California Instruments

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P/N 4600-960

3091LD Series
AC Load
User Manual

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User Manual
AC Load
California Instruments
Models:

- 3091LD
- 3091

SAFETY SUMMARY

This AC Load contains high voltage and current circuits, which are potentially lethal. Because of its size and weight, mechanical stability must be ensured. The following safety guidelines must be followed when operating or servicing this equipment. These guidelines are not a substitute for vigilance and common sense. California Instruments assumes no liability for the customer's failure to comply with these requirements. If the power source is used in a manner not specified by California Instruments, the protection provided by the equipment may be impaired.

BEFORE APPLYING POWER

1. Verify the correct voltage is applied to the unit (for example 240V).

2. The chassis and cabinet of this power source must be grounded to minimize shock hazard. A chassis ground is provided at the input terminal block. This is located at the back of the cabinet on the lower right hand side. The chassis ground must be connected to an electrical ground through an insulated wire of sufficient gauge.

FUSES

Use only fuses of the specified current, voltage, and protection speed (slow blow, normal blow, fast blow) rating. Do not short out the fuse holder or use a repaired fuse.

DO NOT OPERATE IN A VOLATILE ATMOSPHERE

Do not operate the power source in the presence of flammable gases or fumes.

DO NOT TOUCH ENERGIZED CIRCUITS

Disconnect the power cable before servicing this equipment. Even with the power cable disconnected, high voltage can still exist on some circuits. Discharge these voltages before servicing. Only qualified service personnel may remove covers, replace components or make adjustments.

DO NOT SERVICE ALONE

Do not remove covers, replace components, or make adjustments unless another person, who can administer first aid, is present.

DO NOT EXCEED INPUT RATINGS

Do not exceed the rated input voltage or frequency. Additional hazards may be introduced because of component failure or improper operation.

DO NOT MODIFY INSTRUMENT OR SUBSTITUTE PARTS

Do not modify this instrument or substitute parts. Additional hazards may be introduced because of component failure or improper operation.

MOVING THE POWER SOURCE

When moving the power source, observe the following:

1. Remove all AC power to unit.

2. Use two people to prevent injury.

SAFETY SYMBOLS:

THIS SYMBOL INDICATES DIRECT CURRENT


THIS SYMBOL INDICATES ALTERNATING CURRENT


THIS SYMBOL INDICATES BOTH DIRECT AND ALTERNATING CURRENT


THIS SYMBOL INDICATES THREE–PHASE ALTERNATING CURRENT


THIS SYMBOL INDICATES EARTH (GROUND) TERMINAL


THIS SYMBOL INDICATES PROTECTIVE CONDUCTOR TERMINAL


THIS SYMBOL INDICATES FRAME OR CHASSIS TERMINAL

THIS SYMBOL INDICATES ON (SUPPLY)


THIS SYMBOL INDICATES OFF (SUPPLY)


THIS SYMBOL INDICATES CAUTION, RISK OF ELECTRIC SHOCK


THIS SYMBOL INDICATES CAUTION (REFER TO ACCOMPANYING DOCUMENTS)

WARRANTY INFORMATION

CALIFORNIA INSTRUMENTS CORPORATION warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are fuses and batteries that carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned freight prepaid, and when examination reveals that the fault has not occurred because of misuse, abnormal conditions of operation, user modification, or attempted user repair. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALIFORNIA INSTRUMENTS will submit an estimate for such charges before commencing repair, if so requested.

SERVICE PROCEDURE

If a fault develops, notify CALIFORNIA INSTRUMENTS at support@calinst.com or its local representative, giving full details of the difficulty, including the model number and serial number. On receipt of this information, service information or a Return Material Authorization (RMA) number will be given. Add the RMA number furnished to the shipping label. Pack the instrument carefully to prevent transportation damage, affix label to shipping container, and ship freight prepaid to the factory. CALIFORNIA INSTRUMENTS shall not be responsible for repair of damage due to improper handling or packing. Instruments returned without RMA No. or freight collect may be refused at California Instruments discretion. Instruments repaired under Warranty will be returned either via prepaid surface freight or low cost airfreight at California Instruments discretion. Instruments repaired outside the Warranty period will be returned freight collect, Ex Works CALIFORNIA INSTRUMENTS 9689 Towne Centre Drive, San Diego, CA 92121-1964. If requested, an estimate of repair charges will be made before work begins on repairs not covered by the Warranty.

DAMAGE IN TRANSIT

The instrument should be tested when it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed immediately with the carrier. The claim agent should obtain a full report of the damage, and a copy of this report should be forwarded to us by fax or email (Fax: 858 677 0940, Email: support@calinst.com). CALIFORNIA INSTRUMENTS will prepare an estimate of repair cost and repair the instrument when authorized by the claim agent. Please include model number and serial number when referring to the instrument.

SPARE PARTS

To order spare parts, user manuals, or determine the correct replacement part for your California Instruments products, please contact the Customer Service department by phone at + 1 858 677 9040, press 2 or by email support@calinst.com.

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1. Introduction

This instruction manual contains information on the installation, operation, calibration and maintenance of all power systems that use the 3091LD AC Load.

The Model 3091LD family of AC Electronic Loads is designed to provide precise non-linear loading requirements for UPS, AC power supply test and other evaluation and test applications. Using the 3091LD, the user can vary current, crest factor and power factor to ensure that the products under test are evaluated under worst case conditions, similar to those encountered in the field. The Model 3091LD offers more flexibility, enhanced reliability, less space and lower cost than an assortment of passive resistive loads.

Figure 1-1: Model 3091LD AC Load

1.1 General Description

The 3091LD is a high efficiency, light weight programmable AC Load. The LD Series input can accommodate voltages from 50 V_{RMS} to 350 V_{RMS}. Maximum dissipated power is 3000 Watt per 3091LD unit. The load current waveform is synchronized to the voltage waveform for the set current, crest factor and power factor. Consequently, multiple units may be paralleled to provide higher power dissipation levels. For three phase applications, three units can be connected as a three phase system.

Programmable crest factor and power factor allows the 3091LD to emulate a non-linear load such as a switching power supply. The AC Load's capability to provide a variety of loads from sinusoidal to high crest factor allows manufacturers to characterize UUT's to worst-case conditions.

1.2 Available Emulation Modes

To allow AC products to be tested under a variety of load conditions, the Model 3091LD AC Load offers a broad spectrum of emulation modes:

- Constant Current (CC) mode allows current to be drawn constantly, making it suitable for non-linear, linear and regulation loading.
- Constant Resistance (CR) mode allows the load to emulate a power resistor
- Constant Voltage (CV) allows it to emulate a shunt regulator.
- Constant Power (CP) mode emulates a constant power load such as a switching power supply.
- Short circuit (SC) mode allows the load to test the UUT's short circuit protection capability.
- Unity power factor (UPF) mode causes power factor to be as close as possible to unity, useful when the input voltage is non-sinusoidal.

These capabilities combine to make the Model 3091LD a flexible load, which replaces an assortment of resistive loads and short circuit relays, used currently by manufacturers.

1.3 Test Sequencing

The built in sequencer allows patterns of test loads to be programmed from the front panel or the bus and executed using an external trigger mode. This feature can be used to automate repetitive test tasks with little or no operator intervention.

1.4 High Accuracy Measurements

The Model 3091LD AC Load supports high accuracy frequency, voltage, peak voltage, current, peak current, crest factor, apparent power, true power, peak power, reactive power, power factor and resistance measurements. The ability to make all measurements internally eliminates multiple external measurement instruments plus associated signal matrixing. In this manner the load provides for a more compact, less costly and considerably faster test system. Waveforms may be graphically displayed on the front panel for operator feedback, often eliminating the need for an oscilloscope.

1.5 Easy Front Panel Operation

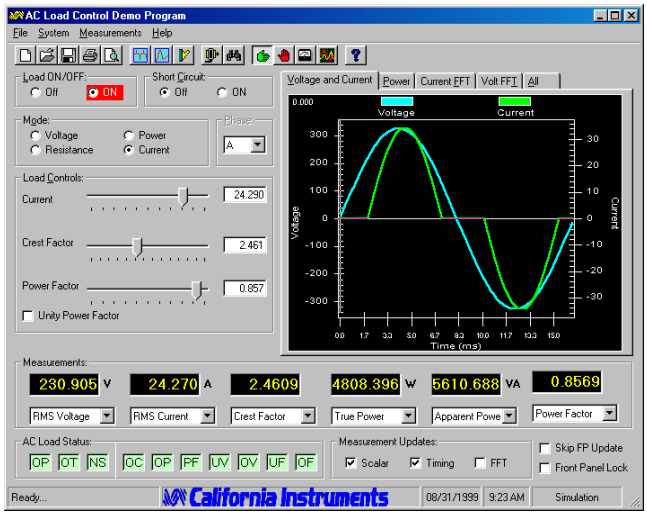
A large backlit LCD display supports the menu driver front panel operation of the Model 3091LD AC load. This allows load experiments to be set up quickly with out the need for a computer or programming. For many development tasks, front panel operation and built in measurement display is all that is needed to test products in their design stage.

The large LCD display also supports display of all measurement parameters, voltage and current waveform and FFT results. Simple English language menu and a large rotary knob to set load modes and parameters make the 3091LD the easiest AC load to use by far.

1.6 Fast System Integration

The use of industry standards such as IEEE-488.2, RS232C, SCPI command protocol and instrument drivers for common software development platforms greatly facilitate integration of the 3091LD with new or existing power supply test systems. Programmers can be up and running in little time using familiar Standard Commands for Programmable Instruments (SCPI) syntax and/or instrument driver software panels.

The included Windows™ Graphical User Interface provides turn-key PC control and data logging without the need to write a single line of code.



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2. Specifications

All specifications are for a single 3091LD chassis and 23° ± 5° C.

2.1 Model Numbers

This user manual covers the following 3091LD Series models. Standard units have rack mount front panel ears and handles.

Model	**Description**	**Line Input** ± 10%, 47 to 63Hz
3091LD	3000 W AC load.	115 V AC L-N
3091LD-230	3000 W AC load	230 V AC L-N
3091	3000 W AC load auxiliary unit	115 V AC L-N
3091-230	3000 W AC load auxiliary unit	230 V AC L-N

2.1.1 Included with each 3091LD Series system

- Instruction / Programming Manual
- Windows™ Graphical User Interface
- Load Input Connector
- RS232C Serial Cable, 9 pin to 9 pin

2.1.2 Factory Installed Options:

-230 AC Line input 230 V L-N. Must be specified at the time of original order.

-RMS Rack Mount Slides. Recommended for rack mounting.

MSK Master Auxiliary Kit. Consists of a set of interface and coaxial cables to use a 3091LD Master unit as an auxiliary unit. Included with 3091 Auxiliary units.

C Cabinet. Add prefix “C” to model number for a rack-mounted system.

DISCONTINUED:

-BTM - Bench Top Model. This version has no handles or rack mount ears.

2.2 Ratings

Power:	3000 W @ 0-37° C,
	2400 W @ 38-50°C
Max. Peak power:	17 kW (up to 18% duty cycle) Wpeak = Vpeak * Ipeak = Wpeak = Vrms * Sqrt(2) * Irms max * CFmax Wpeak = 350 V * Srqt(2) * 8.6 * 4 Vpeak max = 495 * 34.4 = 17 KW Average power limit = 3KW, max. duty cycle = 3/17 = 18%.
Current:	30 ARMS
Max. Peak current:	90 A
Voltage:	50 to 350V RMS
Max. Peak voltage:	500 V
Frequency:	45 to 440 Hz

2.3 Operating Modes

Constant Current	
Range:	0 to 30A RMS
Accuracy:	0.2 % of full scale
Resolution:	0.05 % of full scale
Min. Set Current	Voltage / Maximum Set Resistance
Constant Voltage	
Range:	50 to 350V RMS
Accuracy:	0.2 % of full scale
Resolution:	0.05 % of full scale
Constant Resistance	
Range:	2.5 to 100 Ohms
	100 to 1000 Ohms
Accuracy:	1% FS, 5% FS
Resolution:	0.05 % FS
Max. Set Resistance	1 / (Freq.*1.3e-5)
Constant Power	
Range:	3000 W @ 0-37° C,
	2400 W @ 38-50°C
Accuracy:	0.5% of full scale
Resolution:	0.1% of full scale
Crest factor	
Range:	1.4142 to 4.0,
	limited to 90 Apeak
Accuracy:	1 % of full scale

Resolution:	0.1 % of full scale
Power factor	
Range:	0 to 1 lead or lag. Limited by Crest Factor settings.
Accuracy:	1 % of full scale
Resolution:	0.1 % of full scale
Short circuit Mode	
Max. Surge current:	300 A peak, up to
	50 msec
Max. Cont. current:	30A RMS
Max. Voltage drop:	2.5V RMS

2.4 Measurements

2.4.1 Scalar Measurements

Frequency	
Range:	45 to 440 Hz
Accuracy:	0.1% FS
Resolution:	0.05% FS
Voltage	
Range:	50 to 350V RMS
Accuracy:	0.1% FS
Resolution:	0.05% FS
Peak Voltage	
Range:	50 to 500 V
Accuracy:	0.5% FS
Resolution:	0.1% FS
Current	
Range:	0 to 30A RMS
Accuracy:	0.2% FS
Resolution:	0.1% FS
Peak Current	
Range:	0 to 90A
Accuracy:	0.5% FS
Resolution:	0.1% FS
Crest factor	
Range:	1.4142 to 4.0
Accuracy:	0.5% FS
Resolution:	0.1% FS

Apparent Power	
Range:	0 to 3000 VA
Accuracy:	0.5% FS
Resolution:	0.1% FS
True Power	
Range:	0 to 3000 W
Accuracy:	0.5% FS
Resolution:	0.1% FS
Peak Power	
Range:	0 to 45,000 W
Accuracy:	1% FS
Resolution:	0.1% FS
Reactive Power	
Range:	0 to 3000 VA
Accuracy:	0.5% FS
Resolution:	0.1% FS
Power factor	
Range:	0 to 1
Accuracy:	0.5% FS
Resolution:	0.1% FS
Resistance	
Range:	2.5 to 100 Ohms,
	100 to 1000 Ohms
Accuracy:	1% FS, 5% FS
Resolution:	0.05% FS

2.4.2 FFT Measurements

Voltage	
Frequency Range:	DC to 50th Harmonic
Accuracy:	0.1% FS
Resolution:	0.05% FS
Current	
Frequency Range:	DC to 50 th Harmonic
Accuracy:	0.2% FS
Resolution:	0.1% FS

2.4.3 Waveform Acquisition

Voltage	
Datapoints:	128
Time Window:	1 Signal period, fixed
Vertical Resolution:	16 Bits
Current	
Datapoints:	128
Time Window:	1 Signal period, fixed
Vertical Resolution:	16 Bits
Power	
Datapoints:	128
Time Window:	1 Signal period, fixed
Vertical Resolution:	16 Bits

2.5 Protection

Over Current	Limited by input
	Circuit Breaker and Set Maximum Current Limit in software.
Over Voltage	Output protected for voltage transients over 500 V in hardware.
Over Power	Power limited at maximum average and peak rated power in hardware. Limited to Set Maximum Power Limit in software.
Over Temperature	Monitors heat sink temperature.

2.6 Regulatory

Electromagnetic Emissions and Immunity:	CE Mark
Acoustic Noise:	65 dBA maximum at 0% to 50% load, 75 dBA maximum greater than 50% load to 100% load. Measured at one meter.
Safety:	IEC 61010, CE Mark

2.7 Front Panel Controls

Controls:	
Shuttle knob:	Allows continuous change of all values including output calibration and range change.
Decimal keypad:	A conventional decimal keypad facilitates quick entry of numerical values such as mode and set values. The large blue enter key will make the value you enter effective. Using the SET key allows the user to preset all parameter values and update them all at once by pressing the Enter key.
Up/down arrow keys:	A set of up and down arrow keys is used to move the cursor position in all menus. This allows quick selection of the desired function or parameter.
Function keys:	Measure key will display most measurement values. Program key will show all program parameters. Input on/off key for load On/Off state control. Phase key will switch display to show program and measured values for each phase.
Displays:	
LCD graphics display:	A large high contrast LCD display with backlight provides easy to read guidance through all setup operations. An adjustable viewing angle makes it easy to read from all practical locations.
Status indicators:	Large and bright status indicators inform the user of important power source conditions. The Remote lamp informs the user that the unit is under remote control. The Overload lamp indicates that excessive power is being dissipated by the load. The Over temperature lamp illuminates when internal heat sink temperatures are too high. The Fault light indicates an error condition in the AC Load hardware. The Input On/Off indicator is on when the load state is enabled.

2.8 Connectors

Line input:	IEC fused Input
Load Power Input / Remote sense:	ITT CANNON, DSUB 17 - 4 CO-AX ITT CANNON, DSUB contact 40 A ITT CANNON, DSUB shell ITT CANNON, DSUB Screw Lock
Interfaces:	24 pin IEEE-488 9 pin RS232C

2.9 Dimensions, Weight, Environmental

Height:	8.75” / 222 mm
Width:	16.88” / 429 mm
Depth:	25” / 635 mm
Weight:	72 lbs / 32 Kg. Net 85 lbs / 40 Kg Shipping
Vibration and Shock:	Designed to meet NSTA project 1A transportation levels
Cooling:	Forced air cooling, front and side air intake, rear exhaust.
Operating Humidity:	0 to 95 % RH, non condensing
Operating Temperature:	3000 W @ 0-37° Celsius, 2400 W @ 39-50° Celsius
Storage Temperature:	-20 to + 85 ° Celsius

Note: Dimension and weight are for a single 3091LD chassis. Multi chassis configurations are shipped as individual units unless the C prefix for rack mount is added to the part number when ordering.

2.10 Supplemental Characteristics

Remote Sensing:	Max. 2V drop between sense and load lines
Isolation:	1000 V between input and chassis ground
AC Line input:	115 Vac, ± 10%, 47 to 63Hz, 1.4 A Max 230 Vac (model -230) ± 10%, 47 to 63Hz, 0.7 A Max
AC Input Fuse Ratings:	115Vac model, 3 A, 120V. 230Vac model, 1 A, 250V.

2.11 Current Distortion

The 3091LD is an electronic load and as such uses electronic control circuits to control the load current and match the requested load settings as closely as possible. To do so, the AC load tries to track the voltage waveform present at its sense inputs. Any noise, distortion or other anomalies on the voltage waveform will affect the resulting current waveform. The current waveform may not always be sinusoidal, which translates into a certain amount current distortion. In addition to the control loop induced distortion, there is a certain amount of crossover distortion at the zero crossing of the current, which also contributes to the current distortion. This effect increases as the amount of RMS current decreases.

Typical total harmonic current distortion of a 3091LD is shown in the graph below as a function of power level. Data shown is typical in Constant Power mode, 100V RMS AC input Voltage with < 1% distorted voltage waveform.

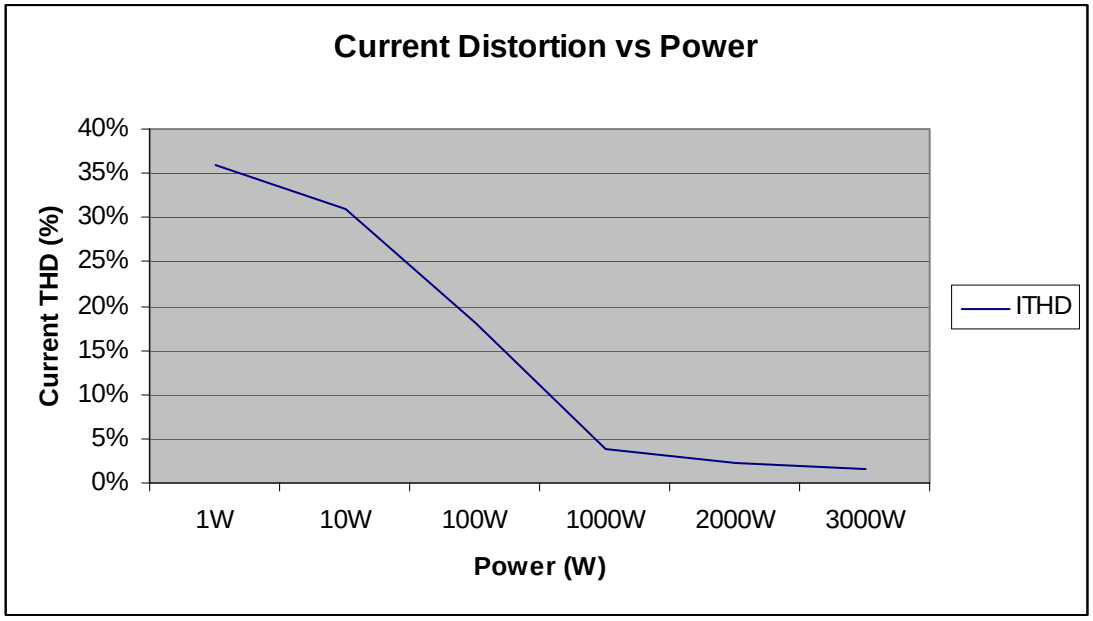


Figure 2-1: Typical Current distortion as a function of power level.

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. See section 7.3 for information on service returns.

WARNING: This product weighs 72 lb (32 kg). Rack handles are for sliding unit in and out of instrument racks and are not designed for lifting the unit. Obtain adequate help when moving or mounting the unit.

3.2 Power Requirements

The 3091LD AC Load has been designed to operate from a single-phase 115 volt AC line. The 3091LD-230 AC Load has been designed to operate from a single-phase 230 volt AC line.

Model Generations

There are two generations of 3091 models. Models shipped ***before April 2008*** have a fixed input voltage configuration and cannot be reconfigured. These 3091LD models cannot be converted to a 3091LD-230 or vice versa. These older models can be identified by the bottom right location of the AC input on the rear panel when looking at the back of the unit.

Rear panel of units shipped prior to April 2008.

Models shipped ***since April 2008*** can be reconfigured to a –230 input version or vice versa if needed by replacing the fuse and reversing the plug jumper between 100/115 and 200/230 settings. A new serial tag has to be applied in this case as well. For assistance, contact customer service. Note that these are ***NOT*** universal input models. These newer models can be identified by the bottom central location of the AC input on the rear panel when looking at the back of the unit.

Rear panel of units shipped since April 2008.

Regardless of the type unit, each AC Line input version must be ordered from the factory. If 230 V AC line is to be used, the -230 option must be specified at the time of ordering.

CAUTION: Do not connect the 115 V Line input 3091LD to a 230 V AC line. The result could be a severely damaged unit.

3.3 Mechanical Installation

The 3091LD is a completely self contained AC Load. It may be used free standing on a bench top or rack mounted. The 3091LD AC Load is fan cooled, drawing air in from the sides and exhausting at the rear. The sides of the unit must be kept clear of obstruction and a 6" clearance must be maintained to the rear. Special consideration of overall air flow characteristics and the resultant internal heat rise must be allowed for with systems installed inside enclosed cabinets to avoid self heating and over temperature problems, especially for higher power, multi-unit configurations.

For rack mount applications, the 3091LD model must be used as it provides the required rack ears and pull out handles. The optional -RMS rack mount slides are required for rack mounting unless the end-user provides another mean so support in the instrument rack. The rubber feet at the bottom of the unit need to be removed for rack mount installation. They are intended for bench top use only.

3.4 AC Line Input Wiring

The AC line input IEC connector is located at the rear of the unit. A standard equipment power cord must be used to connect the AC Load to line power. The mains connection must have a current rating equal to or greater than the input fuse and the input wiring must be sized to satisfy the applicable electrical codes. The AC line input fuse is located at the rear panel of the unit. A standard US line cord and a universal 'pig-tail' line cord which can accept a country specific AC plug are included with each unit.

CAUTION: Always check the serial tag AC line input rating to determine the correct AC input voltage requirement before applying power.

3.5 Load AC Input Connections

Single unit:

Pin	Signal	Description
A1		No Connection
A2	Neutral	Load power input
A3		No Connection
A4	Line	Load power input
1		No Connection
2	Neutral Sense	Remote voltage sense
3-7		No Connection
8	Line Sense	Remote voltage sense
9-17		No Connection

The voltage sense wires are also located on this connector. The voltage sense wires must be connected to the load wires either at this connector or at the source. The load will not operate with these voltage sense wires disconnected. It will generate an under voltage error.

Mating connector type is:

CI Part #	Description	Commercial Part #	Manufacturer
	DSUB 17 - 4 CO-AX	DCM-21 WA4S	ITT CANNON
	DSUB contact 40 A	DM 53744-1	ITT CANNON
	DSUB shell	DCM 24660	ITT CANNON
	DSUB Screw Lock	D20419-21	ITT CANNON

3.5.1 EUT Wiring

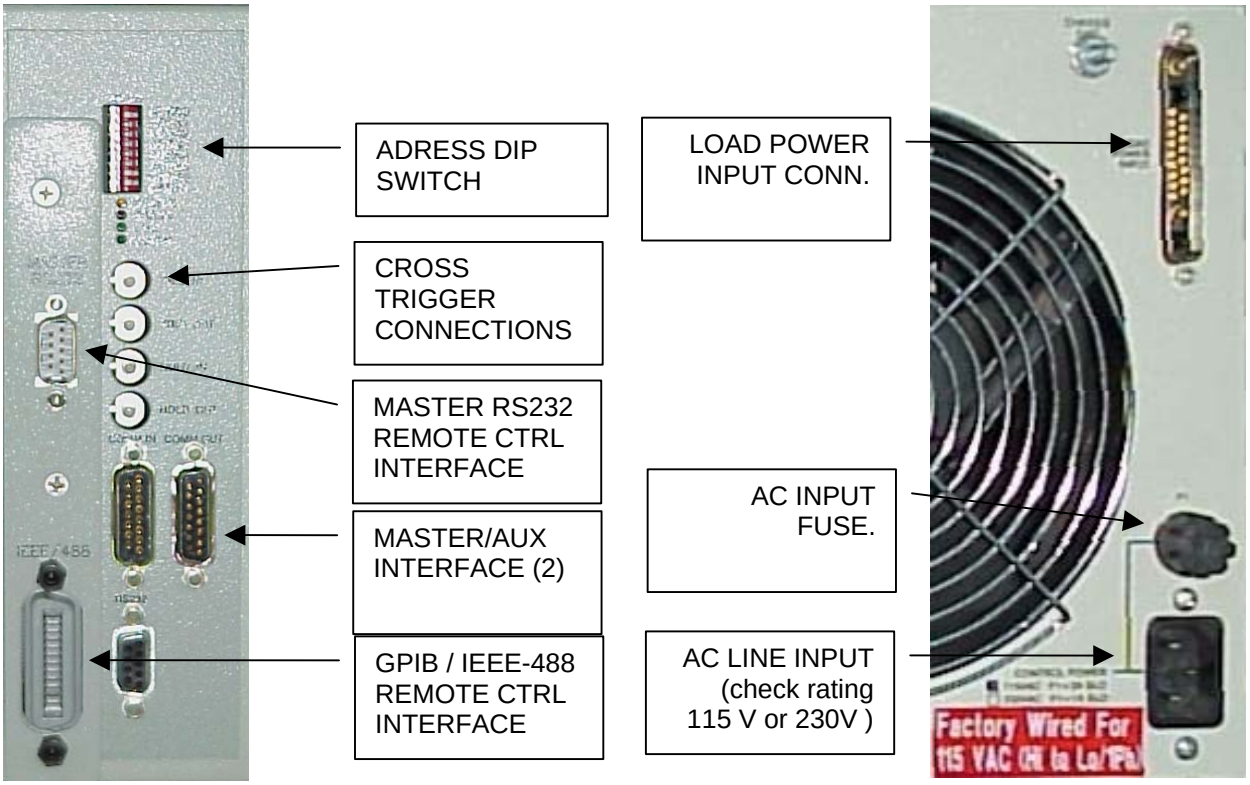
The AC input connector is located at the rear of the unit. The Load input power cables must be large enough to prevent a total voltage drop exceeding 1% of the rated output voltage between the power source and the load. Table 3-1 shows the AWG size of the cables that may be used. Cable lengths must not exceed twenty-five (25) feet. For lengths greater than 25 feet, calculate the voltage drop from the following formula:

2 X DISTANCE X CABLE RESISTANCE PER FT. X CURRENT = VOLT DROP

Table 3-1: Wire Sizes

LOAD CURRENT	WIRE GAGE
22 AMPS	10 AWG
37 AMPS	8 AWG
74 AMPS	4 AWG
111 AMPS	2 AWG

Figure 3-1: Model 3091LD Rear Panel View and Connectors



3.6 Unit Address Settings

Multi-unit AC Load systems can be controlled from a single master controller. Each unit has an Address Dip switch on the rear panel which has to be set correctly for multi-box operation. This address dips switch has 6 address bits (AD0 - AD5) and two group address bits (GR0 - GR1). The 3091LD master controller firmware defaults to the following unit address assignments:

Table 3-2: Multi box Configuration Address Ranges

Phase	Address Range Start Address
A	1 - 10
B	11 - 20
C	21 - 30

Address 0 should not be used. Addresses above 30 will also be assigned to phase C. The maximum supported number of units for single phase configurations is 4. All four units should have their addresses set within the 1 -10 range.

For three phase configurations, one or more units may be located in each phase's address range. The controller configures itself at power-on by searching each address range for one or more units. The start addresses for units found on each phaseThere is no difference in setting the address on a 3091LD Master or 3091 Auxiliary unit.

The address ranges can be changed on the master controller if desired by using the Configuration menu. Select the phase for which you want to change the Start Address using the PHASE key on the front panel. The selected phase is displayed in the top right hand corner of the LCD. With the desired phase selected, move the cursor to the St. Addr field and change the start address value if needed. Note that the start address for phase A, B and C should still be in ascending order. See section 4.2.9.5 for details.

The Group address dip switches should both always be set to 1.

3.7 Single-Phase and Three Phase Multiple Box System Configurations

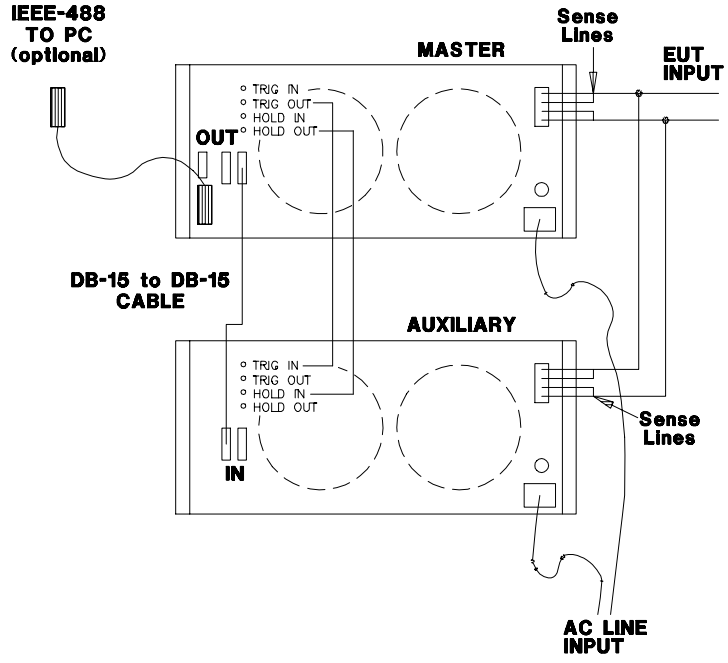
Single Phase System

In a single phase system consisting of two or three units, there is only one model 3091LD master unit that has a full controller and one or more model 3091 auxiliary units with a blank front panel except for the circuit breaker and AC Line on/off switch. It is possible to use a 3091LD master unit as an auxiliary unit in a multi-box configuration by disabling the front panel controller. See Section 4.2.9.5 for details. At power on, the master will identify itself as a 6091LD or 9091LD configuration when in single phase mode.

The units must all be connected with the RS422 interface cable. The HI inputs on all the terminal blocks should be connected together. The LO outputs should all be connected together and a heavy-duty cable run to the load from the HI and LO outputs. See Table 3-1 for cable sizing.

The RS422 Address Dip switches must be set to within the Phase A range shown in the configuration screen of the master**. Each unit must have a unique address.** At power up, the master will search all addresses and configure itself based on the number of units found. **All Auxiliary units must be powered up first before the master.** If it becomes necessary to change a three unit single phase system to three-phase output, the RS422 address of the two auxiliary units must be set to a value in the phase B and C address range respectively. Power on the master must be cycled for the new configuration to take effect.

Figure 3-2: 6091LD Two Unit Single Phase Wiring



Three Phase System

A three phase system must be configured by setting the model 3091 Auxiliary unit addresses to within the phase B and C range as displayed on the 3091LD Master configuration menu. The master with the controller is identified as Phase A. The other two units are identified as Phase B and C. There is always only one master unit that will have a full controller and one or more auxiliary units with a blank front panel except for the circuit breaker and AC Line on/off switch. A 3091LD Master unit may be used as an auxiliary unit by disabling the controller. See Section 4.2.9.5 for details. At power on, the master will identify itself as a 9093LD configuration when in three phase mode. **Power must be applied to all Auxiliary units before the master.**

The three units must be interconnected using the RS422 15 pin to 15 pin Interface cable. The EUT connected may be either WYE (Figure 3-3) or Delta (Figure 3-4).

If the system is to be changed to a single phase system, refer to the previous paragraph.

Figure 3-3: 9093LD Three Phase WYE Wiring

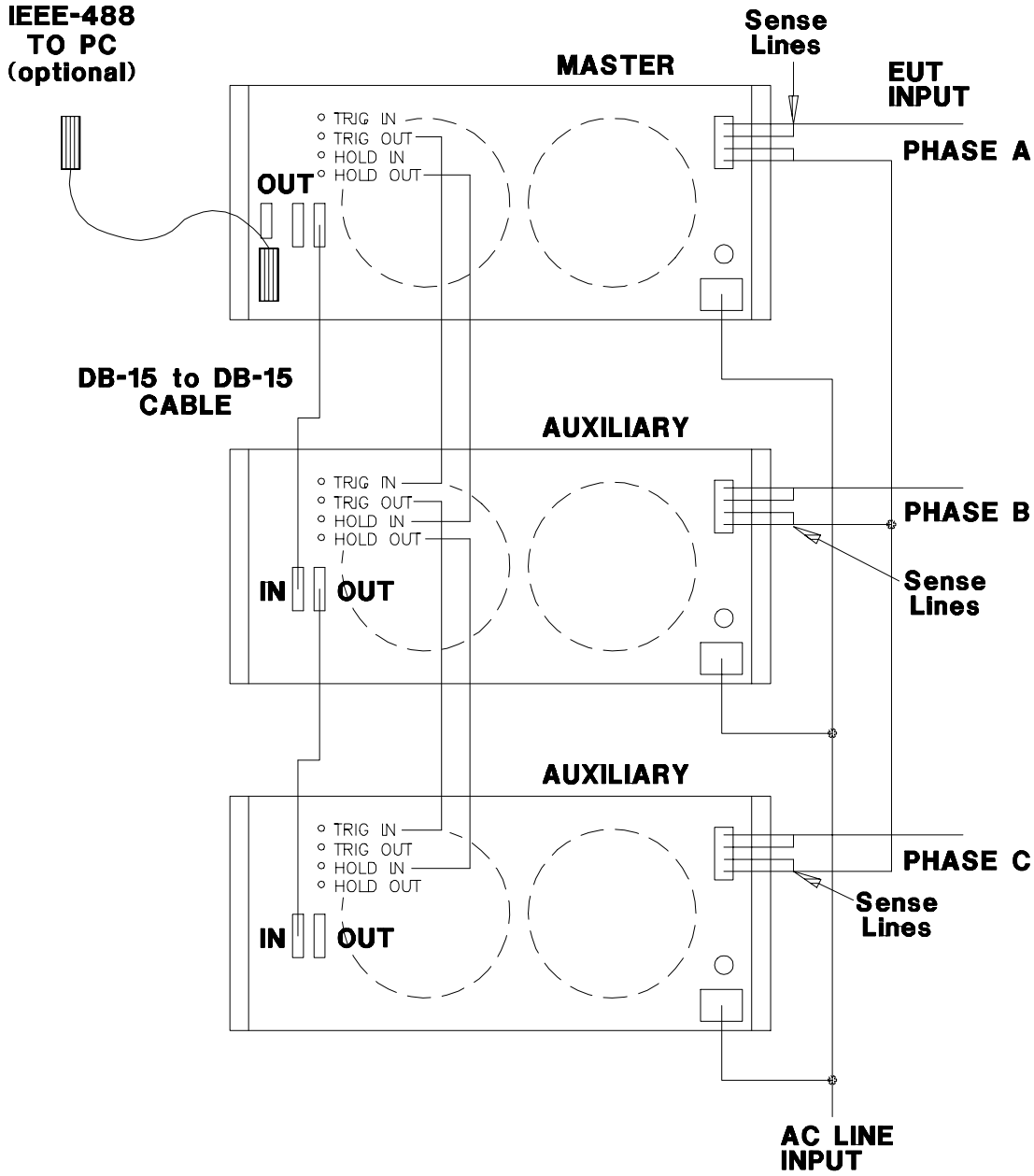
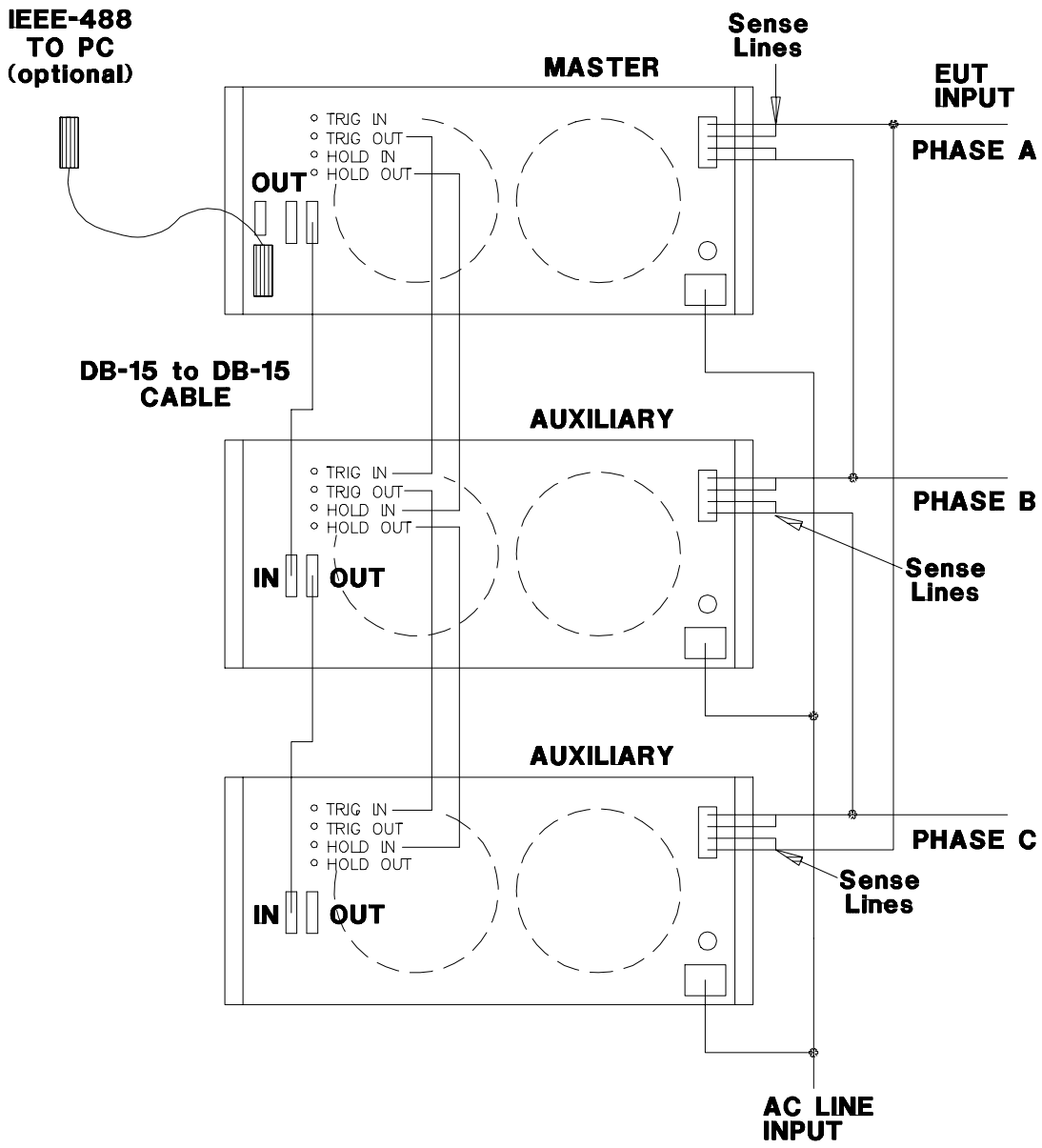


Figure 3-4: 9093LD Three-Phase DELTA Wiring



3.8 Multi Box System Interface

When more than one 3091LD AC load unit is used, the system interface needs to be connected between the master controller and the auxiliary units. The system interface comprises the following signals:

- RS422 Communication Link. A DB-15 to DB-15 cable is included with 3091 Auxiliary units. This cable can also be obtained at most computer stores.
- Hold Synchronization Link
- Trigger Link

3.8.1 RS422 Communication Link

The RS422 serial communication links support communication between the master controller and the auxiliary unit controller(s). Auxiliary units have no front panel controls and can only be operated from the master unit.

Pin	COMM OUT – FEMALE	Pin	COMM IN - MALE
1	TX_IN-	1	TX_IN-
2	TRIGIN+	2	TRIGIN+
3	GND	3	GND
4	TX_IN+	4	TX_IN+
5	INTLKIN+	5	INTLKIN+
6	INTLKIN-	6	INTLKIN-
7	LCLOUT0+	7	LCLIN0+
8	LCLOUT-	8	LCLIN0-
9	RX_IN-	9	RXOUT-
10	TRGOUT+	10	TRGOUT+
11	TRGOUT-	11	TRGOUT-
12	RX_IN+	12	RXOUT+
13	TRIGIN-	13	TRIGIN-
14	LCL1OUT+	14	LCLIN1+
15	LCL1OUT-	15	LCLIN1-

Signal levels on this connector are differential with levels conforming to RS422 specification. This connection is used by the master 3091LD unit to control one or more auxiliary units. A suitable DB-15 to DB-15 cable is included with 3091 Auxiliary models. Mating connector type is:

CI Part	Description	Commercial Part #	Manufacturer
	DSUB 15 Socket (COMM IN)	DA15S	ITT CANNON
	DSUB 15 Plug (COMM OUT)	DA15P	ITT CANNON
	DSUB Shell	DA24658	ITT CANNON
	DSUB Screw Lock	D20419-21	ITT CANNON

3.8.2 Hold Synchronization In/Out

Paralleled units wait or hold until all are ready to execute new commands simultaneously. Paralleled units will work without this connection but may not execute commands simultaneously. Connect Hold Out to Hold In from one unit to the next in a daisy chain fashion for all loads in parallel. Do not connect anything else to this connector.

Connector	Description
Hold In/Out	Open collector output.

Mating Connector type is:

CI Part	Description	Commercial Part #	Manufacturer
	SMB CO-AX 50 Ohm	131-1403-016 EF	JOHNSON

This connector is used with RG178 type 50-ohm CO-AXIAL cable.

3.8.3 Trigger Link In/Out

These are the hardware trigger input and output connectors for use with the sequencer.

Connector	Description
Trigger In	Negative true TTL level signal with 1K Ohm pull up to +5V
Trigger Out	Negative true TTL level output with 39 Ohm series resistor

Mating Connector type is:

CI Part	Description	Commercial Part #	Manufacturer
	SMB CO-AX 50 Ohm	131-1403-016	EF JOHNSON

This connector is used with RG178 type 50-ohm CO-AXIAL cable.

4. Front Panel Operation

4.1 Tour of the Front Panel

Before operating the AC Load 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

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

- Load circuit breaker
- Status Indicator lights
- Shuttle knob
- LCD display
- FUNCTION keypad
- DATA ENTRY keypad

4.1.2 Load Circuit Breaker (CB)

The load circuit breaker located on the bottom left side of the front panel disconnects the AC Load from the EUT power source. It will automatically trip when the input current rating of the AC Load is exceeded. For normal operation, this circuit breaker must be closed at all times. This breaker can not be controller over the bus as is the case for the LOAD State which can be toggled on or off. Note that the breaker presents a physical disconnect whereas the AC load state only disables the load state.

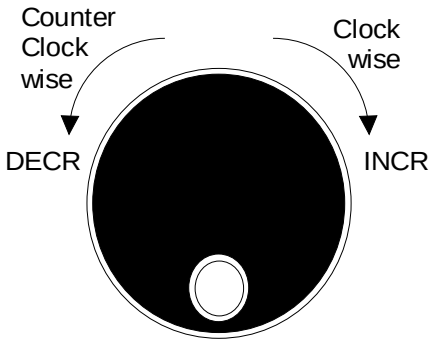
4.1.3 Status Indicator Lights

Four LED status indicators are located directly above the mains circuit breaker. These LED's correspond to the following conditions:

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 REM line(REMOTE ENABLE) line is asserted by the IEEE controller. If the RS232C 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 AC Load is disabled. There is no LOCAL button that allows the user to regain control of the front panel. This prevents accidental change of settings in ATE applications.
OVERLOAD	The OVERLOAD 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.

OVER TEMPERATURE	The OVER TEMPERATURE 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.
FAULT	The FAULT LED indicates an imbalance in load sharing between the four load modules contained in the 3091LD AC load. If this LED comes on, consult chapter 7 for diagnostics and service.

4.1.4 The Shuttle Knob

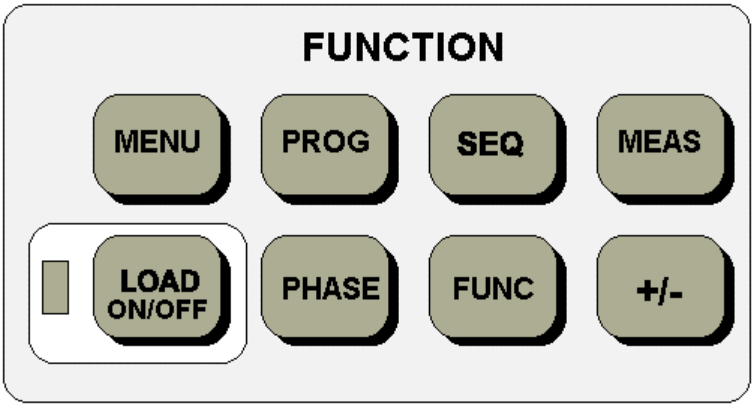


The shuttle knob is located to the right of the LCD screen and is used to change setup parameters. Note that it cannot be used to move the cursor position between menu fields. Use the UP and DOWN arrow keys in the FUNCTION keypad for this.

Changes made using the shuttle knob take effect immediately. There is no need to use the ENTER key when slewing numeric value fields with the shuttle knob. When using the decimal keypad however, changes don't take effect until the ENTER key is pressed.

4.1.5 FUNCTION Keypad

The function keypad provides access to all menus and measurement screens. The following keys are located in the FUNCTION keypad:

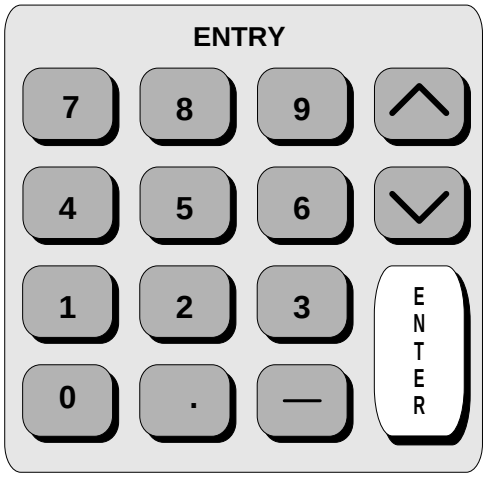


KEY	DESCRIPTION
MENU	The top level menu is accessed by pressing the MENU key. Three shortcut keys are used to provide direct access to the PROGRAM, SEQUENCE, and MEASUREMENT screens as these are among the most frequently used screens. Thus, instead of going through the main menu to reach the PROGRAM, SEQUENCE, and MEASUREMENT screens, they can be accessed directly by pressing the PROG, SEQ, and MEAS keys respectively. A map of the Main menus is provided on the next few pages. There are three top-level menus in the 3091LD AC Load Series.
PROG	The PROG key is a shortcut to access the PROGRAM menu directly. The PROGRAM menu is one of the most frequently used menus. Thus, instead of going through the main menu to reach the PROGRAM menu, it can be accessed directly by pressing the PROG key.
SEQ	The SEQ key is a shortcut to access the SEQUENCE screen directly. The SEQUENCE screen is used to select program and / or execute a sequence of AC load settings.
MEAS	The MEAS key is a shortcut to access the MEASUREMENT screen directly. The MEASUREMENT screen is one of the most frequently used screens. Thus, instead of going through the main menu to reach the MEASUREMENT screen, it can be accessed directly by pressing the MEAS key.

LOAD ON/OFF	The LOAD ON/OFF key toggles the AC Load State on or off. The state of the Load is reflected by the green LED located directly to the left of the LOAD ON/OFF key. If the green LED is lit, the Load is enabled (closed) and the programmed mode and set value is active. If the green LED is off, the AC Load is disengaged and presents a high impedance to the EUT power source. The ON/OFF button provides a convenient way to disconnect the load without having to remove any wires. Note that in addition to the AC load On/Off State, the Load Power Circuit breaker must be closed to engage the load. This CB provides a current limit protection function and can not be controlled over the IEEE-488 or RS232C bus.
PHASE	The PHASE key is used to select the phase on a three phase load system. Pressing the PHASE key will toggle phase A, B, C or ABC. Some screens may not support the ABC mode or show all phase information in which case this mode is ignored.
FUNC	The FUNC key is reserved for future use. It presently has no effect and is ignored when pressed.
+/-	The +/- key can be used to toggle the sign for those parameters for which it is relevant. This is typically the power factor setting. For fields that have only two possible values such as the Unity Power Factor or Short Circuit fields, the +/- key can be used to toggle between these two values.

4.1.6 DECIMAL KEYPAD

The decimal keypad may be used to enter any numeric parameter required in any of the menu fields. Several fields accept input from either the keypad or the knob. Data entered from the keypad is normally accepted once the ENTER key is pressed unless the front panel mode is in the SET mode. The following keys are available on the decimal keypad:



CURSOR UP	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.

CURSOR DOWN	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.

The decimal keypad can be used at any time in lieu of the shuttle knob to change output parameters. Direct data entry is often faster to effect large changes in values than using the shuttle knob.

0 through 9	The numeric keys provide all decimal numbers for entry of parameters.
DECIMAL POINT	The decimal point key is used to enter fractional parts of values for fields that have a resolution less than 1. The amount of resolution for each menu field is normally visible on the LCD. If more digits are entered after the decimal point than can be accepted by a field, the value is automatically rounded to the available resolution when the ENTER key is pressed.
BACKSPACE	The BACKSPACE (←) key can be used to erase one digit at a time if you make a data entry error.

4.1.7 LCD Display

The LCD display of the AC Load provides information on instrument settings and also guides the user through the various menus. To ease reading of the displayed information, most screens are widely spaced. A sample of the main menu 1 screen that appears when the 3091 LD AC Load is powered up is shown in Figure 4-1. Due to the amount of space available on each screen, some menus have been split into parts. The MORE selection located at the bottom right hand side provides access to menu choices at the same level that did not fit on a single screen. Thus, to access MENU 2, the cursor should be placed on the 'MORE' selection followed by pressing the 'ENTER' key. Alternatively, the MENU key may be pressed to move to the MENU 2 screen.

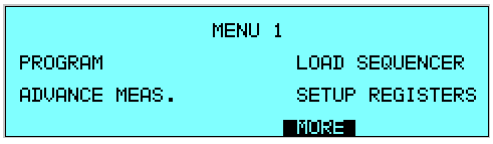
The present cursor position is always shown with a inverse bar. The cursor is located on the 'MORE' selection in Figure 4-1. Pressing ENTER would cause MENU 2 to be displayed.

The cursor position can be moved by using the UP and DOWN keys located in the **DECIMAL** keypad.

4.2 Menu Structure

The next few pages show a map of the available menus. There are two main level (Main 1 and Main 2) menus from which all other menus can be reached. Frequently used (level 2) menus

Figure 4-1: Cursor Position



have a short cut key that provides direct access. Examples of such menus are Program, Measurements, and Sequence. In any case, there are never more than three levels of menus, although some menus may be spread across more than one screen.

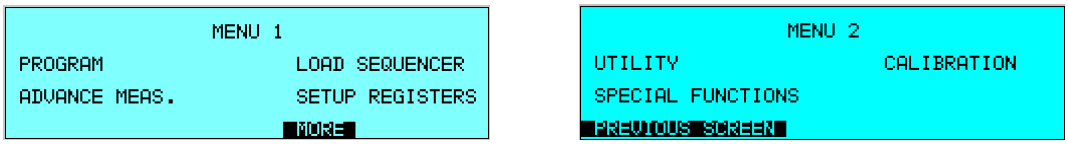
4.2.1 MAIN Menus

The top level menu is split in two parts, MENU 1 and MENU 2 to allow spacing between menu entries. MENU 2 can be reached from MENU 1 by selecting the MORE entry or by pressing the MENU key repeatedly which will toggle between MENU 1 and 2. The division of menu choices between the two screens is graphically illustrated in 4.2.2 by the boxes in level 1. Each box represents one screen. Subsequent screens can be reached using the MORE entry.

The following top level menu choices can be accessed from the MENU key:

Entry	Description

Figure 4-2: Main Menus



MENU 1

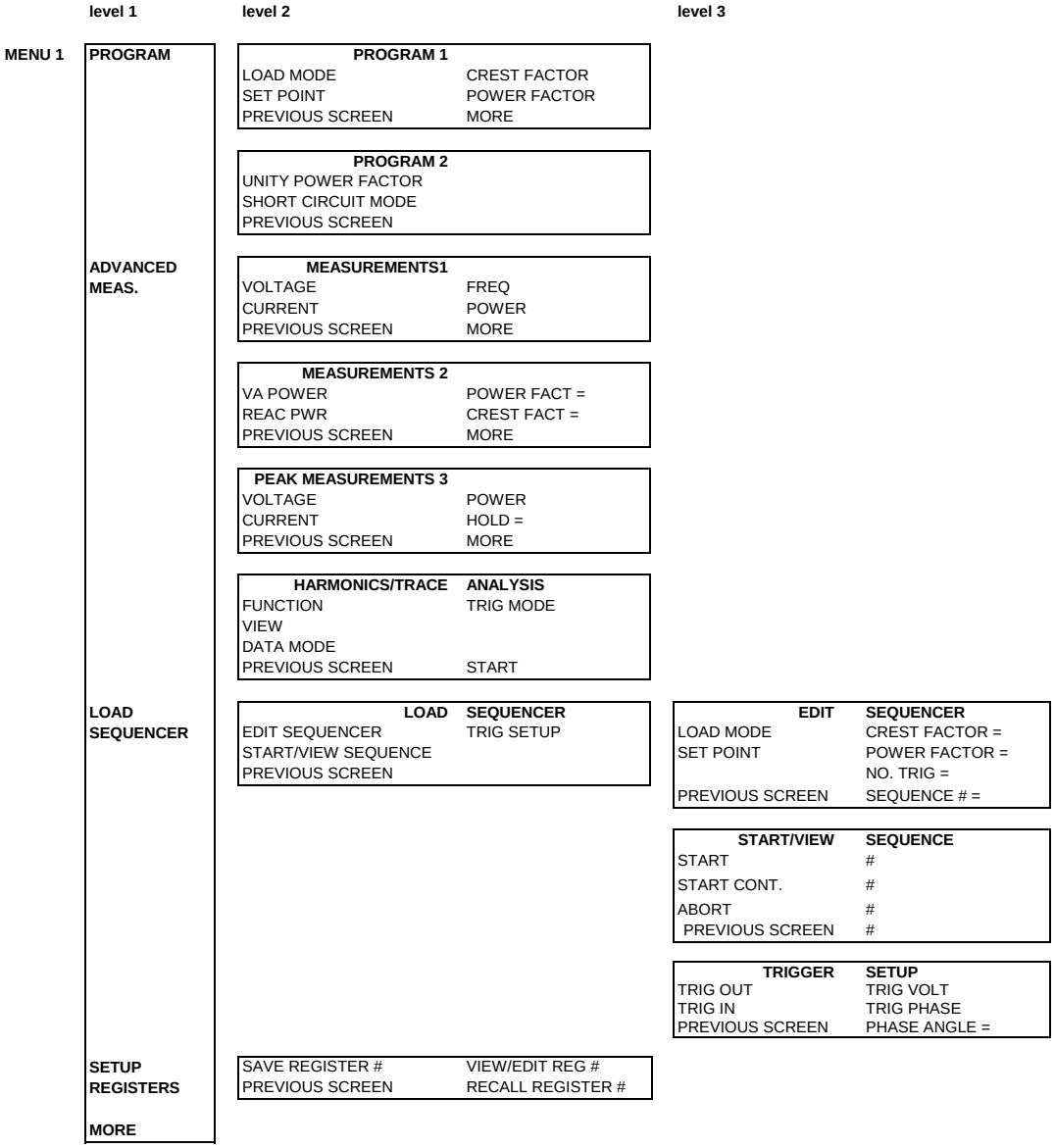
PROGRAM	The PROGRAM menu allows output parameters the be changed.
ADVANCE. MEAS.	Most of the ADVANCE MEAS. screens are not menus in that no user entries are required.
LOAD SEQUENCER	The LOAD SEQUENCER menu allows load sequences to be programmed.
SETUP REGISTERS	The SETUP REGISTERS menu allows complete instrument settings and transient list programs to be saved to nonvolatile memory.
MORE	The MORE selection causes the second part of the MENU screen to be displayed. (MENU 2)

MENU 2

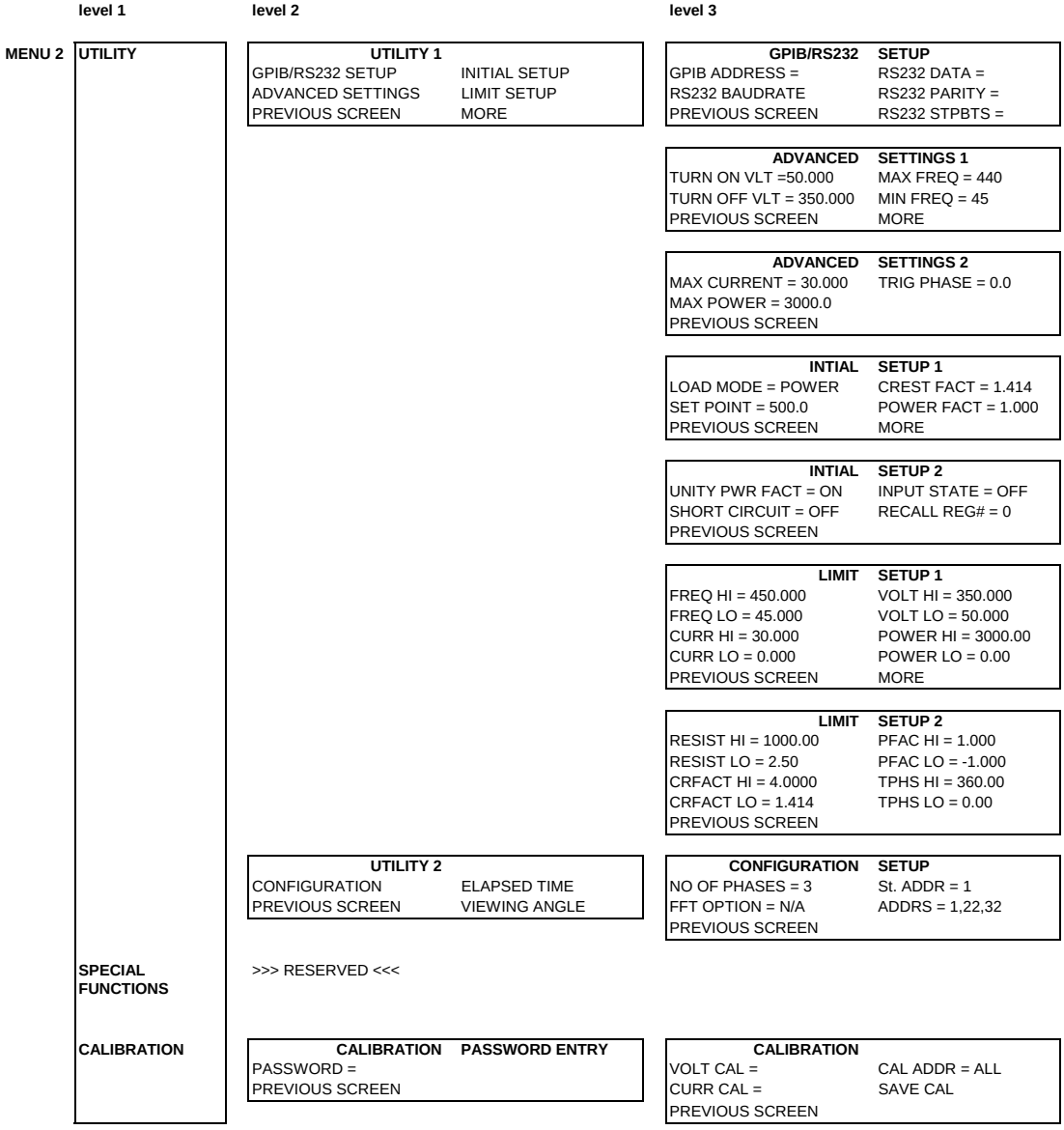
UTILITY	The UTILITY menu provides access to less commonly used setup screens such as those for the GPIB and RS232C interface settings, initial startup values, etc.
SPECIAL FUNCTIONS	The SPECIAL FUNCTIONS menu provides access to the optional firmware application programs that may be installed in the AC Load.
CALIBRATION	The CALIBRATION menu allows for calibration of the AC Load measurement system. The measurement system is used to control the AC load control loop as well. No other calibration is required.

Following the Menu overview pages is a detailed description of each menu and sub menu.

4.2.2 Overview of Main Menu 1



4.2.3 Overview of Main Menu 2



4.2.4 PROGRAM Menu

The PROGRAM 1 menu is shown in Figure 4-3. It can be reached in one of two ways:

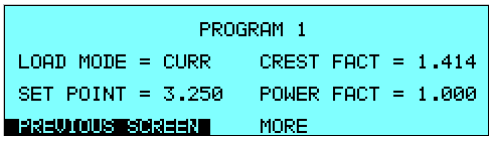
1. by selecting the PROGRAM entry in the MENU screen and pressing the ENTER key
2. by pressing the PROG key in the FUNCTION keypad

The PROGRAM menu is used to change output parameters. The most commonly used setup parameters such as Mode and Set point are all located in PROGRAM 1. The PREVIOUS SCREEN entry, when selected, will return the user to the most recently selected menu. This is normally the MENU screen unless the PROGRAM menu was selected using the PROG key on the FUNCTION keypad. Less frequently used parameters are located in PROGRAM 2 which can be reached from the PROGRAM 1 screen using the MORE selection, or by pressing the PROGRAM key twice.

The following choices are available in the PROGRAM menus:

Entry	Description

Figure 4-3: Program Menus



PROGRAM 1

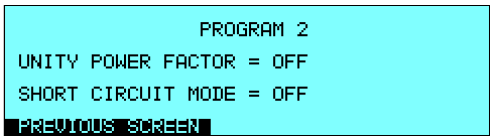
LOAD MODE	Programs the AC Load main operating mode. Available modes are Off, Current, Power, Resistance and Voltage. The selected mode can be changed using the shuttle or the +/- key when the cursor is on this field.
SET POINT	The SET POINT determines the AC load value. The dimension of the value changes with the mode selected. If the Mode is OFF, changing this field has no effect. The resolution of the set point may change as the mode is changed. The value of this field can be changed with the shuttle or the numeric keypad.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
CREST FACT	Sets the requested Crest Factor. This value can only be set while in CURR or POWER mode. The range of the crest factor is between 1.414 and 4.000. The Crest Factor value will affect the Power Factor setting as well. Thus, not all combinations of Crest Factor and Power Factor are available. The value of this field can be changed with the shuttle or the numeric keypad.
POWER FACT	Sets the requested Power Factor. This value can only be set while in CURR or POWER mode. The range of the power factor is between -1.000 (lagging) and +1.000 (leading). The Power Factor value will affect the Crest Factor setting as well. Thus, not all combinations of Crest Factor and Power Factor are available. The value of this field can be changed with the shuttle or the numeric keypad.

MORE	Moving the cursor to the MORE field and pressing the Enter key selects the second PROGRAM 2 menu. The same can be accomplished by pressing the PROG key on the front panel.

PROGRAM 2

Entry	Description
UNITY POWER FACTOR	Toggles the Unity Power Factor mode on or off. When enabled, the AC load acts as a resistive load, even in Constant current and constant power modes. The Crest Factor and Power Factors settings are ignored while in the Unity Power Factor mode. The selected mode can be changed using the shuttle or the +/- key when the cursor is on this field.

Figure 4-4: Program 2 Menu



SHORT CIRCUIT MODE	Toggles the Short Circuit mode on or off. In this mode, a cross-bar is used to short the inputs of the AC load together. All other AC load settings except the AC load state are ignored while in this mode.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.

4.2.5 ADVANCED MEASUREMENTS Screens

The 3091LD Series uses a dual DSP based data acquisition system to provide extensive information regarding the AC load conditions. This data acquisition system digitizes the voltage and current waveforms and calculates several parameters from this digitized data. The result of these calculations are displayed in a series of measurement data screens. The actual digitized waveforms can also be displayed by selecting the Harmonics/Trace Analysis screen. A total of four measurement screens are used to display all this information.

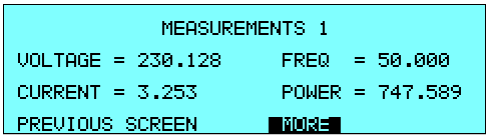
The first three Measurements screens available on the 3091LD Series are not strict menus in that no changes can be made anywhere. Instead, these three screens provide load parameter readouts. The fourth measurement screen provides access to the advanced measurements and does offer several user accessible fields. The measurement screens can be reached by successively pressing the MEAS key, which will toggle, to all four available screens.

For three phase systems, 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 all three phases simultaneously.

The following parameters are available in the first three measurement screens:

Entry	Description

Figure 4-5: Measurements 1 screen

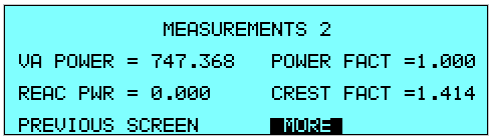


MEASUREMENTS 1

VOLTAGE	Displays the true RMS input AC voltage (V) measured at the input sense lines.
CURRENT	Displays the true RMS input AC current (A) drawn by the load.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
FREQ	Displays the input frequency (Hz) measured at the load power terminals.
POWER	Displays the True power (W) consumed by the load.
MORE	Moving the cursor to the MORE field and pressing the Enter key selects the second MEASUREMENTS 2 screen. The same can be accomplished by pressing the MEAS key on the front panel.

Entry	Description

Figure 4-6: Measurements 2 screen

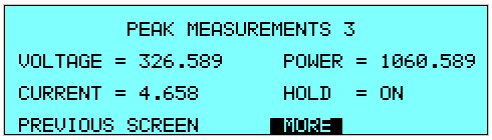


MEASUREMENTS 2

VA POWER	Displays the Apparent power (VA) consumed by the load.
REAC PWR	Displays the Reactive power (VAR) consumed by the load. The relationship between true, apparent and reactive power is: Apparent Power = SQR(True power^2 + Reactive power^2).
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
POWER FACT	Displays the actual power factor of the load. Depending on AC load mode and crest factor settings, the measured power factor may be different from the programmed power factor.
CREST FACT	Displays the actual crest factor (ratio between peak current and RMS current). Depending on AC load mode and crest factor settings, the measured power factor may be different from the programmed power factor.

Entry	Description

Figure 4-7: Peak Measurements 3 screen



PEAK MEASUREMENTS 3

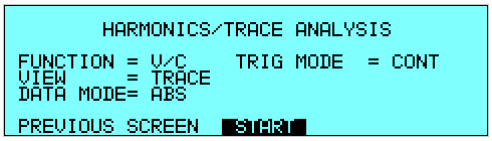
VOLTAGE	Displays the peak voltage. This value can be positive or negative and may depending on any DC offset that may be present on the input.
CURRENT	Displays the peak current. This value can be positive or negative and may depending on any DC offset that may be present on the input.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
POWER	Displays the peak power.
HOLD	This field toggles the Hold mode on or off. If the Hold mode is on, the 3091LD tracks the highest value found until reset. This mode is suitable for peak inrush measurements. If the Hold mode is off, cycle to cycle peak values are reported instead.

4.2.6 HARMONICS/TRACE ANALYSIS Screen

The fourth measurement screen is dedicated to the harmonics and waveform analysis. The Harmonics/Trace Analysis measurement screen is a true menu screen offering several user accessible fields. These fields are used to select the desired acquisition trigger and display modes. The actual data is displayed whenever the ENTER key is pressed while the cursor is on the START field. The following fields are available on this menu:

Entry	Description

Figure 4-8: Harmonics/Trace Analysis screen



FUNCTION — Selects Voltage, Current or Both (V/C) parameters for display. The display mode is determined by the VIEW field.

VIEW — Available display modes for the selection FUNCTION are TABLE, BAR and TRACE.

Figure 4-9: Voltage Harmonics data in Table display mode

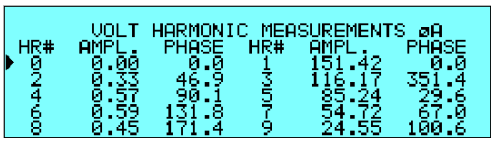
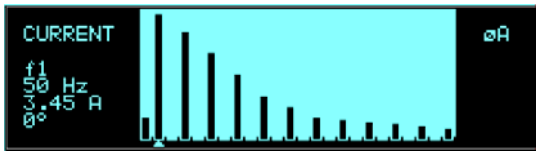


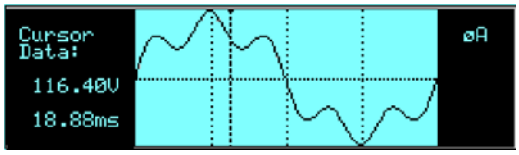
TABLE mode: displays the first 50 harmonics in a tabular text format.

Figure 4-10: Voltage Harmonics data in Bar display mode



BAR mode: displays the first 50 harmonics in a graphical bar chart display.

Figure 4-11: Voltage data in Trace display mode



TRACE mode: displays the selected Function in a time domain (waveform) graphical display.

DATA MODE	Selects absolute or relative harmonics display for TABLE and BAR view modes. In relative mode, all harmonics are shown in a percentage of the fundamental, which is normalized at 100 %. In absolute mode, the harmonic amplitudes are shown in absolute volts or amperes. This mode does not apply to the TRACE view display mode and is ignored when this mode is selected.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
TRIG MODE	This field sets the trigger mode for the acquisition. Available options are SINGLE (single shot acquisition) or CONT (continuous acquisition). In SINGLE shot mode, the acquisition is triggered once each time the START field is selected and the ENTER key is pressed. Once the acquisition has been triggered, the data are displayed and do not change until the next acquisition is triggered. This mode is most appropriate for single shot events such as start up currents. In the CONT mode, acquisitions occur repeatedly and the data is updated on screen after each trigger occurs. This provides a continuous update of the data and is most appropriate for repetitive load conditions.
START	The START field is used to start a new acquisition run. To start an acquisition, place the cursor on the START field and press the ENTER key. Once the ENTER key is pressed, the display toggles to the data display mode selected in the VIEW field as soon as the selected trigger event occurs. To return to the HARMONICS/TRACE ANALYSIS menu, press the ENTER key while in the data display mode. To change display modes without triggering a new acquisition, make the desired changes in the menu and move the cursor to the VIEW field. Once on the VIEW field, press the ENTER key. This will not trigger a new acquisition, which means the original data is retained.

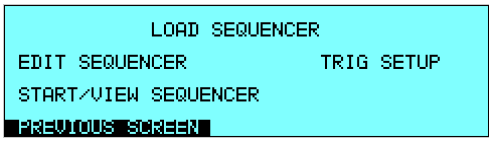
4.2.7 LOAD SEQUENCER Menu

The sequence menu provides access to the load sequence list. The sequence list can have up to 100 sequence commands. One or more commands are combined in a sequence step. Steps are separated by a WAIT FOR TRIGGER command which consumes an entry in the available sequence list as well. This effectively limits the number of commands in each sequence list to 50 usable commands.

The following entries can be found in the LOAD SEQUENCE menu:

Entry	Description

Figure 4-12: Load Sequencer Menu



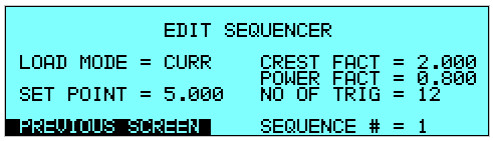
EDIT SEQUENCER	Selects the EDIT SEQUENCER menu. This allows new sequence steps to be entered or existing sequence steps to be edited on screen. Refer to paragraph 4.2.7.1 for details.
START/VIEW SEQUENCE	Selects the START/VIEW SEQUENCE menu. This entry allows the user to switch to the sequence execution menu. This menu provides a list of all available sequence list steps and their sequence numbers. From this menu, sequence list execution can be started. The same menu can be used to view or edit any available transient list step or erase a step using the backspace key. Refer to paragraph 0 for details on this menu.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
TRIG SETUP	Selects the TRIG SETUP menu used to define the trigger mode for the sequence.

4.2.7.1 EDIT SEQUENCER Menu

A sequence list is composed of up to 32 sequence steps numbered from 0 through 99. Steps are executed in numeric order. The numbers don't have to be contiguous however, allowing for gaps in sequence numbers which allow new list entries to be added later.

From the LOAD SEQUENCER menu, the desired sequence step type can be created by selecting the EDIT SEQUENCER entry and pressing the ENTER key. The START/VIEW SEQUENCE sub menu allows the user to review and change any sequence step or execute the sequence list. When executing a sequence list, steps are executed in ascending numerical order. Steps that are not defined are skipped.

Figure 4-13: Load Sequencer Menu



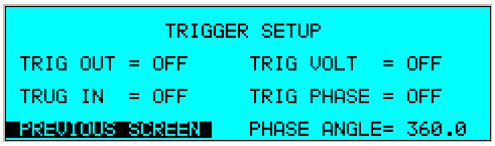
The following entries can be found in the SEQUENCE menu:

Entry	Description
MODE	This field sets the AC Load mode for each sequence list point. The load mode can be changed dynamically during sequence execution by setting different load modes for each step. The selected load mode will affect the availability of other list parameters such as crest and power factor. For example, if the mode is set to Resistance, both CF and PF are fixed to 1.414 and 1.000 respectively.
SET POINT	The set point determines the sequence step value for the selected mode. The value of this field can be changed with the shuttle or the numeric keypad.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
CREST FACTOR	If the selected mode supports crest factors greater than 1.414, this field determines the programmed crest factor for this sequence step. Note that this value is also linked to the selected power factor. The value of this field can be changed with the shuttle or the numeric keypad.
POWER FACTOR	If the selected mode supports power factors less than 1.000, this field determines the programmed power factor for this sequence step. Note that this value is also linked to the selected crest factor. The value of this field can be changed with the shuttle or the numeric keypad.
NO OF TRIG	Sequence steps are advanced based on the occurrence of a trigger event. By default, one trigger event will advance the next step in the sequence list. The NO OF TRIG field allows a step to be held for an additional number of trigger events. The amount of trigger events that can be entered in this field is limited by the maximum number of commands that can be queued up (100). Depending on the complexity of the sequence list, the actual number available may be less.

SEQUENCE # =	The sequence number for each step can be set to any value between 0 and 99. Sequence steps are executed in ascending numerical order. It is allowed to leave gaps between subsequent list step numbers to allow insertion of steps at a later time. The value of this field can be changed with the shuttle or the numeric keypad. Note that the total number of sequence steps is limited to 32.

4.2.7.2 TRIGGER SETUP sub menu

Figure 4-14: Trigger Setup menu



The TRIGGER SETUP menu is used to control sequence execution. Sequence execution requires an event trigger to proceed from list point to list point. Unless the NO OF TRIG field is set to a value higher than 1 in which case the number of triggers required to advance to the next sequence list entry is increased to the set number. This menu may be used to determine the type of trigger and the trigger value used to proceed through a sequence list.

Note that more than one trigger source may be enabled at a time. All trigger sources are OR-ed together to create a trigger event for the sequencer.

The TRIGGER SETUP screen has the following fields:

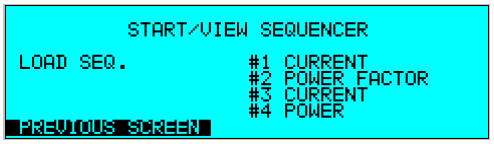
Entry	Description
TRIG OUT	Toggles the output trigger (BNC connector) on the rear panel of the master unit on or off.
TRIG IN	Toggles the input trigger (BNC connector) on or off. When turned on, the user must ensure that a valid TTL trigger signal is present at the TRIG input on the rear panel of the master 3091LD unit.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
TRIG VOLT	Toggles the voltage trigger source on or off. A trigger is generated when the input voltage drops below the TURN OFF voltage or rises above the TURN ON voltage. The level of the TURN OFF and TURN ON voltage can be set in the ADVANCED SETTINGS menu. See section 4.2.9.2 for details.
TRIG PHASE	Toggles the phase angle trigger source on or off. A trigger is generated each time the input voltage reaches the set phase angle. The phase angle to use is set by the PHASE ANGLE field. Using the TRIG PHASE mode, an AC load setting change can be effected for each cycle of the input voltage.
PHASE ANGLE =	Sets the value of the trigger phase angle. The phase angle of the voltage input is used to generate the requested trigger signal.

4.2.7.3 START/VIEW SEQUENCER sub menu

The START/VIEW SEQUENCER screen is used to control sequence execution. It also provides an overview of available sequence list events. This list appears in the order they were assigned event numbers. Editing an existing event can be accomplished from this screen by positioning the cursor on the event to be edited and pressing the ENTER key. This method can also be used to review the parameters of a previously entered event.

Unless a command sequence is in progress, the display will show a LOAD SEQ. entry. This

Figure 4-15: Sequencer Load menu

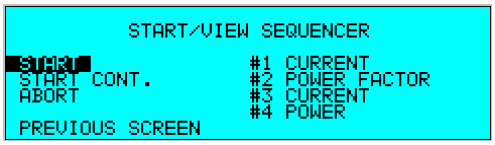


menu entry allows the programmed sequence to be initialized. Once initialized, the menu changes to display START and START CONT. The START field may be used to execute a sequence once. The START CONT. entry will cause the programmed sequence to run repeatedly until ABORT is selected.

The START/VIEW TRANSIENT SEQUENCE screen has the following fields:

Entry	Description

Figure 4-16: Sequencer Execution menu



START / ARMED

The START field is used to start the sequencer. When the cursor is positioned on the START field and the ENTER key is pressed, sequence execution starts. The input circuit breaker must be closed and the AC load state must be ON or an error message will appear and the sequence will not start.

Once a sequence is in progress, this field changes to ARMED to indicate the sequence is waiting for a trigger event. If the sequence list completes execution, the field reverts back to START.

START CONT.

The START CONT. field is used to start continuous execution of the programmed sequence. When the cursor is positioned on the START CONT. field and the ENTER key is pressed, sequence execution starts. The input circuit breaker must be closed and the AC load state must be ON or an error message will appear and the sequence will not start.

ABORT

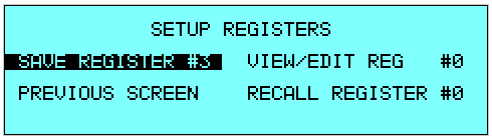
Once a sequence is in progress, it can be aborted by moving the cursor to the ABORT field and pressing the ENTER key. If the transient completes execution, the LOAD SEQ. field reappears and the START and ABORT fields disappear. For sequences that are run continuously, the ABORT is the only method to stop a sequence.

PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.

4.2.8 SETUP REGISTERS Menu

The SETUP REGISTERS menu allows the user to store and recall complete instrument setups, including the sequencer list. A total of 8 non volatile setup registers is available, numbered sequentially from 0 through 7.

Figure 4-17: Setup Register Menu



The following entries can be found in the SETUP REGISTERS menu:

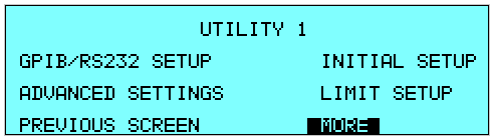
Entry	Description
SAVE REGISTER	Save present instrument setup to a register number selected by the user. The numeric data entry keypad should be used to enter a number between 0 and 7. Once the ENTER key is pressed, all settings are saved. A message will appear at the bottom of the screen to confirm the save operation.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
VIEW/EDIT REGISTER	The View/Edit entry can be used to display the contents of a setup register before it is recalled. After the user enters a register number to view or edit and presses the ENTER key, the PROGRAM screen will appear. All parameters that will be changed by recalling the register will be blinking. If ENTER is pressed again, the register will be recalled and the new values take effect. To edit the register content, change all parameters that need to be changed. Pressing ENTER will save the new values and make them active.
RECALL REGISTER	Recall instrument setup from a register number selected by the user. The numeric data entry keypad should be used to enter a number between 0 and 7. Once the ENTER key is pressed, all settings are recalled. A message will appear at the bottom of the screen to confirm the recall operation.

4.2.9 UTILITY Menus

The UTILITY menu provides access to less frequently used setup items. There is no connection between the various entries in the UTILITY menu other than there is no other logical place to put them. The following entries can be found in the UTILITY menu:

Entry	Description

Figure 4-18: Utility 1 Menu

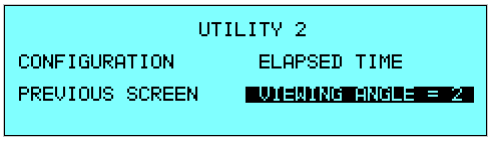


UTILITY 1

GPIB/RS232 SETUP	This entry provides access to the setup parameters for either the IEEE-488 bus or the RS232C bus. All parameters are saved in non-volatile memory so their is rarely a need to change these values.
ADVANCED SETTINGS	This entry provides access to the ADVANCED SETTINGS menu. For details, refer to paragraph 4.2.9.2
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
INITIAL SETUP	This entry provides access to the INITIAL SETUP menu. For details, refer to paragraph 4.2.9.3
LIMIT SETUP	This entry provides access to the LIMIT SETUP menu. For details, refer to paragraph 4.2.9.4

Entry	Description

Figure 4-19: Utility 2 Menu



UTILITY 2

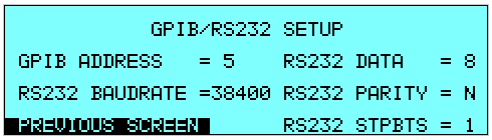
CONFIGURATION	The Configuration menu shows the installed options. This screen is for reference only and no fields can be changed by the user.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
ELAPSED TIME	The elapsed time screen, when selected from the UTILITY menu, will appear for about 3 seconds. The elapsed time shown is the cumulative amount of time the AC Load has been on from its initial build. This value is read only and cannot be changed by the user.
VIEWING ANGLE	The viewing angle can be used to change the contrast ratio of the LCD display. The range of the viewing angle parameter is from -10 to +10. Setting the right viewing angle is matter of personal taste. Set this parameter to a value that is most comfortable for the user.

4.2.9.1 GPIB/RS232 SETUP menu

The GPIB/RS232 SETUP menu may be used to change the interface parameter settings for both the IEEE-488 interface and the RS232 serial interface. The following parameters can be set from this menu:

Entry	Description

Figure 4-20: GPIB/RS232 Setup Menu



GPIB ADDRESS	Sets the IEEE-488 address used by the AC Load. The address value can be set from 0 through 31. Address 0 is often reserved for the IEEE-488 controller. The factory setting is address 1. Once changed, the IEEE-488 address is retained in nonvolatile memory.
RS232 BAUDRATE	This field can be used to set the RS232 baud rate to 9600, 19200 or 38400 baud. The baud rate set on the AC Load must match the one programmed for the communications port of the controller.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
RS232 DATA	This field is used to set the number of data bits to either 7 or 8. Factory setting is 8 bits. This value must match the number of data bits set on the communications port of the controller.
RS232 PARITY	This field is used to set the parity. Available options are Even (E), Odd (O) or no parity (N). Factory setting is No parity. This value must match the parity set on the communications port of the controller.
RS232 STPBITS	This field is used to set the number of stop bits used on the serial port. Available options are 1 or 2 bits. Factory setting is 1 stop bit. This value must match the parity set on the communications port of the controller. The number of start bits is always fixed to 1 bit.

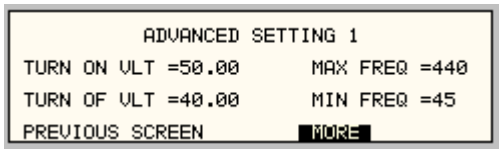
4.2.9.2 ADVANCED SETTINGS Menu

The advanced settings menu may be used to set user defined limits on the AC input as seen by the AC load. If any of the user defined limits are exceeded, the AC load state is turned off. When the input returns to the range set by the user in the Advanced Settings screen, the output state is turned on again. This feature may be used to protect the equipment under test from damage due to excessive load conditions.

Note that user defined settings can never exceed the hardware limits of the AC Load.

Entry	Description

Figure 4-21: Advanced Settings 1 Menu

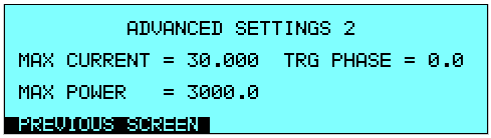


ADVANCED SETTINGS 1

TURN ON VLT	Minimum input voltage allowed. The load state will turn ON when this value is exceeded. The Turn-on voltage must be at least 10 Volt higher than the Turn-off voltage. (Hysteresis of 10 Volt or more.) This value is also used in generating triggers for the command sequencer. See section 4.6.3.
TURN OF VLT	Maximum input voltage allowed. The load state will turn OFF when this value is exceeded. The Turn-off voltage must be at least 10 Volt lower than the Turn-on voltage. (Hysteresis of 10 Volt or more.) This value is also used in generating triggers for the command sequencer. See section 4.6.3.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
MAX FREQ	Maximum input frequency allowed.
MIN FREQ	Minimum input frequency allowed.
MORE	Moving the cursor to the MORE field and pressing the Enter key selects the ADVANCED SETTINGS 2 screen.

Entry	Description

Figure 4-22: Advanced Settings 2 Menu



ADVANCED SETTINGS 2

MAX CURRENT	Maximum AC load RMS current allowed. The load will limit the current to this value.
MAX POWER	Maximum AC load RMS power allowed. The load will limit the power to this value.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
TRG PHASE	Maximum trigger phase for sequence execution. This phase angle sets the timing for generating trigger events to the command sequencer. Allowable range is 0° to 360°. Note however that a 360° value signifies a random trigger angle. See section 4.6.3.

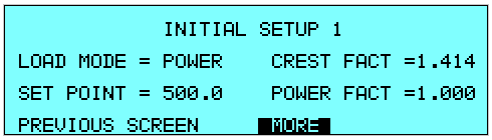
4.2.9.3 INITIAL SETUP menu

Any time the AC Load is powered up, the output will reflect the settings stored as the INITIAL setup values. This allows the unit to be powered up in a known state at all times. The INITIAL values can be set using the INITIAL SETUP menus. These menus can be reached from the UITILITY 1 menu.

The initial setup can be used to power up the AC load with the Load state on and a known load setting. Note however that the position of the load circuit breaker cannot be controlled in firmware. The user is responsible for closing the circuit breaker on the front panel to connect the load to the EUT.

The following fields are provided in the INITIAL SETUP menus:

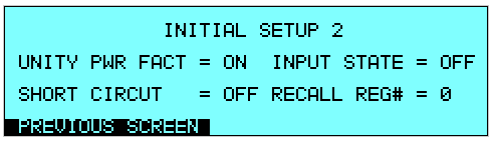
Figure 4-23: Initial Setup 1 Menu



Entry	Description
	INITIAL SETUP 1
LOAD MODE	Sets the power-on AC load mode to any of the available modes; Power, Current, Voltage, Resistance.
SET POINT	Sets the power-on setting value.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
CREST FACT	Sets the power-on crest factor value.
POWER FACT	Sets the power-on power factor value.
MORE	Moving the cursor to the MORE field and pressing the Enter key selects the INTIAL SETUP 2 screen.

Entry	Description

Figure 4-24: Initial Setup 2 Menu



	INITIAL SETUP 2
UNITY PWR FACT	Sets the power-on Unity Power Factor mode to On or Off. The shuttle or the +/- key may be used to change the value of this field.
SHORT CIRCUIT	Sets the power-on Short Circuit mode to On or Off. The shuttle or the +/- key may be used to change the value of this field.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.

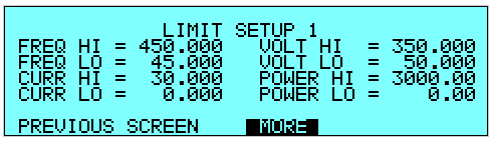
INPUT STATE	Sets the power-on AC state to On or Off. The shuttle or the +/- key may be used to change the value of this field.
RECALL REG #	This field can be set to OFF or to any of the available setup registers. See paragraph 4.2.8 for details on setting register content. If a valid setup register is set in the field, the settings contained in this register will be recalled on power up. In this case, any other settings in the INTIAL SETUP menus are overridden. The use of a register for defined the power state also allows a load sequence to be loaded at power up. Any load sequence contained in a setup registers and recalled at power up still has to be initiated and triggered. It will not execute automatically at power on.

4.2.9.4 LIMIT SETUP screen

The limit setup screen is not a menu but only serves to inform the user of the hardware capabilities of the AC Load. The cursor can be moved to any of the fields in this screen but none of these fields can be changed. The following information is provided on this screen:

Entry	Description

Figure 4-25: Limit Setup 1 Screen

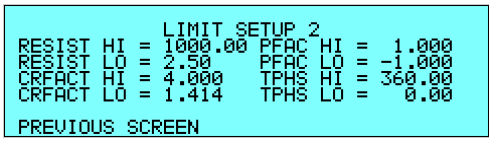


LIMIT SETUP 1

FREQ HI	Maximum AC Frequency of input voltage signal. If this value is exceeded, the AC Load state will turn off until the input returns within the allowable range.
FREQ LO	Minimum AC Frequency of input voltage signal. If the input drop below this frequency, the AC Load state will turn off until the input returns within the allowable range.
CURR HI	Maximum AC RMS current that can be absorbed by the AC Load. The load will limit the maximum current to this level.
CURR LO	Minimum AC RMS current. This value is typically zero.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
VOLT HI	Highest possible input voltage. If this value is exceeded, the AC Load state will turn off until the input returns within the allowable range.
VOLT LO	Lowest possible input voltage. If the input voltage drops below this value, the AC Load state will turn off until the input returns within the allowable range.
POWER HI	Highest possible power dissipation allowed. The load will limit the maximum power to this level.
POWER LO	Lowest possible power dissipation allowed. This value is typically zero.

Entry	Description

Figure 4-26: Limit Setup 2 Screen



LIMIT SETUP 2

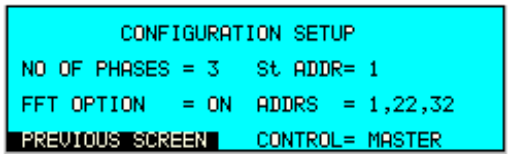
RESIST HI	Maximum resistance value supported by AC load. This value cannot be exceeded when in Constant Resistance mode.
RESIST LO	Minimum resistance value supported by AC load. Values below this limit cannot be selected when in Constant Resistance mode.
CRFACT HI	Maximum Crest Factor value supported by AC load. This value cannot be exceeded in any mode.
CRFACT LO	Minimum Crest Factor value supported by AC load. This is the crest factor value of a sine wave current.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
PFACT HI	Maximum Power Factor value supported by AC load. This value cannot be exceeded in any mode. A positive power factor indicates the current is leading.
PFACT LO	Minimum Power Factor value supported by AC load. This value cannot be exceeded in any mode. A negative power factor indicates the current is lagging.
TPHS HI	Maximum Trigger phase value supported by AC load. This value cannot be exceeded in any mode.
TPHS LO	Minimum Trigger phase value supported by AC load. Trigger phase angles below this value cannot be set.

4.2.9.5 CONFIGURATION SETUP screen

The configuration setup screen is not a menu but only serves to inform the user of the software features and options installed in the AC load. It also provides information on the number of 3091LD Auxiliary units connected to the master 3091LD. The cursor can be moved to any of the fields in this screen but none of these fields can be changed. The following information is provided on this screen:

Entry	Description

Figure 4-27: Configuration Setup Screen



NO OF PHASES	Displays the number of AC load phases. A single 3091LD AC unit is a single-phase load. To obtain a three phase AC Load, one master 3091LD and two auxiliary 3091 units are needed. Each phase can have more than one 3091 in parallel for higher power load configurations.
FFT OPTION	This field indicates the presence of the FFT option. For details on the FFT measurement menu, refer to paragraph 2.4.2.
PREVIOUS SCREEN	Moving the cursor to the PREVIOUS SCREEN field and pressing the Enter key reverts to the previous screen selected.
St ADDR = 1	Displays the device address of each phase in a three phase system. Auxiliary units are assigned to a phase based on their device address setting. The device address may be set using the DIP switch on the rear panel of each auxiliary unit. The master unit is always the unit with the front panel keyboard, display and RS232C / GPIB interface.
ADDRS = 1,…	Displays the device addresses of all units found on the RS422 device interface bus that connects multiple units of a multi-box system.
CONTROL	This field indicates if the controller is a master or auxiliary unit. Changing this field to an auxiliary unit with the shuttle will disable control of the AC Load from the front panel or the remote programming. The change will take effect only at power up.

4.2.10 CALIBRATION Menu

The CALIBRATION menu provides access to the measurement calibration scale factors for Voltage and Current. All other measurements are mathematically derived from these two parameters and require no further calibration. For three phase configurations, the PHASE key toggles between the three calibration screens, one for each phase. These parameters are password protected and can only be changed after the calibration password has been entered. Selecting the CALIBRATION entry from the MENU 2 screen will yield the following password entry screen:

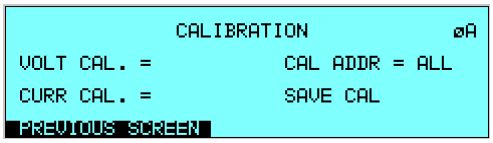
Figure 4-28: Calibration Password Entry screen

To unlock the calibration mode, the correct password needs to be entered. For the 3091LD AC load, the calibration password is: "3091". Enter "3091" without the quotes while the cursor is on the PASSWORD = field using the decimal keypad and press the ENTER key. This will bring up the actual CALIBRATION menu.

Refer to the calibration section in this manual for details on performing a calibration. The following calibration factors are available from this menu:

Entry	Description

Figure 4-29: CALIBRATION menu



VOLT CAL.	Full scale voltage measurement calibration factor. Calibration is performed by entering an external voltage reference reading. The 3091LD performs a measurement and adjusts the calibration coefficient to match the external voltage reading. To perform this calibration, apply 300 V RMS to the AC load.
CURR CAL.	Full scale current measurement calibration factor. Calibration is performed by entering an external current reference reading. The 3091LD performs a measurement and adjusts the calibration coefficient to match the external current reading. To perform this calibration, apply 90 % of the maximum rate RMS current to the AC load.
CAL ADDR.	For current calibration in multi box unit configurations having more than one 3091 unit per phase, the CAL ADDR field may be used to select an individual unit. All other units on that phase will be disabled so each unit can be calibrated in turn. This is not required for Voltage calibration as all units on a phase see the same voltage. Field values are ALL or a specific unit number. The phase can be selected with the PHASE button on the front panel and is displayed in the top right hand corner of the LCD.

SAVE CAL.	Selecting this field and pressing the ENTER key will cause the newly calculated measurement scale factors to be stored in Flash EPROM. If this step is skipped, the prior calibration scale factors will take effect the next time the AC Load is turned on.

Note: Flash EPROM has a finite number of available write cycles. Do not save calibration scale factors unless the final adjustment has been made.

4.3 Load Mode Programming

This section covers basic mode programming operations performed through the front panel menus. Examples are provided for common applications.

4.3.1 Set the Load Mode

AC Load mode parameters are all set from the PROGRAM 1 and PROGRAM 2 screens.

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

   or

2. Use the PROG key to directly bring up the PROGRAM 1 menu.

There are two methods for programming output parameters:

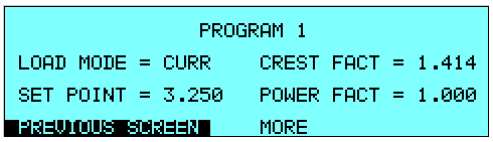
Slewing using the Shuttle

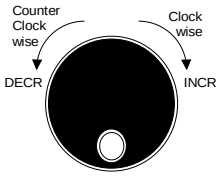
Keypad entry

4.3.2 Slewing Load Values with the Shuttle

The default mode of operation is an immediate mode in which changes to settings made by the user with the shuttle or the keypad take immediate effect.

To change the mode to power:

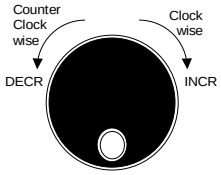




1. Place the cursor on the LOAD MODE entry
2. Rotate the shuttle clockwise to scroll through the available load modes

These changes take effect immediately.

To change the power dissipated by the AC Load:



1. Place the cursor on the SET POINT entry
2. Rotate the shuttle clockwise to increase the value, counterclockwise to decrease the value

These changes take effect immediately.

4.3.3 Change Mode Values with the Keypad

The keypad can be used to directly enter new load settings. Data entered using the decimal keypad does not take effect until the ENTER key is pressed. If an incorrect number is pressed, the backspace key (<-) can be used to correct it.

To change the AC load mode using the keypad:

1. Place the cursor on the LOAD MODE entry
2. Press the +/- key repeatedly until the CURRENT mode is displayed
3. Place the cursor on the SET POINT entry
4. Type in "3", ".", "2" and "5".
5. The SET POINT field will display the new current value but it will not be in effect yet until the ENTER key is pressed or the cursor is moved to a different field.
6. Press the ENTER key.

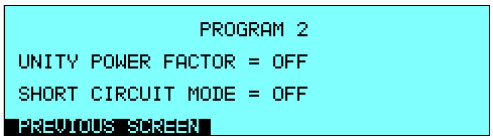
Notice the change in load current that takes effect - assuming a sufficiently high input voltage is present at the load terminals. Both mode and current set point are now in effect at the AC load input.

4.3.4 Setting Crest Factor and Power Factor values

The crest factor and power factor can be set to any value between the high and low limits as indicated in the LIMITS screen. To obtain the desired crest factor however, the power factor will automatically be affected. Thus, the selected combination of crest factor and power factor may not be possible at any given moment. If this is the case, a warning prompt will appear in the top left corner of the LCD display indicating a setting conflict. The AC Load will always try to match the user-requested settings. See section 5.4 for more details on this interaction.

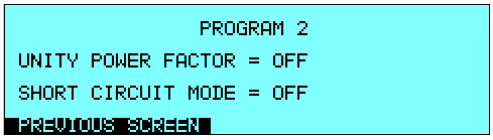
Note: Crest Factor and Power Factor controls are only available in CURRENT and POWER modes of operation.

4.3.5 Selecting Unity Power Factor Mode



The Unity Power Factor mode overrides the Power Factor setting - and by implication, the Crest Factor mode. This forces the AC load to operate in a Resistance mode of operation. This mode can be selected from the PROGRAM 2 screen by toggling the UNITY POWER FACTOR field ON or OFF using either the shuttle or the +/- key on the keypad.

4.3.6 Selecting Short Circuit Mode



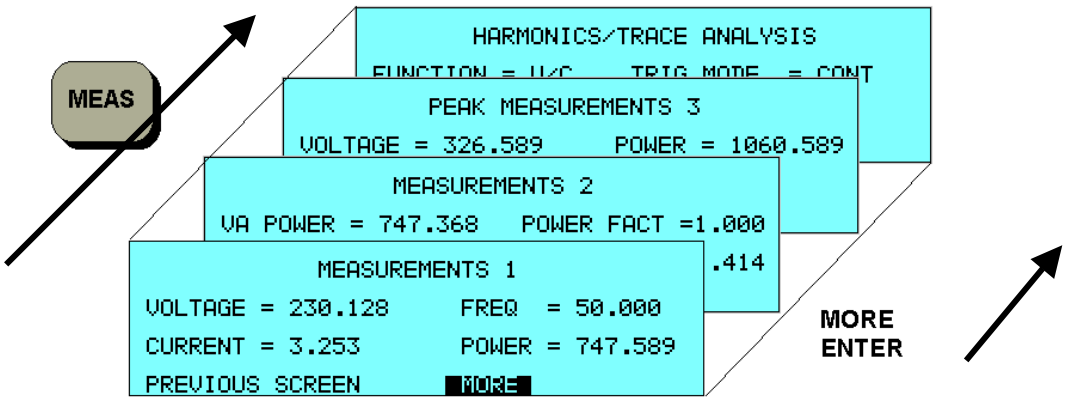
The Short Circuit mode engages a crowbar circuit between the AC load input terminal, creating a short circuit condition. This feature may be used to test the Equipment Under Test's (EUT) ability to handle short circuit or overload conditions. Selecting this mode of operation overrides all other load settings in effect until this mode is turned off. This mode can be selected from the PROGRAM 2 screen by toggling the SHORT CIRCUIT MODE field ON or OFF using either the shuttle or the +/- key on the keypad.

See specification table for maximum short current rating per unit.

4.4 Standard Measurements

Standard measurements are always available through the MEAS key on the front panel. These measurements are spread across four 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. Alternatively, the cursor can be moved to the MORE entry at the bottom of the first three measurement screens and pressing the ENTER key on the keypad.

Figure 4-30: Measurement screen navigation



4.4.1 Available Measurement Screens

The following four measurements and screens are available:

Mode	
	MEASUREMENTS 1
VOLTAGE	AC RMS voltage
CURRENT	AC RMS current
FREQUENCY	Frequency
POWER	True Power
	MEASUREMENTS 2
VA POWER	Apparent Power
REAC PWR	Reactive Power
POWER FACT	Power factor
CREST FACT	Crest factor
	PEAK MEASUREMENTS 3
VOLTAGE	Peak Voltage
CURRENT	Peak Current
POWER	Peak Power
HOLD	Peak Hold mode
	HARMONICS / TRACE ANALYSIS
FUNCTION	Voltage, Current, Both (V/C)
VIEW	Display mode; Trace, Bar, Table
DATA MODE	Absolute, Relative (Bar mode only)
TRIGGER MODE	Single or Continuous
START	Start acquisition and display data

Measurements are always running in the background. When the user selects a measurement screen for display, the AC Load first updates all the measurement parameters before displaying the requested screen. This process may take up to a second. During this time, a message:

"Processing Measurements - Please wait…."

appears on the LCD.

Consequently, pressing the MEAS key may not always bring up the selected screen immediately. There will be a perceptible delay. This processing delay will prevent the screen from appearing with invalid or blank measurement readouts.

4.4.2 Accuracy Considerations

Any measurement system has a finite accuracy specification. Measurement specifications are listed in Section 2. When using the AC Load 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 3091LD is a high power AC load optimized for sinking and measuring high AC load currents. When simulating 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 3091LD Series uses a data acquisition system with a 20 kHz bandwidth. This means that high 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 3091LD Series measurements. When using an external measurement reference, this may account for discrepancies in readings between the 3091LD and high bandwidth DMM's.

4.5 Advanced Measurements

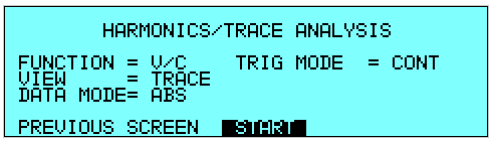
The AC Load offers advanced power analyzer measurement capabilities. These functions may be accessed using the MEAS button. The phase for which the analysis or waveform acquisition is done may be selected using the PHASE key when in three phase configurations. This chapter covers the use and application of these advanced measurement functions.

4.5.1 Harmonic Analysis

The AC Load analyzer performs Fast Fourier Transformation (FFT) on both voltage and current for each available phase on a cycle by cycle basis. The resulting frequency spectrum can be displayed on the LCD display in a tabular as well as a graphical mode. The same data is also available over the bus.

4.5.1.1 Acquiring FFT data

To perform an FFT analysis on the input of the AC Load, proceed as follows:



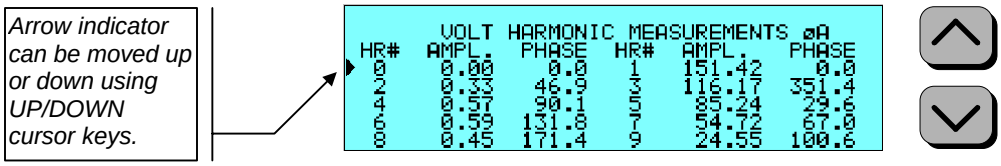
1. Press the MEAS button four times or until the HARMONICS/TRACE ANALYSIS screen appears.
2. Move the cursor to the FUNCTION field and select VOLT or CURR. (The V/C selection will default to CURR as only one FFT result can be displayed at a time.)
3. Move the cursor to the VIEW field and select the TABLE or BAR display mode. The TRACE display mode does not apply to FFT results.
4. Move the cursor to the DATA MODE field and select ABS or REL. Absolute display mode will show all harmonic components in volts or amps. Relative display mode will use the fundamental as a 100 % reference and display all harmonics as a percentage of the fundamental. Phase angles are always shown with respect to the fundamental frequency. The phase angle of the fundamental is always shown with respect to phase A.
5. Skip the SCALE field as it only applies to the TRACE display mode.
6. Move the cursor to the TRIG MODE and select SINGLE or CONT. The SINGLE mode will acquire the data once and show the result. If you select CONT, the data will be updated continuously.
7. Move the cursor to the START field and press the ENTER key. The display that you selected will be shown. If you are in CONT trigger mode, the data will be updated about once per second.

You can return to the HARMONICS/TRACE ANALYSIS screen by pressing the ENTER key. To display the data in a different format, change to the selections you want and move the cursor to the VIEW field. Pressing the ENTER key will re-display the data without triggering a new acquisition. (This is true even if you were in CONT trigger mode.) To start a new acquisition, you must go through the START field instead.

4.5.1.2 Analyzing FFT data

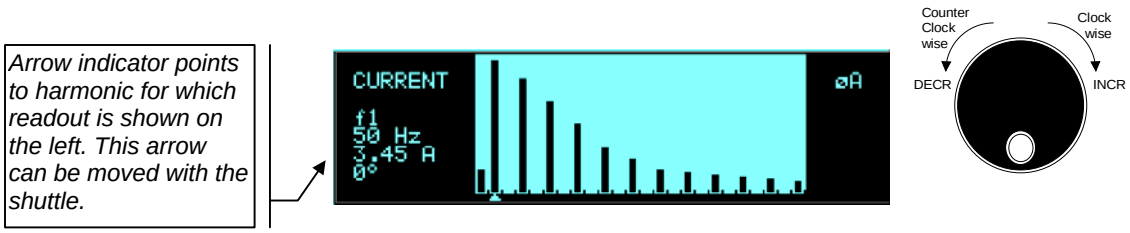
The data displays available for FFT data allow you to scroll through the entire data set. For table displays, the UP and DOWN arrow keys may be used to scroll through the table data vertically. The knob has no function while in this display mode. The triangle on the left edge of the LCD screen points to the current position in the table.

Figure 4-31: Scrolling through tabular FFT data



Bar chart format FFT data displays show the same data in a graphical format. While the amplitude information is shown graphically, phase data is only displayed in numeric form to the left for the currently selected harmonic component. The display can show up to 24 components at a time. The triangle at the bottom of the display shows the currently selected component for which numeric data is shown on the left. This data includes the harmonic number (DC through 50), the absolute or relative amplitude (depending on selected VIEW mode) and the phase angle with respect to the fundamental. The knob can be used to scroll through the display horizontally. The UP and DOWN cursor keys have no effect in this display mode.

Figure 4-32: Scrolling through bar chart FFT data

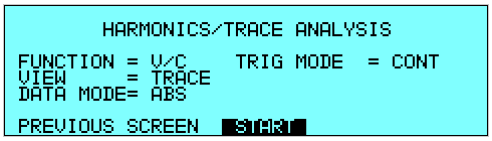


4.5.2 Waveform Acquisition

The waveform acquisition mode allows voltage and/or current data waveforms to be captured and displayed. This mode is selected by choosing the VIEW = TRACE mode in the HARMONICS/TRACE ANALYSIS screen. Voltage and current may be viewed separately or combined into a single display using the FUNCTION field.

4.5.2.1 Acquiring waveform data

To perform a waveform acquisition on the input of the AC load, proceed as follows:



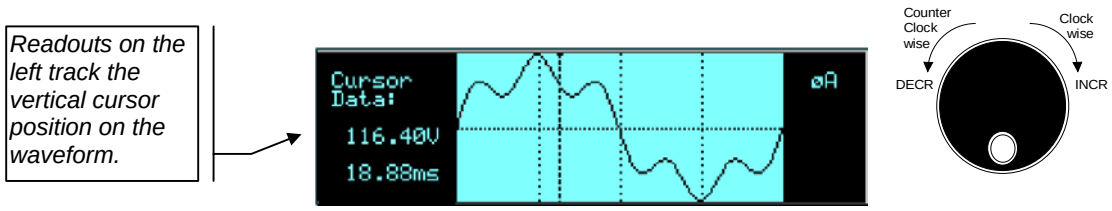
1. Press the MEAS button four times or until the HARMONICS/TRACE ANALYSIS screen appears.
2. Move the cursor to the FUNCTION field and select VOLT, CURR or V/C for both.
3. Move the cursor to the VIEW field and select the TRACE display mode.
4. Skip the DATA MODE field as it only applies to the TABLE and BAR display modes.
5. Move the cursor to the SCALE field and select a horizontal time base value to allows you to see at least one cycle of the output waveform. If the output is programmed at 50 Hz, a 20 ms scale would display exactly one signal period.
6. Move the cursor to the TRIG MODE and select SINGLE or CONT. The SINGLE mode will acquire the data once and show the result. If you select CONT, the data will be updated continuously.
7. Move the cursor to the START field and press the ENTER key. The display that you selected will be shown. If you are in CONT trigger mode, the data will be updated about once per second.

You can return to the HARMONICS/TRACE ANALYSIS screen by pressing the ENTER key. To display the data in a different format or to select voltage instead of current or current instead of voltage, change to the selections you want and move the cursor to the VIEW field. Pressing the ENTER key will re-display the data without triggering a new acquisition. (This is true even if you were in CONT trigger mode.) To start a new acquisition, you must go through the START field instead.

4.5.2.2 Analyzing waveform data

Acquired waveform data are shown in graphical form on the LCD display. The acquisition system captures one cycle of the input waveform, regardless of the input signal frequency. The sampling clock for the measurement system is synchronized to the input voltage and tracks it continuously. Thus, there is no need to set the sampling rate, time base or display scale of the graph display.

Figure 4-33:Scrolling through acquired waveform data



The left portion of the LCD display is used to read out the data under the vertical cursor. This cursor is a vertical dotted line that can be moved horizontally using the shuttle. As the cursor is moved, the data under the cursor is read out on the left hand side of the LCD display.

4.5.3 Acquisition Modes

The following acquisition modes are supported by the AC Load:

Single (SINGLE)	This mode causes the acquisition system to be armed only once. The AC Load waits for the user to press the ENTER key while on the START field. As soon as the trigger event specified occurs, data is acquired and the acquisition system is put in an idle state. A new user initiated START event must be given to trigger an new acquisition. This mode is appropriate for capturing events that occur only once such as the inrush current when turning on a load.
Continuous (CONT)	This mode causes the trigger system to re-arm itself after each trigger event. Every time a new trigger event occurs, new data is acquired and the LCD display is updated. No user intervention is required after the initial START event. This mode is appropriate for capturing repetitive events or to monitor the source output continuously. Display updates will occur about once per second.

4.6 Sequence Programming

4.6.1 Introduction

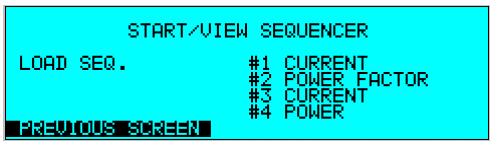
Sequence programming provides precise timing control over load changes. This mode of operation can be used to test a product for susceptibility to common AC load conditions such as shorts, load transients and high inrush currents.

During normal AC load operation, user inputs received from the front panel or the remote control bus are executed as soon as they are received. During sequencer operation, commands are only executed when a trigger is received. This allows very fast changes - every cycle if needed - in current which can reveal important information about regulation, output voltage and current or peak current capabilities of the EUT in just one test. Sequence lists can be executed as a single shot (ONCE) or in a continuous loop (CONT.).

The term transient is also used commonly in conjunction with the load sequencer as it enables the simulation of rapid load changes (transients). This manual uses the term "sequence" and "sequencer" for consistency.

4.6.2 Sequence Execution

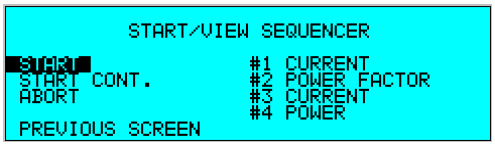
Figure 4-34:START/VIEW SEQUENCER menu



A sequence list can be executed from the START/VIEW SEQUENCER menu. To start execution of a sequence list, position the cursor on the LOAD SEQ. field and press the ENTER key. This will cause the programmed sequence to be compiled and initiated.

The screen will change to show the two available run options, single (START) or continuous

Figure 4-35: Sequence Initiated

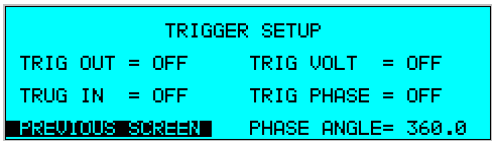


(START CONT.) Selecting the START field and pressing the ENTER key will arm the sequencer. It will now respond to the selected trigger source and move from step to step as triggers are received. Each trigger will advance the sequence by one step unless the NO. TRIG field for a step was set to a value higher than 1. The NO. TRIG field can be used to dwell on a given step for more than one trigger event. The maximum number that can be entered per step is 50 and the total for all steps is also 50. If the sequence ends, the field will return to the LOAD SEQ. setting. If the START CONT. mode is selected instead, an ABORT has to be used to stop the sequencer.

A single run sequence that runs for a longer period of time - as is the case when external trigger source is selected and only occasional triggers are generated. - can be aborted as well. For sequences of short duration, the ABORT field will likely not be visible as the sequence will complete before the screen is updated.

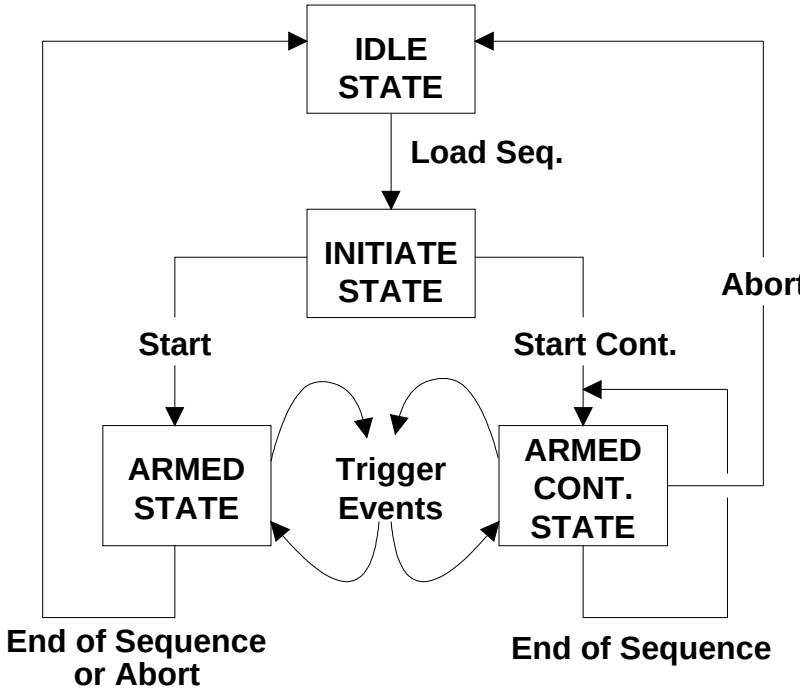
4.6.3 Sequence Trigger Modes

Figure 4-36: Sequence Trigger Menu



Command sequences can be executed from the front panel by moving the cursor to the LOAD SEQ. field and pressing the ENTER key. This will move the sequencer from the IDLE state to the INITIATED state. Once initiated, a sequence can be armed using the START or START CONT. field. In the ARMED state, the sequencer waits for a trigger signal to proceed from step to step. The Idle, Initiate, Arm and Continuous sequencer state diagram is shown in the figure below.

Figure 4-37: Sequencer Trigger State Diagram



Several trigger sources may be selected. All selected trigger sources are OR-ed together to produce the trigger event for the sequencer. Specifically, the following trigger source options are available:

Trigger Mode	Description
External Trigger Input	The load accepts a trigger input from the external trigger input BNC located on the back of the unit. This input requires a negative true TTL level signal of at least 50 μsec in duration.
Voltage Trigger	The load will generate a trigger to the sequencer when one of two events occurs: 1. The input voltage starts below the Turn-off voltage setting, then rises and exceeds the Turn-on voltage setting. 2. The input voltage starts above the Turn-on voltage setting, then falls below the Turn-off voltage setting. See section 4.2.9.2 for details on setting the voltage thresholds.
Phase Trigger	A trigger is generated to the sequencer when the input voltage is at the specified phase angle. This results in a trigger at every cycle of the input voltage. Available trigger phase angles range from 0 to 359.9°. Setting the trigger phase angle to 360.0° will result in random phase angle triggers. See section 4.2.9.2 for details on setting the trigger phase angle and enabling the trigger mode.

A trigger event is required to progress through the sequence list, including the first step of the list. Thus, all list points are advanced through triggers. Only one trigger mode can be in effect at any given time. If the end of the list is reached, the sequencer will return to the IDLE state unless the CONTINUOUS mode is selected. In CONTINUOUS mode, the sequencer loops back to the first list point and continuous execution from there.

4.6.4 External Trigger Out Signal

During sequence execution, a trigger out signal may be generated to the outside world. This trigger output signal is available on the Trigger Out BNC located on the rear panel of the master 3091LD AC load. A trigger pulse is generated each time an external trigger is received, regardless of the trigger mode selected. The trigger out signal is a negative true, TTL level signal reference to ground of at least 50 μsec duration.

4.6.5 Sequence Status Register

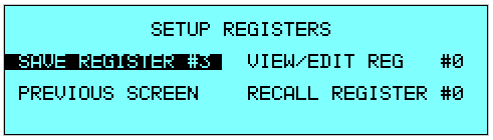
An eight-bit status register is available which contains the sequence status information. This information is available over the bus only using the TRIGGER:STATUS and TRIG:SYNC:SOURCE queries. See the programming section for command details. The following status bits are contained in this register:

Bit	Name	Description
0 - 1	Mode	00 Idle 01 Initiated. Commands are queued in this mode and held in the sequence queue. 10 Armed. Sequencer is armed and waiting for next trigger event. After last list point has been processed, status returns to Idle 11 Continuous. Same as Armed state except after last list point has been processed, the list is executed starting at the first point again.
2	Enable Output	Output triggers are generated on the external trigger out BNC located at the rear of the unit.
3	Trigger Output	0 When Enable Output bit is 0 1 Latched with each trigger event, reset after register read.
4	Trigger Input	Hardware Input Trigger BNC enabled state.
5	Voltage Input	Turn on/off voltage trigger enabled
6	Phase Angle	Phase angle trigger enabled
7	Queue Full	The sequence list buffer is full. The maximum number of entries is 100.

4.6.6 Saving Sequence List Programs

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

To save a sequence list, proceed as follows:



1. Press the MENU key two times to bring up the MENU 2 screen.
2. Move the cursor to the SETUP REGISTERS entry and press the ENTER key.
3. The cursor will default to the SAVE REGISTER # position. Enter a number from 0 through 7 and press the ENTER key.
4. A message will appear at the bottom of the screen indicating that the front panel settings and the sequence list data have been saved in the setup register you selected.

4.6.7 Sequence Example - Inrush Current

The following example uses the AC load sequence function to simulate a high inrush current that decreases as a function of time.

1. Select the TRIGGER SETUP menu from the SEQUENCER menu.
2. Set the trigger Phase angle to 0°. This will cause the load current to change at the zero crossing of the input voltage.
3. Enable the Trigger Sync mode and return to the SEQEUNCER menu.
4. Select the EDIT SEQUENCER menu from the SEQUENCER menu and enter the following sequence list points:

#	Mode	Set Point	CF	PF	NO TRIG
1	CURR	20.000	1.414	1.00	1
2	CURR	10.000	1.414	1.00	1
3	CURR	5.000	1.414	1.00	3

5. Select the START/VIEW SEQUENCER menu and select the START field.
6. Press the ENTER key and observe the load current using an external scope and current probe.

5. Principle of Operation

5.1 Architecture

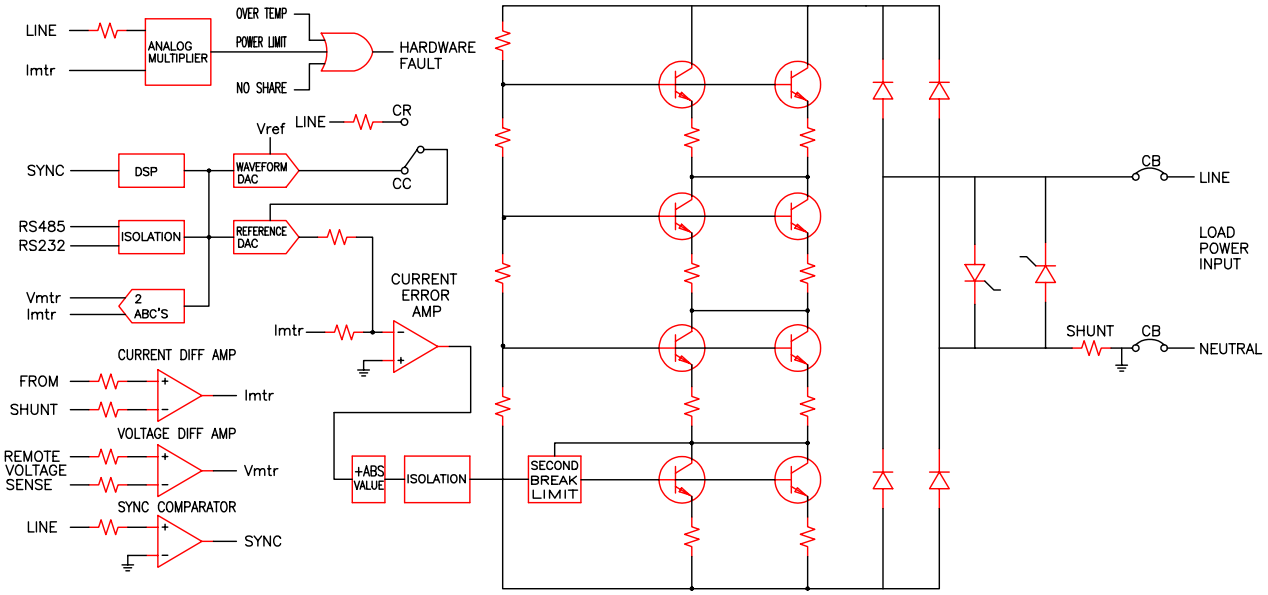
The load contains dual Texas Instruments TMS320C32, a 32 bit floating point digital signal processors. One DSP is dedicated to controlling the AC Load hardware. This DSP performs all setup, control, synchronization and measurement functions for the AC waveform, control hardware initialization and setup via memory mapped control/status registers.

The second DSP is used to interface to the front panel, the RS232C serial interface and the GPIB / IEEE-488 bus interface. The DSP uses FLASH PROM for code, calibration, configuration data, hardware control registers and DMA's for output waveform generation and measurement. The DSP boot kernel is in a "read only" EPROM separate from the FLASH memory.

The load accepts commands from either the front panel or either remote control interface using the industry standard SCPI command protocol. Setup and measurement information can be queried over the bus or read from the front panel LCD. For both control and measurement purposes, high accuracy is obtained by the use of 16-bit instrument grade digital to analog converters and analog to digital converters.

5.2 Block Diagram

A simplified block diagram of the 3091LD AC Load is shown here. See subsequent paragraph for a function description of each section.



5.3 Operation

5.3.1 Synchronization

The load power input voltage waveform is scaled down by 50 to 1 then converted to a square wave by a comparator. The output of this comparator is the sync signal. The period of the sync signal is measured, inverted then displayed as frequency. The voltage at the remote voltage sense terminals is scaled down 50 to 1 by a differential amplifier. This signal is then sent to the voltage 16 bit analog to digital converter and sampled synchronously at a power of 2 multiple of the input frequency. The DSP then calculates AC RMS voltage and other metering values. The current through the shunt generates a voltage, which is scaled up 100 to 1 by a differential amplifier. This signal is then sent to the current 16bit analog to digital converter and sampled synchronously at a power of 2 multiple of the input frequency. The DSP then calculates AC RMS current and other metering values.

5.3.2 **Constant Resistance** Mode

The hardware emulates a resistor in this mode. The hardware operates in this mode under any one of the following conditions:

1. Constant resistance is programmed.
2. Voltage mode is programmed
3. Constant current mode is programmed and unity power factor is on. The load does not respond to the programmed crest factor or power factor.
4. Constant power mode is programmed and unity power factor is on. The load does not respond to the programmed crest factor or power factor.

Voltage from the load power input is scaled down 50 to 1 and feed into the reference DAC. The reference DAC scales this signal to obtain the desired resistance.

The current error amp compares the output of the reference DAC to the metered current and generates the signal required to drive the power transistors.

5.3.3 **Constant Current** Mode

The DSP generates a waveform with the desired crest factor and power factor in this mode. The hardware is in this mode when constant current or constant power is programmed and unity power factor is off. The DSP generates a waveform at the output of the waveform DAC. This waveform synchronizes to the input voltage using the sync signal. The waveform is scaled by the reference DAC to obtain the desired current.

The current error amp compares the output of the reference DAC to the metered current and generates the signal required to drive the power transistors.

5.4 Crest Factor and Power Factor Relationship

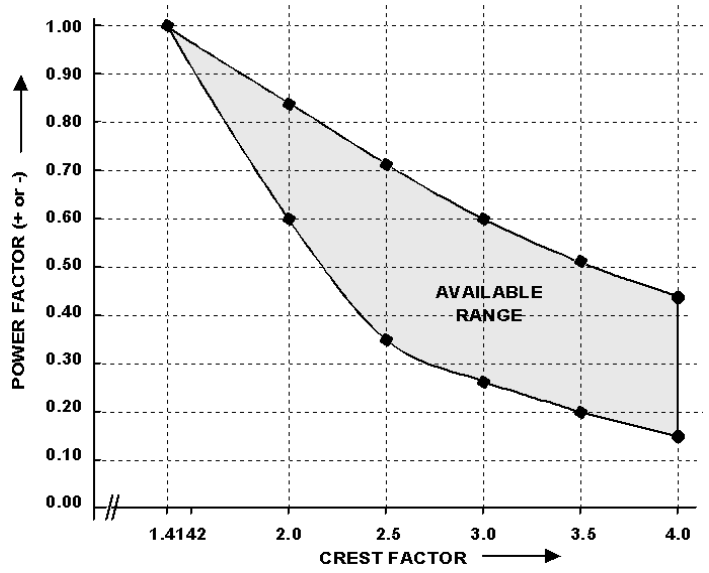
This section discusses the relationship between crest factor and power factor. This only applies when the input voltage is sinusoidal, unity power factor is off and the load is in constant current or constant power mode. For non-sinusoidal input voltages select unity power factor mode.

Crest factor is peak current divided by RMS current. When a crest factor of 1.414 is programmed, the DSP creates a sinusoidal current waveform. When a higher crest factor is programmed the DSP creates a modified sinusoidal current waveform with the correct crest factor. The DSP can directly create the desired crest factor.

Power factor is true power divided by apparent power. For a resistive load the power factor is 1. Assuming a constant voltage RMS and constant current RMS, as crest factor increases, power factor decreases because apparent power remains constant and true power decreases. True power decreases because current is not flowing during the entire cycle.

For a given crest factor there is only a limited range of possible power factors. The load cannot directly create the desired power factor; it can only attempt to meet the desired power factor. The programmed power factor is achieved by programming an appropriate crest factor and the DSP will phase shift the current. As crest factor increases the range of possible power factor decreases. This relationship is depicted in Figure 5-1.

Figure 5-1: Crest Factor versus Power Factor control



For example:

- With a crest factor of 1.4, the only power factor allowed is 1.
- With a crest factor of 2, the power factor may range from 0.6 to 0.85.
- With a crest factor of 3, the power factor may range from 0.28 to 0.6.
- If a higher power factor is desired, program a lower crest factor. If a lower power factor is desired, program a higher crest factor.
- If the power factor programmed is positive it will be a leading power factor. If the power factor programmed is negative it will be a lagging power factor.

5.5 Power Section

The load power input is connected to a circuit breaker. The circuit breaker is connected to the shorting SCR's and the AC side of a diode bridge. The DC side of the Diode Bridge is connected the power transistor array. The power transistor array consists of 4 load modules in series. Each load module has 28 power transistors in parallel.

5.6 Protection

The following protection is provided in the AC Load:

Circuit Breaker

An input circuit breaker is provided. This circuit breaker will trip if input current exceeds the AC Load ratings.

Over voltage

Over voltage protection is provided is two stages. During the first stage the load will turn on and clamp voltages above rating. The load will act like a zener diode. If the energy is greater than the load can absorb, the second stage is turning on the shorting SCR's. This is an over voltage crowbar.

Over temperature

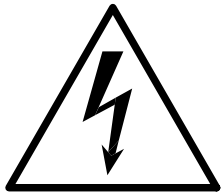
A temperature switch is located on each of the 4 load modules. Any one will shut down the load if its temperature trigger point is exceeded. These devices automatically reset when the temperature returns to a safe value.

Over power

The AC Load will not allow the load to draw more than rated power. If the remote sense wires are not properly connected the load cannot calculate the actual power dissipated. To circumvent this condition, an analog multiplier creates an average true power signal, which will shut down the load if rated input power is exceeded.

Fault

The 4 load modules should dissipate equal energy. If their energy dissipation is not balanced, this circuit will shut down load.



CAUTION

HIGH VOLTAGES MAY BE PRESENT IN CERTAIN SECTIONS OF THIS PRODUCT. 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.

6.1 Calibration Equipment

Digital Multimeter:	Fluke 8506A / HP 34401A or equivalent
10 milliohm Current Shunt:	Isotek Model RUG-Z-R010-0.1 or equivalent

6.2 Calibration setup

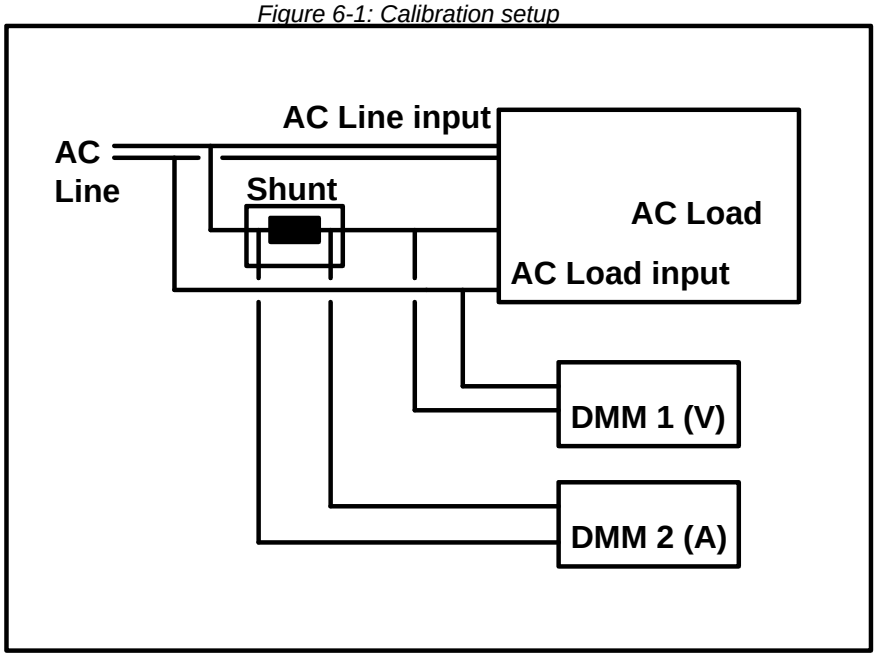
The AC load can be calibrated using a suitable AC Source to provide input voltage and current or it can be connected to single phase AC Mains. The input voltage must exceed the 50 Volt Turn-off value which is the case for all single phase AC line voltages used around the world. The setup can include either a single or dual DMM's. If a single DMM is used, it has to be moved between voltage measurements and current measurement. Each calibration can be done in turn so there is no compelling reason to have two DMM's for this procedure.

Connect the current shunt in series with the AC load input connector. Then connect the AC Load input to the mains line. A 230 V line will provide better calibration as it is closer to the full scale value of the AC load input voltage range. A 2:1 step-up autotransformer should be used in places where the line voltage is 100-120 V RMS.

Connect the DMM for the voltage reference reading across the AC load input terminal closest to the rear panel connector. Connect a second DMM to the current shunt output or be prepared to move the first DMM between the AC voltage sense and the Current shunt. In both cases, the DMM function should be on AC Voltage.

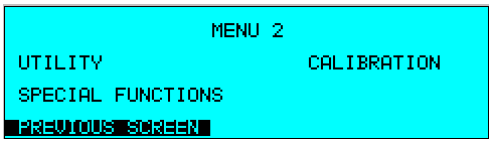
The connection diagram is shown below.

Figure 6-1: Calibration setup



6.3 Selecting the Calibration Screen

Figure 6-2: Selecting the Calibration menu

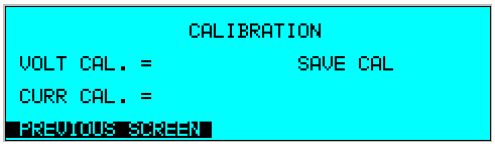


To access the CALIBRATION screen, press the MENU key twice to display the MENU 2 screen. Press the ↑ or ↓ key several times to highlight CALIBRATION. Press the ENTER key. The will display the password entry screen which prevents unauthorized access to the calibration parameters of the AC Load.

Figure 6-3: Entering the Calibration password

In the Password field, type 3091 using the numeric keypad and press the ENTER key to access the CALIBRATION adjustment screen. For multi phase systems, each phase needs to be calibrated in turn. Use the PHASE key on the front panel to select the phase to be calibrated for a 9093LD AC load system with one controller.

Figure 6-4: Calibration Menu



To adjust the calibration of voltage and current, enter the external reference reading in the corresponding field using the numeric keypad and press the ENTER key. The 3091LD will perform a measurement and adjust its calibration scale factors to match the external reference reading entered. Once both parameters have been calibrated, it is important to save the new scale factors in Flash EPROM memory. To do so, move the cursor to the SAVE CAL field and press ENTER.

Note: Only save the scale factors when you are satisfied that the calibration was performed correctly to avoid needless erasure cycles of the Flash EPROM.

7. Service

7.1 Cleaning

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

7.2 Symptoms

7.2.1 Load Power Circuit Breaker Trips

This circuit breaker will trip when:

- Input current is exceeded during short mode. Reduce short circuit current.
- The over voltage protection crowbar turned on. Reduce input voltage.
- The diode bridge or power transistor array has shorted. Return for repair.

7.2.2 Over temperature LED Lit

This led is lit when one of the 4 load modules has overheated. Allow more and cooler air to flow through the load. If the load is clogged with dirt, vacuum the dirt out. When the unit cools down sufficiently, the LED will go out.

7.2.3 Over power LED Lit

Overpower, the hardware analog multiplier detected an average true power greater than rated input power. The remote sense wires may not be connected correctly and the AC Load cannot calculate power correctly. The load may need to be calibrated. When the over power condition has been removed, the LED will go out.

7.2.4 Fault LED Lit

No share, the load modules are not sharing power equally. A load board may be shorted or an internal wiring error may have occurred. Return for repair. When the hardware fault has been removed, the LED will go out.

7.2.5 Status LED Not Blinking

The status led is located on the rear panel of the AC load. Verify that the control power switch/led is on and lit. This indicates control power is present at the control board. If control power is present and the status LED is not blinking at a 1 hertz rate, the DSP is not functioning properly. Try switching all eight positions of the “S6k AD” switch to the off position. Remove and reapply control power. This will cause a reboot from EPROM. If the status LED is still not blinking, return for repair. If the status LED now blinks at a 1 Hz rate, return the S6k AD switch settings to their original setting and reapply control power. The Load should now boot from its normal control program. If this does not clear up the error condition, the firmware may have to be reloaded.

7.2.6 Error LED Lit

The ERROR LED is located on the rear panel of the AC Load. This LED will light when an internal software error occurs. Usually the controlling computer will read the error and clear it quickly. If this LED is lit and no computer communication has occurred, a selftest error has occurred. Connect the load to a controlling computer to read the error. If all eight positions of this switch are off when the load is turned on, it will boot from firmware in EPROM and not from FLASH. The LED will be on because of an EPROM error. Set the “S6k AD” switch to the proper address to allow computer communication. This will allow new firmware to be downloaded into flash if previously corrupted.

7.2.7 No Computer Communication

Verify the communication cable is connected from the computer to the load. Either RS232 or IEEE-488 may be used.

- If RS232 is used, verify the computer program software is set to the correct Comm port, baud rate, start bits and stop bits. These settings can be checked on the AC load using the UTILITY menu. An RS232C serial cable is supplied with the AC load. This is a straight through cable, which can be obtained from any local computer store as well if needed.
- If IEEE-488 is used, verify the correct IEEE address is selected on both the AC load and the control program. An IEEE-488 cable is not supplied with the AC Load but any IEEE-488/GPIB cable can be used. Make sure the cable is properly seated and screwed down at both ends.
- Verify the status LED is blinking on the rear panel.
- When data is transmitted from the controlling computer to the load, the listen LED will blink on with each byte.
- When data is transmitted from the load to the controlling computer, the talk LED will blink on with each byte.

7.2.8 Zero Frequency

This indicates that the load cannot measure the input frequency and will not operate. Verify input power is connected and the input circuit breaker is ON. Also check to make sure the input voltage exceeds the lower voltage limits are reported in the LIMIT SETUP 1 screen. See section 4.2.9.4.

7.2.9 Negative Power Displayed

The remote sense wires are reversed.

7.2.10 Under Voltage

If the remote sense wires are not connected, the load will sense an under voltage and not operate.

7.3 Repair Procedure.

In the unlikely event that the AC load needs to be returned for repair or service, contact your local California Instruments representative from whom you purchased the instrument.

If no local service center is available, the unit may be shipped back to the factory using suitable packaging. Before returning a unit to the factory, you need to obtain a Return Material Authorization number. You can request an RMA number by fax or email using the following data:

Fax: + 1 858 677 0940

Email: support@calinst.com

Once you have received an RMA number, use the following shipping address to return the instrument for service:

California Instruments Corporation.
Attention: Customer Service
9689 Towne Centre Drive
San Diego, California 92121-1964
United States of America

7.4 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. California Instruments' part number for the sub-assembly where the component is located. (California Instruments PART #)

c. Component reference designator. (SEQ #)

d. Component description.

e. Component manufacturers' FSCM number. (VENDOR)

All replaceable part orders should be addressed to:

California Instruments Corporation.
Attention: Customer Service
9689 Towne Centre Drive
San Diego, California 92121-1964
United States of America

Orders may be placed by fax using the fax following fax number:

+1 858 677 0940

Table 7-1: Replaceable Parts

CI PART #	DESCRIPTION
Contact Factory for replacement part numbers	
7000-723-2	Keyboard / LCD Display board
4600-700-1	Front panel CPU Board
7000-715-2	LED Status board

8. Remote Control

8.1 Introduction

The 3091LD is comes standard equipped with a combination IEEE-488 and RS232C control interface. Also included is the California Instruments AC Load Graphical User Interface program - LDGUI32. This Windows™ program provides a soft front panel to the instrument when connected to a PC through the RS232C or IEEE-488 interface. Additional benefits are obtained from using the PC as a control interface instead of the regular front panel. Some of these benefits include the ability to store measurement data to disk, interact with other programs, and create a disk library of AC Load sequences to test a variety of EUT's.

The LDGUI32 is a Windows™ program and as such requires a PC capable of running Windows Windows 98™, or Windows XP™. For best performance, a Pentium based PC is recommended.

Complete information on how to use the LDGUI32 can be found in the on-line help supplied with the program. Use the Help menu or press on any of the many Help keys located in all program windows for an explanation of the relevant screen or function.

As always, California Instruments appreciates your patronage and would welcome any comments and suggestions you might have regarding this software or any of its other products. Use the End-user feedback form located on page **Error! Bookmark not defined.**. The same form can be used to report software bugs should you encounter any.

8.2 LDGUI32 Program Requirements

To successfully install and operate the LDGUI32 program, you will need the following equipment:

California Instruments 3091LD Series AC Load . Supported models are :

- 3091LD
- 6091LD
- 9091LD
- 9093LD
- 12093LD
- 18093LD

PC capable of running Windows 98™ or Windows NT™

- RS232C communications port
- RS232C serial cable (supplied with the -OP1 option package.) See next section for RS232C cable wiring

  or

- National Instruments IEEE-488 Controller Card

Note: The LDGUI32 can be run in the absence of an AC Load. If no AC Load is available, the LDGUI32 can be operated in a simulation mode. The program will detect these conditions and start up in simulation mode. Measurements in this case will be simulated and should not be used for any analytical purpose.

8.3 IEEE Interface

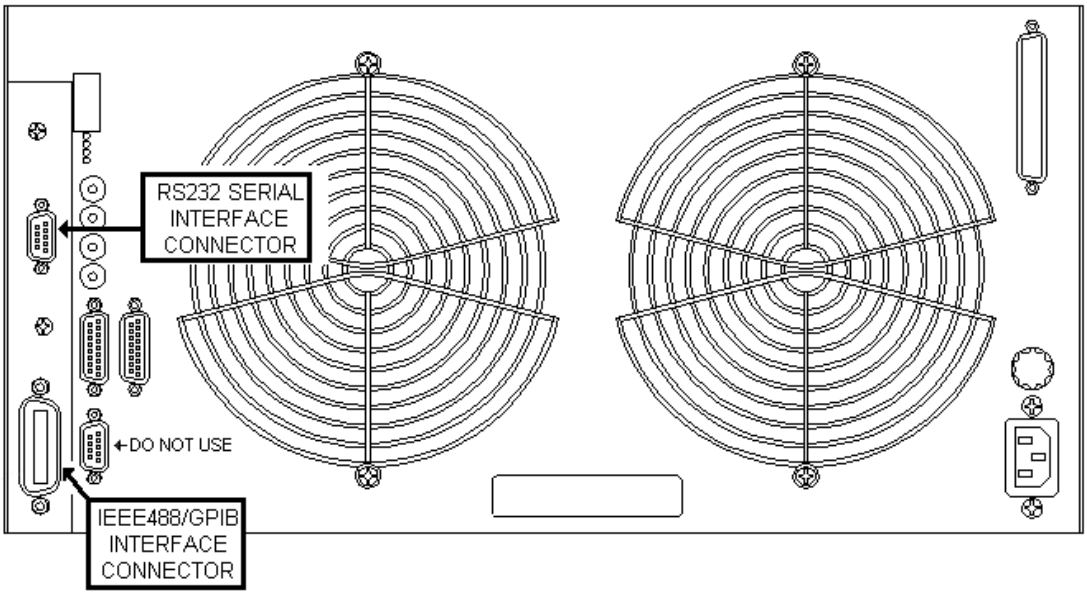
The 3091LD Series is equipped with both RS232C and IEEE-488 interfaces. Both interfaces can be active at a time although this it is not recommended to do so. The IEEE address for the AC load can be set from the GPIB/RS232 SETUP menu. See section 4.2.9.1 for details.

8.4 RS232C Interface

A suitable cable to connect the 3091LD AC Load to a 9 pin PC-AT style serial port is supplied with the product. This is a straight through cable and can be replaced easily if lost.

Note: There are two 9-pin RS232 connectors on the rear panel of the AC Load. Use the RS232 connector marked as "MASTER RS232" to connect the AC Load to a PC.

The 3091LD Series expects a LF (Hex 10) terminator at the end of each string sent over the RS232C interface. If the programming environment you use to develop test programs does not append a LF terminator to each output string, the RP Series will not respond. This is true of programs like LabView™ using VISA drivers.



8.5 LDGUI32 Setup and Installation

This section covers installation of the LDGUI32 from the distribution disk to the user's PC. Make sure the PC is capable of running Windows with at least 32 Mbytes of memory and 4 Mbytes of available hard disk space. For report print outs, a copy of Microsoft Word for Windows needs to be present on the PC.

8.5.1 Connecting the AC Load to the PC When Using RS232

Connect the AC Load to the PC using a straight through RS232C cable.

Required AC Load com port settings to work with the LDGUI32 are as follows:

Baud rate: 9600 to 38400 baud
Data bits: 8
Stop bits 1
Parity bits: none
Handshake: Hardware
The AC Load is configured to accept the above setting.

8.5.2 Connecting the AC Load to the PC Using IEEE-488

Connect the AC Load to the PC using an IEEE-488 interface cable. A National Instruments GPIB controller card is required to use the LDGUI32 program. Set the desired IEEE address using the GPIB/RS232 SETUP menu. See section 4.2.9.1 for details.

8.5.3 Installing the LDGUI32 Software

The LDGUI32 software is distributed on a set of 3.5 inch high density floppy diskettes or on CD-ROM. The LDGUI32 must be installed from these diskettes or CD using the included setup program as all required files are compressed. You cannot copy the contents of these diskettes or CD to your PC hard drive and run the program. To install the LDGUI32, proceed as follows:

1. Turn on the PC and boot up in Windows™
2. Insert the first disk (labeled Disk 1 of 3) in drive A or B or insert the CD in your CD-ROM drive.
3. From the Windows Start Menu, select RUN.
4. At the "Open" prompt, type A:Setup or B:Setup depending on which disk drive you used and click on the OK button. If you are installing from CD ROM, locate the sub directory called LDGUI32 on the CDROM and run the setup program located in this directory.
5. Follow the instructions provided by the setup program to complete the installation. For installations from floppy disks, you will be asked to insert subsequent disks. Remove the present disk and replace it with the next and press OK to continue the installation. Continue through the last disk.
6. When the installation has completed, remove the last disk from the floppy drive and store the disks in a safe place.

Reboot the PC to activate the new settings. You are now ready to start using the LDGUI32 software.

8.6 LDGUI32 Distribution Files

The installation program will install the following files in the directories specified. Note that files with the same name that already exists in these directories will not be overwritten as part of the installation process. If older files of the same name are found, they will be replaced. If you need to retain a copy of these older version files, we recommend you back these files up prior to running the installation program.

Application directory files

The following files are copied to the application directory. The application directory name is chosen by the user during the installation process. The default directory for the LDGUI32 is:

C:\Program Files\California Instruments\LDGUI32

Ldgui32.exe	Executable
Ldgui32.hlp	On Line Help file
Ldgui32.cnt	Help Contents file

Windows System directory files

The following shared files are stored in the Windows\System directory during installation:

Mscomm32.ocx	Microsoft Serial communications active control
ss32x25.ocx	Grid spreadsheet active control
Comdlg32.ocx	Microsoft Common dialog active control
Comctl32.ocx	Microsoft Common controls
Msvbvm60.dll	Microsoft Visual Basic 6.0 virtual machine library
Mfc42.dll	Microsoft Foundation Classes
Mfcans32.dll	Microsoft Foundation Classes
Msvcrt.dll	Microsoft Visual C++ run-time library

Pego32.ocx	Graphics Engine
Pegraph32.dll	Graphics Engine library
OC30.dll	Object library
Oleaut32.dll	Microsoft OLE automation server

Test Sequence Program Directory Files

File name	Description
Sample sequence test file.SEQ	Sample sequence file

Report_Files Directory Files

File name	Description
LD_1Phase_Harm Report Template.dot	Harmonic data report Word template - 1 ø
LD_1Phase_Seq Report Template.dot	Load Sequencer report Word template - 1 ø
LD_1Phase_Test Report Template.dot	Measurement data Report Word template - 1 ø
LD_3Phase_Test Report Template.dot	Measurement data Report Word template 3 ø

Note: The location of these files as well as the files themselves may change with future versions of the LDGUI32. Consult the included readme file for last minute program information.

8.7 Software Registration

Updates of this and other California Instruments programs are posted on a regular basis on the California Instruments web site. You can find available programs by selecting the Software, GUI's and Drivers menu. To gain access to these downloads, you will need to register as a user on our web site. For instructions on how to register and request the required access level for software downloads, visit our web site at

www.calinst.com

9. Introduction to SCPI

SCPI (Standard Commands for Programmable Instruments) is a programming language for controlling instrument functions over the RS232 or IEEE 488 bus. The same SCPI commands and parameters control the same functions in different classes of instruments. For example, you would use the same MEAS:VOLT? command to measure the AC Load input voltage using the AC Load measurement system or a SCPI-compatible Multimeter.

9.1 Conventions Used in This Manual

Angle brackets<>	Items within angle brackets are parameter abbreviations. For example, <NR1> indicates a specific form of numerical data.
Vertical bar	Vertical bars separate alternative parameters. For example, 0 | 1 indicates that either "0" or "1" can be used as a parameter.
Square Brackets[]	Items within square brackets are optional. The representation [:LEVel]:AMPLitude means that :LEVel may be omitted.
Boldface font	Boldface font is used to emphasize syntax in command definitions. CURR <NRf> shows a command definition.
Upper case font	Upper case font is used to show program lines in text. OUTP 1 shows a program line.

9.2 The SCPI Commands and Messages

This paragraph explains the syntax difference between SCPI Commands and SCPI messages.

Types of SCPI Commands

SCPI has two types of commands, common and subsystem.

- Common commands are generally not related to specific operations but to controlling overall AC Load functions such as reset, status and synchronization. All common commands consist of a three-letter mnemonic preceded by an asterisk:

  *RST *IDN? *SRE 255

- Subsystem commands perform specific AC Load functions. They are organized into an inverted tree structure with the "root" at the top. Some are single commands while others are grouped within specific subsystems. **You must include the root header in all commands sent to the AC Load.**

Types of SCPI Messages

There are two types of SCPI messages, program and response.

- A program message consists of one or more properly formatted SCPI commands sent from the controller to the AC Load. The message, which may be sent at any time, requests the AC Load to perform some action.
- A response message consists of data in a specific SCPI format sent from the AC Load to the controller. The AC Load sends the message only when commanded by a program message called a "query."

The SCPI Command Tree

As previously explained, the basic SCPI communication method involves sending one or more properly formatted commands from the SCPI command tree to the instrument as program messages. The following figure shows a portion of a subsystem command tree, from which you access the commands located along the various paths.

ROOT				
:LOAD	[:MODE]	:CURRent	[:LEVel]	[:AMPLitude]
		:VOLTage	[:LEVel]	[:AMPLitude]
:MEASure	[:SCALer]	:CURRent	:AMPLitude	:MAX

The Root Level

Note the location of the ROOT node at the top of the tree. Commands at the root level are at the top level of the command tree. The SCPI interface is at this location when:

- the AC Load is powered on
- a device clear (DCL) is sent to the AC Load
- the SCPI interface encounters a message terminator
- the SCPI interface encounters a root specifier

Active Header Path

In order to properly traverse the command tree, you must understand the concept of the active header path. When the AC Load is turned on (or under any of the other conditions listed above), the active path is at the root. That means the SCPI interface is ready to accept any command at the root level, such as LOAD or MEASurement.

If you enter LOAD the active header path moves one colon to the right. The interface is now ready to accept :VOLTage or :CURRent as the next header. You must include the colon, because it is required between headers.

If you now enter :CURRent, the active path again moves one colon to the right. The interface is now ready to accept either :LEVel or :AMPLitude as the next header.

If you now enter :AMPLitude you have reached the end of the command string. The active header path remains at :CURRent. If you wished, you could have entered :AMPLitdue 15;AMPLitude 11 and it would be accepted as a compound message consisting of:

1. LOAD:CURR:AMPL 15
2. LOAD:CURR:AMPL 11

The entire message would be:

LOAD:CURR:AMPL 15;AMPL 11<newline>

The <newline> message terminator after AMPL 11 returns the path to the root.

Moving Among Subsystems

In order to combine commands from different subsystems, you need to be able to restore the active path to the root. You do this with the root specifier (:). For example, you could set the current to 2 A RMS and set the Power factor to 0.8.

```
:CURR 2
:PFAC 0.8
```

Because the root specifier resets the command parser to the root, you can use the root specifier and do the same thing in one message:

```
CURR 2;:PFAC 0.8
```

Including Common Commands

You can combine common commands with system commands in the same message. Treat the common command as a message unit by separating it with a semicolon (the message unit separator). Common commands do not affect the active header path; you may insert them anywhere in the message.

```
CURRent 5;*ESE 255
OUTPut 0;*RCL 2
```

9.3 Using Queries

Observe the following precautions with queries:

- Set up the proper number of variables for the returned data.
- Read back all the results of a query before sending another command to the AC Load. Otherwise a Query Error will occur and the non-returned data will be lost.

9.4 Structure of a SCPI Message

SCPI messages consist of one or more message units ending in a message terminator. The terminator is not part of the syntax, but implicit in the way your programming language indicates the end of a line (such as a New Line or end-of-line character).

The Message Unit

The simplest SCPI command is a single message unit consisting of a command header (or keyword) followed by a message terminator.

```
CURRent?<newline>
PFACtor?<newline>
```

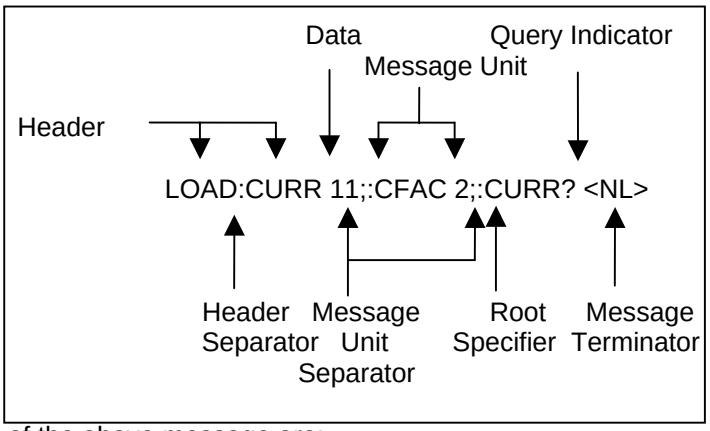
The message unit may include a parameter after the header. The parameter usually is numeric:

```
CURRent 20<newline>
```

Combining Message Units

The following command message is briefly described here, with details in subsequent paragraphs.

Figure 9-1: Command Message Structure



The basic parts of the above message are:

Message Component	Example
Headers	LOAD CURR CFAC
Header Separator	The colon in LOAD:CURR
Data	11 2
Data Separator	The space in CURR 11 and CFAC 2
Message Units	CURR 11 CFAC 2 CURR?
Message Unit Separator	The semicolons in CURR 11; and CFAC 2;
Root Specifier	The colon in :CFAC and :CURR?
Query Indicator	The question mark in CURR?
Message Terminator	The <NL> (newline) indicator. Terminators are not part of the SCPI syntax

Headers

Headers are instructions recognized by the AC Load. Headers (which are sometimes known as "keywords") may be either in the long form or the short form.

Long Form	The header is completely spelled out, such as CURRENT, SYSTEM, and OUTPUT.
Short Form	The header has only the first three or four letters, such as CURR, SYST, and OUTP.

The SCPI interface is not sensitive to case. It will recognize any case mixture, such as VOLTAGE, VOLTage or Voltage. Short form headers result in faster program execution.

Header Convention

In the command descriptions used throughout this manual, the proper short form is shown in upper-case letters, such as CURRent.

Header Separator

If a command has more than one header, you must separate them with a colon
SYSTem:ERRor LIMit:FREQuency:LOW

Optional Headers

The use of some headers is optional. Optional headers are shown in brackets, such as CURRent[:LEVel] 100.

Query Indicator

Following a header with a question mark turns it into a query (MODE?, CURRent?).

Message Unit Separator

When two or more message units are combined into a compound message, separate the units with a semicolon (CURR 12.5;:PFAC 0.8).

Root Specifier

When it precedes the first header of a message unit, the colon becomes the root specifier. It tells the command parser that this is the root or the top node of the command tree. Note the difference between root specifiers and header separators in the following examples:

LOAD:VOLTage:LEVel 100	All colons are header separators
:LOAD:VOLTage:LEVel 100	Only the first colon is a root specifier
LOAD:VOLTage:LEVel 100;:CFAC 3.5	Only the third colon is a root specifier

You do not have to precede root-level commands with a colon; there is an implied colon in front of every root-level command.

Message Terminator

A terminator informs SCPI that it has reached the end of a message. The only permitted message terminator is:

- newline (<NL>), which is ASCII decimal 10 or hex 0A.

In the examples of this manual, there is an assumed message terminator at the end of each message. If the terminator needs to be shown, it is indicated as <NL> regardless of the actual terminator character.

9.5 SCPI Data Formats

All data programmed to or returned from the AC Load is in ASCII. The data type may be numerical or character string.

Numerical Data Formats

Symbol	Data Form
Talking Formats	
<NR1>	Digits with an implied decimal point assumed at the right of the least-significant digit. Examples: 273
<NR2>	Digits with an explicit decimal point. Example:.0273
<NR3>	Digits with an explicit decimal point and an exponent. Example: 2.73E+2
<Bool>	Boolean Data. Example: 0 | 1
Listening Formats	
<Nrf>	Extended format that includes <NR1>, <NR2> and <NR3>. Examples: 273.2 , 2.73E2
<Bool>	Boolean Data. Example: 0 | 1

Character Data

Character strings returned by query statements may take either of the following forms, depending on the length of the returned string:

<CRD>	Character Response Data. Permits the return of character strings.
<AARD>	Arbitrary ASCII Response Data. Permits the return of un-delimited 7-bit ASCII. This data type has an implied message terminator.
<SRD>	String Response Data. Returns string parameters enclosed in double quotes.

10. SCPI Command Reference

This chapter is organized as follows:

- Subsystem commands, arranged by subsystem
- IEEE 488.2 common commands

Related Commands

Where appropriate, related commands or queries are included. These are listed because they are either directly related by function, or because reading about them will clarify or enhance your understanding of the original command or query.

Subsystem commands

Subsystem commands are specific to AC Load functions. They can be a single command or a group of commands. The groups are comprised of commands that extend one or more levels below the root. The description of common commands follows the description of the subsystem commands.

The subsystem command groups are listed in alphabetical order and the commands within each subsystem are grouped alphabetically under the subsystem. Commands followed by a question mark (?) take only the query form. When commands take both the command and query form, this is noted in the syntax descriptions.

IEEE 488.2 common commands

Common commands are defined by the IEEE-488.2 standard and are described in chapter 0 of this manual.

10.1 Subsystem Commands

Subsystem commands are specific to AC Load functions. They can be a single command or a group of commands. The groups are comprised of commands that extend one or more levels below the root. The description of common commands follows the description of the subsystem commands.

The subsystem command groups are listed in alphabetical order and the commands within each subsystem are grouped alphabetically under the subsystem. Commands followed by a question mark (?) take only the query form. When commands take both the command and query form, this is noted in the syntax descriptions.

10.2 Calibration Subsystem

The commands in this subsystem allow you to do the following:

- Enable and disable the calibration mode
- Calibrate the current and voltage gain of the AC load.
- Store the new calibration constants in nonvolatile memory.

Subsystem Syntax

CALibrate

:PASSword	Allows entry of calibration password required to change calibration coefficients
:SAVe	
:CURRent	Calibrate full scale AC current
:VOLTage	Calibrate full scale AC voltage

10.2.1 Password

CALibrate:PASSword

This command allows the entry of the calibration password. The calibration password is required to use the data entry form of the calibration commands. Without the use of this password new calibration can not be performed. The calibration password is defined as the numeric portion of the AC load serial number spelled backwards. The password needs to be enclosed by single or double quotation marks. Thus, if the unit's serial number is HK12345, the calibration password is “54321” and the command syntax would be:

CAL:PASS “54321”

Note that any non-numeric characters such as the HK in the example shown here need to be discarded when sending the calibration password. Only the numeric portion is to be used.

Command Syntax	CALibrate:PASSword<SRD>
Parameters	<numeric portion of serial number reversed> (default)
Examples	CAL:PASS '34593' CAL:PASS "35461"
Related Commands	*IDN?

10.2.2 Save

CALibration:SAVE

This command saves the calibration coefficients into the flash memory. This command must be executed after the calibration is performed successfully. If not, the previous calibration coefficients will be user after the next power on cycle.

Command Syntax	CALibrate:SAVe
Parameters	none
Examples	CAL:SAVE
Related Commands	*IDN?

10.2.3 Current

CALibrate:CURRent <NRf>

This command initiates the calibration of the AC current full-scale measurement.

Command Syntax	CALibrate:CURRent
Parameters	<NRf> (actual load current measured with external device)
Examples	CAL:CURR 28.0
Query Syntax	CALibrate:CURRent?
Returned Parameters	<NR2> (value range -1000 to +1000)

10.2.4 Voltage

CALibrate:VOLTage <NRf>

This command initiates the calibration of the AC voltage full-scale measurement.

Command Syntax	CALibrate:VOLTage
Parameters	<NRf> (voltage measured with external device)
Examples	CAL:VOLT 270
Query Syntax	CALibrate:VOLTage?
Returned Parameters	<NR2> (value range -1000 to +1000)

10.3 Instrument Subsystem

The Instrument subsystem controls the phase mode of the AC load for configurations capable of operating in three-phase mode.

Subsystem Syntax

INSTrument

COUPle ALL | NONE	Couples or uncouples commands
:NSELect 1 | 2 | 3	Selects phase A, B or C using numeric references
:SELect A | B | C	Selects phase A, B or C using character references

INSTrument:COUPle

This command may be used to couple all AC load phases in multi phase mode. When the phases are coupled, commands issued subsequently affect all three phases. This allows the load current to be programmed for all three phases using a single command and without the need to select each phase individually. When uncoupled, commands issued must be preceded by the INST:NSEL command and will only affect the selected command.

Available parameters are ALL to couple all phases and NONE to uncouple all phases. In single phase mode, the INST:COUP commands are ignored.

Command Syntax	INSTrument:COUPle
Parameters	ALL | NONE
Examples	INST:COUP ALL
Query Syntax	INST:COUP?
Returned Parameters	<CRD>
Related Commands	INST:NSEL INST:SEL

INSTrument:NSELect

This command may be used select a specific load phase in three phase mode using a numeric reference. A "1" denotes phase A, a "2" denotes phase B and a "3" denotes Phase C. As long as the instrument state is coupled, programming commands will affect all phases. As soon as the INST:COUP NONE command is issued, the last selected phase becomes selected. To immediately change the output of a single phase only, make sure the instrument state is uncoupled when issuing the INST:NSEL command.

Note that the MEASuse and FETCh subsystems are not affected by the INST:COUP command and always operate on the selected phase only. This means the instrument can remain in coupled mode while doing measurement queries using "`INST:NSEL <n>;MEAS:VOLT?`". Note that when the instrument is subsequently put in the uncoupled state using "`INST:COUP NONE`", the last issued phase selection will be in effect. To make sure the desired phase is selected, follow the "`INST:COUP NONE`" command with an "`INST:NSEL <n>`" command

Command Syntax	INSTrument:NSEL
Parameters	1 | 2 | 3
Examples	INST:NSEL 1
Query Syntax	INST:NSEL?
Returned Parameters	<CRD>
Related Commands	INST:COUP INST:SEL

INSTrument:SELect

This command may be used select a specific output phase in multi phase mode using a character reference. “A” denotes phase A, “B” denotes phase B and “C” denotes Phase C. As long as the instrument state is coupled however, programming command will affect all phases. As soon as the INST:COUP NONE command is issued, the last selected phase becomes selected. To immediately change the output of a single phase only, make sure the instrument state is uncoupled when issuing the INST:SEL command.

Note that the MEASuse and FETCh subsystems are not affected by the INST:COUP command and always operate on the selected phase only. This means the instrument can remain in coupled mode while doing measurement queries using “`INST:SEL <n>;FETC:VOLT?`”. Note that when the instrument is subsequently put in the uncoupled state using “`INST:COUP NONE`”, the last issued phase selection will be in effect. To make sure the desired phase is selected, follow the “`INST:COUP NONE`” command with an “`INST:SEL <n>`” command

Command Syntax	INSTrument:SEL	
Parameters	A | B | C	
Examples	INST:SEL A	
Query Syntax	INST:SEL?	
Returned Parameters	<CRD>	
Related Commands	INST:COUP	INST:NSEL

10.4 Array Measurement Subsystem

This command subsystem lets you retrieve arrays containing measurement data. Only current, voltage and power measurements are stored in an array. Two measurement commands are available:

- MEASure triggers the acquisition of new measurement data before returning a reading.
- FETCh returns a reading computed from previously acquired data.

Individual outputs of a three-phase load are specified by the setting of INSTrument:NSELect.

Subsystem Syntax

```
MEASure | FETCh
    :ARRay
        :CURRent
            [:DC]?              Returns the digitized instantaneous current
            :HARMonic
                [:AMPLitude]?   Returns amplitudes of the first 50 harmonics
                :PHASe?         Returns phase angles of the first 50 harmonics

        :MODE                   Selects waveform data transfer format.

        :VOLTage
            [:DC]?              Returns the digitized instantaneous voltage
            :HARMonic
                [:AMPLitude]?   Returns amplitudes of the first 50 harmonics
                :PHASe?         Returns phase angles of the first 50 harmonics

        :POWer
            [:DC]?              Returns the digitized instantaneous power
            :HARMonic
                [:AMPLitude]?   Returns amplitudes of the first 50 harmonics
                :PHASe?         Returns phase angles of the first 50 harmonics
```

10.4.1 Current Array Data

MEASure:ARRay:CURRent[:DC]?
FETCh:ARRay:CURRent[:DC]?

Phase Selectable

These queries return an array containing the instantaneous load current in amperes. The data is returned in arbitrary block data format as follows:

#3<block length n><b0><b1><b2><b3>.....<bn-3><bn -2><bn-1><bn>

where b0,b1,b2,b3 are four or eight bytes representing an IEEE single precision floating number, where b0 is the most significant byte and b3 is the least significant byte. See MEAS:ARR:MODE command for details

The load current is digitized whenever a measure command is issued. The time interval between samples can be found by querying the sample rate. The query SENSe:SWEep:TINTerval? will return the time interval between samples in µs.

Query Syntax	MEASure:ARRay:CURRent[:DC]? FETCh:ARRay:CURRent[:DC]?
Parameters	None
Examples	MEAS:ARR:CURR?FETC:ARR:CURR?
Returned Parameters	128 data points in arbitrary block data format
Related Commands	INST:NSEL

MEASure:ARRay:CURRent:HARMonic? [<nrf>]
FETCh:ARRay:CURRent:HARMonic? [<nrf>]

Phase Selectable

These queries return an array of harmonic amplitudes of load current in RMS amperes. The first value returned is the dc component, the second value is the fundamental frequency, and so on up to the 50th harmonic. Harmonic orders can be measured up to the fundamental measurement bandwidth of the measurement system, which can be determined by querying the time interval between samples of the measurement system in µs. This time will vary based on the fundamental frequency of the voltage applied to the load. Thus, the maximum harmonic that can be measured is dependent on the input frequency. Any harmonics that represent frequencies greater than the measurement system bandwidth are returned as 0.

The total number of harmonic values returned may be specified as a parameter to the query command. Only harmonic data values from 0 (dc) to the number specified will be returned. This capability may be used to reduce the transfer time by avoiding the transfer of unwanted data.

Query Syntax	MEASure:ARRay:CURRent:HARMonic[:AMPLitude]? [<nrf>] FETCh:ARRay:CURRent:HARMonic[:AMPLitude]?
Parameters	None
Examples	MEAS:ARR:CURR:HARM? 20 FETC:ARR:CURR:HARM? 20
Returned Parameters	21 NR2 values
Related Commands	INST:NSEL

MEASure:ARRay:CURRent:HARMonic:PHASe? [<nrf>]
FETCh:ARRay:CURRent:HARMonic:PHASe? [<nrf>]

Phase Selectable

These queries return an array of harmonic phases of load current in degrees, referenced to the positive zero crossing of the fundamental component. The fundamental component will return a value relative to the fundamental voltage.

The first value returned is the dc component (always returned as 0 degrees phase). The second value is the fundamental frequency, and so on up to the 50th harmonic. Harmonic orders can be measured up to the fundamental measurement bandwidth of the measurement system, which can be determined by querying the time interval between samples of the measurement system in µs. This time will vary based on the fundamental frequency of the voltage applied to the load. Thus the maximum harmonic that can be measured is dependent on the input frequency. Any harmonics that represent frequencies greater than the measurement system bandwidth are returned as 0.

Query Syntax	MEASure:ARRay:CURRent:HARMonic:PHASe?<NRf> FETCh:ARRay:CURRent:HARMonic:PHASe?<NRf>
Parameters	None
Examples	MEAS:ARR:CURR:HARM:PHAS? 16 FETC:ARR:CURR:HARM:PHAS? 16
Returned Parameters	17 NR2 values
Related Commands	INST:NSEL

10.4.2 Waveform Array Data Format Mode

MEASure:ARRay:MODe

This command selects the waveform array data format to be used. (Available in firmware revision 1.1 or higher only.) The default mode is binary (BIN) which uses an IEEE floating point data format in which each data sample is transferred as a 4 byte floating point binary data word. Alternatively, an ASCII format may be selected (ASCii) in which each data sample is sent as 8 ASCII Hex values representing the 4 byte IEEE floating point data. Note that the transfer mode only applies to MEAS:ARR:VOLT and MEAS:ARR:CURR queries. All other measurement queries always return ASCII data. Note that at power on, the default mode is always set to binary (BIN).

Syntax	MEASure:ARRay:MODE
Parameters	BIN | ASCii
Examples	MEAS:ARR:MOD ASC
Query Syntax	MEASure:ARRay:MODE?
Returned paramters	BIN or ASC
Related Commands	MEAS:ARR:VOLT MEAS:ARR:CURR

Note: The MEAS:ARR:MOD command is provided to allow waveform data transfers in ASCII on DBCS versions of MS Windows. Examples of DBCS versions are Chinese, Korean, Japanese etc. On most Windows versions, the binary mode can be used as it reduces the amount of data transferred and thus provides better throughput.

The ASCII mode will double the number of characters transferred so provisions for a larger receive buffer on the PC may have to be made.

Conversion function sample VB6. Converting waveform data from either transfer mode to a single precision value can be accomplished using the following sample routine:

```
Public Function StringToIEEEFloat(ByVal sData As String, ByVal bAsciiMode As Boolean) As
Single
'============================================================
'bAsciiMode flag is used if data is received as 8 ascii chars
'representing Hex 0-9,A-F. If bAsciiMode flag is false, then
'data is process as 4 char representing a byte each. Ascii
'mode is needed for DCBS windows
'============================================================
  Dim i         As Integer
  Dim j         As Integer
  Dim iChar     As Integer
  Dim expo      As Long
  Dim mantisse  As Long
  Dim expo_val  As Variant
  Dim mant_f    As Single
  Dim c(3)      As Long    'Must use 32 bit integers to allow for
                       'intermediate result of 24 bit shift
  Dim sign      As Boolean
'============================================================
Const MANT_MAX = &H7FFFFF
Const EXPO_MAX = 2 ^ 126
'============================================================

On Error GoTo FloatConvError
  If bAsciiMode Then
    'Retrieve ASC values from eight hex byte input data
    sData = UCase(sData)
    For i = 0 To 3
      c(i) = 0
      For j = 0 To 1
        iChar = AscB(Mid$(sData, i * 2 + j + 1, 1)) - 48
        If iChar > 9 Then iChar = iChar - 7
        c(i) = c(i) * 16 * j + iChar
      Next j
```

```
    Next i
  Else
    'Retrieve ASC values from four byte input data
    'Note: Don't use ASCB or ASCW functions as results will differ
    'based on character sets, even on non DCBS Windows
    'Retrieve ASC values from four byte input data
    For i = 0 To 3
      c(i) = Asc(Mid$(sData, i + 1, 1))
    Next i
  End If
  'Get sign bit
  sign = ((c(0) And &H80) = &H80)
  'Get exponent value less sign bit
  expo = (c(0) And &H7F) * 2
  'Pick up exponent sign
  If (c(1) And &H80) = &H80 Then expo = expo Or 1
  'get data less exponent sign bit
  c(1) = c(1) And &H7F
  mantisse = c(1) * &H10000 + c(2) * &H100 + c(3)
  mant_f = mantisse / MANT_MAX
  'Process exponent
  If (expo <> 0) And (expo <> &HFF) Then
    expo = expo - 127
    mant_f = mant_f + 1
    expo_val = 2 ^ Abs(expo)
    If (expo > 0) Then mant_f = mant_f * expo_val
    If (expo < 0) Then mant_f = mant_f / expo_val
  Else
    If (mant_f <> 0) Then
      If expo = 0 Then
        mant_f = mant_f / EXPO_MAX
      Else
        mant_f = mant_f * EXPO_MAX
      End If
    End If
  End If
  'Append number sign and return value
  If sign Then mant_f = -mant_f
  StringToIEEEFloat = mant_f
Exit Function
'============================================================

FloatConvError:
  'Conversion errors are truncated to zero
  StringToIEEEFloat = 0
  Exit Function

End Function
```

10.4.3 Voltage Array Data

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

Phase Selectable

These queries return an array containing the instantaneous voltage applied to the load in volts. The data returned in arbitrary block data format as follows:

#3<block length n><b0><b1><b2><b3>.....<bn-3><bn -2><bn-1><bn>

where b0,b1,b2,b3 are four or eight bytes representing an IEEE single precision floating number, where b0 is the most significant byte and b3 is the least significant byte. See MEAS:ARR:MODE command for details.

The load voltage is digitized whenever a measure command is. The time interval between samples can be found by querying the sample rate. The query SENSe:SWEep:TINTerval? will return the time interval between samples in µs.

Query Syntax	MEASure:ARRay:VOLTage[:DC]? FETCh:ARRay:VOLTage[:DC]?
Parameters	None
Examples	MEAS:ARR:VOLT? FETC:ARR:VOLT?
Returned Parameters	128 data points in arbitrary block data format
Related Commands	INST:NSEL

MEASure:ARRay:VOLTage:HARMonic? [<nrf>]
FETCh:ARRay:VOLTage:HARMonic? [<nrf>]

Phase Selectable

These queries return an array of harmonic amplitudes of voltage applied to the load. The first value returned is the dc component, the second value is the fundamental frequency, and so on up to the 50th harmonic. Harmonic orders can be measured up to the fundamental measurement bandwidth of the measurement system, which can be determined by querying the time interval between samples of the measurement system in µs. This time will vary based on the fundamental frequency of the voltage applied to the load. Thus, the maximum harmonic that can be measured is dependent on the input frequency. Any harmonics that represent frequencies greater than the measurement system bandwidth are returned as 0.

The total number of harmonic values returned may be specified as a parameter to the query command. Only harmonic data values from 0 (dc) to the number specified will be returned. This capability may be used to reduce the transfer time by avoiding the transfer of unwanted data.

Query Syntax	MEASure:ARRay:VOLTage:HARMonic[:AMPLitude]? [<nrf>] FETCh:ARRay:VOLTage:HARMonic[:AMPLitude]? [<nrf>]
Parameters	None
Examples	MEAS:ARR:VOLT:HARM? FETC:ARR:VOLT:HARM?
Returned Parameters	51 NR2 values
Related Commands	INST:NSEL

MEASure:ARRay:VOLTage:HARMonic:PHASe? [<nrf>]
FETCh:ARRay:VOLTage:HARMonic:PHASe? [<nrf>]

Phase Selectable

These queries return an array of harmonic phases of the voltage applied to the load in degrees, referenced to the positive zero crossing of the fundamental component. The fundamental component will return a zero value.

The first value returned is the dc component (always returned as 0 degrees phase) , the second value is the fundamental frequency, and so on up to the 50th harmonic. Harmonic orders can be measured up to the fundamental measurement bandwidth of the measurement system, which can be determined by querying the time interval between samples of the measurement system in µs. This time will vary based on the fundamental frequency of the voltage applied to the load. Thus the maximum harmonic that can be measured is dependent on the input frequency. Any harmonics that represent frequencies greater than the measurement system bandwidth are returned as 0.

Query Syntax	MEASure:ARRay:VOLTage:HARMonic:PHASe?<NRf> FETCh:ARRay:VOLTage:HARMonic:PHASe?<NRf>
Parameters	None
Examples	MEAS:ARR:VOLTage:HARM:PHAS? 30 FETC:ARR:VOLTage:HARM:PHAS? 30
Returned Parameters	31 NR2 values
Related Commands	INST:NSEL

10.4.4 Power Array Data

MEASure:ARRay:POWer[:DC]?
FETCh:ARRay:POWer[:DC]?

Phase Selectable

These queries return an array containing the instantaneous load power in watts. The data returned in arbitrary block data format as follows:

#3<block length n><b0><b1><b2><b3>.....<bn-3><bn -2><bn-1><bn>

where b0,b1,b2,b3 are four or eight bytes representing an IEEE single precision floating number, where b0 is the most significant byte and b3 is the least significant byte. See MEAS:ARR:MODE command for details.

The load power is digitized whenever a measure command is.The time interval between samples can be found by query the sample rate. The query SENSe:SWEep:TINTerval? will return the time interval between samples in µs.

Query Syntax	MEASure:ARRay:POWer[:DC]? FETCh:ARRay:POWer[:DC]?
Parameters	None
Examples	MEAS:ARR:POW? FETC:ARR:POW?
Returned Parameters	128 data points in arbitrary block data format
Related Commands	INST:NSEL

MEASure:ARRay:POWer:HARMonic? [<nrf>]
FETCh:ARRay:POWer:HARMonic? [<nrf>]

Phase Selectable

These queries return an array of harmonic amplitudes of load power in watts. The first value returned is the dc component, the second value is the fundamental frequency, and so on up to the 50th harmonic. Harmonic orders can be measured up to the fundamental measurement bandwidth of the measurement system, which can be determined by querying the time interval between samples of the measurement system in µs. This time will vary based on the fundamental frequency of the voltage applied to the load. Thus, the maximum harmonic that can be measured is dependent on the input frequency. Any harmonics that represent frequencies greater than the measurement system bandwidth are returned as 0.

The total number of harmonic values returned may be specified as a parameter to the query command. Only harmonic data values from 0 (dc) to the number specified will be returned. This capability may be used to reduce the transfer time by avoiding the transfer of unwanted data.

Query Syntax	MEASure:ARRay:POWer:HARMonic[:AMPLitude]? [<nrf>] FETCh:ARRay:POWer:HARMonic[:AMPLitude]?
Parameters	None
Examples	MEAS:ARR:POW:HARM? 20 FETC:ARR:POW:HARM? 20
Returned Parameters	21 NR2 values
Related Commands	INST:NSEL

MEASure:ARRay:POWer:HARMonic:PHASe? [<nrf>]
FETCh:ARRay:POWer:HARMonic:PHASe? [<nrf>]

Phase Selectable

These queries return an array of harmonic phases of load power in degrees, referenced to the positive zero crossing of the fundamental component. The fundamental component will return a value relative to the fundamental voltage.

The first value returned is the dc component (always returned as 0 degrees phase) , the second value is the fundamental frequency, and so on up to the 50th harmonic. Harmonic orders can be measured up to the fundamental measurement bandwidth of the measurement system, which can be determined by querying the time interval between samples of the measurement system in µs. This time will vary based on the fundamental frequency of the voltage applied to the load. Thus the maximum harmonic that can be measured is dependent on the output frequency. Any harmonics that represent frequencies greater than the measurement system bandwidth are returned as 0.

Query Syntax	MEASure:ARRay:POWer:HARMonic:PHASe?<NRf> FETCh:ARRay:POWer:HARMonic:PHASe?<NRf>
Parameters	None
Examples	MEAS:ARR:POW:HARM:PHAS? 16 FETC:ARR:POW:HARM:PHAS?
Returned Parameters	17 NR2 values
Related Commands	INST:NSEL

10.5 Current Measurement Subsystem

This subsystem programs the current measurement capability of the AC load. Two measurement commands are available: MEASure and FETCh.

- MEASure triggers the acquisition of new measurement data before returning a reading.
- FETCh returns a reading computed from previously acquired data.

Individual outputs of a three-phase load are specified by the setting of INSTrument:NSELect.

Subsystem Syntax

```
MEASure | FETCh
    [:SCALar]
        :CURRent
            [:AC]?              Returns RMS value of the current
            :AMPLitude
                :MAX?           Returns peak current
                :MODE           The highest peak current measurement is held
            :CREStfactor?       Returns current crest factor
```

MEASure:CURRent[:AC]?
FETCh:CURRent[:AC]?

Phase Selectable

These queries return the AC component of the RMS current being dissipated at the load.

Query Syntax	MEASure[:SCALar]:CURRent[:AC]? FETCh[:SCALar]:CURRent[:AC]?
Parameters	None
Examples	MEAS:CURR:AC? FETC:CURR?
Returned Parameters	<NR2>
Related Commands	INST:NSEL

MEASure:CURRent:AMPLitude:MAXimum?
FETCh:CURRent:AMPLitude:MAXimum?

Phase Selectable

These queries return the absolute value of the peak current as sampled over one measurement acquisition of 1024 data points. The returned value will be updated continuously or only when a larger value is found depending on the peak hold mode. To update the value with every measurement, the peak current hold mode should be set to OFF. To update the value only when a larger value is found, the peak current hold mode should be set to ON.

Query Syntax	MEASure[:SCALar]:CURRent:AMPLitude:MAXimum? FETCh[:SCALar]:CURRent:AMPLitude:MAXimum?
Parameters	None
Examples	MEAS:CURR:AMPL:MAX? FETC:CURR:AMPL:MAX?
Returned Parameters	<NR2>
Related Commands	INST:NSEL MEAS:CURR:AMPL:MODE

MEASure:CURRent:AMPLitude:MODE

Phase Selectable

This command will define the peak current measurement mode. If the mode command is set to ON, the peak current measurement is updated only when the value measured exceed the last measured value. This mode may be used to capture peak inrush current conditions.

Command Syntax	MEASure[:SCALar]:CURRent:AMPLitude:MODE OFF|ON
Parameters	OFF | ON | 0 | 1
Examples	MEAS:CURR:AMPL:MODE ON
Query syntax	MEAS:CURR:AMPL:MODE?
Returned Parameters	0 | 1
Related Commands	MEAS:CURR:AMPL:MAX?

[1]MEASure:CURRent:CFACtor?
FETCh:CURRent:CFACtor?

Phase Selectable

These queries return the current crest factor of the load. This is the ratio of peak load current to RMS load current.

Query Syntax	MEASure[:SCALar]:CURRent:CREStfactor? FETCh[:SCALar]:CURRent:CREStfactor?
Parameters	None
Examples	MEAS:CURR:CRES? FETC:CURR:CRES?
Returned Parameters	<NR2>
Related Commands	INST:NSEL

[1] *Early prototype firmware may still use "MEASure:CURRent:CFACtor" syntax.*

10.6 Frequency Measurement Subsystem

This subsystem programs the frequency measurement capability of AC load. The frequency measured represent the frequency of the voltage applied to the load. The frequency measurements will return a zero value if the voltage applied to the load is above or below the voltage threshold settings. A zero value will also be returned if the frequency of the input voltage is above or below the frequency limits of the AC Load. See LIMIT subsystem.

Subsystem Syntax

MEASure | FETCh
[:SCALar]
:FREQuency? Returns the output frequency

MEASure:FREQuency?
FETCh:FREQuency?

This query returns the output frequency in Hertz.

Query Syntax	MEASure[:SCALar]:FREQuency?
Parameters	None
Examples	MEAS:FREQ?
Returned Parameters	<NR2>

10.7 Power Measurement Subsystem

This subsystem programs the power measurement capability of the AC Load. Two measurement commands are available:

- MEASure triggers the acquisition of new measurement data before returning a reading.
- FETCh returns a reading computed from previously acquired data.

Individual outputs of a three-phase load are specified by the setting of INSTrument:NSELect.

Subsystem Syntax

```
MEASure | FETCh
    [:SCALar]
        :POWer
            [:REAL]?            Returns real power
            :APParent?          Returns VA
            PFACtor?            Returns power factor
            :REACtive           Returns the reactive componet of power
            :AMPLitude?
                MAXimum         Return the peak power
```

MEASure:POWer?
FETCh:POWer?

Phase Selectable

This query returns the in-phase component of power being dissipated by the load in Watts (W).

Query Syntax	MEASure[:SCALar]:POWer[:REAL]?
Parameters	None
Examples	MEAS:POW? FETC:POW?
Returned Parameters	<NR2>
Related Commands	None

MEASure:POWer:APParent?
FETCh:POWer:APParent?

Phase Selectable

This query returns the apparent power being dissipated by the load in volt-amperes (VA).

Query Syntax	MEASure[:SCALar]:POWer:APParent?
Parameters	None
Examples	MEAS:POW:APP? FETC:POW:APP?
Returned Parameters	<NR2>
Related Commands	None

MEASure:POWer:AC:FACTor?
FETCh:POWer[:AC]:FACTor?

Phase Selectable

This query returns the load power factor. The power factor is computed as:

power factor = real power / apparent power

Query Syntax	MEASure[:SCALar]:POWer:PFACtor?
Parameters	None
Examples	MEAS:POW:PFAC? FETC:POW:PFAC?
Returned Parameters	<NR2>
Related Commands	None

[2]MEASure:POWer:REACtive?
FETCh:POWer:REACtive?

Phase Selectable

This query returns the reactive component of the power being dissipated by the load at the input terminals in Volt-Amperes (VA).

Query Syntax	MEASure[:SCALar]:POWer:REAC?
Parameters	None
Examples	MEAS:POW:REAC? FETC:POW:REAC?
Returned Parameters	<NR2>
Related Commands	None

MEASure:POWer:AMPLitude:MAXimum?
FETCh:POWer:AMPLitude:MAXimum?

Phase Selectable

These queries return the value of the peak power as sampled over one measurement acquisition of 1024 data points. The returned value will be updated continuously or only when a larger value is found depending on the peak hold mode setting. To update the value with every measurement, the peak current hold mode should be set to OFF. To update the value only when a larger value is found, the peak hold mode should be set to ON.

Query Syntax	MEASure[:SCALar]:POWer:AMPLitude:MAXimum? FETCh[:SCALar]:POWer:AMPLitude:MAXimum?
Parameters	None
Examples	MEAS:POW:AMPL:MAX? FETC:POW:AMPL:MAX?
Returned Parameters	<NR2>
Related Commands	INST:NSEL MEAS:CURR:AMPL:MODE

[2] *Early prototype firmware may still use "MEASure:POWer:FACTor" syntax.*

10.7.1 Voltage Measurement Subsystem

This subsystem programs the voltage measurement capability of AC load. Two measurement commands are available:

- MEASure triggers the acquisition of new measurement data before returning a reading.
- FETCh returns a reading computed from previously acquired data.

Individual outputs of a three-phase load are specified by the setting of INSTrument:NSELect.

Subsystem Syntax

```
MEASure | FETCh
    [:SCALar]
        :VOLTage
            [:AC]?              Returns AC RMS voltage
            AMPLitude
                MAXimum         Return the peak voltage
```

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

Phase Selectable

These queries return the AC RMS voltage being applied at the load terminals.

Query Syntax	MEASure[:SCALar]:VOLTage:AC? FETCh[:SCALar]:VOLTage:AC?
Parameters	None
Examples	MEAS:VOLT:AC? FETC:VOLT:AC?
Returned Parameters	<NR2>
Related Commands	INST:NSEL

MEASure:VOLTage:AMPLitude:MAXimum?
FETCh:VOLTage:AMPLitude:MAXimum?

Phase Selectable

These queries return the value of the peak voltage as sampled over one measurement acquisition of 1024 data points. The returned value will be updated continuos or only when a larger value is found depending on the peak holds mode. To update the value with every measurement, the peak current hold mode should be set to OFF. To update the value only when a larger value is found, the peak hold mode should be set to ON.

Query Syntax	MEASure[:SCALar]:VOLTage:AMPLitude:MAXimum? FETCh[:SCALar]:VOLTage:AMPLitude:MAXimum?
Parameters	None
Examples	MEAS:VOLT:AMPL:MAX? FETC:VOLT:AMPL:MAX?
Returned Parameters	<NR2>
Related Commands	INST:NSEL MEAS:CURR:AMPL:MODE

10.7.2 Resistance Measurement Subsystem

This subsystem programs the resistance measurement capability of AC load. Two measurement commands are available:

- MEASure triggers the acquisition of new measurement data before returning a reading.
- FETCh returns a reading computed from previously acquired data.

Individual outputs of a three-phase load are specified by the setting of INSTrument:NSELect.

Subsystem Syntax

MEASure | FETCh
[:SCALar]
:RESistance Return the resistance in ohms

MEASure:RESistance?
FETCh:RESistance?

Phase Selectable

These queries return the resistance in ohms of the AC load.

Query Syntax	MEASure[:SCALar]:RESistance? FETCh[:SCALar]:RESistance?	
Parameters	None	
Examples	MEAS:RES:AC?	FETC:RES:AC?
Returned Parameters	<NR2>	
Related Commands	INST:NSEL	

10.8 Output Subsystem

This subsystem controls the external outputs of the AC load. Specifically, the Trigger Out control signal available at the rear panel can be enabled or disabled using this sub system.

Subsystem Syntax

OUTPut
:TTLTrg
[:STATe] <bool> Enable/disable trigger out drive

10.8.1 External Trigger Output

OUTPut:TTLTrg

This command enables or disables the Trigger Out (Trigger out) signal, which is available at the BNC connector on the rear panel of the AC load. Refer 3.8.3 for location information and signal levels for the Trigger Out signal.

Command Syntax	OUTPut:TTLTrg[:STATe]<bool>
Parameters	0|1|OFF|ON
*RST Value	OFF
Examples	OUTP:TTLT 1 OUTP:TTLT OFF
Query Syntax	OUTPut:TTLTrg[:STATe]?
Returned Parameters	0 | 1

10.9 Load subsystem

This subsystem controls the AC load state and the mode of operation.

Subsystem Syntax

LOAD:
- :STATe — Enables or disables the load
- MODE — Controls the operating mode of the load.
- SCIRcuit — Act as a short circuit applied to the EUT.

LOAD:STATe

Phase selectable

This command enables or disables the AC load. If the state is disabled, the operation mode is set to CURRENT and the load current is programmed to 0 Amps RMS. If the state is enabled, it reverts to it previously programmed mode and setting. The query form returns the load state.

Command Syntax	LOAD:STATe<bool>	
Parameters	0 | OFF | 1 | ON	
*RST Value	OFF	
Examples	LOAD:STAT 1	LOAD:STAT ON
Query Syntax	LOAD:STATe?	
Returned Parameters	0 | 1	
Related Commands	*RCL *SAV	

LOAD:MODE

Phase selectable

This command selects the operating mode of the AC load. The AC load can be programmed to operate for constant current, power, voltage or resistance. The query form returns the load operating mode. The OFF parameter effectively turns the LOAD state off and is equivalent to the LOAD:STATE OFF command.

Command Syntax	LOAD:MODE <numerated data>
Parameters	CURRent|POWer|VOLTage|RESistance
*RST Value	OFF
Examples	LOAD:MODE CURR
Query Syntax	LOAD:MODE?
Returned Parameters	OFF|CURR|POW|VOLT|RES
Related Commands	*RCL *SAV

LOAD:SCIRcuit

Phase selectable

This command applies a short circuit to the unit under test. The load will override all other settings.

Command Syntax	LOAD:SCIRcuit
Parameters	OFF | ON
*RST Value	OFF
Examples	LOAD:SCIR ON
Query Syntax	LOAD: SCIR?
Returned Parameters	OFF | ON
Related Commands	

10.9.1 Current Subsystem

This subsystem programs the constant current mode of the AC load.

Subsystem Syntax

```
[LOAD:]
    CURRent
        [:LEVel]
            [:AMPLitude] <n>      Sets the RMS current
            HIGH <n>              Set the maximum set RMS current
        :LIMit?                   Query the range of the set RMS current
```

CURRent[:LEVel][:AMPLitude]

Phase selectable

This command sets the RMS current of the AC load. The AC load insures that the load current stays constant at the set value.

Command Syntax	[LOAD:]CURRent[:LEVel][:AMPLitude]<NRf+>
Parameters	<NRf>
Unit	A (RMS amperes)
*RST	Defined by the PONSetup:CURRent
Examples	CURR 5 CURR:LEV .5
Query Syntax	[LOAD:]CURRent[:LEVel][:AMPLitude]?
Returned Parameters	<NR2>
Related Commands	CURR:LIMit? LOAD:MODE

CURRent[:LEVel]:HIGH

Phase selectable

This command sets the maximum RMS current value the AC load will accept. (User limit value). This value must be equal or less than the maximum RMS current limit of the AC load current as defined by the LIMIT sub system. Note that this value is set to the maximum value for a single 3091LD model (30A) when the *RST command is issued or the AC load is reset over the bus. For multi unit Load configurations, it will be necessary to set this value to the available maximum current using the CURR:HIGH? MAX command and using the response to this query to re-program the user limit value. Alternatively, the CURR:LIM? MAX query can be used to obtain maximum available current setting.

Command Syntax	[LOAD:]CURRent[:LEVel]:HIGH <NRf+>
Parameters	<NRf>
Unit	A (RMS Amperes)
*RST	Set to the maximum current
Examples	CURR:HIGH 5 CURR:LEV:HIGH .5
Query Syntax	[LOAD:]CURRent[:LEVel]:HIGH?
Returned Parameters	<NR2>
Related Commands	CURR:LIMit?

CURRent:LIMit?

This query only command reports the range of values for the load current that can be programmed. A set value outside its minimum and maximum range will generate a data out of range error.

Query Syntax	[LOAD:]CURRent:LIMit?	
Parameters	MINimum|MAXimum	
Examples	CURR:LIM? MAX	CURR:LIM? MIN
Returned Parameters	<NR2>	
Related Commands	CURR:HIGH?	

10.9.2 Power Subsystem

This subsystem programs the constant power mode of the AC load.

Subsystem Syntax

```
[LOAD:]
    POWer
        [:LEVel]
            [:AMPLitude] <n>        Sets the power in watts
            HIGH <n>                Set the maximum power in watts
        :LIMit?                     Query the range of set power
```

POWer[:LEVel][:AMPLitude]

Phase selectable

This command sets the power of the AC load in Watts. The AC load insures that the load power stays constant at the set value.

Command Syntax	[LOAD:]POWer[:LEVel][:AMPLitude]<NRf+>
Parameters	<NRf>
Unit	W (watts)
*RST	Defined by the PONSetup:POWer
Examples	CURR 5 CURR:LEV .5
Query Syntax	[LOAD:]POWer[:LEVel][:AMPLitude]?
Returned Parameters	<NR2>
Related Commands	POWer:LIMit? LOAD:MODE

POWer[:LEVel]:HIGH

Phase selectable

This command sets the maximum power value the AC load will accept in Watts. This value must be equal or less than the maximum limit of the AC load power. Note that this value is set to the maximum value for a single 3091LD model (3000W) when the *RST command is issued or the AC load is reset over the bus. For multi unit Load configurations, it will be necessary to set this value to the available maximum power using the POW:HIGH? MAX command and using the response to this query to re-program the user limit value. Alternatively, the POW:LIM? MAX query can be used to obtain maximum available power setting.

Command Syntax	[LOAD:]POWer[:LEVel]:HIGH <NRf+>
Parameters	<NRf>
Unit	W (watts)
*RST	Set to the maximum power
Examples	POW:HIGH 500 POW:LEV:HIGH 200
Query Syntax	[LOAD:]POWer[:LEVel]:HIGH?
Returned Parameters	<NR2>
Related Commands	POWer:LIMit?

POWer:LIMit?

This query only command defines the range of values that the power can be programmed to. A set value outside this minimum and maximum range will generate a data out of range error.

Query Syntax	[LOAD:]POWer:LIMit?	
Parameters	MINimum|MAXimum	
Examples	POW:LIM? MAX	POW:LIM? MIN
Returned Parameters	<NR2>	
Related Commands	POW:HIGH?	

10.9.3 Resistance Subsystem

This subsystem programs the constant resistance mode of the AC load.

Subsystem Syntax

```
[LOAD:]
    RESistance
        [:LEVel]
            [:AMPLitude] <n>        Sets the resistance in ohms
        :LIMit?                     Query the range of set resistance
```

RESistance[:LEVel][:AMPLitude]

Phase selectable

This command sets resistance of the AC load in Ohms. The AC load insures that the load resistance stays constant at the set value.

Command Syntax	[LOAD:]RESistance[:LEVel][:AMPLitude]<NRf+>
Parameters	<NRf>
Unit	Ohms
*RST	Defined by the PONSetup:RESistance
Examples	RES 100 RES:LEV 50
Query Syntax	[LOAD:]RESistance[:LEVel][:AMPLitude]?
Returned Parameters	<NR2>
Related Commands	RES:LIMit? LOAD:MODE

RESistance:LIMit?

This query only command defines the range of values that the load resistance can be programmed to. A set value outside this minimum and maximum range will generate a data out of range error.

Query Syntax	[LOAD:]RESistance:LIMit?
Parameters	MINimum|MAXimum
Examples	RES:LIM? MAX RES:LIM? MIN
Returned Parameters	<NR2>
Related Commands	RES:HIGH?

10.9.4 Voltage Subsystem

This subsystem programs the constant voltage mode of the AC load. This mode should not be used with constant AC voltage output EUT's such as UPS's or AC sources as the AC load will attempt to regulate the voltage by increasing or decreasing the current.

Subsystem Syntax

```
[LOAD:]
    VOLTage
        [:LEVel]
            [:AMPLitude] <n>      Sets the RMS voltage
            HIGH <n>              Sets the maximum RMS set voltage
            LOW<n>                Sets the minimum RMS set voltage
        :LIMit?                   Query the range of set voltage
```

VOLTage[:LEVel][:AMPLitude]

Phase selectable

This command sets the RMS voltage of the AC load. The AC load will attempt to change the voltage applied to the load to the set value by increasing or decreasing the RMS current drawn.

Command Syntax	[LOAD:]VOLTage[:LEVel][:AMPLitude]<NRf+>
Parameters	<NRf>
Unit	V (RMS voltage)
*RST	Defined by the PONSetup:VOLTage
Examples	VOLT 120 VOLT:LEV 240
Query Syntax	[LOAD:]VOLTage[:LEVel][:AMPLitude]?
Returned Parameters	<NR2>
Related Commands	VOLT:LIMit? LOAD:MODE

VOLTage[:LEVel]:HIGH

Phase selectable

This command sets the maximum RMS voltage value the AC load will accept. This value must be equal or less than the maximum limit of the AC load input voltage. A value applied on the load that exceeds this value will cause the load to shut itself off.

Command Syntax	[LOAD:]CURRent[:LEVel]:HIGH <NRf+>
Parameters	<NRf>
Unit	V (RMS voltage)
*RST	Set to the maximum voltage
Examples	VOLT:HIGH 120 VOLT:LEV:HIGH .120
Query Syntax	[LOAD:]VOLTage[:LEVel][:AMPLitude]?
Returned Parameters	<NR2>
Related Commands	VOLTage:LIMit?

VOLTage[:LEVel]:LOW

Phase selectable

This command sets the minimum RMS voltage value the AC load will accept. This value must be equal or higher than the minimum limit of the AC load input voltage. A value applied on the load that is below this value will cause the load to shut itself off.

Command Syntax	[LOAD:]CURRent[:LEVel]:LOW <NRf+>
Parameters	<NRf>
Unit	V (RMS voltage)
*RST	Set to the minimum voltage
Examples	VOLT:LOW 120VOLT:LEV:LOW .120
Query Syntax	[LOAD:]VOLTage[:LEVel][:AMPLitude]?
Returned Parameters	<NR2>
Related Commands	VOLTage:LIMit?

VOLTaget:LIMit?

This query only command defines the range of values the load voltage can be programmed to. A set value outside this minimum and maximum range will generate a data out of range error. If the applied voltage exceeds the maximum value or drops below this minimum value, the load will shut itself off.

Query Syntax	[LOAD:]VOLTage:LIMit?
Parameters	MINimum|MAXimum
Examples	VOLT:LIM? MAX VOLT:LIM? MIN
Returned Parameters	<NR2>
Related Commands	VOLT:HIGH?

10.9.5 Crest Factor Subsystem

This subsystem programs the crest factor of the AC load. This capability is only available in Constant Current and Constant Power modes of operation.

Subsystem Syntax

```
[LOAD:]
    CFACtor
        [:LEVel]
            [:AMPLitude] <n>        Sets the RMS current
        :LIMit?                     Query the range of set current
```

CFACtor[:LEVel][:AMPLitude

Phase selectable

This command sets the crest factor of the AC load. The AC load will attempt to program the crest factor to a value as close as possible to the set value. The ability to do so will be affected by the mode and the power factor setting.

Command Syntax	[LOAD:]CFACtor[:LEVel][:AMPLitude]<NRf+>
Parameters	<NRf>
Unit	(ratio)
*RST	Defined by the PONSetup:CFACtor
Examples	CFAC 3 CFAC:LEV 2.5
Query Syntax	[LOAD:]CFACtor[:LEVel][:AMPLitude]?
Returned Parameters	<NR2>
Related Commands	CFAC:LIMit?

CFACtor:LIMit?

This query only commands defines the range of data the load crest factor can be programmed to. A set value outside this minimum and maximum range will generate a data out of range error.

Query Syntax	[LOAD:]CFACtor:LIMit?
Parameters	MINimum|MAXimum
Examples	CFAC:LIM? MAX CURR:LIM? MIN
Returned Parameters	<NR2>

10.9.6 Power Factor Subsystem

This subsystem programs the load current of the AC load.

Subsystem Syntax

```
[LOAD:]
    PFACtor
        [:LEVel]
            [:AMPLitude] <n>    Sets the power factor
        :LIMit?                 Query the range of set current
```

PFACtor[:LEVel][:AMPLitude]

Phase selectable

This command sets the power factor of the AC load. The AC load will attempt to set the power factor to the set value. The power factor set range is coupled to the crest factor set value. For a crest factor of 1.414, unity power factor is the only valid value. See section 5.4 for details on the correlation between the crest factor and power factor.

Command Syntax	[LOAD:]PFACtor[:LEVel][:AMPLitude]<NRf+>
Parameters	<NRf>
Unit	(ratio)
*RST	Defined by the PONSetup:PFACtor
Examples	PFACtor 0.7 PFAC:LEV .5
Query Syntax	[LOAD:]PFACtor[:LEVel][:AMPLitude]?
Returned Parameters	<NR2>
Related Commands	PFAC:LIMit?

PFACtor:LIMit?

This query only command defines the range of data the load power factor can be programmed to. A set value outside this minimum and maximum range will generate a data out of range error.

Query Syntax	[LOAD:]PFACtor:LIMit?
Parameters	MINimum|MAXimum
Examples	PFAC:LIM? MAX PFAC:LIM? MIN
Returned Parameters	<NR2>

10.9.7 Frequency Subsystem

This subsystem programs the load frequency limit of the AC load. A input voltage frequency outside these limits will cause the AC load to shut down.

Subsystem Syntax

```
[LOAD:]
    FREQuency
        [:FIXed]
            HIGH <n>      Sets the maximum frequency at which the load can operate.
            LOW <n>       Sets the minimum frequency at which the load can operate.
        :LIMit?           Queries the range of frequency.
```

FREQuency[:FIXed]:HIGH

This command sets the high limit frequency at which the AC load can operate. The set value must not exceed the high frequency limit. A frequency above the set value will cause the load to shut down.

Command Syntax	[LOAD:]FREQuency[:FIXed]:HIGH <NRf+>
Parameters	<NRf>
Unit	Hz (hertz)
Examples	FREQ 300
Query Syntax	[LOAD:]FREQuency[:FIXed]:HIGH?
Returned Parameters	<NR2>
Related Commands	FREQ:LIMit?

FREQuency[:FIXed]:LOW

This command sets the low limit frequency at which the AC load can operate. The set value must not be below the low frequency limit. A frequency below the set value will cause the load to shut down.

Command Syntax	[LOAD:]FREQuency[:FIXed]LOW <NRf+>
Parameters	<NRf>
Unit	Hz (hertz)
Examples	FREQ 40
Query Syntax	[LOAD:]FREQuency[:FIXed]:LOW?
Returned Parameters	<NR2>
Related Commands	FREQ:LIMit?

FREQuency:LIMit?

This query only command defines the range of frequencies the load can operate at. The load will shut down if it detects a frequency outside these limits.

Query Syntax	[LOAD:]FREQuency:LIMit?
Parameters	MINimum|MAXimum
Examples	FREQ:LIM? MAX FREQ:LIM? MIN
Returned Parameters	<NR2>

10.10 Sense Subsystem

This subsystem controls the measurement current range, the data acquisition sequence, and the harmonic measurement window of the AC source.

Subsystem Syntax

SENSe
:SWEep
:TINTerval? Queries the digitizer sample interval

SENSe:SWEep:TINTerval?

This command queries the time period between samples when voltage, current or power digitization is controlled by the measurements system. The query response of the sample period query will be in μs.

Query Syntax	SENSe:SWEep:TINTerval?
Returned Parameters	<NR2>
Related Commands	MEAS:ARR

10.11 List Subsystem

This subsystem controls the generation of complex sequences of load changes with rapid, precise timing and synchronized with internal or external signals. Each subsystem command for which lists can be generated has an associated list of values that specify the load settings at each list step. Each step can have a load current, power, resistance, or voltage value combined with a power factor and crest factor setup. The dwell time of each step is controlled with internal or external trigger. A number of triggers will advance the list to the next step as defined by the repeat list. Each list can have a maximum of 50 data points. All list points will be compiled to generate a sequence of load changes pasted by a trigger control. This compiled sequence can not exceed 100 load commands. Each list points could use a maximum of 40 steps.

Subsystem Syntax

```
[LOAD:]
    LIST
        :MODE
            [:TYPE]        set the type of data points
            :POINts?       query the length of points
        :DATA
            [:LEVel]       set the level of data
            :POINts?       query the length of data points
        CFACtor
            [:LEVel]       set the level of crest factor
            :POINts        query the length of crest factor data points
        PFACtor
            [:LEVel]       set the level of power factor
            :POINts        query the length of power factor data points
        REPeat
            [:COUNt]       set the number of trigger.
            POINts         query the length of repeat data points
```

LIST:MODE[:TYPE]

Phase Selectable

This command sets the sequence of mode points for the list. The mode points are given as command parameters, separated by commas. The order in which the points are entered determines the sequence in which they are output when a list is triggered.

Command Syntax	[LOAD:]LIST:MODE[:TYPE]<numerated>,<nummerated>
Parameters	numerated data define the type mode
Examples	LISTMODE CURR,POW,CURR
Query Syntax	[LOAD:]LIST:MODE?
Returned Parameters	<numerated>
Related Commands	LIST:MODE:POIN? LIST:DATA

LIST:MODE:POINts?

This query returns the number of points specified in LIST:MODE. Note that it returns only the total number of points, not the actual point values.

Query Syntax	[LOAD:]LIST:MODE:POINts?
Returned Parameters	<NR1>
Example	LIST:MODE:POIN?
Related Commands	LIST:MODE

LIST:DATA[:LEVel]

Phase Selectable

This command sets the sequence of data points the list. The data points types are defined by the list mode. The data points are given as command parameters, separated by commas. The order in which the points are entered determines the sequence in which they are output when a list is triggered.

Command Syntax	[LOAD:]LIST:DATA[:LEVel]<nrf>,<nrf>
Parameters	data represents current, power, resistance or volt setting
Examples	LIST:DATA 2,400,3
Query Syntax	[LOAD:]LIST:DATA?
Returned Parameters	<nr2>,<nr2>…
Related Commands	LIST:DATA:POIN? LIST:MODE

LIST:DATA:POINts?

Phase Selectable

This query returns the number of points specified in LIST:DATA. Note that it returns only the total number of points, not the actual point values.

Query Syntax	[LOAD:]LIST:DATA:POINts?
Returned Parameters	<NR1>
Example	LIST:DATA:POIN?
Related Commands	LIST:DATA

LIST:CFACtor[:LEVel]

Phase Selectable

This command sets the sequence of crest factor values that for the list. The data points are given in the command parameters, separated by commas. The order in which the points are entered determines the sequence in which they are output when a list is triggered.

Command Syntax	[LOAD:]LIST:CFACtor[:LEVel]<nrf>,<nrf>
Parameters	data represent crest factor setting
Examples	LIST:CFAC 3,2.5,3.5
Query Syntax	[LOAD:]LIST:CFAC?
Returned Parameters	<nr2>,<nr2>…
Related Commands	LIST:CFAC:POIN?

LIST:CFACtor:POINts?

Phase Selectable

This query returns the number of points specified in LIST:CFACtor. Note that it returns only the total number of points, not the actual point values.

Query Syntax	[LOAD:]LIST:CFAC:POINts?
Returned Parameters	<NR1>
Example	LIST:CFAC:POIN?
Related Commands	LIST:CFAC

LIST:PFACtor[:LEVel]

Phase Selectable

This command sets the sequence of power factor points for the list. The data points are given in the command parameters, separated by commas. The order in which the points are entered determines the sequence in which they are output when a list is triggered.

Command Syntax	[LOAD:]LIST:PFACtor[:LEVel]<nrf>,<nrf>
Parameters	data represent power factor setting
Examples	LIST:PFAC 3,2.5,3.5
Query Syntax	[LOAD:]LIST:PFAC?
Returned Parameters	<nr2>,<nr2>…
Related Commands	LIST:PFAC:POIN?

LIST:PFACtor:POINts?

Phase Selectable

This query returns the number of points specified in LIST:PFACtor. Note that it returns only the total number of points, not the actual point values.

Query Syntax	[LOAD:]LIST:PFAC:POINts?
Returned Parameters	<NR1>
Example	LIST:PFAC:POIN?
Related Commands	LIST:PFAC

LIST:REPeat[:COUNt]

Phase Selectable

This command sets the number of trigger events for which the sequence will dwell at the set load parameters before advancing to the next step in the list.

Command Syntax	[LOAD:]LIST:REPeat[:COUNt]<nrf>,<nrf>
Parameters	0 to 49
Examples	LIST:REP 2
Query Syntax	[LOAD:]LIST:REP?
Returned Parameters	<nr2>,<nr2>
Related Commands	LIST:DATA:POIN? LIST:MODE

LIST:REPeat:POINts?

Phase Selectable

This query returns the number of points specified in LIST:REPeat. Note that it returns only the total number of points, not the actual point values.

Query Syntax	[LOAD:]LIST:REPeat:POINts?
Returned Parameters	<NR1>
Example	LIST:REP:POIN?
Related Commands	LIST:REP

10.12 Power On Setup Subsystem

This subsystem will control the initial condition of the AC load at the power on state.

Subsystem syntax

```
[LOAD:]
    PONSetup:
        MODE   <CURR|VOLT|POW|RES>      Sets the mode
        CURRent <n>                     Sets the current value
        POWer  <n>                      Sets the power value
        RESistor <n>                    Sets the resistance value
        VOLTage <n>                     Sets the voltage value
        CFACtor <n>                     Sets the crest factor
        PFACtor
            [:LEVel] <n>                Sets the power factor
            :UNITy                      Sets unity power factor
        SCIRcuit                        Sets short circuit mode
        STATe  <0|OFF|1|ON              Sets the load state
        REGister <n>                    Sets the power on register number
```

PONSetup:MODE

This command selects the initial operating mode of the AC load. The AC load can be programmed to operate for constant current, power, voltage or resistance. The query form returns the initial operating mode set.

Command Syntax	LOAD:PONSetup:MODE <numerated data>
Parameters	CURRent|POWer|VOLTage|RESistance
Examples	LOAD:MODE CURR
Query Syntax	LOAD:MODE?
Returned Parameters	OFF|CURR|POW|VOLT|RES

PONSetup:CURRent

This command sets the initial RMS current setting of the AC load. The AC load insures that the load current stays constant at the set value.

Command Syntax	[LOAD:]PONSetup:CURRent <NRf+>
Parameters	<NRf>
Unit	A (rms amperes)
Examples	PONSetup:CURR 5
Query Syntax	[LOAD:]PONSetup:CURRent?
Returned Parameters	<NR2>

PONSetup:POWer

This command sets the initial power of the AC load. The AC load insures that the load power stays constant at the set value.

Command Syntax	[LOAD:]PONSetup:POWer <NRf+>
Parameters	<NRf>
Unit	W (watts)
Examples	PONSetup:POWer 500
Query Syntax	[LOAD:]PONSetup:POW?
Returned Parameters	<NR2>

PONSetup:RESistor

This command sets the initial resistance of the AC load. The AC load insures that the load resistance stays constant at the set value.

Command Syntax	[LOAD:]PONSetup:RESistance <NRf+>
Parameters	<NRf>
Unit	(ohms)
Examples	PONSetup:RES 100
Query Syntax	[LOAD:]PONSetup:RES?
Returned Parameters	<NR2>

PONSetup:VOLTage

This command sets the initial RMS voltage applied on the AC load. The AC load attempts to maintain the input voltage at the set value.

Command Syntax	[LOAD:]PONSetup:VOLTage <NRf+>
Parameters	<NRf>
Unit	V (rms volts)
Examples	PONSetup:VOLT 115
Query Syntax	[LOAD:]PONSetup:VOLT?
Returned Parameters	<NR2>

PONSetup:CFACtor

This command sets the initial current crest factor of the AC load. The AC load attempts to maintain the current crest factor at the set value.

Command Syntax	[LOAD:]PONSetup:CFACtor <NRf+>
Parameters	<NRf>
Unit	ratio
Examples	PONSetup:CFAC 3
Query Syntax	[LOAD:]PONSetup:CFAC?
Returned Parameters	<NR2>

PONSetup:PFACtor

This command sets the initial power factor of the AC load. The AC load attempt to maintain the power factor at or near the set value.

Command Syntax	[LOAD:]PONSetup:PFACtor <NRf+>
Parameters	<NRf>
Unit	ratio
Examples	PONSetup:PFAC .7
Query Syntax	[LOAD:]PONSetup:PFAC?
Returned Parameters	<NR2>

PONSetup:UNITy

This command sets the initial power factor of the AC load to unity. The AC load will override both the power factor and the crest factor with a unity power factor and a 1.414 crest factor

Command Syntax	[LOAD:]PONSetup:UNITy
Parameters	none
Examples	PONSetup:UNIT
Query Syntax	[LOAD:]PONSetup:UNIT?
Returned Parameters	0|1

PONSetup:SCIRcuit

This command sets the initial load to act as a short circuit. The AC load will override all other settings.

Command Syntax	[LOAD:]PONSetup:SCIRcuit
Parameters	none
Examples	PONSetup:SCIR
Query Syntax	[LOAD:]PONSetup:SCIR?
Returned Parameters	0|1

PONSetup:STATe

This command sets the initial load state. The AC load will power up in a disabled state if the state is off.

Command Syntax	[LOAD:]PONSetup:STATe 0|OFF|1|ON
Parameters	none
Examples	PONSetup:STAT OFF
Query Syntax	[LOAD:]PONSetup:STAT?
Returned Parameters	0|1

PONSetup:REGister

This command will specify one of the 8- setup registers as the power on setup. If register 0 through 7 are specified and the register contains valid setup data, the AC load will use the data in this register as the power on initialization parameters and will override the parameters set by the PONSetup subsystem.

Command Syntax	[LOAD:]PONSetup:REGister none|0..7
Parameters	none|0…7
Examples	PONSetup:REG NONE PONS:REG 1
Query Syntax	[LOAD:]PONSetup:REG?
Returned Parameters	NONE|0|1

10.13 Status Subsystem Commands

This subsystem programs the AC Load status registers. There are four groups of status registers;

- **Operation Status Group**
- **Questionable Status Group**
- **Questionable Instrument Isummary Group**
- **Standard Event Group**

The Standard Event group is programmed with Common commands. The Operation, Questionable, and Instrument ISummary status groups each consist of the following three registers:

Condition	Enable	Event

Refer to chapter 12 for more information about the status registers.

Subsystem Syntax

```
STATus
    :OPERation
        :EVENt              Returns the value of the event register
        :CONDition          Returns the value of the condition register
        :ENABle <n>         Enables specific bits in the Event register
    :QUEStionable
        :EVENt              Returns the value of the event register
        :CONDition          Returns the value of the condition register
        :ENABle <n>         Enables specific bits in the Event register
        :INSTruments
            :ISUMmary
                :EVENt      Returns the selected phase's event register value
                :CONDition  Returns the selected phase's condition register
                :ENABle     Enable specific bits in selected phase's Event register values
```

10.13.1 Bit Configuration of Status Operation Registers

Bit Position	15 - 8	7	6	5	4	3	2	1	0
Bit Name	Not Used	Over power	Not used	Over current	Power factor	Over voltage	Under voltage	Over frequency	Under frequency
Bit Weight		128	64	32	16	8	4	2	1

Under Frequency	The frequency at the load terminal is below the limits
Over Frequency	The frequency at the load terminal is over the limits
Under Voltage	The voltage at the load terminal is below the limits
Over Voltage	The voltage at the load terminal is over the limits
Power Factor	The programmed power factor is outside the range
Over Current	The load current exceed the limits
Over Power	The load power exceed the limits

STATus:OPERation:EVENt?

This query returns the value of the Operation Event register. The Event register is a read-only register, which holds (latches) all events. Reading the Operation Event register clears it.

Query Syntax	STATus:OPERation:EVENt?
Parameters	None
Returned Parameters	<NR1>(Register Value)
Examples	STAT:OPER:EVEN?
Related Commands	*CLS

STATus:OPERation:CONDition?

This query returns the value of the Operation Condition register. This is a read-only register, which holds the real-time (unlatched) operational status of the AC load.

Query Syntax	STATus:OPERation:CONDition?
Parameters	None
Examples	STAT:OPER:COND?
Returned Parameters	<NR1>(Register value)

STATus:OPERation:ENABle

This command and its query set and read the value of the Operation Enable register. This register is a mask for enabling specific bits from the Operation Event register to set the operation summary bit (OPER) of the Status Byte register. The operation summary bit is the logical OR of all enabled Operation Event register bits.

Command Syntax	STATus:OPERation:ENABle <NRf+>
Parameters	0 to 32727
Default Value	0
Examples	STAT:OPER:ENAB 32 STAT:OPER:ENAB 1
Query Syntax	STATus:OPERation:ENABle?
Returned Parameters	<NR1>(Register value)
Related Commands	STAT:OPER:EVEN

10.13.2 Bit Configuration of Questionable Registers

Bit Position	15 - 12	12	11	10	9	8	7-3	2	1	0
Bit Name	not used	ISUM	RAM	CAL	FW	EPR	Not used	OP	OT	Fault
Bit Weight		4096	2048	1024	512	256		4	2	1

Fault	Internal module not sharing
OT	Over-temperature protection has tripped
OP	Over-power protection has tripped
EPR	Code execution from EPROM
FW	Firmware check sum error
CAL	Calibration data check sum error
RAM	RAM test failed

STATus:QUEStionable:EVENt

This query returns the value of the Questionable Event register. The Event register is a read-only register which holds (latches) all events. Reading the Questionable Event register clears it.

Query Syntax	STATus:QUEStionable[:EVENt]?
Parameters	None
Returned Parameters	<NR1>(Register Value)
Examples	STAT:QUES:EVEN?
Related Commands	*CLS

STATus:QUEStionable:CONDition?

This query returns the value of the Questionable Condition register. This is a read-only register which holds the real-time (unlatched) questionable status of the AC Load.

Query Syntax	STATus:QUEStionable:CONDition?
Example	STAT:QUES:COND?
Returned Parameters	<NR1>(Register value)

STATus:QUEStionable:ENABle

This command sets or reads the value of the Questionable Enable register. This register is a mask for enabling specific bits from the Questionable Event register to set the questionable summary (QUES) bit of the Status Byte register. This bit (bit 3) is the logical OR of all the Questionable Event register bits that are enabled by the Questionable Status Enable register.

Command Syntax	STATus:QUESionable:ENABle <NRf+>
Parameters	0 to 32727
Default Value	0
Examples	STAT:QUES:ENAB 18
Query Syntax	STATus:QUEStionable:ENABle?
Returned Parameters	<NR1>(Register value)
Related Commands	STAT:QUES:EVEN?

STATus:QUEStionable:INSTrument:ISUMmary?

Phase Selectable

This command returns the value of the Questionable Event register for a specific output of a three-phase AC Load. The particular output phase must first be selected by INST:NSEL.

The Event register is a read-only register, which holds (latches) all events that are passed by the Questionable NTR and/or PTR filter. Reading the Questionable Event register clears it.

Query Syntax	STATus:QUESionable:INSTrument:ISUMmary[:EVENt]?
Parameters	None
Returned Parameters	<NR1> (Register Value)
Examples	STAT:QUES:INST:ISUM:EVEN?
Related Commands	*CLS STAT:QUES:INST:ISUM:NTR STAT:QUES:INST:ISUM:PTR

STATus:QUEStionable:INSTrument:ISUMmary:CONDition?

Phase Selectable

This query returns the value of the Questionable Condition register for a specific output of a three-phase AC Load. The particular output phase must first be selected by `INST:NSEL.` The Condition register is a read-only register, which holds the real-time (unlatched) questionable status of the AC Load.

Query Syntax	STATus:QUEStionable:INSTrument:ISUMmary:CONDition?
Example	STAT:QUES:INST:ISUM:COND?
Returned Parameters	<NR1> (Register value)

STATus:QUEStionable:INSTrument:ISUMmary:ENABle

Phase Selectable

This command sets or reads the value of the Questionable Enable register for a specific output of a three-phase AC Load. The particular output phase must first be selected by `INST:NSEL`. The Enable register is a mask for enabling specific bits from the Questionable Event register to set the questionable summary (QUES) bit of the Status Byte register. This bit (bit 3) is the logical OR of all the Questionable Event register bits that are enabled by the Questionable Status Enable register.

Command Syntax	STATus:QUEStionable:INSTrument:ISUMmary:ENABle <NRf+>
Parameters	0 to 32767
Default Value	0
Examples	STAT:QUES:INST:ISUM:ENAB 18
Query Syntax	STATus:QUEStionable:INSTrument:ISUMmary:ENABle?
Returned Parameters	<NR1> (Register value)

10.14 System Commands

The system commands control the system-level functions of the AC Load.

Subsystem Syntax

SYSTem	
:ERRor?	Returns the error number and error string
:VERSion?	Returns the SCPI version number
:LOCal	Go to local mode (RS-232 only)
:REMote	Go to remote mode (RS-232 only)
:ETIMe?	Returns the elapse time
:CONFigure	Sets system configuration (Password required)
[:BYTE]	
:NPHase?	Return the number of phases in the system
:ADDRess	
[:STARt]	Specify the start of address in a muli phase system
:GROUp?	Return the adresses of the units in a specific phase
:COMMunicate	
:GPIB	
:ADDRess	Sets GPIB address
:SERial	
:BAUD	Sets the baud rate
:PARity	Sets the parity type
:BITS	Sets number of bits
:SBITs	Sets number of stop bits
:CONTROL	Configure the AC Load to a master or auxiliary unit

SYSTem:ERRor?

This query returns the next error number followed by its corresponding error message string from the remote programming error queue. The queue is a FIFO (first-in, first-out) buffer that stores errors as they occur. As it is read, each error is removed from the queue. When all errors have been read, the query returns 0,No Error. If more errors are accumulated than the queue can hold, the last error in the queue is -350,Too Many Errors.

Query Syntax	SYSTem:ERRor?
Parameters	None
Returned Parameters	<NR1>,<SRD>
Example	SYST:ERR?

SYSTem:VERSion?

This query returns the SCPI version number to which the AC Load complies. The returned value is of the form YYYY.V, where YYYY represents the year and V is the revision number for that year.

Query Syntax	SYSTem:VERSion?
Parameters	None
Returned Parameters	<NR2>
Example	SYST:VERS?

SYSTem:LOCal

This command can only be used with the RS-232 interface. It sets the interface in Local state, which enables the front panel controls.

Command Syntax	SYSTem:LOCal
Parameters	None
Example	SYST:LOC
Related Commands	SYST:REM

SYSTem:REMote

This command can only be used with the RS-232 interface. It sets the interface in the Remote state, which disables all front panel controls.

Command Syntax	SYSTem:REMote
Parameters	None
Example	SYST:REM
Related Commands	SYST:LOC

SYSTem:ETIMe?

This command will return the elapsed time since turn-on (total number of accumulated hours, minutes and seconds).

Command Syntax	SYSTem:ETIMe?
Parameters	none
Example	SYST:ETIM?
Returned Parameters	<NR1>,<NR1>,<NR1>

SYSTem:CONFigure[:BYTE]

This command will set the system configuration. This is a protected command and requires a password. The query response is available however.

Command Syntax	SYSTem:CONFigure	
Parameters	FFT	
Example	SYST:CONF FFT	SYST:CONF?
Returned Parameters	<CRD>	
Related Commands	*OPT?	

SYSTem:CONFigure:NPHase?

This is a query only command which returns the number of phases for the AC load system.

Command Syntax	SYSTem:CONFigure:NPHase?
Parameters	none
Example	SYST:CONF:NPH?
Returned Parameters	<NR2>

SYSTem:CONFigure:ADDRess[:STARt] <nrf>, ..,[<nrf>]

This command will partition the address space into a group of address. Each group of address will start with the first address specified and will end at an address before the beginning of the second group of addresses. Each group of address will be designated to an AC Load phase in a multi-phase system. All AC load units that are assigned addresses within the same group will be designated as units in parallel. User must use the first address space before going to the second address space. This command will take a maximum of 6 group start addresses.

Command Syntax	SYSTem:CONFigure:ADDRess[:STARt] <nrf1>, …<nrf6>
Parameters	<nrf>
Example	SYST:CONF:ADDR 1,12,24,36,48,60
Query	SYST:CONF:ADDR?
Returned Parameters	<NR2>,….<NR2>

SYSTem:CONFigure:ADDRess:GROup?

Phase Selectable

This is a query only command, which returns all addresses of the AC load master and auxiliary units in a selected phase.

Command Syntax	SYSTem:CONFigure:ADDRess:GROup?
Parameters	none
Query	SYST:CONF:ADDR:GRO?
Returned Parameters	<NR1>….<NR1>

SYSTem:COMMunicate:GPIB:ADDRess

This command sets the GPIB address.

Command Syntax	SYSTem:COMMunicate:GPIB:ADDRess <NRF>
Parameters	0 to 31 <listen address>
Example	SYST:COMM:GPIB:ADDR 2
Returned Parameters	<NR1>

SYSTem:COMMunicate:SERial:BAUD

This command sets the SERial port communication baud rate.

Command Syntax	SYSTem:COMMunicate:SERial:BAUD <NRF>
Parameters	9600 | 19200 | 38400
Example	SYST:COMM:SER:BAUD 38400
Returned Parameters	<NR1>

SYSTem:COMMunicate:SERial:PARity

This command sets the SERial communication parity.

Command Syntax	SYSTem:COMMunicate:SERial:PARity <parity>
Parameters	NONE|EVEN|ODD
Example	SYST:COMM:SER:PAR NONE
Returned Parameters	<CRD>

SYSTem:COMMunicate:SERial:BITS

This command sets the number of data bits for the SERial communication port.

Command Syntax	SYSTem:COMMunicate:SERial:BITS <NRF>
Parameters	7|8
Example	SYST:COMM:SER:BITS 8
Returned Parameters	<NR1>

SYSTem:COMMunicate:SERial:SBITs

This command sets the number of stop bits for the SERial communication port.

Command Syntax	SYSTem:COMMunicate:SERial:SBITs <NRF>
Parameters	1|2
Example	SYST:COMM:SER:SBITs 1
Returned Parameters	<NR1>

SYSTem:CONTrol

This command will set the AC Load to a master or auxiliary unit mode. The setting will take place only at power up.

Command Syntax	SYSTem:CONTrol MASTer | AUXiliary
Parameters	MASTer | AUXiliary
Example	SYST:CONT AUX

10.15 Trigger Subsystem

This subsystem controls the triggering of the AC load. See section 4.6.3 for an explanation of the Trigger Subsystem. The INITiate command controls the initialization of the sequencer system. The trigger subsystem must first be enabled using the INITiate commands or no triggering action will occur.

Subsystem Syntax

ABORt	Resets the trigger system to the Idle state
INITiate	
[:IMMediate]	Initiates the system for a trigger
ARMed	
[:IMMedaite]	Sequencer waits for a trigger condition
:CONTinuous	Trigger in continuous mode
TRIGger	
[:SYNChronize]	
[:SOURce]	
:PHASe	
[:STATe]	Enables voltage phase synchronization
:ANGle<n>	Sets the synchronous voltage phase reference
:EXTernal	Enables external trigger input source
:VOLTage	Enables voltage trigger source
:STATe?	Returns the active trigger state (IDLE|INIT|ARM|ARMC)

ABORt

This command resets the transient trigger systems to the IDLE state. Any load sequence that is in progress is immediately aborted.

Command Syntax	ABORt	
Parameters	none	
Examples	ABOR	
Related Commands	INIT	*RST

INITiate[:IMMediate]

The INITiate command controls the initiation of the sequencer. It causes the trigger system to make a transition from the IDLE state to the INITIATE state. If the trigger system is not in the IDLE state, the initiate command is ignored. The initiate command is also ignored if there is no valid sequence list available. The initiate will compile the load sequence list data programmed using the LIST sub system. Regular Load commands will not be accepted while the unit is in this state.

Command Syntax	INITiate[:IMMediate]	
Parameters	None	
Examples	INIT	
Related Commands	ABOR	ARM

ARMed[:IMMediate]

This command sets the trigger state to ARM. The sequence system is waiting for a valid trigger to execute the sequence list. This command will be ignored if the trigger system not in the INITIATE state.

Command Syntax	ARMed[:IMMediate]
Parameters	none
Examples	ARM
Related Commands	INIT ABOR ARM:CONT

ARMed:CONTinuous

This command will set the trigger state to ARMC. The sequence system is waiting for a valid trigger to execute the sequence list. When the list is completed, the trigger system will continue from the beginning of the list. The trigger state will remain ARMC until and abort is issued. This command will be ignored if the trigger system not in the INITIATE state.

Command Syntax	ARMed:CONTinuous
Parameters	none
Examples	ARM:CONT
Related Commands	INIT ABOR ARM

TRIGger[:SYNChronize][:SOURce]:PHASe[:STATe]

This command qualifies the voltage phase angle as a synchronizing trigger source used to advance the load sequencer list. Note that more than one trigger source be selected at the same time.

Command Syntax	TRIGger: [:SYNChronize][:SOURce]:PHASe OFF|ON
Parameters	OFF|0|1|ON
*RST Value	OFF
Examples	TRIG: PHAS ON
Query Syntax	TRIG:PHAS?
Returned Parameters	0|1
Related Commands	TRIG:PHAS:ANGle ARM ARM:CONT

TRIGger[:SYNChronize][:SOURce]:PHASe:ANGLe

This command set the voltage phase angle to sync the trigger signal to.

Command Syntax	TRIGger [:SYNChronize][:SOURce]:PHASe:ANGLe <nrf>|RAND
Parameters	<nrf>
*RST Value	RAND
Examples	TRIG: PHAS ON
Query Syntax	TRIG:PHAS?
Returned Parameters	0|1
Related Commands	TRIG:PHAS:ANGle ARM ARM:CONT

TRIGger[:SYNChronize][:SOURce]:EXTernal

This command enables the external TTL trigger level as a synchronizing trigger source used to advance the load sequencer list. Note that more than one trigger source be selected at the same time.

Command Syntax	TRIGger: [:SYNChronize][:SOURce]:EXTernal OFF|ON
Parameters	OFF|0|1|ON
*RST Value	OFF
Examples	TRIG: EXT ON
Query Syntax	TRIG:EXT?
Returned Parameters	0|1
Related Commands	ARM ARM:CONT

TRIGger[:SYNChronize][:SOURce]:VOLTage

This command enables the input voltage as a synchronizing trigger source used to advancing the load sequencer list. Note that more than one trigger source be selected at the same time. A trigger will be generated if the input voltage drops below the set Volt Turn Off level or exceeds the set Volt Turn On level. These levels can be programmed using the VOLT:HIGH and VOLT:LOW commands. See section 10.9.4.

Command Syntax	TRIGger: [:SYNChronize][:SOURce]:VOLTage OFF|ON
Parameters	OFF|0|1|ON
*RST Value	OFF
Examples	TRIG: VOLT ON
Query Syntax	TRIG:VOLT?
Returned Parameters	0|1
Related Commands	ARM ARM:CONT

TRIG:STATe?

This is a query only command. The response will define the state of the sequence trigger system as follows:

IDLE The trigger is in idle state.

INIT The trigger is in the initiation state.

ARM The trigger is waiting for a trigger

ARMC The trigger is waiting for a trigger and at completion it will remain armed and will start from the beginning of the sequence.

Query Syntax	TRIGger:STATe?
Returned Parameters	<CRD>
Related Commands	ABOR INIT ARM ARMC

11. Common Commands

Common commands begin with an * and consist of three letters (command) or three letters and a ? (query). Common commands are defined by the IEEE 488.2 standard to perform some common interface functions. The AC Load responds to the required common commands that control status reporting, synchronization, and internal operations. It also responds to optional common commands that control triggers, and stored operating parameters.

Common commands and queries are listed alphabetically. If a command has a corresponding query that simply returns the data or status specified by the command, then both command and query are included under the explanation for the command. If a query does not have a corresponding command or is functionally different from the command, then the query is listed separately. The description for each common command or query specifies any status registers affected. Refer to chapter 12 for details on how to read specific register bits and use the information that they return.

Common Commands Syntax

*CLS	Clear status
*ESE <n>	Standard event status enable
*ESE?	Return standard event status enable
*ESR?	Return event status register
*IDN?	Return instrument identification
*OPC	Enable "operation complete" bit in ESR
*OPC?	Return a "1" when operation complete
*OPT?	Return option number
*PSC <bool>	Power-on status clear state set/reset
*PSC?	Return power-on status clear state
*RCL <n>	Recall instrument state
*RST	Reset
*SAV <n>	Save instrument state
*SRE <n>	Set service request enable register
*SRE?	Return service request enable register
*STB?	Return status byte
*TRG	Trigger
*WAI	Hold off bus until all device commands done

11.1 *CLS

This command clears the following registers (see chapter 12 for descriptions of all status registers):

- Standard Event Status
- Operation Status Event
- Questionable Status Event
- Status Byte
- Error Queue

Command Syntax	*CLS
Parameters	None

11.2 *ESE

This command programs the Standard Event Status Enable register bits. The programming determines which events of the Standard Event Status Event register (see *ESR?) are allowed to set the ESB (Event Summary Bit) of the Status Byte register. A "1" in the bit position enables the corresponding event. All of the enabled events of the Standard Event Status Event Register are logically ORed to cause the Event Summary Bit (ESB) of the Status Byte Register to be set. See for descriptions of the Standard Event Status registers.

The query reads the Standard Event Status Enable register.

Bit Configuration of Standard Event Status Enable Register

Bit Position	7	6	5	4	3	2	1	0
Bit Name	PON	not used	CME	EXE	DDE	QYE	not used	OPC
Bit Weight	128		32	16	8	4		1

CME	Command error	DDE	Device-dependent error
EXE	Execution error	OPC	Operation complete
PON	Power-on	QYE	Query error

Command Syntax	*ESE <NRf>
Parameters	0 - 255
Power-On Value	0 (see *PSC command)
Example	*ESE 129
Query Syntax	*ESE?
Returned Parameters	<NR1>(Register value)
Related Commands	*ESR? *STB?

11.3 *ESR?

This query reads the Standard Event Status Event register. Reading the register clears it. The bit configuration of this register is the same as the Standard Event Status Enable register (see *ESE). See Chapter 12 for a detailed explanation of this register.

Query Syntax	*ESR?
Parameters	None
Returned Parameters	<NR1>(Register value)
Related Commands	*CLS *ESE *ESE? *OPC

11.4 *IDN?

This query requests the AC Load to identify itself. It returns the data in four fields separated by commas.

Query Syntax	*IDN?	
Returned Parameters	<AARD>	
	Field	Information
	California Instruments	Manufacturer
	xxxxxx	Model number and letter
	nnnnnn	Serial number or 0
	Rev. n.n/n.n	Revision levels of firmware
Example	"CALIFORNIA INSTRUMENTS,3091LD, 1234, Rev 1.0/2.1"	

11.5 *OPC

This command causes the interface to set the OPC bit (bit 0) of the Standard Event Status register when the AC Load has completed all pending operations. (See *ESE for the bit configuration of the Standard Event Status registers.)

Pending operations are complete when all commands sent before *OPC have been executed. This includes overlapped commands. Most commands are sequential and are completed before the next command is executed. Overlapped commands are executed in parallel with other commands. Commands such as measurement and calibration are overlapped with subsequent commands sent to the AC/DC power source. The *OPC command provides notification that all overlapped commands have been completed.

*OPC does not prevent processing of subsequent commands but Bit 0 will not be set until all pending operations are completed.

The query causes the interface to place an ASCII "1" in the Output Queue when all pending operations are completed.

Command Syntax	*OPC
Parameters	None
Query Syntax	*OPC?
Returned Parameters	<NR1>
Related Commands	*TRIG *WAI

11.6 *OPT?

This query causes the AC source to identify any options that are installed. Options are identified by a string keyword or a number. A 0 indicates no options are installed. If an option is installed, its corresponding keyword will be returned. Refer to the SYSTem:CONFigure[:BYTE] command on page 137 for more details.

Query Syntax	*OPT?
Returned Parameters	<CRD>,[<CRD>]

11.7 *PSC

This command controls the automatic clearing at power-on of the Service Request Enable and the Standard Event Status Enable registers (see chapter 12 under 12.6.2 for register details):

*PSC ON | 1	Prevents the register contents from being saved causing them to be cleared at power-on. This prevents a PON event from generating a SRQ at power-on.
PSC OFF | 0	Saves the contents of the Standard Event Enable and Service Request Enable registers in nonvolatile memory and recalls them at power-on. This allows a PON event to generate SRQ at power-on. Using the PCS command in this mode allows the control program to detect a power failure condition that caused the source to power down and back up again.

Command Syntax	*PSC<bool>
Parameters	0 | 1 | OFF | ON
Example	*PSC 0 *PSC 1
Query Syntax	*PSC?
Returned Parameters	0 | 1
Related Commands	*ESE *SRE

11.8 *RCL

This command restores the AC Load to a state that was previously stored in memory (including the sequence list) with a *SAV command to the specified location. All states are recalled with the following exceptions:

- The trigger system is set to the IDLE state by an implied ABORt command (this cancels any uncompleted trigger actions)

Command Syntax	*RCL <NRf>
Parameters	0 through 7
Example	*RCL 3
Related Commands	*RST *SAV

11.9 *RST

The reset (*RST) command has the same effect as an IEEE-488 Device Clear bus command but can be used over the RS232C interface as well. This command resets the AC load to the following factory-defined states:

*Table 11-1: *RST default parameter values*

Item	Value	Item	Value
TRIG:STAT	IDLE	LOAD:MODE	OFF
LOAD:STAT	OFF	CURR:HIGH	30 A
OUTP:TTLT	OFF	POW:HIGH	3000 W

Parameters	None
Related Commands	*SAV

A *RST command or a IEEE-488 Device Clear also clears all status registers but does not change the Event Enable registers for each status register group.

Note that sending a *RST command will result in the user limits for current and power to be set to the maximum value for a single 3091LD model. For multi unit Load configurations such as 6091LD, 9091LD or 18093LD, it will be necessary to set this value to the available maximum current using the CURR:LIM? MAX and POW:LIM? MAX commands and using the response to these queries to re-program the user limit values. Alternatively, the CURR:HIGH? MAX and POW:HIGH? MAX queries can be used to obtain maximum available current or power setting.

11.10 *SAV

This command stores the present state of the AC Load to a specified location in memory. Up to 8 states (including the sequence list) can be stored in nonvolatile memory.

Command Syntax	*SAV
Parameters	0 through 7
Related Commands	PSC *RCL *RST

11.11 *SRE

This command sets the condition of the Service Request Enable Register. This register determines which bits from the Status Byte Register (see *STB for its bit configuration) are allowed to set the Master Status Summary (MSS) bit and the Request for Service (RQS) summary bit. A 1 in any Service Request Enable Register bit position enables the corresponding Status Byte Register bit and all such enabled bits then are logically ORed to cause Bit 6 of the Status Byte Register to be set. See paragraph 12.5 for more details concerning this process.

When the IEEE-488 BUS controller conducts a serial poll in response to an SRQ, the RQS bit is cleared, but the MSS bit is not. When *SRE is cleared (by programming it with 0), the source cannot generate an SRQ to the controller.

Command Syntax	*SRE <NRf>
Parameters	0 to 255
Default Value	0 (see *PSC command)
Example	*SRE 255
Query Syntax	*SRE?
Returned Paramters	<NR1>(Register binary value)
Related Commands	*ESE *ESR

11.12 *STB?

This query reads the Status Byte register, which contains the status summary bits and the Output Queue MAV bit. Reading the Status Byte register does not clear it. The input summary bits are cleared when the appropriate event registers are read (see chapter 12 for more information). A serial poll also returns the value of the Status Byte register, except that bit 6 returns Request for Service (RQS) instead of Master Status Summary (MSS). A serial poll clears RQS, but not MSS. When MSS is set, it indicates that the AC Load has one or more reasons for requesting service.

Bit Configuration of Status Byte Register

Bit Position	7	6	5	4	3	2 - 0
Bit Name	OPER	MSS RQS	ESB	MAV	QUES	not used
Bit Weight	128	64	32	16	8	

OPER	operation status summary	MSS	master status summary
ESB	event status byte summary	RQS	request for service
QUES	questionable status summary	MAV	message available

Query Syntax	*STB?
Returned Paramters	<NR1> (Register binary value)
Related Commands	*SRE *ESE *ESR

11.13 *TRG

This command is not implemented on the AC Load and is ignored.

Command Syntax	*TRG
Parameters	None

11.14 *WAI

This command instructs the AC load not to process any further commands until all pending measurement and calibration operations are completed. Pending operations are complete when all commands sent before *WAI have been executed. This includes overlapped commands. Most commands are sequential and are completed before the next command is executed. Overlapped commands are executed in parallel with other commands. Commands that affect output voltage or state, relays, and trigger actions are overlapped with subsequent commands sent to the AC source. The *WAI command prevents subsequent commands from being executed before any overlapped commands have been completed.

The *WAI command may be used when performing measurement queries (MEAS or FETCh) to force the AC load to respond to the query before processing any subsequent command.

*WAI can be aborted by sending any other command after the *WAI command.

Command Syntax	*WAI
Parameters	None
Related Commands	*OPC

12. Status Registers

You can use status register programming to determine the operating condition of the AC Load at any time. For example, you may program the AC Load to generate an interrupt (assert SRQ) when an event such as a voltage fault occurs. When the interrupt occurs, your program can then act on the event in the appropriate fashion.

Figure 12-1 shows the status register structure of the AC Load. Table 11-1 defines the status bits. The Standard Event, Status Byte, and Service Request Enable registers as well as the Output Queue perform standard IEEE-488 functions as defined in the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation. The Operation Status, and the Questionable Status registers, implement functions that are specific to the AC Load.

12.1 Power-On Conditions

All status register groups are cleared at power on. This means all data bits and all Event Enable register bits are cleared. It is possible however the set the PON mask in the Event enable register to cause a SRQ. This can be accomplished using the *PSC command. Once set, this condition is retained in non-volatile memory and will be recalled when power is applied to the AC/DC source. See paragraph 11.7 for details on the use of the *PSC command.

12.2 Operation Status Group

The Operation Status group records signals that occur during normal operation. The group consists of the following registers:

Table 12-1: Operation Status Register

Register	Command	Description
Condition	STAT:OPER:COND?	A register that holds real-time status of the circuits being monitored. It is a read-only register.
Event	STAT:OPER:EVEN?	A register that latches any condition. It is a read-only register that is cleared when read.
Enable	STAT:OPER:ENAB <n>	A register that functions as a mask for enabling specific bits from the Event register. It is a read/write register.

The outputs of the Operation Status register group are logically-ORed into the OPER(ation) summary bit (7) of the Status Byte register.

Figure 12-1: Status System Model

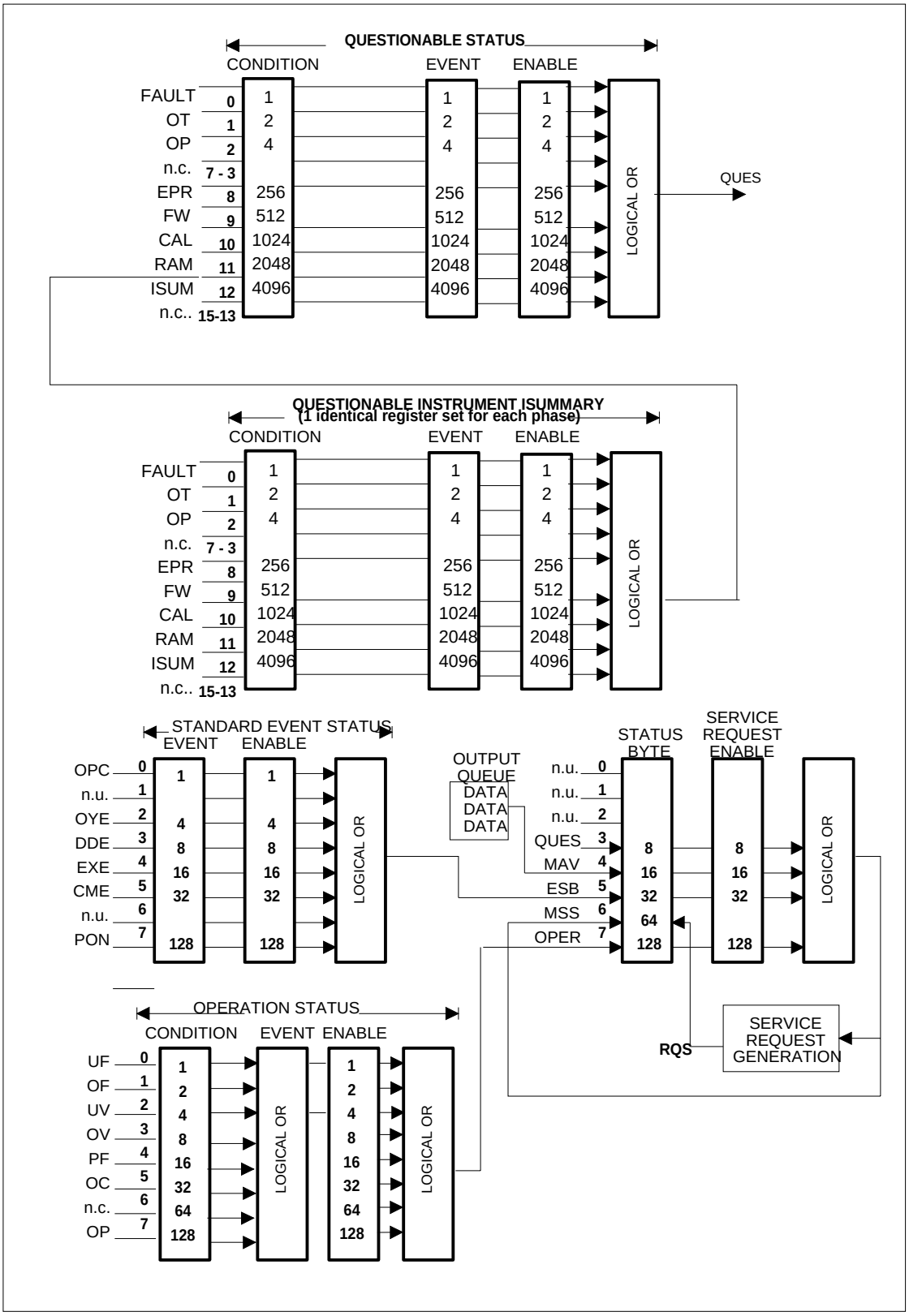


Table 12-2: Configuration of Status Register

Bit	Signal	Meaning
Operation Status Group		
0	UF	Under Frequency. Input frequency too low.
1	OF	Over Frequency Input frequency too high.
2	UV	Under Voltage. Input voltage too low
3	OV	Over Voltage. Input voltage too high.
4	PF	Power Factor setting conflict
5	OC	Over Current
6		Reserved
7	OP	Over Power
15 - 8		Reserved
Questionable and Questionable Instrument Isummary Status Groups		
0	FAULT	One or more of the four load modules has failed.
1	OT	The over temperature protection circuit has tripped
2	OP	The over power protection circuit has tripped
7 - 3		Reserved
8	EP	E Prom
9	FW	Firmware check sum error. Reload firmware to Flash Eprom.
10	CAL	Calibration data check sum error. Re-cal required.
11	RAM	System RAM Test failed.
12	ISUM	Summary Bit
Standard Event Status Group		
0	OPC	Operation complete
1		Reserved
2	QYE	Query error
3	DDE	Device-dependent error
4	EXE	Execution error
5	CME	Command error
6		Reserved
7	PON	Power-on
Status Byte and Service Request Enable Registers		
3	QUES	Questionable status summary bit
4	MAV	Message Available summary bit
5	ESB	Event Status Summary bit
6	MSS	Master Status Summary bit
	RQS	Request Service bit
7	OPER	Operation status summary bit

12.3 Questionable Status Group

The Questionable Status registers record signals that indicate abnormal operation of the AC Load. As shown in Figure 12-1, the group consists of the same type of registers as the Status Operation group.

Table 12-3: Questionable Status Register

Register	Command	Description
Condition	STAT:QUES:COND?	A register that holds real-time status of the circuits being monitored. It is a read-only register.
Event	STAT:QUES:EVEN?	A register that latches any condition. It is a read-only register that is cleared when read.
Enable	STAT:QUES:ENAB <n>	A register that functions as a mask for enabling specific bits from the Event register. It is a read/write register.

The outputs of the Questionable Status group are logically-ORed into the QUEStionable summary bit (3) of the Status Byte register.

12.4 Standard Event Status Group

This group consists of an Event register and an Enable register that are programmed by Common commands. The Standard Event register latches events relating to the interface communication status (see Figure 12-1). It is a read-only register that is cleared when read. The Standard Event Enable register functions similarly to the enable registers of the Operation and Questionable status groups.

Command	Action
*ESE	programs specific bits in the Standard Event Enable register.
*ESR?	reads and clears the Standard Event Event register.

The PON bit in the Standard Event Event register is set whenever the AC Load is turned on. The most common use for PON is to generate an SRQ at power-on following an unexpected loss of power.

12.5 Status Byte Register

This register summarizes the information from all other status groups as defined in the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation. The bit configuration is shown in Table 12-2.

Command	Action
*STB?	Reads the data in the register but does not clear it (returns MSS in bit 6)
serial poll	Reads and clears the data in the register (returns RQS in bit 6)

The MSS Bit

This is a real-time (unlatched) summary of all Status Byte register bits that are enabled by the Service Request Enable register. MSS is set whenever the AC Load has one or more reasons for requesting service. *STB? reads the MSS in bit position 6 of the response but does not clear any of the bits in the Status Byte register.

The RQS Bit

The RQS bit is a latched version of the MSS bit. Whenever the AC Load requests service, it sets the SRQ interrupt line true and latches RQS into bit 6 of the Status Byte register. When the controller does a serial poll, RQS is cleared inside the register and returned in bit position 6 of the response. The remaining bits of the Status Byte register are not disturbed.

The MAV bit and Output Queue

The Output Queue is a first-in, first-out (FIFO) data register that stores AC Load-to-controller messages until the controller reads them. Whenever the queue holds one or more bytes, it sets the MAV bit (bit 4) of the Status byte register.

12.6 Examples

The following section contains examples of commonly used operations involving the status registers.

12.6.1 Determining the Cause of a Service Interrupt

You can determine the reason for an SRQ by the following actions:

Step 1 : Determine which summary bits are active. Use:

```
*STB? or serial poll
```

Step 2 : Read the corresponding Event register for each summary bit to determine which events caused the summary bit to be set. Use:

```
STATus:QUEStionable:EVENt?
STATus:OPERation:EVENt?
ESR?
```

Note: ***When an Event register is read, it is cleared. This also clears the corresponding summary bit.***

Step 3 : Remove the specific condition that caused the event. If this is not possible, the event may be disabled by programming the corresponding bit of the status group Enable. A faster way to prevent the interrupt is to disable the service request by programming the appropriate bit of the Service Request Enable register.

12.6.2 Servicing Questionable Status Events

This example assumes you want a service request generated whenever the AC Load's overvoltage, overcurrent, or overtemperature circuits have tripped. From Figure 12-1, note the required path for Questionable Status conditions at bits 0, 1, and 3 to generate a service request (RQS) at the Status Byte register. The required register programming is as follows:

Step 1 : Program the Questionable Status Enable register to allow the latched events to be summed into the QUES summary bit. Use:

```
STATus:QUEStionable:ENABle 11
```

Step 2 : Program the Service Request Enable register to allow the QUES summary bit from the Status Byte register to generate RQS. Use:

```
*SRE 8
```

Step 3 : When you service the request, read the event register to determine which Questionable Status Event register bits are set and clear the register for the next event. Use:

```
STATus:QUEStionable:EVENt?
```

12.7 SCPI Command Completion

SCPI commands sent to the AC Load are processed either sequentially or in parallel. Sequential commands finish execution before a subsequent command begins. Parallel commands allow other commands to begin executing while the parallel command is still executing. Commands that affect list and trigger actions measurements and calibration are among the parallel command.

The *WAI, *OPC, and *OPC? common commands provide different ways of indicating when all transmitted commands, including any parallel ones, have completed their operations. The syntax and parameters for these commands are described in chapter 0. Some practical considerations for using these commands are as follows:

*WAI	This prevents the AC Load from processing subsequent commands until all pending operations are completed except for transients.
*OPC?	This places a 1 in the Output Queue when all pending operations have completed. Because it requires your program to read the returned value before executing the next program statement, *OPC? can be used to cause the controller to wait for commands to complete before proceeding with its program.
*OPC	This sets the OPC status bit when all pending operations have completed. Since your program can read this status bit on an interrupt basis, *OPC allows subsequent commands to be executed.
TRIG:STATe?	This query will report the state of the sequencer trigger subsystem and will return IDLE, ARM or BUSY to allow the user to monitor the state of the trigger system.

13. Options

Appendix A: Error Messages

Table 13-1: Error Messages

Error Number	Error Message String	Possible Cause
0	"No error"	
-100	"Command error"	Command is not allowed in this context
-102	"Syntax error"	Command mis-spelled
-103	"Invalid separator"	Wrong separator used
-104	"Data type error"	Different data type expected
-108	"Parameter not allowed"	A parameter was send with the command but none was expected,
-109	"Missing parameter"	A parameter was expected but none was send with the command.
-110	"Command header error"	Wrong command header. Check command syntax.
-111	"header separator error"	Invalid command separator. Use ";"
-112	"Program mnemonic too long"	Command too long. Try breaking up into smaller commands.
-113	"Undefined header"	Command not recognized. Check command syntax
-120	"Numeric data error"	Error in number
-121	"Invalid character in number"	Number send as part of command is not a valid number.
-123	"Exponent too large"	Exponent out of range.
-128	"Numeric data not allowed"	Command probably uses string parameters
-168	"Block data not allowed"	Block data only supported for specific commands.
-200	"Execution error"	Command execution failed. Unit could be in wrong mode or range
-201	"Invalid while in local"	Unit only accepts IEEE bus commands while in REMOTE. Use ATN line to put unit in remoter before sending commands.
-203	"Command protected"	Command requires password unlock first.
-210	"Trigger error"	Trigger request failed
-211	"Trigger ignored"	Trigger command could not be executed, possibly due to setup problem. Check program flow and syntax.
-213	"Init ignored"	Subsystem could not be initialized. Check program flow and syntax.
-220	"Parameter error"	Invalid parameter or parameter of wrong type.
-221	"Setting conflict"	Requested setting conflicts with other setting. Check mode and operating restrictions.
-222	"Data out of range"	Parameter data send with command is out of range. Check mode or range settings.
-223	"Too much data"	More data send with command than expected.
-224	"Illegal parameter value"	Parameter value not correct
-226	"Lists not same length"	Sequence list for one or more sequence parameters has a different length
-241	"Hardware missing"	Command requires hardware that is not present.
-254	"Media full"	Not enough free memory or media available to save requested data or setup Delete one or more files or registers.
-255	“Directory full”	No more directory entries available. Delete one or more files or registers.
-256	“File name not found”	File or register requested for load or restore operation

Error Number	Error Message String	Possible Cause
		could not be found. Try changing media.
-257	“File name error”	Error in file name. Check syntax and format.
-258	“Illegal variable name”	Name of variable is not allowed. May conflict with other key words.
3	"Temperature fault"	Temperature too high. Check airflow, vents and fans.
4	"External sync. error"	Unable to sync to external unit.
5	"Initial memory lost"	Power on setup memory corrupted.
6	"Limit memory lost"	Configuration memory corrupted.
7	"System memory lost"	
8	"Calibration memory lost"	Calibration coefficients lost. Recalibrate unit.
11	"Duplicate sequence"	Error programming sequence.
12	"Too many sequence"	Number of steps in sequence is too high.
13	"Missing list parameter"	One or more parameters for list not specified or incorrect.
16	"Illegal during transient"	Requested operation can not occur while sequence or transient is in progress.
20	"Input buffer full"	Communication input buffer overrun. Try breaking up commands in smaller strings.
-300	"Device specific error"	Hardware specific errror.
-311	"Memory error"	
-314	"Save/recall memory lost"	Registers may never have been saved to.
-315	"Configuration memory lost"	Check limit settings
-330	"Self-test failed"	Power on self test failure. Contact service.
-350	"Queue overflow"	Too many errors without reading error queue
-400	"Query error"	Unable to respond to query
-410	"Query INTERRUPTED"	Another command came in before the response to a query was picked up. Check program flow.
-420	"Query UNTERMINATED"	Response to a query never picked up. Check program flow.
-430	"Query DEADLOCKED"	Two or more queries are interleaved. Check program flow.
-440	"Query UNTERMINATED"	Response to a query never picked up. Check program flow.

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