct command syntax |
| -113 | "Undefined header" | Command not <br> recognized error | Check programming manual for <br> correct command syntax |
| -120 | "Numeric data error" | Data received is not <br> a number | Check programming manual for <br> correct command syntax |
| -121 | "Invalid character in <br> number" | Number received <br> contains non-numeric <br> character(s) | Check programming manual for <br> correct command syntax |
| -123 | "Exponent too large" | Exponent in number <br> exceeds limits | Check programming manual for <br> correct parameter range |
| -128 | "Numeric data not <br> allowed" | Number received <br> when number is not <br> allowed. | Check programming manual for <br> correct command syntax |
| -168 | "Block data not allowed" | Block data was sent. | Check programming manual for |


| Number | Message String | Cause | Remedy |
| :--- | :--- | :--- | :--- |
| -200 | "Execution error" | Command could not <br> be executed | Command may be inconsistent with <br> mode of operation. |
| -201 | "Invalid while in local" | Command issued but <br> unit is not in remote <br> state | Put instrument in remote state before <br> issuing GPIB commands. |
| -203 | "Command protected" | Command is locked <br> out | Some commands are supported by the <br> unit but are locked out for protection of <br> settings and are not user accessible. |
| -210 | "Trigger error" | "Trigger ignored" | Problem with trigger <br> system. |
| Trigger request has <br> been ignored. | Unit could not generate trigger for <br> transient execution or measurement. |  |  |
| -211 | Trigger setup incorrect or unit was not <br> armed when trigger was received. <br> Check transient system or <br> measurement trigger system settings. |  |  |
| -213 | "Init ignored" | "Illegal variable name" | "Dariable name illegal. |


| Number | Message String | Cause | Remedy |
| :---: | :---: | :---: | :---: |
| -311 | "Memory error" | Waveform memory checksum error. | May be the result of incomplete userdefined waveform download. Check interface and try downloading waveform again. Successful download may clear this error condition. <br> Alternatively, use TRAC:DEL:ALL command to clear waveform memory. |
| -314 | "Save/recall memory lost" | User setup register contents lost | Store setup in same register again. |
| -315 | "Configuration memory lost" | Hardware configuration settings lost. | Contact AMETEK service department at service@programmablepower.com to obtain instructions on restoring configuration data. |
| -330 | "Self-test failed" | Internal error | Contact AMETEK service department at service@programmablepower.com |
| -350 | "Queue overflow" | Message queue full. | Too many message. Read status using SYST:ERR query until 0, "No Error" is received indicating queue empty. |
| -400 | "Query error" | Unable to complete query. | Check programming manual for correct query format and parameters |
| -410 | "Query INTERRUPTED" | Query issued but response not read. | Check application program for correct flow. Response must be read after each query to avoid this error. |
| -420 | "Query <br> UNTERMINATED" | Query incomplete. | Check for terminator after query command. |
| -430 | "Query DEADLOCKED" | Query cannot be completed | Check application program for multiple queries |
| -440 | "Query <br> UNTERMINATED" | Query incomplete. | Check for terminator after query command. |
| 0 | "No error" | No errors in queue |  |
| 2 | " Non-volatile RAM CONFIG section checksum failed" | Controller failure during Self-test. | Contact AMETEK service department at service@programmablepower.com |
| 3 | " Non-volatile RAM CAL section checksum failed" | Controller failure during Self-test. | Contact AMETEK service department at service@programmablepower.com |
| 4 | " Non-volatile RAM WAVEFORM section checksum failed" | Controller failure during Self-test. | Contact AMETEK service department at service@programmablepower.com |
| 10 | "Ram self test | Controller failure during Self-test. | Contact AMETEK service department at service@programmablepower.com |
| 40 | "Voltage self test error, output 1 | No. 1/A amplifier in Master source has no output during Selftest. | Contact AMETEK service department at service@programmablepower.com |
| 41 | "Voltage self test error, output 2 | No. 2/B amplifier in Master source has no output during Selftest | Contact AMETEK service department at service@programmablepower.com |
| 42 | "Voltage self test error, output 3 | No. 3/C amplifier in Master source has no output during Self- | Contact AMETEK service department at service@programmablepower.com |


| Number | Message String | Cause | Remedy |
| :---: | :---: | :---: | :---: |
|  |  | test |  |
| 43 | "Current self test error, output 1 | No. 1/A amplifier in Aux. Source has no output during Selftest. | Contact AMETEK service department at service@programmablepower.com |
| 44 | "Current self test error, output 2 | No. 2/B amplifier in Aux. Source has no output during Selftest. | Contact AMETEK service department at service@programmablepower.com |
| 45 | "Current self test error, output 3 | No. 3/C amplifier in Aux. Source has no output during Selftest. | Contact AMETEK service department at service@programmablepower.com |
| 216 | " RS-232 receiver framing error" | Communication failure. | Check RS232 port settings and cable. |
| 217 | " RS-232 receiver parity error" | Communication failure. | Check RS232 port settings and cable. |
| 218 | " RS-232 receiver overrun error" | Communication failure. | Check RS232 port settings and cable. |
| 402 | "CAL password is incorrect" | Calibration password does not equal high voltage range value. | Re-enter correct password. |
| 403 | "CAL not enabled" | No password entered for calibration | Enter correct CAL password. |
| 600 | "Systems in mode:list have different list lengths" | Transient lists have unequal lengths | Check list settings and correct to same no of data points. |
| 601 | "Requested voltage and waveform exceeds peak voltage capability" | Wave shape selected and RMS voltage combine to exceed peak voltage capability. | Reduce RMS or crest factor of wave shape. |
| 602 | "Requested voltage and waveform exceeds transformer volt-second rating" | The selected wave shape exceeds output transformer capability. | The volt-second product of he wave form (magnitude and time in the + and - half of wave form). |
| 603 | "Command only applies to RS-232 interface" | Command not relevant for GPIB interface. | Do not use command. |
| 604 | "Trigger received before requested number of pre-trigger readings" | Data acquisition pretrigger buffer not filled yet. | Hold off trigger or reduce pre-trigger delay. |
| 605 | "Requested RMS current too high for voltage range" | Max RMS current is function of voltage range selected. | Reduce programmed RMS current limit or select low voltage range. |
| 606 | "Waveform data not defined" | No waveform name specified | Specify waveform name before sending waveform data. |
| 607 | "VOLT,VOLT:SLEW, and FUNC:SHAPe modes incompatible" | Conflict between wave shape and programmed slew | Reduce slew or change waveform type. |
| 608 | "Measurement overrange" | Measurement data out of range. |  |
| 609 | "Output buffer overrun" | Too much data in | Check receive mode on application |

$\left.\begin{array}{|c|l|l|l|}\hline \text { Number } & \text { Message String } & \text { Cause } & \text { Remedy } \\ \hline 610 & \begin{array}{l}\text { "Command cannot be } \\ \text { given with present } \\ \text { SYST:CONF setting" }\end{array} & \begin{array}{l}\text { Output buffer. } \\ \text { with available } \\ \text { hardware or firmware } \\ \text { option settings. }\end{array} & \begin{array}{l}\text { program. Program is not reading data } \\ \text { sent by AC source. }\end{array} \\ \hline 801 & \text { "Output volt fault" } & \begin{array}{l}\text { - Output voltage does } \\ \text { options and features. } \\ \text { not match program } \\ \text { value when ALC is } \\ \text { on. } \\ \text { - Over load } \\ \text { - Voltage kick-back } \\ \text { - No output voltage }\end{array} & \begin{array}{l}\text { Load exceeds current limit and unit is } \\ \text { in Constant Voltage (CV) mode of } \\ \text { operation. } \\ \text {-Reduce load or increase CL setting. }\end{array} \\ \hline 802 & \text { "Current limit fault" } & \begin{array}{l}\text { Output voltage is driven above } \\ \text { programmed voltage by external } \\ \text { influence (Load, voltage kickback, etc.) }\end{array} \\ \hline 817 & \begin{array}{l}\text { Current limit } \\ \text { exceeded. }\end{array} & \begin{array}{l}\text { Load exceeds current limit and unit is } \\ \text { in Constant Voltage (CV) mode of }\end{array} \\ \text { operation. Reduce load or increase CL } \\ \text { setting }\end{array}\right\}$

| Number | Message String | Cause | Remedy |
| :---: | :--- | :--- | :--- |
|  |  | clock |  |
| 820 | "Input buffer full" | Too much data <br> received. | Break up data in smaller blocks. |
| 821 | "Amplifier unbalance" | Hardware error. An <br> amplifier has an <br> overload condition. | Check amplifier balance adjustment. If <br> error persists contact AMETEK service <br> at service@programmablepower.com. |
| 822 | "Waveform harmonics <br> limit" | Harmonic contents of <br> user defined wave <br> shape is too high and <br> could damage <br> amplifier output <br> stage. | Reduce harmonic content or reduce <br> fundamental frequency programmed. |
| 823 | "Amplifier fault" | An amplifier failure. <br> Can be reported at <br> any time. | Determine which amplifier is at fault <br> with self-test or checking LED on <br> Relay Board. Replace amplifier. |
| 824 | "Auxiliary down" | One or more auxiliary <br> units is not powered <br> up or not working. | Turn on all auxiliary units. |
| 825 | "Over voltage prot trip" | Over voltage <br> detected on output | Check output voltage for correct RMS <br> value. |
| 826 | "Peak current prot trip" | Peak current limit <br> exceeded. | Peak current exceeded. Could be <br> caused by switching EUT on or off. |
| 827 | "Frequency error" | Frequency error <br> during self-test. | Correct frequency was not measured <br> during self-test. May be result of 801 <br> error. |
| 828 | "Phase error" | Self test error phase <br> angle | Correct phase angle was not <br> measured during self-test. May be <br> result of 801 error. |
| 829 | "Dc component exceed <br> limit" | Too much DC <br> content in loaded <br> ARB waveform. | Check waveform programming. |

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[^0]:    ${ }^{1}$ Note that operation below 208 V L-L AC input is available with the following derating considerations:

    1) If operating at less than a 5000 VA output power there will be no affect on the output.
    2) If operating in 3 -phase mode, with a full-scale output voltage and a frequency less than three times the line frequency, the voltage distortion may exceed specification between 5500 and 6000 VA output.
    3) If operating in 1 -phase mode above 5000 VA , above $85 \%$ of full-scale output voltage and an output frequency less than three times the line frequency, the voltage distortion may exceed specification and the output may fault with a crest factor load more than 2.
    In most applications, these conditions are not likely to exits. At AC input voltages of 208 V or higher, the 6000Lx/Ls meets specifications under all conditions.
[^1]:    ${ }^{1}$ The distortion specification for the Lx Series applies at full-scale voltage, full resistive load conditions.

[^2]:    ${ }^{1}$ Programming resolution reduced if -LKM/-LKS option is installed. See paragraphs 2.6.5 and 2.7.5.
    ${ }^{2}$ Programming resolution of 0.5 Hz above 819.1 Hz may be used over the remote control bus with $\pm 0.5 \mathrm{~Hz}$ accuracy.

[^3]:    ${ }^{1}$ Frequency measurement specifications valid with output voltage of 30 Vrms or higher. If output relay is open, frequency measurement will return 0.0 Hz .

[^4]:    ${ }^{1}$ Frequency measurement specifications valid with output voltage of 30 Vrms or higher. If output relay is open, frequency measurement will return 0.0 Hz .

[^5]:    ${ }^{1}$ Multi box systems -HF frequency limit is set to 5000 Hz but performance to specification is guaranteed only to 2000 Hz . Above 2000 Hz , full power may not be available due to amplifier unbalance. Current measurements accuracy is affected by system interface cable cross talk above 2000 Hz .
    ${ }^{2}$ Frequency measurement specifications valid with output voltage of 30 Vrms or higher. If output relay is open, frequency measurement will return 0.0 Hz .

[^6]:    ${ }^{1}$ This message will disappear when the controls on the auxiliary unit are operated. However, changing settings on the auxiliary unit controller will not affect the output. Use the master unit controller and or remote control interface to operate the system.

[^7]:    ${ }^{1}$ This feature requires firmware revision 1.40 or higher. If you upgraded from a lower firmware revision, the LAN configuration has to be enabled to display this menu. Contact customer service for information on enabled this screen.

[^8]:    Note: Voltage modulation levels change linearly from frequency 1.7 Hz to 10 Hz and again from 25 Hz to 75 Hz . See Figure 8-4.

[^9]:    ${ }^{1}$ Note: This DO160 Rev E implementation uses arbitrary waveform capabilities and harmonic measurements, both of which require the -ADV (advanced features) option on the Ls Series. These capabilities are standard on the Lx Series. Contact California Instruments for information on upgrading Ls Series models with the -ADV option.

