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Keysight DC Electronics Loads

Models N3300A, N3301A, N3302A, N3303A
N3304A, N3305A, N3306A, and N3307A

User's Guide

KEYSIGHT TECHNOLOGIES

NOTICE: This document contains references to Agilent Technologies. Agilent's former Test and Measurement business has become Keysight Technologies. For more information, go to **www.keysight.com.**



Warranty Information

CERTIFICATION

Keysight Technologies certifies that this product met its published specifications at time of shipment from the factory. Keysight Technologies further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Keysight Technologies hardware product is warranted against defects in material and workmanship for a period of one year from date of delivery. Keysight Technologies software and firmware products, which are designated by Keysight Technologies for use with a hardware product and when properly installed on that hardware product, are warranted not to fail to execute their programming instructions due to defects in material and workmanship for a period of 90 days from date of delivery. During the warranty period Keysight Technologies will, at its option, either repair or replace products which prove to be defective. Keysight Technologies does not warrant that the operation for the software firmware, or hardware shall be uninterrupted or error free.

For warranty service, with the exception of warranty options, this product must be returned to a service facility designated by Keysight Technologies. Customer shall prepay shipping charges by (and shall pay all duty and taxes) for products returned to Keysight Technologies for warranty service. Except for products returned to Customer from another country, Keysight Technologies shall pay for return of products to Customer.

Warranty services outside the country of initial purchase are included in Keysight Technologies product price, only if Customer pays Keysight Technologies international prices (defined as destination local currency price, or U.S. or Geneva Export price).

If Keysight Technologies is unable, within a reasonable time to repair or replace any product to condition as warranted, the Customer shall be entitled to a refund of the purchase price upon return of the product to Keysight Technologies.

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The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the Customer, Customer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation and maintenance. NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. KEYSIGHT TECHNOLOGIES SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

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ASSISTANCE

The above statements apply only to the standard product warranty. Warranty options, extended support contacts, product maintenance agreements and customer assistance agreements are also available. Contact your nearest Keysight Technologies Sales and Service office for further information on Keysight Technologies' full line of Support Programs.

Safety Summary

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Keysight Technologies assumes no liability for the customer's failure to comply with these requirements.

GENERAL

This product is a Safety Class 1 instrument (provided with a protective earth terminal). The protective features of this product may be impaired if it is used in a manner not specified in the operation instructions.

Any LEDs used in this product are Class 1 LEDs as per IEC 825-1.

This ISM device complies with Canadian ICES-001.
Cet appareil ISM est conforme à la norme NMB-001 du Canada.

ENVIRONMENTAL CONDITIONS

This instrument is intended for indoor use in an installation category II, pollution degree 2 environment. It is designed to operate at a maximum relative humidity of 95% and at altitudes of up to 2000 meters. Refer to the specifications tables for the ac mains voltage requirements and ambient operating temperature range.

BEFORE APPLYING POWER

Verify that all safety precautions are taken. Note the instrument's external markings described under "Safety Symbols".

GROUND THE INSTRUMENT

This product is a Safety Class 1 instrument (provided with a protective earth terminal). To minimize shock hazard, the instrument chassis and cover must be connected to an electrical ground. The instrument must be connected to the ac power mains through a grounded power cable, with the ground wire firmly connected to an electrical ground (safety ground) at the power outlet. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury.

ATTENTION: Un circuit de terre continu est essentiel en vue du fonctionnement sécuritaire de l'appareil. Ne jamais mettre l'appareil en marche lorsque le conducteur de mise … la terre est d,branch,.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

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

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers except as instructed in this Guide for installing or removing electronic load modules. Component replacement and internal adjustments must be made only by qualified service personnel. Do not replace components with power cable connected. Under certain conditions dangerous voltages may exist even with the power cable removed. To avoid injuries always disconnect power, discharge circuits, and remove external voltage sources before touching components.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person capable of rendering first aid resuscitation is present.

DO NOT EXCEED INPUT RATINGS

This instrument may be equipped with a line filter to reduce electromagnetic interference and must be connected to a properly grounded receptacle to minimize shock hazard. Operation at line voltages or frequencies in excess of those stated on the data plate may cause leakages in excess of 5.0mA peak.

Instruments that appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

SAFETY SYMBOLS

	Direct current
	Alternating current
	Both direct and alternating current
	Three-phase alternating current
	Earth (ground) terminal
	Protective earth (ground) terminal
	Frame or chassis terminal
	Terminal is at earth potential. Used for measurement and control circuits designed to be operated with one terminal at earth potential.
	Terminal for Neutral conductor on permanently installed equipment
	Terminal for Line conductor on permanently installed equipment
	On (supply)
	Off (supply)
	Standby (supply). Units with this symbol are not completely disconnected from ac mains when this switch is off. To completely disconnect the unit from ac mains, either disconnect the power cord or have a qualified electrician install an external switch.
	In position of a bi-stable push control
	Out position of a bi-stable push control
	Caution, risk of electric shock
	Caution, hot surface
	Caution (refer to accompanying documents)
WARNING	The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.
Caution	The CAUTION sign denotes a hazard. It calls attention to an operating procedure, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

Declaration of Conformity

To obtain the latest Declaration of Conformity, go to http://regulations.corporate.keysight.com and click on “Declarations of Conformity.”

Acoustic Noise Information

Herstellerbescheinigung

Diese Information steht im Zusammenhang mit den Anforderungen der Maschinenlä
minformationsverordnung vom 18 Januar 1991.

* Schalldruckpegel Lp <70 dB(A)
* Am Arbeitsplatz
* Normaler Betrieb
* Nach EN 27779 (Typprüfung).

Manufacturer's Declaration

This statement is provided to comply with the requirements of the German Sound Emission Directive, from 18 January 1991.

* Sound Pressure Lp <70 dB(A)
* At Operator Position
* Normal Operation
* According to EN 27779 (Type Test).

Printing History

The edition and current revision of this manual are indicated below. Reprints of this manual containing minor corrections and updates may have the same printing date. Revised editions are identified by a new printing date. A revised edition incorporates all new or corrected material since the previous printing date.

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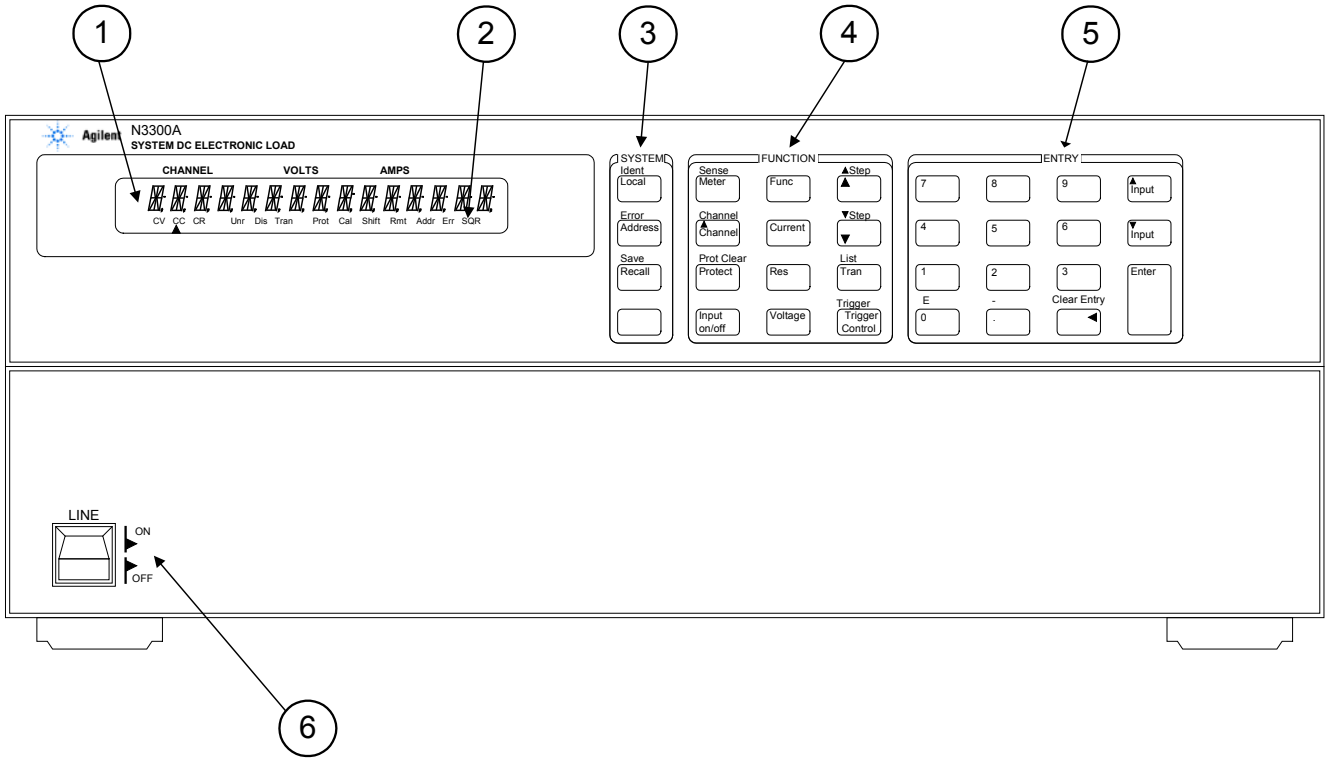
The Front Panel -At a Glance

① 15-character display shows channel, voltage and current measurements.

② Annunciators indicate operating modes and status conditions.

③ System keys:

- Return to Local mode.
- Set the GPIB address.
- Set the RS-232 interface.
- Display SCPI error codes.
- Save and recall instrument states.



④ Function keys:

- Select metering functions.
- Enable/disable input.
- Program current, resistance and voltage modes.
- Set and clear protection functions.
- Scroll through front panel menu commands.

⑤ Entry keys:

- Enter values.
- Increment or decrement values.

⑥ Turns the electronic load on and off.

The Rear Panel At a Glance

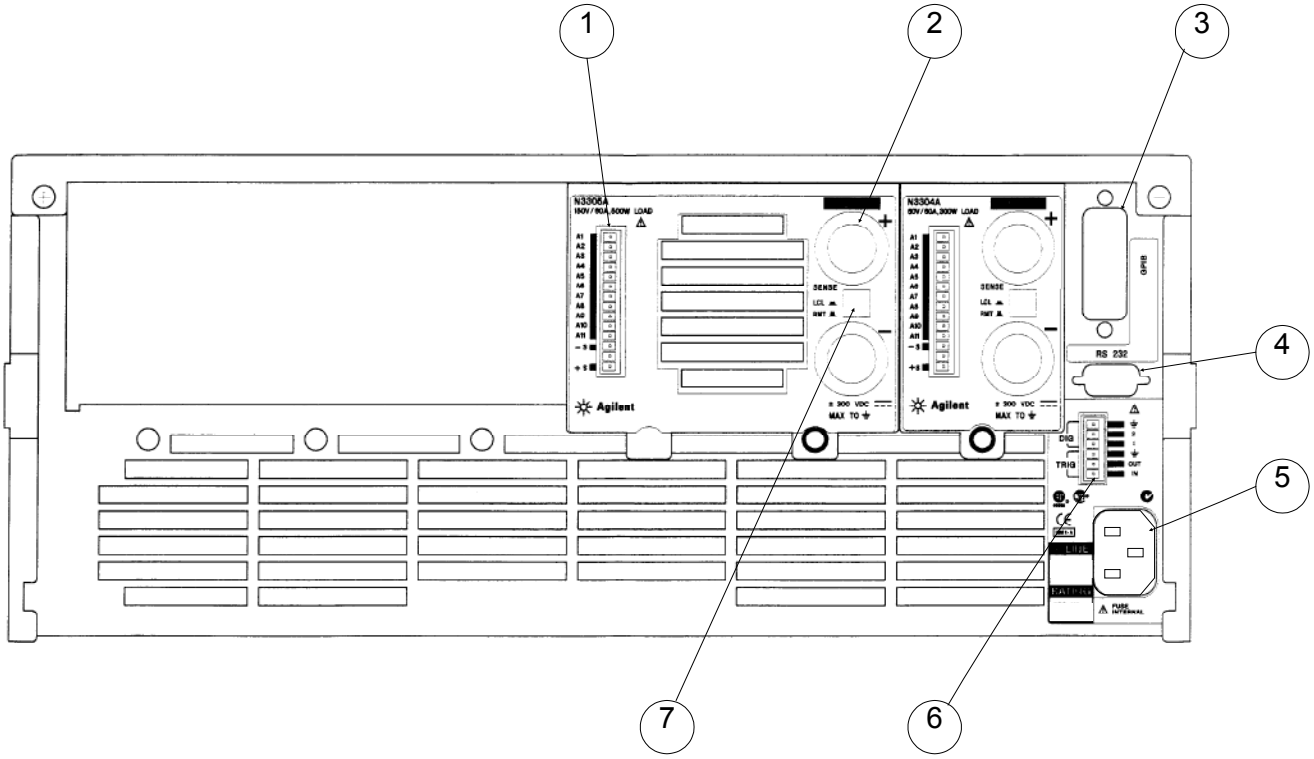
Refer to chapter 3 for detailed information about the rear panel connections.

① 14-pin control connector

② Input binding post

③ Standard 24-pin GPIB connector

④ 9-pin RS-232 interface connector



⑤ 3-pin IEC 320 ac input connector. (power cord requires ground conductor)

⑥ 6-pin trigger/digital connector

⑦ Sense switch

Instrument Configuration

Use the front panel Address menu to

- Select GPIB or RS-232 interface (see Chapter 5 in User's Guide).
- Select the GPIB bus address (see Chapter 5 in User's Guide).
- Configure the RS-232 interface (see Chapter 5 in User's Guide).

Front Panel Number Entry

Enter numbers from the front panel as follows:

Use the Entry Scroll keys to adjust the input setting in Meter mode.



If **CC** is lit, the input current changes.

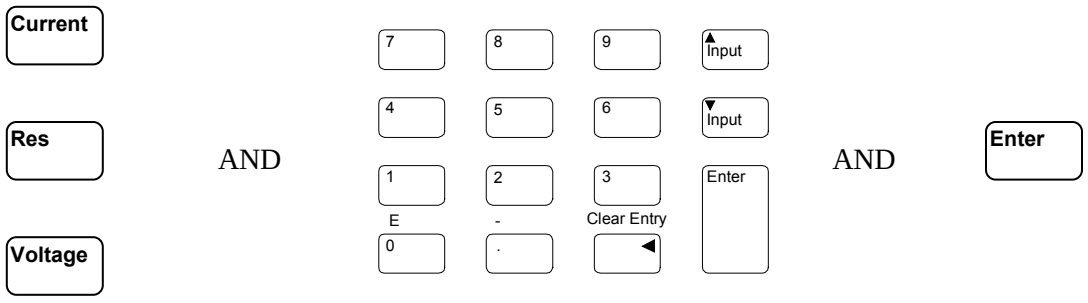
If **CV** is lit, the input voltage changes.

If **CR** is lit, the input resistance changes.

NOTE The input must be on for input values to change.

Use the Function keys and Entry keys to enter a new value

NOTE If you make a mistake use the Backspace key to delete the number, or press the Meter key to return to the Meter mode.



Front Panel Annunciators



ϕ1	A list is initiated or running.	**Prot**	Indicates that a channel protection feature is active on any channel. Press the Prot Clear key to clear the protection condition.
CV	The selected input channel is in the constant voltage (CV) mode.	**Cal**	Calibration mode is ON. Calibration can only be done through the computer interface.
CC	The selected input channel is in the constant current (CC) mode.	**Shift**	Indicates that the shift key has been pressed.
CR	The selected input channel is in the constant resistance (CR) mode.	**Rmt**	Indicates that the electronic load is in remote state (either GPIB or RS-232). In the remote state, only the active key is the Local key.
Unr	The selected input channel is unregulated.	**Addr**	The electronic load is addressed to talk or listen.
Dis	The input is OFF. Press the Input on/off key to turn the input on.	**Err**	A remote programming error(s) have occurred.
Tran	The selected input channel is enabled for transient operation.	**SQR**	The electronic load is requesting a service.

Immediate Action Keys

Input On/Off	A toggle switch that turns the input of the electronic load on or off.
Local	Activates front panel control when the unit is in remote mode (unless a Lockout command is in effect).
▲ Input	Increases the input current (CC), voltage (CV), or resistance (CR) in Meter mode.
▼ Input	Decreases the input current (CC), voltage (CV), or resistance (CR) in Meter mode.
▲ Channel	Selects another channel.
Shift + **Trigger**	Causes an initiate and trigger to occur. Used with transient subsystem or list.
Protect	Displays any protection functions that are tripped.
Shift + **Prot Clear**	Resets the protection circuit and allows the unit to return to its last programmed state.
Shift + **Ident**	Identifies the module installed in the selected channel location. (not available)
Meter	Returns the front panel to metering mode from any other mode.

Front Panel Menus - At a Glance

Address	*ADDRESS 5*	Sets the GPIB Address
▼	*INTF GPIB*	Selects an interface (GPIB or RS232)
▼	*BAUDRATE 300*	Selects baud rate (300, 600, 1200, 2400, 4800, 9600) *
▼	*PARITY NONE*	Selects message parity (NONE, EVEN, ODD, MARK, SPACE) *
▼	*FLOW NONE*	Selects flow control (XON-XOFF, RTS-CTS, DTR-DSR, NONE) *
Recall	**RCL 0*	Recalls the instrument state
▼	**RST*	Resets the instrument to its power-on state
Shift Save	**SAV 0*	Saves the present instrument state
Shift Error	*ERROR 0*	Displays the number of errors in the SCPI error queue
Shift Channel	*CHANNEL 1*	Allows selection of channel to be controlled by the front panel
Shift Sense	*S:PNT*	Defines the number of data points in the measurement
▼	*S:TIN*	Sets the digitizer sample spacing
▼	*S:WIN*	Sets the measurement window function (RECT, HANN)
▼	*S:OFF*	Defines the data offset in the measurement
▼	*S:C:RNG*	Selects the current measurement range
▼	*S:V:RNG*	Selects the voltage measurement range
Func	*FUNC*	Sets the regulation mode (CURR, RES, VOLT)
▼	*FNC:MODE*	Selects what controls regulating mode (FIX, LIST)
▼	*INP:SHOR*	Enable/disables the input short (OFF/ON)
Protect	*OC -- -- --*	General protection status (overcurrent fault shown)
▼	*RRV --- --*	Voltage protection status (remote reverse voltage fault shown)
Meter	*XXXX XXXX*	Displays the input voltage and current
▼	*XXXX V MAX*	Displays the maximum voltage
▼	*XXXX V MIN*	Displays the minimum voltage
▼	*XXXX V RMS*	Displays the rms voltage
▼	*XXXX A MAX*	Displays the maximum current
▼	*XXXX A MIN*	Displays the minimum current
▼	*XXXX A RMS*	Displays the rms current
▼	*XXXX WATTS*	Displays the wattage
▼	*XXXX W MAX*	Displays the maximum wattage
▼	*XXXX W MIN*	Displays the minimum wattage
Current	*CURR*	Sets the input current
▼	*C:MODE*	Sets the current mode (FIXED, LIST)
▼	*C:RANG*	Sets the input current range
▼	*C:SLEW*	Sets current slew rate
▼	*C:SLW:N*	Sets current slew rate for negative transitions
▼	*C:SLW:P*	Sets current slew rate for positive transitions
▼	*C:TLEV*	Sets the transient input current
▼	*C:TRIG*	Sets the triggered input current
Res	*RES*	Sets the input resistance
▼	*R:MODE*	Sets the resistance mode (FIXED, LIST)
▼	*R:RANG*	Sets the input resistance range
▼	*R:SLEW*	Sets resistance slew rate
▼	*R:SLW:N*	Sets resistance slew rate for negative transitions
▼	*R:SLW:P*	Sets resistance slew rate for positive transitions
▼	*R:TLEV*	Sets the transient input resistance
▼	*R:TRIG*	Sets the triggered input resistance

*Only applicable for use with RS-232

Front Panel Menus - continued

Voltage	*VOLT*	Sets the input voltage
▼	*V:MODE*	Sets the voltage mode (FIXED, LIST)
▼	*V:RANG*	Sets the input voltage range
▼	*V:SLEW*	Sets voltage slew rate
▼	*V:SLW:N*	Sets voltage slew rate for negative transitions
▼	*V:SLW:P*	Sets voltage slew rate for positive transitions
▼	*V:TLEV*	Sets the transient input voltage
▼	*V:TRIG*	Sets the triggered input voltage
Tran	*TRAN*	Enables/disables the transient generator (OFF/ON)
▼	*T:DCYC*	Sets the transient duty cycle in continuous mode
▼	*T:FREQ*	Sets the transient frequency in continuous mode
▼	*T:MODE*	Sets the transient mode (CONT, PULSE, TOGGLE)
▼	*T:TWID*	Sets the transient pulse width in pulse mode
Trigger	*INIT:IMMED*	Initiates the trigger system
▼	*ABORT*	Aborts the initiated trigger
List	*LST:STEP*	Sets the method of incrementing steps (ONCE, AUTO)
▼	*LST:CNT*	Specifies the number of times the list is cycled
▼	*DWEL:0 EOL*	Specifies the time period of each step
▼	*CURR:0 EOL*	Specifies the current setting for each step
▼	*C:RANG:0 EOL*	Specifies the current range for each step
▼	*C:SLEW:0 EOL*	Sets the current slew rate for each step
▼	*C:SLW:N:0 EOL*	Sets the negative current slew rate for each step
▼	*C:SLW:P:0 EOL*	Sets the positive current slew rate for each step
▼	*C:TLEV:0 EOL*	Sets the transient input current for each step
▼	*FUNC:0 EOL*	Sets the list regulation mode (CURR, RES, VOLT)
▼	*RES:0 EOL*	Specifies the resistance setting for each step
▼	*R:RANG:0 EOL*	Specifies the resistance range for each step
▼	*R:SLEW:0 EOL*	Sets the resistance slew rate for each step
▼	*R:SLW:N:0 EOL*	Sets the negative resistance slew rate for each step
▼	*R:SLW:P:0 EOL*	Sets the positive resistance slew rate for each step
▼	*R:TLEV:0 EOL*	Sets the transient input resistance for each step
▼	*TRAN:0 EOL*	Enables/disables the transient level for each step
▼	*T:DCYC:0 EOL*	Sets the transient duty cycle for each step
▼	*T:FREQ:0 EOL*	Sets the transient frequency for each step
▼	*T:MODE:0 EOL*	Sets the mode of the transient generator (CONT, PULSE)
▼	*T:TWID:0 EOL*	Sets the transient pulse width for each step
▼	*VOLT:0 EOL*	Specifies the voltage setting for each step
▼	*V:RANG:0 EOL*	Specifies the voltage range for each step
▼	*V:SLEW:0 EOL*	Sets the voltage slew rate for each step
▼	*V:SLW:N:0 EOL*	Sets the negative voltage slew rate for each step
▼	*V:SLW:P:0 EOL*	Sets the positive voltage slew rate for each step
▼	*V:TLEV:0 EOL*	Sets the transient input voltage for each step

SCPI Programming Commands - At a Glance

NOTE Most [optional] commands have been omitted for clarity. Refer to the Programming Guide for a complete description of all programming commands.

```
ABORt
CALibrate
        :DATA <n> [,<n>]
        :IMON:LEVel <points>
        :IPRog:LEVel <points>
        :LEVel <points>
        :PASSword <n>
        :SAVE
        :STATE <bool> [,<n>]
CHANnel | INSTrument
        [:LOAD] <n>
INITiate
        [:IMMediate]
                :SEQuence[1] | :SEQuence2
                :NAMe LIST | ACQuire
        CONTinuous
                :SEQuence1 <bool>
                :NAMe LIST <bool>
INPut | OUTput
        [:STATe] <bool>
        :PROTection
                :CLEar
        :SHORt
                [:STATe] <bool>
MEASure | FETCh
        :ARRay
                :CURRent?
                :POWer?
                :VOLTage?
        [:SCALar]
                :CURRent?
                        :ACDC?
                        :MAX?
                        :MIN?
                :POWer?
                        :MAX?
                        :MIN?
                :VOLTage?
                        :ACDC?
                        :MAX?
                        :MIN?
PORT0[:STATe] <bool>
PORT1[:LEVel] <n>
SENSe
        :CURRent
                :RANGe <n>
        :SWEep
                :OFFSet
                :POINts <n>
                :TINTerval <n>
        :WINDow <type>
        :VOLTage
                :RANGe <n>
```

```
[SOURce:]CURRent
                [:LEVel] <n>
                        :TRIG <n>
                :MODE <mode>
                :PROTection
                        [:LEVel] <n>
                        :DELay <n>
                        :STATe <bool>
                :RANGe <n>
                :SLEW
                        [:BOTH] <n>
                        :NEGative <n>
                        :POSitive <n>
                :TLEVel <n>
        FUNCtion | MODE
                :MODE <mode>
        LIST
                :COUNt <n>
                :CURRent
                        [:LEVel] <n> {,<n>}
                                :POINts?
                        :RANGe <n> {,<n>}
                                :POINts?
                        :SLEW
                                [:BOTH] <n> {,<n>}
                                        :POINts?
                                :NEGative <n> {,<n>}
                                : POSitive <n> {,<n>}
                        :TLEVel <n> {,<n>}
                                :POINts?
                :DWELl <n> {,<n>}
                        :POINts?
                :FUNCtion | MODE <mode>
                :RESistance
                        [:LEVel] <n> {,<n>}
                                :POINts?
                        :RANGe <n> {,<n>}
                                :POINts?
                        :SLEW
                                [:BOTH] <n> {,<n>}
                                        :POINts?
                                :NEGative <n> {,<n>}
                                : POSitive <n> {,<n>}
                        :TLEVel <n> {,<n>}
                                :POINts?
                :STEP <step>
                :TRANsient
                        [:STATe] <bool> {,<bool>}
                                :POINts?
                        :DCYCle <n> {,<n>}
                                :POINts?
                        :FREQuency <n> {,<n>}
                                :POINts?
                        :MODE <mode> {<mode>}
                                :POINts?
                        :TWIDth <n> {,<n>}
                                :POINts?
```

SCPI Commands - continued

```
[SOURce:]LIST (continued)
                :VOLTage
                        [:LEVel] <n> {,<n>}
                                :POINts?
                        :RANGe <n> {,<n>}
                                :POINts?
                        :SLEW
                                [:BOTH] <n> {,<n>}
                                        :POINts?
                                :NEGative <n> {,<n>}
                                : POSitive <n> {,<n>}
                        :TLEVel <n> {,<n>}
                                :POINts?
        RESistance
                [:LEVel] <n>
                        :TRIG <n>
                :MODE <mode>
                :RANGe <n>
                :SLEW
                        [:BOTH] <n>
                        :NEGative <n>
                        :POSitive <n>
                :TLEVel <n>
        TRANsient
                [:STATe] <bool>
                :DCYCle <n>
                :FREQuency <n>
                :MODE <mode>
                :TWIDth <n>
        VOLTage
                [:LEVel] <n>
                        :TRIG <n>
                :MODE <mode>
                :RANGe <n>
                :SLEW
                        [:BOTH] <n>
                        :NEGative <n>
                        : POSitive <n>
                :TLEVel <n>

STATus
        :CHANnel
                [:EVENt]?
                :CONDition?
                :ENABle <n>
        :CSUMmary
                [:EVENt]?
                :ENABle <n>
        :OPERation
                [:EVENt]?
                :CONDition?
                :ENABle <n>
                :NTRansition <n>
                :PTRansition <n>
        :QUEStionable
                [:EVENt]?
                :CONDition?
                :ENABle <n>
SYSTem
        :ERRor?
        :VERSion?
        :LOCal
        :REMote
        :RWLock
TRIGger
        [:IMMediate]
        :DELay
        :SOURce <source>
        :TIMer
        :SEQuence2 | ACQuire
                :COUNt
```

2

General Information

Document Orientation

This manual describes the operation of the Keysight Model N3300A, N3301A, N3302A, N3303A N3304A, N3305A, N3306A and N3307A DC Electronic Loads. Unless otherwise noted, all units will be referred to by the description "electronic load" throughout this manual. The following documents and software are shipped with your electronic load:

- A User's Guide (this document), contains installation, checkout and front panel information.
- A Programming Guide, contains detailed GPIB programming information.

The following Getting Started Map will help you find the information you need to complete the specific task that you want to accomplish. Refer to the table of contents or index of each guide for a complete list of the information contained within.

Getting Started Map

Task	**Where to find information**
Installing the unit Line voltage connections Installing modules Load connections	User's Guide
Checking out the unit Verifying proper operation Using the front panel Calibrating the unit	User's Guide
Using the front panel Front panel keys Front panel examples	User's Guide
Using the programming interface GPIB interface RS-232 interface	User's Guide Programming Guide
Programming the unit using SCPI commands SCPI commands SCPI programming examples	Programming Guide
Programming the unit using VXIplug&play instrument driver Installing the instrument driver Instrument driver functions C/C++ example programs Visual BASIC example programs Lab VIEW example programs Keysight VEE example programs	VXIplug&play on-line help NOTE: The driver must be installed on your computer to access the on-line information. Drivers for Keysight instruments are available on the web at www.keysight.com/find/drivers

Safety Considerations

This electronic load is a Safety Class 1 instrument, which means it has a protective earth terminal. That terminal must be connected to earth ground through power source equipped with a ground receptacle. Refer to the Safety Summary page at the beginning of this guide for general safety information. Before installation or operation, check the electronic load and review this guide for safety warnings and instructions. Safety warnings for specific procedures are located at appropriate places in the Guide.

Options and Accessories

Table 2-1 Options

Option	Description
800	One rack mount kit for two N3301A half-rack units side by side*. Consists of: Lock-link kit (p/n 5061-9694) and Flange kit (p/n 5062-3978)
908	One rack mount kit*. Consists of: Flange kit for N3300A (order 2 p/n 5062-3974) Flange kit for one N3301A with blank filler panel (p/n 5062-3960)
909	One rack mount kit with handles for N3300A* (order 2 p/n 5062-3975).
UJ1	8mm input screw terminal connectors (see chapter 3)

*Support rails (p/n E3663AC) are required.

Table 2-2 Accessories

GPIB cables	Keysight Part Number
1.0 meter (3.3 ft)	10833A
2.0 meters (6.6 ft)	10833B
4.0 meters (13.2 ft)	10833C
0.5 meters (1.6 ft)	10833D
RS-232 cable (9-pin F to 9-pin F, 2.5 meter, null modem/printer cable with one 9-pin M to 25 pin F adapter)	34398A
RS-232 adapter kit (contains 4 adapters) 9-pin M to 25-pin M for pc or printer 9-pin M to 25-pin M for pc or printer 9-pin M to 25-pin M for modem 9-pin M to 9-pin M for modem	34399A

Description

The N3300A is a DC Electronic Load Mainframe used for design, manufacturing, and evaluation of dc power supplies, batteries, and power components. Other applications include use as a power circuit breaker or crowbar, high current function or pulse generator, fuel-cell and photovoltaic cell test, and de-energizing superconducting magnets.

The mainframe contains six slots for load modules. Load modules occupy either 1 or 2 slots depending on the power rating of the module. The mainframe can dissipate up to 300 watts per slot, to a total of 1800 watts for a fully loaded mainframe. Each individual module has its own channel number and contains its own input connector. The mainframe contains a processor, GPIB connector, RS-232 connector and interface circuits, trigger circuits, front-panel keypad and display, and other circuits common to all the load modules.

The N3301A is a DC Electronic Load Mainframe that is functionally identical to the N3300A, but is a half-rack width with only two slots for load modules. The mainframe can dissipate up to 300 watts per slot, to a total of 600 watts for a fully loaded mainframe.

The N3302A, N3303A N3304A, N3305A, N3306A and N3307A are electronic load modules that can be installed in the N3300A and N3301A mainframes. The module specific pages in Appendix A include specifications and other information pertinent to a particular model. Each module can operate independently in constant current (CC) mode, constant voltage (CV) mode, or constant resistance (CR) mode. In addition, each input can be turned on or off (open-circuited), or short-circuited.

Features and Capabilities

- Constant current (CC), constant voltage (CV), or constant resistance (CR) mode operation.
- Built-in GPIB and RS-232 interface programming with SCPI command language.
- Triggered input and measurement functions.
- Front panel control with keypad.
- Independent channel operation.
- Built-in pulse generator for continuous, pulsed, and toggled transient operation.
- Overvoltage, overcurrent, overpower, and overtemperature protection.
- Extensive selftest, status reporting and software calibration.
- Fan speed control for reduced acoustic noise under light load conditions.

Front Panel Controls

The front panel has keyboard controls for setting the input voltage, current and resistance. The panel display provides digital readouts of a number of functions including the inputs. Annunciators display the operating status of the electronic load. System keys let you perform system functions such as setting the GPIB address and recalling operating states. Front panel function keys access the electronic load function menus. Front panel Entry keys let you select and enter parameter values. Refer to chapter 5 for a complete description of the front panel controls.

Remote Programming

The electronic load may be remotely programmed via the GPIB bus and/or an RS-232 serial port. GPIB programming is done with SCPI (Standard Commands for Programmable Instruments) commands, which make the electronic load programs compatible with those of other GPIB instruments that are also SCPI compatible.

Local (front panel) control is in effect immediately after power is applied. The front panel keypad and display allow manual control of each individual module when the electronic load is used in bench test applications. Remote (computer) control goes into effect (front panel Rmt annunciator is on) as soon as the mainframe receives a command via the GPIB. A built-in GPIB interface and SCPI commands allow control and readback of all functions when the electronic load is used in computer controlled applications.

With remote control in effect, only the computer can control the electronic load; the front panel keypad has no effect. You can still use the front panel display to view the input voltage and current readings. To return the electronic load to local control, press the **Local** key. This will return the electronic load to local control, unless the local-lockout command has been received from the GPIB controller.

Most functions that can be performed remotely over the GPIB or RS-232 can also be performed from the front panel. Whenever possible the function menu commands reflect their corresponding SCPI commands. Thus, learning to operate the electronic load from the front panel will aid you when writing computer programs.

Operating Modes

The three modes of operation are:

- Constant current (CC).
- Constant voltage (CV).
- Constant resistance (CR).

When programmed to a mode, a module remains in that mode until the mode is changed or until a fault condition, such as an overpower or overtemperature, occurs.

The current, resistance, and voltage mode parameters described in subsequent paragraphs can be programmed whether or not the mode is presently selected. When a mode is selected via the front panel or via the GPIB or RS-232, most of the associated parameters will take effect at the input (exceptions are noted in the mode descriptions).

Constant Current CC (Mode)

In this mode, the module will sink a current in accordance with the programmed value regardless of the input voltage (see Figure 2-1). The CC mode can be set with front panel keys or via the GPIB or RS-232. The CC mode parameters are discussed in the following paragraphs.

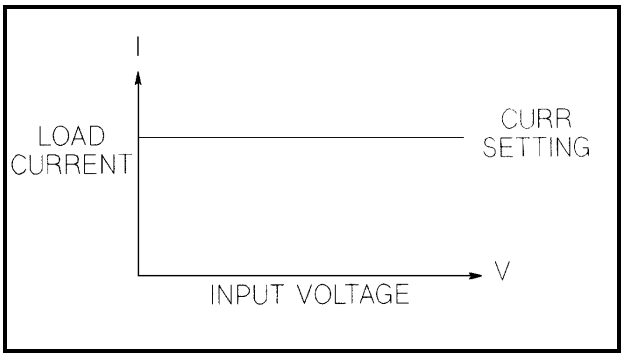


Figure 2-1. Constant Current Mode

Ranges

Current may be programmed in either of two overlapping ranges, a Low range and a High range. The low range provides better resolution at low current settings. The range can be set at the front panel or via the GPIB (**CURR:RANG** command). The electronic load selects the range that corresponds to the range value that you program. If the range value falls in a region where ranges overlap, the electronic load selects the Low range. If the present input setting is outside the Low range, the electronic load will automatically adjust the input setting to the highest value available in the Low range. If you subsequently program an input value that is outside the Low range, an OUT OF RANGE message will appear on the front panel display.

Immediate Current Level

The current level can be set at the front panel or via the GPIB (**CURR** command). If the CC mode is the active mode, the new setting immediately changes the input at a rate determined by the slew setting (described below). If the module is not in the CC mode, the new setting is saved for use when the mode is changed to CC.

Triggered Current Level

A current level can be preset (stored in the electronic load) allowing the input to be updated when a trigger is received instead of immediately as described above.

If the CC mode is the active mode, the preset current level will become the actual value and the input will be updated when a trigger occurs. If the CC mode is not the active mode, the preset current level will become the actual value when a trigger occurs but there will be no effect on the input until the CC mode becomes active. Once a level is triggered, subsequent triggers will have no effect on the input unless another **CURR:TRIG** command is sent. The trigger sources available to the electronic load are described later in this chapter. The electronic load has a status reporting capability to keep track of pending triggers and other operating conditions. The status reporting capability is described in detail in the *Programming Guide.*

Transient Current Level

The transient current level can be set at the front panel or via the GPIB. The transient current level can be higher or lower than the main current level. The module input will switch between the main level and the transient level when transient operation is turned on.

Software Current Limit

The electronic load allows the user to set a current limit (0 to 102% of full scale) for each module via the GPIB (**CURR:PROT** command) which will shut down the input if the current limit is exceeded beyond a programmable time delay. Note that the software current limit is in effect for any mode of operation (not just the CC mode). The software current limit feature is described later in this chapter under *Protection Features*.

Slew Rate

The current slew rate determines the rate at which the input current to a module changes to a new programmed value. Current slew rates are programmed in amperes per second. Slew rates can be set at the front panel or via the GPIB (CURR:SLEW command). The programmed slew rate remains in effect for the immediate, triggered, and transient level changes previously described.

Any slew rate can be programmed provided that it falls between the fastest and the slowest slew rates shown in Figure 2-8A. If a value is programmed that is outside these limits, the module will automatically adjust the programmed value to either the fastest or the slowest slew rates shown in the figure.

Constant Resistance (CR) Mode

In this mode, the module will sink a current linearly proportional to the input voltage in accordance with the programmed resistance (see Figure 2-2). The CR mode can be set at the front panel or via the GPIB (**MODE:RES** command). The CR mode parameters are described in the following paragraphs.

Ranges

Resistance may be programmed in any of four overlapping ranges. The range can be set at the front panel or via the GPIB (**RES:RANG** command). The electronic load selects the range that corresponds to the range value that you program. If the range value falls in a region where ranges overlap, the electronic load selects the range with the highest resolution. If the present input setting is outside the range that you select, the electronic load will automatically adjust the input setting to the closest available value within the newly selected range. If you subsequently program an input value that is outside the newly selected range, an OUT OF RANGE message will appear on the front panel display.

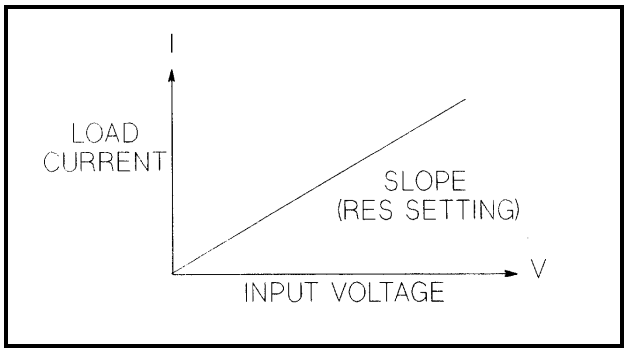


Figure 2-2. Constant Resistance Mode

Immediate Resistance Level

The resistance level can be set at the front panel or via the GPIB (**RES** command). If the CR mode is active, the new setting immediately changes the input at a rate determined by the voltage or current slew setting (see description below). If the module is not in the CR mode, the new setting is saved for use when the mode is changed to CR.

Triggered Resistance Level

A resistance level can be preset (stored in the electronic load) allowing the input to be updated when a trigger is received instead of immediately as described above.

If the CR mode is active, the preset resistance level will become the actual value and the input will be updated when a trigger occurs. If the CR mode is not the active mode, the preset resistance level will become the actual value when a trigger occurs but there will be no effect on the input until the CR mode becomes active. Once a level is triggered, subsequent triggers will have no effect on the input unless another **RES:TRIG** command is sent.

Transient Resistance Level

The transient resistance level can be set at the front panel or via the GPIB (**RES:TLEV** command). The transient level and the main level are used in transient operation, which is described later in this chapter.

Slew Rate

The resistance slew rate determines the rate at which the input resistance to a module changes to a new programmed value. Resistance slew rates are programmed in ohms per second. Slew rates can be set at the front panel or via the GPIB (RES:SLEW command). The programmed slew rate remains in effect for the immediate, triggered, and transient level changes previously described.

Constant Voltage (CV) Mode

In this mode, the module will attempt to sink enough current to control the source voltage to the programmed value (see Figure 2-3). The module acts as a shunt voltage regulator when operating in the CV mode. The CV mode can be set at the front panel or via the GPIB (**MODE:VOLT** command). The CV mode parameters are described in the following paragraphs.

Ranges

Voltage may be programmed in either of two overlapping ranges, a low range and a high range. The low range provides better resolution at low voltage settings. The range can be set at the front panel or via the GPIB

(**VOLT:RANG** command). The electronic load selects the range that corresponds to the range value that you program. If the range value falls in a region where ranges overlap, the electronic load selects the Low range. If the present input setting is outside the Low range, the electronic load will automatically adjust the input setting to the highest value available in the Low range. If you subsequently program an input value that is outside the Low range, an OUT OF RANGE message will appear on the front panel display.

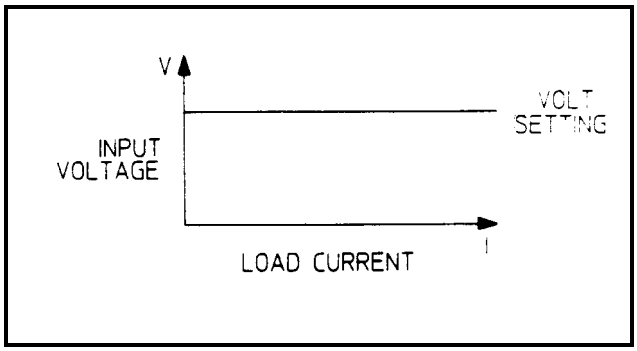


Figure 2-3. Constant Voltage Mode

Immediate Voltage Level

The voltage level can be set at the front panel or via the GPIB (**VOLT** command). If the CV mode is active, the new setting immediately changes the input at a rate determined by the voltage slew setting. If the module is not in the CV mode, the new setting is saved for use when the mode is changed to CV.

Triggered Voltage Level

The voltage level can be preset (stored in the electronic load) allowing the input to be updated when a trigger is received instead of immediately as described above.

If the CV mode is the active mode, the preset current level will become the actual value and the input will be updated when a trigger occurs. If the CV mode is not the active mode, the preset current level will become the actual value when a trigger occurs, but there will be no effect on the input until the CV mode becomes active. Once a level is triggered, subsequent triggers will have no effect on the input unless another **VOLT:TRIG** command is sent.

Transient Voltage Level

The transient voltage level can be set at the front panel or via the GPIB (**VOLT:TLEV** command). The module input will switch between the main level and the transient level when transient operation is turned on. The transient voltage level determines the higher voltage level.

Slew Rate

The voltage slew rate determines the rate at which the input voltage to a module changes to a new programmed value. Voltage slew rates are programmed in volts per second. Slew rates can be set at the front panel or via the GPIB (VOLT:SLEW command). The programmed slew rate remains in effect for the immediate, triggered, and transient level changes previously described.

Any slew rate can be programmed provided that it falls between the fastest and the slowest slew rates shown in Figure 2-8B. If a value is programmed that is outside these limits, the module will automatically adjust the programmed value to either the fastest or the slowest slew rates shown in the figure.

Transient Operation

Transient operation enables the module to periodically switch between two load levels, as might be required for testing power supplies. A power supply's regulation and transient characteristics can be evaluated by monitoring the supply's output voltage under varying combinations of load levels, frequency, duty cycle, and slew rate. Transient operation can be turned on and off at the front panel or via the GPIB (**TRAN ON** and **TRAN OFF** commands). Before you turn on transient operation, you should set the desired mode of operation as well as all of the parameters associated with transient operation. Transient operation may be used in the CC, CR, or CV modes and can be continuous, pulsed, or toggled.

Continuous Generates a repetitive pulse stream the toggles between two load levels.

Pulse Generates a load change that returns to its original state after some time period.

Toggled Generates a repetitive pulse stream that toggles between two load levels. Similar to Continuous mode except that the transient points are controlled by explicit triggers instead of an internal transient generator.

Continuous Transient Operation

In continuous operation, a repetitive pulse train switches between two load levels. In the front panel, the transient commands are located under the **TRAN** key. Continuous transient operation is selected via the GPIB using the **TRAN:MODE CONT** command.

The two load levels in the transient operation are the previously described main level (immediate or triggered) and transient level for current, resistance, or voltage. The rate at which the level changes is determined by the slew rate (see slew rate descriptions for CV, CR, or CV mode as applicable). In addition, the frequency and duty cycle of the continuous pulse train are programmable. The frequency can be set from 0.25 to 10000 Hz at the front panel or via the GPIB (**TRAN:FREQ** command). The duty cycle can be set from 3% to 97% (0.25 Hz to 1 kHz) or from 6% to 94% (above 1 kHz) at the front panel or via the GPIB (**TRAN:DCYC** command).

Pulsed Transient Operation

Pulsed transient operation is similar to continuous operation with the following exceptions:

a. In order to get a pulse, an explicit trigger is required. The trigger can be an external trigger signal received via the TRIGGER input on the rear panel, the **TRIG:SOUR** function, the ***TRG** or **TRIG** commands, the ac line, the internal timer signal, or the front panel **Trigger** key.

b. One pulse results from each trigger. Therefore, frequency cannot be programmed. The main level, transient level, and slew rate are programmed as described for continuous operation. The pulse width is programmable from 0.00005 to 4 seconds via the GPIB (**TRAN:TWID** command).

Toggled Transient Operation

Toggled transient operation causes the module input to alternate between two pre-defined levels as in continuous operation except that the transient points are controlled by explicit triggers instead of the internal transient generator. As in pulsed transient operation, the trigger signal can be an external trigger signal, the GPIB **GET** function, the ***TRG** command, the TRIG command, or the ac line or internal timer signals.

List Operation

List mode lets you generate complex sequences of input changes with rapid, precise timing, which may be synchronized with internal or external signals. This is useful when running test sequences with a minimum amount of programming overhead.

You can program up to 50 settings (or steps) in the list, the time interval (dwell) that each setting is maintained, the number of times that the list will be executed, and how the settings change in response to triggers. All listed data is stored in a non-volatile memory when the *SAV command is executed. This means that the programmed data for any list will be retained when the electronic load is turned off. Note that lists data can only be saved in nonvolatile memory locations 0, 7, 8, or 9. List data will not be saved in other memory locations. Use the *RCL command to recall the saved state.

List steps can be either individually triggered, or paced by a separate list of dwell times which define the duration of each step. Therefore, each of the up to 50 steps has an associated dwell time, which specifies the time (in seconds) that the input remains at that step before moving on to the next step. See chapter 5 for detailed information about programming lists from the front panel.

Triggered Operation

The electronic load has various triggering modes to allow synchronization with other test equipment or events. The triggering circuits are located in the mainframe, and all modules receive the trigger simultaneously (although each module is programmed individually as to what operation, if any, will be triggered. As described previously, triggering can be used for the following applications:

Triggering a preset level Transfers all pending preset levels to the actual level. For the presently active mode, the new level appears at the input. For the modes which are not presently active, the preset levels will not take effect at the input until the applicable mode becomes active.

Triggering a transient pulse Generates a transient pulse of programmable width when pulsed transient operation is in effect.

Toggling Changes the input between the main level and the transient level when toggled transient operation is in effect.

Triggers can be sent from the front panel by pressing the **Trigger** key. However you must first initiate the trigger function by executing the TRIG:IMMED command located in the Trigger Control menu.

Three triggering methods are available over the GPIB: the **GET** function, the ***TRG** common SCPI command, and the **TRIG** subsystem SCPI command (refer to *Programming Guide*). The SCPI **TRIG** subsystem allows you to select either the ac line frequency, internal timer, or **TRIG** command as the trigger source. There is also a **TRIGGER** connector on the rear panel for external trigger inputs.

***TRG** and the **TRIG** command are both synchronous with other commands; that is, the modules are not triggered until pending operations are completed. **GET**, external triggers, ac-line triggers, and internal-timer triggers are all asynchronous; that is, the modules are triggered as soon as the trigger signal is received.

If the ac line is selected via the GPIB as the trigger source, triggers will be generated once for each cycle of ac input power. An ac line frequency of 60 Hz produces a trigger period of 16.67 ms; 50 Hz line frequency produces a trigger period of 20 ms.

The rear-panel **TRIGGER** connector also provides a trigger output signal. This signal is generated synchronously with the trigger signal sent by the mainframe to the modules. The trigger output signal can be used to trigger an external device such as an oscilloscope, DVM, or another electronic load mainframe.

The electronic load has a status reporting capability to keep track of trigger operations. Refer to 'Status Reporting' in the *Programming Guide*.

Slew Rate and Minimum Transition Time

Slew rate is defined as the change in current, resistance, or voltage over time. A programmable slew rate allows a controlled transition from one load setting to another to minimize induced voltage drops on inductive power wiring, or to control induced transients on a test device (such as would occur during power supply transient response testing).

In cases where the transition from one setting to another is large, the actual transition time can be calculated by dividing the voltage or current transition by the slew rate. The actual transition time is defined as the time required for the input to change from 10% to 90% or from 90% to 10% of the programmed excursion. In cases where the transition from one setting to another is small, the small signal bandwidth of the load limits the minimum transition time for all programmable slew rates. Because of this limitation, the actual transition time is longer than the expected time based on the slew rate, as shown in Figure 2-7.

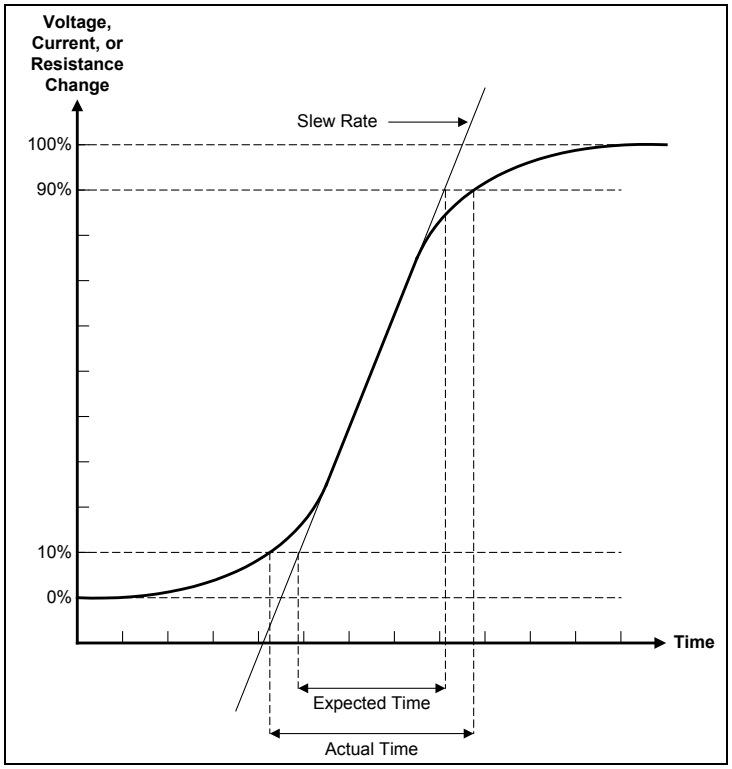


Figure 2-7. Risetime Transition Limitation

Therefore, both minimum transition time and slew rate must be considered when determining the actual transition time. This is shown in Figure 2-8, which shows the minimum transition time for a given slew rate as a horizontal line, and at about a 13.3% or greater load change, the slew rate increases from the minimum transition time to the Maximum transition time at a 100% load change. The actual transition time will be either the minimum transition time, or the total slew time (transition divided by slew rate), whichever is longer.

Use the following formula to calculate the minimum transition time (MinTT) for a given slew rate:

$$\text{MinTT (in seconds)} = \frac{8}{\text{slew rate (in amps/second)}}$$

Use the following formula to calculate the maximum transition time (MaxTT) for a given slew rate:

$$\text{MaxTT (in seconds)} = \frac{60}{\text{slew rate (in amps/second)}}$$

NOTE: In voltage mode, all minimum transition times are based on a low-capacitance current source. These transition times are affected by capacitive loading of the inputs. For example, a capacitance of 2.2 microfarads increases the 85 microsecond minimum transition time (shown in the table) to 110 microseconds.

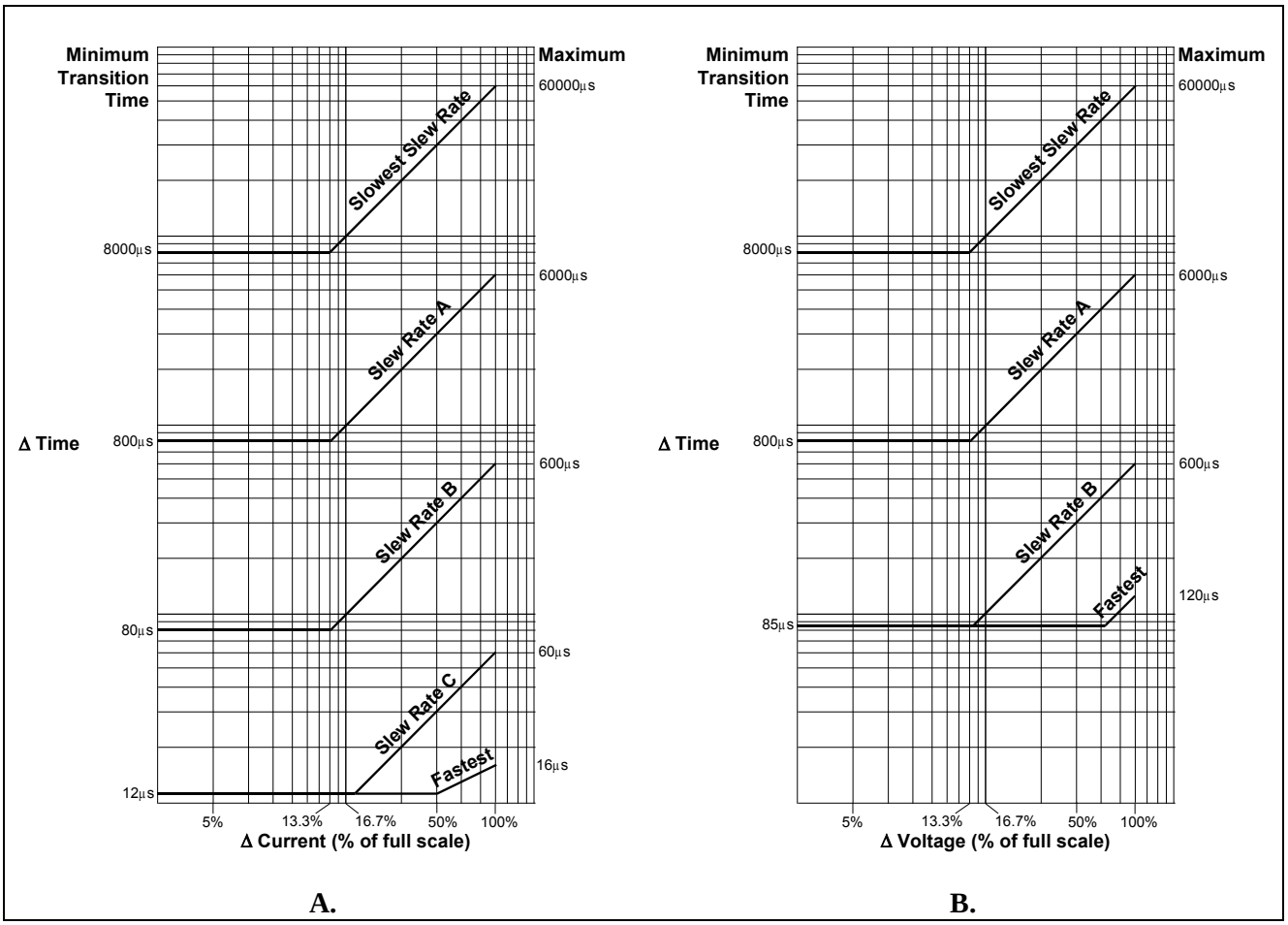


Figure 2-8. Transition Time Slew Rate Examples

Input Control

Short On/Off

A module can simulate a short circuit at its input by turning the load on with full-scale current. The short circuit can be toggled on/off at the front panel using the SHORT command in the **Func** menu, or via the GPIB (**INPUT:SHORT ON|OFF** command). The short on/off change uses the slew rate setting of the active mode and range.

The actual value of the electronic short is dependent on the mode and range that are active when the short is turned on. In CV mode it is equivalent to programming zero volts. In CC mode it is equivalent to programming full-scale current for the present current range. In CR mode it is equivalent to programming the minimum resistance for the present resistance range.

Note that turning the short on in CV mode may cause the load to draw so much current that the software current limit operates, which may turn the input off.

Turning the short circuit on does not affect the programmed settings, and the load input will return to the previously programmed values when the short is turned off.

Input On/Off

A module's input can be toggled on/off at the front panel, or via the GPIB **(INPUT ON|OFF** command). The input on/off change does not use the slew rate setting so the input will change at the maximum slew rate.

Turning the input off (zero current) does not affect the programmed settings. The input will return to the previously programmed values when the input is turned on again. Note that the Input On/Off command supersedes the mode commands and Short On/Off command.

Protection Features

Each load module includes the following protection features:

- Overvoltage.
- Overcurrent (hardware and software).
- Overpower.
- Overtemperature.
- Reverse Voltage.

The appropriate bit(s) in the mainframe's status registers are set when any of the above protection features are active. Also, the **Prot** annunciator comes on and the front-panel alphanumeric display indicates which condition(s) have been detected. For example, if an overtemperature (OT) condition has been detected causing a module's input to be turned off (protection shutdown, PS), the display will indicate **"PS OT".**

Resetting Latched Protection

All of the protection features latch (remain set) when they are tripped, except for the hardware overcurrent and reverse voltage. The latched protection features can be reset via the GPIB (***RST** or **INP:PROT:CLE** commands) or at the front panel. Of course, the condition that caused the protection feature to trip must be removed or it will trip again as soon as it is reset.

Caution To protect the electronic load from possible damage, the input voltage must not exceed the maximum input voltage rating specified in the module-specific pages supplied with each module. Never apply the ac line voltage to a module's input connectors.

Overvoltage

The overvoltage protection circuit is set at a predetermined voltage level, which cannot be changed. If the overvoltage circuit has tripped, the module will attempt to limit the voltage level by drawing current from the dc source. The module limits the value of current drawn such that the resulting power is within the power rating. The overvoltage (OV) and voltage fault (VF) status register bits are set when the OV condition occurs, and will remain set until they are reset as previously described.

An overvoltage condition does not cause the module's input to be turned off. However, a **Fault** signal (pin A6) output at the module's rear-panel control connector will indicate when either an overvoltage condition or a reverse voltage condition has occurred. The **Fault** signal is latched true (high TTL level) when the VF bit in the status register goes true. The Fault output signal can be used to trip an external circuit breaker or control a relay in order to disconnect the electronic load input from the source it is testing when an overvoltage or a reverse voltage condition occurs.

Overcurrent

The electronic load includes both hardware and software overcurrent protection features.

Hardware. When operating in the CR or CV mode, it is possible for a module to attempt to sink more current than it is rated for. Under this condition, the load current will be limited by a current limit circuit, which is set at a value slightly above the current rating of the module. It protects both the electronic load and the device under test from operating too far beyond specified limits. The hardware current limit circuit does not turn the module's input off. The overcurrent (OC) bit in the status register is set when an OC condition occurs, and is reset when the OC condition is removed.

Software. In addition to the hardware overcurrent protection circuit, the electronic load allows the user to define a current protection limit in software, which will shut down a module's input if the limit is exceeded. This feature can only be programmed via the GPIB. It is turned on/off using the **CURR:PROT:STATE ON|OFF** command. The software current limit level (in amps) is set using the **CURR:PROT** command. A programmable delay (in seconds) before trip is also provided with the **CURR:PROT:DEL** command. If the software overcurrent limit is exceeded and persists beyond the specified delay time, the module is turned off. Also, for these conditions, the OC and PS (protection shutdown) status register bits are set and will remain set until the OC condition is removed and the bits are reset as previously described.

Overpower

The power-limit boundary is set by software that monitors the input current and voltage. If the input power exceeds the power limit, the load module sets the overpower status bit, which will reset if the overpower condition ceases. If the overpower condition persists for 3 seconds, the load module's input circuit turns off, and the OP and PS status bits are both latched on. The input circuit remains off, and the OP and PS status bits remain set, until protection clear occurs. Of course, if the overpower condition is not corrected, the load will turn off again.

Overtemperature

Each module has an overtemperature (OT) protection circuit, which will turn off the input if the internal temperature exceeds safe limits. If the OT circuit activates, the OT and PS status register bits are set and will

remain set until they are reset. If the OT condition still exists when the reset is executed, the module's input will remain off. You must wait until the module cools down before you can reset the OT circuit. The fan(s) will continue to operate to cool the unit as quickly as possible.

Reverse Voltage

Caution This feature protects the load module in case the input dc voltage lines are connected with the wrong polarity. If a reverse voltage (LRV or RRV) condition is detected, turn off power to the dc source and the electronic load and make the correct connections.

The electronic load conducts reverse current when the polarity of the dc source connection is incorrect. The reverse voltage (LRV for local reverse voltage; RRV for remote reverse voltage) and voltage fault (VF) bits in the status register are set when reverse voltage is applied. When the reverse voltage is removed the LRV and RRV bits are cleared. However, the VF bit remains set until it is reset. As previously described, the **Fault** output signal at the control connector tracks the state of the VF bit. The **Fault** signal can be used to control an external relay in order to disconnect the module from the dc source if an RV condition occurs. This feature also detects reverse voltage at the Sense terminals.

Reading Remote Programming Errors

Remote programming errors can be read via the GPIB (**SYST:ERR?** query) or at the front panel. The **Err** annunciator indicates when remote programming errors have occurred. The errors are negative numbers grouped into blocks of 100 as follows:

-lxx Command errors

-2xx Execution errors

-3xx Device-specific errors

-4xx Query errors

The **SYST:ERR?** query reads back the errors in the order in which they occurred (the error queue can hold up to 30 entries). Once the error is read back it is removed from the list. A value *0* indicates there is no error; and *0* will be returned when all errors in the list have been read. Pressing the **Error** key displays just the error number. The **SYST:ERR?** query returns the error number and a short description of the error to the computer. Refer to Appendix B in the *Programming Guide.*

Local programming errors generated by front panel operations are not put into the error list, but are immediately put on the electronic load's front panel display; e.g., 'OUT OF RANGE'.

Status Reporting

The electronic load incorporates a status reporting capability. Various status conditions within the electronic load can be reported using this capability. The user determines which condition(s) will be reported. Chapter 5 of the *Programming Guide* describes each of the status registers in the electronic load. (These registers, including the channel status registers, are all maintained in the mainframe.) Notice that the same information is available in both the channel status and questionable status registers, but the channel registers are organized by channel, and the questionable registers are organized by fault. Therefore, depending on which channels and/or faults are most critical in your application, you can use one branch to localize selected faults quickly, and use the other branch for broader fault reporting. By knowing that only a particular fault (questionable branch) or a particular channel (channel branch) is enabled to initiate a service request, you can eliminate the need to read one or more registers to locate a fault.

Saving and Recalling Settings

The electronic load has internal registers in which settings (mode, current, voltage, resistance, slew, transient level, etc.) for each module can be saved. By saving settings and recalling them later you can save programming time.

The present settings for all channels are saved in the specified register (0 to 9) at the front panel or via the GPIB (***SAV** command). All of the settings are saved in the specified location in the mainframe's memory. Settings saved in locations 1 through 6 will be lost when ac line power is cycled. However, the ***SAV 0** command will cause the settings to be stored in a non-volatile memory; and, the next time the electronic load is turned on, these settings will become the power-on settings. In addition, locations 7 through 9 are also saved in non-volatile memory. These locations are used to store lists.

You can recall the saved settings from the specified register (0 to 9) at the front panel or via the GPIB (***RCL** command). All of the parameters for each module which were saved by the ***SAV** command are set to the saved values. At power-on, the electronic load automatically executes a ***RCL 0**, which recalls the values saved in location 0 of non-volatile memory.

You can recall the factory default settings at the front panel or via the GPIB (***RST** command).

Remember that Save and Recall operate on all channels, not just the presently addressed or selected channel.

External Control Signals

Each module has a 14-pin connector mounted on its rear panel. These signals are described in the following paragraphs. See Chapter 3 for connection details.

Remote Sensing

The remote sensing inputs, **+ S** and **- S,** can be used in CV or CR modes. By eliminating the effect of the inevitable voltage drop in the load leads, remote sensing provides greater accuracy by allowing the load to regulate directly at the source's output terminals, as well as measure the voltage there.

Monitor Outputs

The current monitor (pin A11) and voltage monitor (pin A10) output signals indicate the input current and voltage. A 0-to-+10V signal at the appropriate output indicates the zero-to-full scale input current or voltage. An external DVM or oscilloscope can be connected to monitor the input voltage and current.

External Programming Input

CC and CV modes can be programmed with a signal (ac or dc) connected to the external programming (pin A8) input. A 0-to-10V external signal corresponds to the 0-to-full scale input range in CV mode or in CC mode. The external programming signal is combined with the value programmed via the GPIB or the front panel, so that, for example, a programmed value of one-half full scale and a 5-volt external programming input would produce a full-scale value at the input.

Figure 2-9 shows the input waveform that would result from the following setup:

CC Mode
60A Range

20A Input (programmed via GPIB or front panel)
± 1V (2 V peak-peak) 1 kHz external programming signal

The external programming signal (+ 1 and - 1 volt) corresponds to + 6 and - 6 amps at the input (1 volt external programming input = 1/10 full scale). Therefore, the input varies ± 6A at the 20A level.

Fault

The Fault signal becomes active if an overvoltage or reverse voltage occurs at the input, as described in the Protection Features paragraphs.

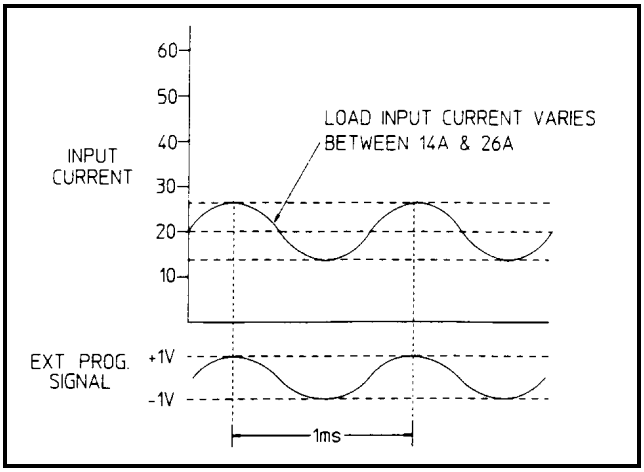


Figure 2-9. External Programming Example

Port On/Off

Port is a general purpose output port that can be used to control an external device such as a relay for power supply test purposes. The output is toggled on and off via the GPIB (**PORT0 ON | OFF** command). It cannot be controlled from the front panel.

The Port output signal is a TTL compatible signal that becomes active (high level) when the **PORT** command is programmed **ON** and becomes inactive (low level) when the **PORT** command is programmed **OFF**.

Input Measurements

Each module's input current, voltage, and power are continuously measured at the front panel.

With remote control in effect, a module may be instructed to measure its dc input voltage, current, or power by sending the appropriate query command (e.g. **MEAS:CURR**). The results will be read back when the electronic load is addressed to talk. Voltage and current measurements are performed with approximately 16-bit resolution of full-scale ratings. Power is computed from this information. Voltage and current are measured simultaneously, so that power data is correct.

All measurements are performed by digitizing the instantaneous input voltage or current for a defined number of samples and sample interval, storing the results in a buffer, and then calculating the measured result. Many parameters of the measurement are programmable. These include the number of samples, the time interval between samples, and the method of triggering. Note that there is a tradeoff between these parameters and the speed, accuracy, and stability of the measurement in the presence of noise. This is described in the *Programming Guide*.

As shipped from the factory, front panel measurements for input voltage and current are calculated from a total of 1000 readings taken at a 10 microsecond sampling rate. There are no trigger controls for front panel measurements. However, you can program both the sampling rate and the number of data points in each front panel measurement using commands in the Sense menu. With this flexibility, measurement accuracy can be improved for waveforms with frequencies as low as several Hertz. The sample buffer size may be varied from 1 to 4096 data points. The sampling rate may be varied from 0.00001 seconds to 0.032 seconds. Values are rounded to the nearest 10-microsecond interval.

DC Measurements

DC voltage and current is measured by acquiring a number of readings at the selected time interval, applying a windowing function to the readings, and averaging the readings. Windowing is a signal conditioning process that reduces the error in dc measurements made in the presence of periodic signals such as line ripple. At power-on and after a *RST command, the interval and number of sample points used for the measurement acquisition is set. Ripple rejection is a function of the number of cycles of the ripple frequency contained in the acquisition window. More cycles in the acquisition window results in better ripple rejection. In addition, the speed of the measurement can be increased by reducing the number of sample points.

To measure the dc input voltage or current using the front panel, press the **Meter** key. The display indicates the present voltage and current reading. Scroll to the appropriate measurement. To measure the voltage or current over the GPIB, use the **MEAS:VOLT?** or **MEAS:CURR?** command.

RMS Measurements

To measure the rms of the input voltage or current, press the **Meter** key and scroll to the V RMS or A RMS menu commands. To measure the rms voltage or current over the GPIB, use **MEAS:VOLT:ACDC?** or **MEAS:CURR:ACDC?**

This returns the total rms measurement, including the dc portion.

Minimum and Maximum Measurements

To measure the maximum or minimum voltage or current, press the **Meter** key and scroll to the V MAX, V MIN, A MAX, or A MIN menu commands. Minimum returns the lowest value in the array; maximum returns the highest value in the array. To measure the maximum/minimum voltage or current over the GPIB, use **MEAS:VOLT:MAX?/MEAS:VOLT:MIN?** or **MEAS:CURR:MAX?/MEAS:CURR:MIN?**

Power Measurements

To measure the average, maximum, or minimum power, press the **Meter** key and scroll to the WATTS, W MAX, or W MIN menu commands. Power is calculated from the latest voltage and current measurements. Use MEASure:POWer? to measure power over the GPIB.

Measurement Ranges

The electronic load has two measurement ranges. The commands that control the measurement ranges are located in the front panel **Sense** menu. To change measurement ranges, scroll to the S:C:RNG or the S:V:RNG commands and enter a value that falls within the range that you wish to set. The electronic load will pick the range with the best resolution for that value. The corresponding SCPI range commands are: **SENS:CURR:RANG** and **SENS:VOLT:RANG**.

3

Installation

Inspection

Damage

When you receive your electronic load, inspect it for any obvious damage that may have occurred during shipment. If there is damage, notify the shipping carrier and nearest Keysight Sales and Support Office immediately. The list of Keysight Sales and Support Offices is at the back of this guide. Warranty information is printed in the front of this guide.

Packaging Material

Until you have checked out the electronic load, save the shipping carton and packing materials in case the unit has to be returned. If you return the electronic load for service, attach a tag identifying the model number and the owner. Also include a brief description of the problem.

Items Supplied

The following user replaceable items are included with your electronic load. Some of these items are installed in the unit.

Table 3-1. Items Supplied

Item	Part Number	Description
Power Cord	Contact nearest Keysight Sales and Support Office	A power cord appropriate for your location.
Trigger/Digital Connector	0360-2693	A 6-pin connector is provided for input and output trigger and digital signals.
Control Connector	0360-2870	A 14-pin control connector is provided for connecting remote sense leads.
Feet	5041-8801	Feet for bench mounting.
User's Guide	5964-8196	Contains installation, checkout, and front panel information.
Programming Guide	5964-8198	Contains detailed GPIB programming information.

Cleaning

Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.

WARNING: To prevent electric shock, unplug unit before cleaning.

Installing the Modules

Procedure

1. With the mainframe off, disconnect the power cord and remove the top cover by loosening the screws with a flat-bladed screwdriver.

2. Remove any packing material from inside the mainframe.

3. Grasp the module using the quarter-turn locking fastener and the input connectors. This reduces the possibility of damage to static sensitive components on the pc board.

4. Start installing the modules in the slot next to the GPIB board (see figure 3-1).

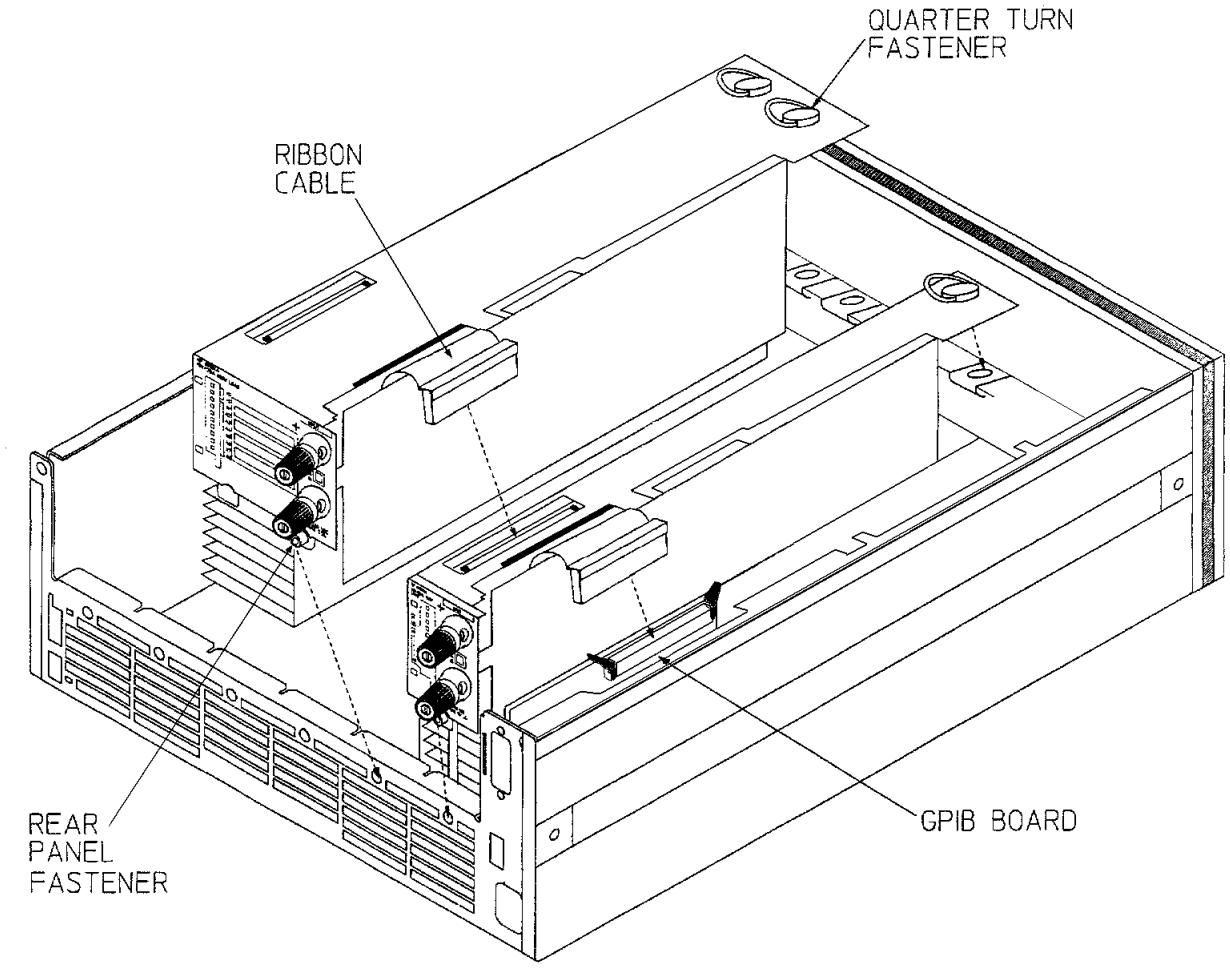


Figure 3-1. Module Installation Diagram

5. Lock the module in place using the quarter-turn locking fastener and the rear panel thumbscrew. Hand-tighten only.

6. Connect the ribbon cable to the adjacent connector pins in the GPIB board (or adjacent module). Make sure the connectors are properly seated.

7. If applicable, install each module in the slot next to the previous module in the same manner (step 3 through 6).

8. Replace the top cover after all modules are installed.

9. Reconnect the power cord.

Channel Number

The channel number of a specific module is determined by the location of that module in relation to the GPIB board. For example, the module next to the GPIB board is always channel number one. Numbering continues sequentially so that the module furthest from the GPIB board is the highest numbered channel in your system.

Figure 3-2 shows the channel assignments for a Keysight N3300A electronic load mainframe containing a N3304A single-width module and a N3305A double-width module. One channel number is automatically assigned to each module according to the order in which it was installed in the mainframe. The maximum number of channels is six for N3300A mainframes, and two for N3301A mainframes.

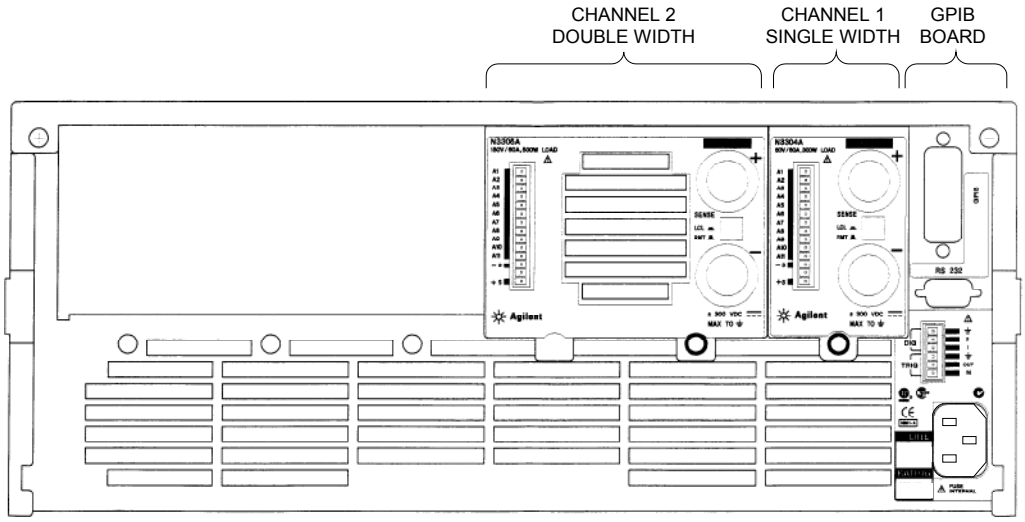


Figure 3-2. Channel Number Example

Location

The outline diagram in figure 3-3A and figure 3-3B gives the dimensions of your electronic load. The electronic load must be installed in a location that allows sufficient space at the sides and back of the unit for adequate air circulation (see Bench Operation).

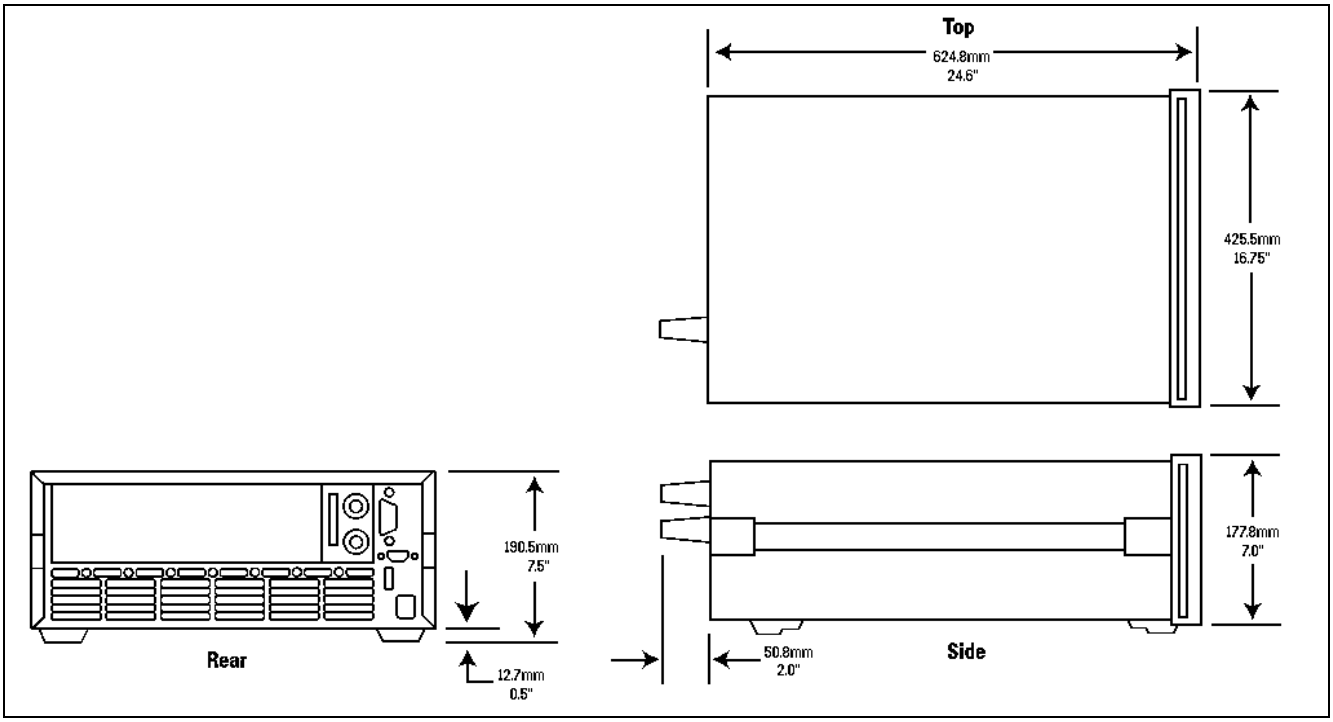


Figure 3-3A. N3300A Outline Diagram

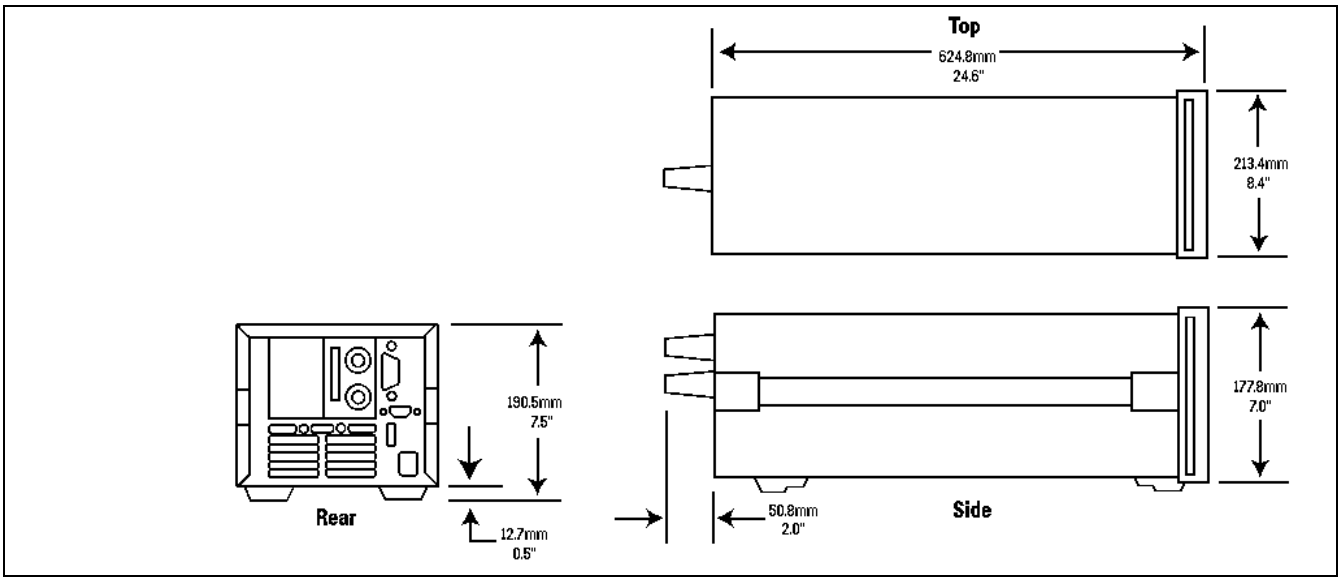


Figure 3-3B. N3301A Outline Diagram

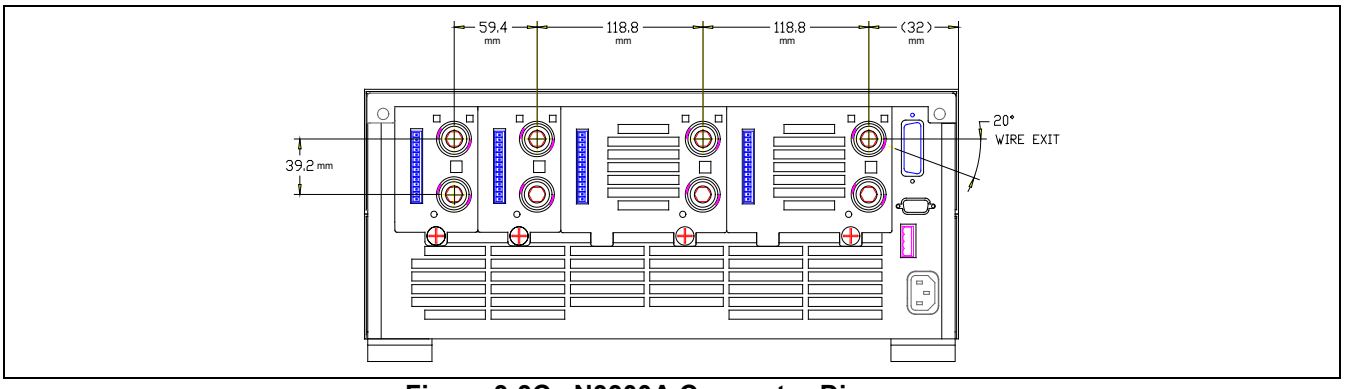


Figure 3-3C. N3300A Connector Diagram

Bench Operation

A fan cools the electronic load by drawing air through the top and sides and exhausting it out the back. Minimum clearances for bench operation are 1 inch (25 mm) along the sides.

Do not block the fan exhaust at the rear of the unit.

Rack Mounting

The N3300A electronic load can be mounted in a standard 19-inch rack panel or cabinet. Rack mount kits are available as Option 908 and 909 (with handles). Support rails are also required for rack mounting. These are normally supplied with the cabinet and are *not* included with the rack mount options.

The N3301A electronic load can also be mounted in a standard 19-inch rack panel or enclosure using an Option 908 rack mount kit (see Figure 3-4). A rack mount kit for joining two half-rack units is available as Option 800. Option 800 must also be used if you are mounting other instruments next to a N3301A electronic load. Support rails are also required for rack mounting. These are normally supplied with the cabinet and are not included with the rack mounting options.

If you are installing equipment on top of your electronic load in the cabinet, use a filler panel above the unit to ensure adequate space for air circulation. A 1U panel (EIA Standard RS-310-C) as shown in Figure 3-4 is sufficient. If your cabinet has a circulation fan, avoid installing the Electronic Load too close to the cabinet fan. The cabinet fan may restrict the airflow required through the Electronic Load.

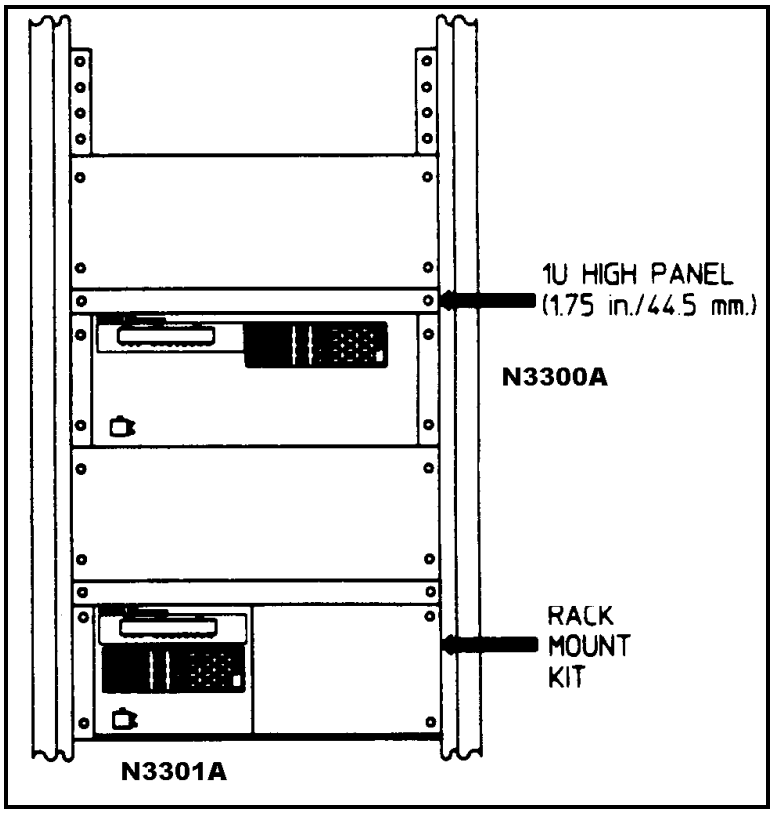


Figure 3-4. Rack Installation

Input Connections

Power Cord

1. Connect the power cord to the IEC 320 connector on the rear of the unit. If the wrong power cord was shipped with your unit, contact your nearest Keysight Sales and Support Office (refer to the list at the back of this guide) to obtain the correct cord. See Figure 3-5 for the part number and ordering options.

WARNING **SHOCK HAZARD** The power cord provides a chassis ground through a third conductor. Be certain that your power outlet is of the three-conductor type with the correct pin connected to earth ground.

Note The detachable power cord may be used as an emergency disconnecting device. Removing the power cord from the ac input connector will disconnect ac input power to the unit.

Option # / Part No.	900 8120 - 1351  United Kingdom	901 8120 - 1369  Australia, New Zealand	902 8120 - 1689  Europe	903 8120 - 4383  United States, Canada
Option # / Part No.	904 8120 - 0698  United States, Canada	906 8120 - 2104  Switzerland	912 8120 - 2956  Denmark	917 8120 - 4211  South Africa, India
Option # / Part No.	918 8120 - 4753  Japan	919 8120 - 6800  Israel	920 8120 - 6869  Argentina	921 8120 - 6980  Chile
Option # / Part No.	922 8120 - 8376  China	L = Line or Active Conductor (also called "live" or "hot") N = Neutral or identified Conductor E = Earth or Safety Ground		

Figure 3-5. Power Cord Configurations

Manually-Tightened Connectors

The standard manually-tightened input connectors are located on the rear panel and are used for connecting unterminated wires directly to the back of the modules.

Two screw-down connectors (+ and –) are provided on each module for connecting the input wires to the electronic load (see figure 3-6a). Connections are made as follows:

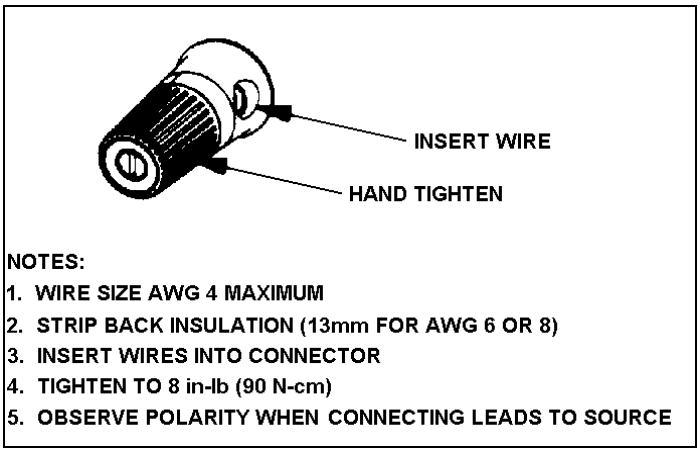


Figure 3-6a. Manual Connector

1. Strip the back wire insulation as indicated

Wire Size	Strip back
AWG 4	16 mm (0.65 in)
AWG 6 or 8	13 mm (0.5 in)
AWG 10 or smaller	10 mm (0.4 in)

2. AWG 4 is the maximum wire size. Stranded copper wire size, AWG 6 or 8 is the recommended wire. If you are connecting more than one wire on each connector, twist the wires to ensure a good contact when the adjustment knob is tightened.

3. Insert the wire into the connector.

WARNING To prevent accidental contact with hazardous voltages, do not extend the wire beyond the contact area inside the input connector.

4. Hand-tighten the adjustment knob to secure the wire in the connector. If you are using a slotted screwdriver, tighten the knob to 8 in-lb (90 N-cm) for a secure connection.

Caution Do not use lubricants or contact cleaners on the connectors. Certain chemical agents can damage the LEXAN material of the connector, causing the part to fail.

8mm Screw Terminal Connector (option UJ1)

The 8mm screw terminal connectors (option UJ1) are located on the rear panel and are used for connecting wires that are terminated by wire lugs to the load modules.

Two 8mm-diameter bolts (+ and –) are provided on each module for connecting the input wires (see figure 3-6b). Connections are made as follows:

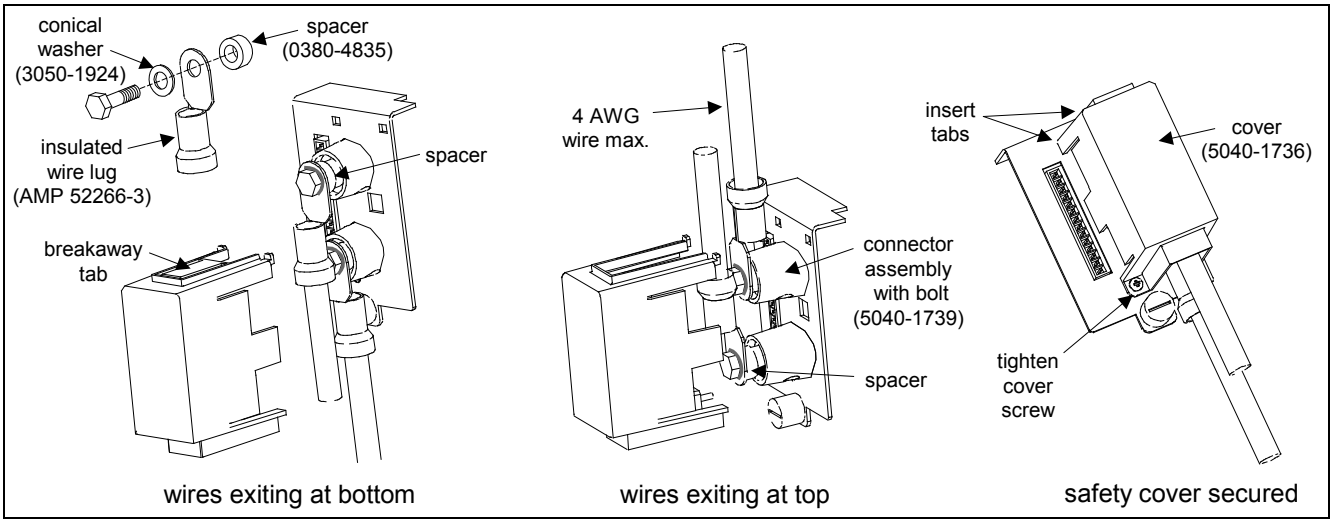


Figure 3-6b. 8mm Screw Terminal Connectors

1. Attach a connecting lug with an insulated ring terminal to the input wires. Connecting lugs must have an opening of at least 8mm in diameter. The recommended wire lug for connecting AWG 4 wire to an 8mm stud is AMP p/n 52266-3. Refer to www.amp.com for information about ordering this wire lug.

2. Wire sizes smaller than the maximum of AWG 4 may be used, provided the wire lugs have the required 8mm diameter opening.

Caution To prevent damaging the wiring insulation, which may result in shorting the input, use the supplied spacer to offset the input wires from each other.

3. Attach the wire lugs to the connector. Place the conical washer *between* the bolt and the wire lug (refer to the exploded view in the upper left corner of figure 3-6b). The wires can exit either out of the top or out of the bottom. Place the supplied spacer *under* the appropriate wire lug to prevent interference between the wires. If the wires exit out of the top, place the spacer on the bottom terminal. If the wires exit out of the bottom, place the spacer on the top terminal.

4. Tighten the bolts to secure the wires to the connectors. Torque the bolts to between 20 and 25 in-lbs (between 225 and 280 N-cm) for a secure connection.

5. Remove the appropriate breakaway tab and install the safety cover over the connectors. Hand-tighten the Torx T10 cover screw.

Wire Considerations

WARNING To satisfy safety requirements, load wires must be heavy enough not to overheat while carrying the short-circuit output current of the device connected to the electronic load. Refer to Table 3-2 for the ampere capacity of various stranded wire sizes.

Input connections are made to the + and – connectors on the back of each module. A major consideration in making input connections is the wire size. The minimum wire size required to prevent overheating may not be large enough to maintain good regulation. It is recommended that stranded, copper wires be used. The wires should be large enough to limit the voltage drop to no more than 0.5 V per lead. Table 3-3 gives the maximum load lead length to limit the voltage drop to the specified limit.

Table 3-2. Stranded Copper Wire Ampere Capacity

Wire Size		Ampacity
AWG	**Cross Section Area in mm^2**	
22		5.0
20		8.33
	0.75	10
18		15.4
	1	13.5
16		19.4
	1.5	16
14		31.2
	2.5	25
12		40
	4	32
10		55
	6	40
8		75
	10	63
6		100
4		135

Notes:

1. Ratings for AWG-sized wires derived from MIL-W-5088B. Ratings for metric-sized wires derived from IEC Publication 335-1.
2. Ampacity of aluminum wire is approximately84% of that listed for copper wire.
3. When two or more wires are bundled together, ampacity for each wire must be reduced to the following percentages:

   2 conductors 94%
   3 conductors 89%
   4 conductors 83%
   5 conductors 76%

4. Maximum temperatures:
   Ambient = 50° C
   Conductor = 105° C

Table 3-3. Maximum Wire Lengths to Limit Voltage Drops

Wire Size		Resistivity		Maximum Length in Meters (Feet) to Limit Voltage Drop to 0.5 V or Less						
AWG	**Cross Section Area in mm2**	**Ω/kft**	**Ω/km**	**5 A**	**10 A**	**20 A**	**30 A**	**40 A**	**50 A**	**60 A**
22		16.15		(6)	(3)	(1.5)	(1)	(0.77)	(0.62)	(0.52)
	0.5		40.1	2.5	1.2	0.6	0.4	0.31	0.25	0.21
20		10.16		(9.5)	(4.5)	(2)	(1.5)	(1.23)	(0.98)	(0.82)
	0.75		26.7	3.7	1.9	0.9	0.6	0.47	0.37	0.31
18		6.388		(15.5)	(7.5)	(3.5)	(2.5)	(2.0)	(1.57)	(1.30)
	1		20.0	5.0	2.5	1.3	0.8	0.63	0.50	0.42
16		4.018		(24.5)	(12)	(6)	(4)	(3.1)	(2.49)	(2.07)
	1.5		13.7	7.3	3.6	1.8	1.2	0.91	0.73	0.61
14		2.526		(39.5)	(19.5)	(9.5)	(6.5)	(4.9)	(3.46)	(3.30)
	2.5		8.21	12.2	6.1	3.0	2.0	1.52	1.22	1.01
12		1.589		(62.5)	(31)	(15.5)	(10.5)	(7.9)	(6.29)	(5.24)
	4		5.09	19.6	9.8	4.9	3.3	2.46	1.96	1.64
10		0.9994		(100)	(50)	(25)	(17)	(12.5)	(10.00)	(8.34)
	6		3.39	29	14.7	7.4	4.9	3.69	2.95	2.96
8		0.6285		(159)	(79)	(39.5)	(27)	(19.9)	(15.91)	(13.25)
	10		1.95	51	25	12.8	8.5	6.41	5.13	4.27
6		0.3953		(252)	(126)	(63)	(40)	(31.6)	(25.30)	(21.07)
	16		1.24	80	40	20	13.4	10.08	8.06	6.72
4		0.2486		(402)	(201)	(100)	(68)	(50.37)	(40.23)	(33.51)

Control Connector

A 14-pin connector and a quick-disconnect mating plug (p/n 0360-2870) are provided on each module for connecting remote sense leads, external V/I monitors, an external programming input, and external control lines (see figure 3-7). The mating plug is packaged in an envelope that is included with the module.

Consistent with good engineering practice, all leads connected to the control connector should be twisted and shielded to maintain the instrument's specified performance. Make all wire connections to the mating plug as required before installing the connector in the module.

A1-A3 Not available

A4 Provides the common connection for the A5 and A6 pins.

A5 A TTL-compatible output signal that becomes active (high level) when the PORT0 command is programmed ON. This signal can be used to control an external device such as a relay for shorting or disconnecting the module's input terminals or as a general purpose digital output port. This signal powers up in the inactive (low-level) state.

A6 A TTL-compatible output (fault) signal that becomes active (high level) when an overvoltage, reverse voltage condition or fault occurs. This signal powers up in the inactive (low-level) state.

A7 Provides the common connection for the external programming input (pin A8).

A8 Connects an external programming input. The CC and CV mode can be programmed with a 0V-to-+10V signal (ac or dc). This signal can act alone or can be combined with values programmed over the GPIB or RS-232. Thus, it is possible to superimpose an ac signal upon a dc level.

A9 Provides the common connection for the current and voltage monitor signals (pins A10 and A11).

A11 and A10 Used to monitor the modules input current and voltage. A 0V-to-+10V signal at the appropriate pin indicates the zero-to-full scale current or voltage. Pin A11 monitors current and pin A10 monitors voltage.

+S and -S Used to connect the remote sense leads to the power source. Pin +S connects the +S signal and pin -S connects the -S signal. Remote sensing can only be used in CV and CR modes, or when using voltage readback.

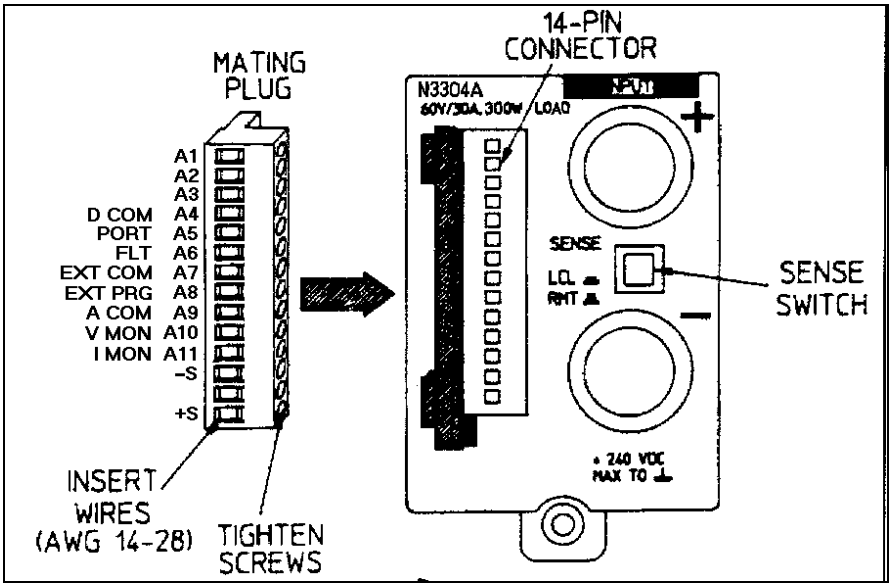


Figure 3-7. Control Connector

Sense Switch

A local/remote sense switch is provided on each module. Unless you are using remote sensing, make sure that the sense switch is set to LCL (depressed). Remote sensing is used in certain applications to achieve better voltage regulation and measurement accuracy (refer to Remote Sense Connections for more information).

NOTE If the sense switch is set to remote operation without having sense leads connected to the sense inputs, the module will continue to work in the CC mode, but the input will turn off in CV and CR modes. Voltage readback will not work in any mode.

Trigger and Digital Connections

A 6-pin connector and a quick-disconnect mating plug are provided on each mainframe for accessing input and output trigger signals as well as two digital output lines (see Figure 3-8).

Consistent with good engineering practice, all leads connected to the connector should be twisted and shielded to maintain the instrument's specified performance.

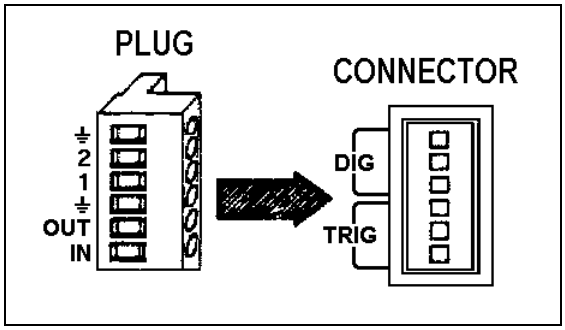


Figure 3-8. Control Connector

TRIG IN A TTL-compatible input that responds to low-level external trigger signals. A trigger applied to this input can be used to change settings (voltage, current, resistance, etc.), toggle between settings in transient-toggle mode, or generate a pulse in transient-pulse mode. An external trigger affects any module that has its external trigger input enabled by the TRIG:SOUR:EXT command.

TRIG OUT A TTL-compatible output signal that becomes active (high-level) whenever the electronic load is triggered by a GPIB command or TRIG IN signal. This signal can be used to trigger external equipment such as oscilloscopes, digitizers, or another electronic load.

TRIG GND Provides the common connection for the trigger signals. This common is directly connected to the chassis.

DIG 1 A programmable digital output line.

DIG 2 A second programmable digital output line.

DIG GND Provides the common connection for the digital signals. This common is directly connected to the chassis.

Computer Connections

The electronic load can be controlled through a GPIB interface or through an RS-232 interface.

GPIB Interface

Each electronic load has its own GPIB bus address, which can be set using the front panel **Address** key as described in Chapter 5. GPIB address data is stored in a non-volatile memory. The electronic load is shipped with its GPIB address set to 5.

Electronic loads may be connected to the GPIB interface in series configuration, star configuration, or a combination of the two, provided the following rules are observed:

- The total number of devices including the GPIB interface card is no more than 15.
- The total length of all cables used is no more than 2 meters times the number of devices connected together, up to a maximum of 20 meters. (Refer to Table 2-2 for a list of GPIB cables available from Keysight Technologies.)
- Do not stack more than three connector blocks together on any GPIB connector.
- Make sure all connectors are fully seated and the lock screws are firmly finger-tightened.

RS-232 Interface

The electronic loads have an RS-232 programming interface, which is activated by commands located in the front panel **Address** menu. All applicable SCPI commands are available through RS-232 programming. When the RS-232 interface is selected, the GPIB interface is disabled.

The RS-232 connector is a DB-9, male connector as shown in figure 3-9. Adapters are available to connect the electronic load to any computer or terminal with a properly configured DB-25 connector (see Table 2-2).

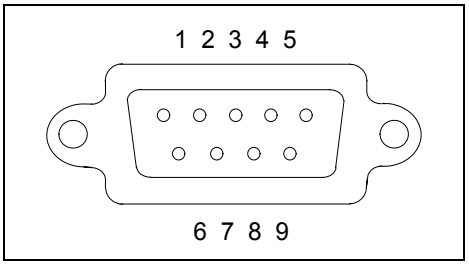


Figure 3-9. RS-232 Connector

Pin	Input/Output	Description
1	-	no connection
2	Input	Receive Data (RxD)
3	Output	Transmit Data (TxD)
4	-	not applicable
5	Common	Signal ground
6	-	not applicable
7	Output	Request to Send (RTS)
8	Input	Clear to Send (CTS)
9	-	No connection

Application Connections

Local Sense Connections

Figure 3-10 illustrates a typical setup with module number 1 connected for constant current or constant resistance operation. Local sensing is used in applications where lead lengths are relatively short, or where load regulation is not critical. The sense switch must be set to **LCL**. Load leads should be bundled or tie-wrapped together to minimize inductance.

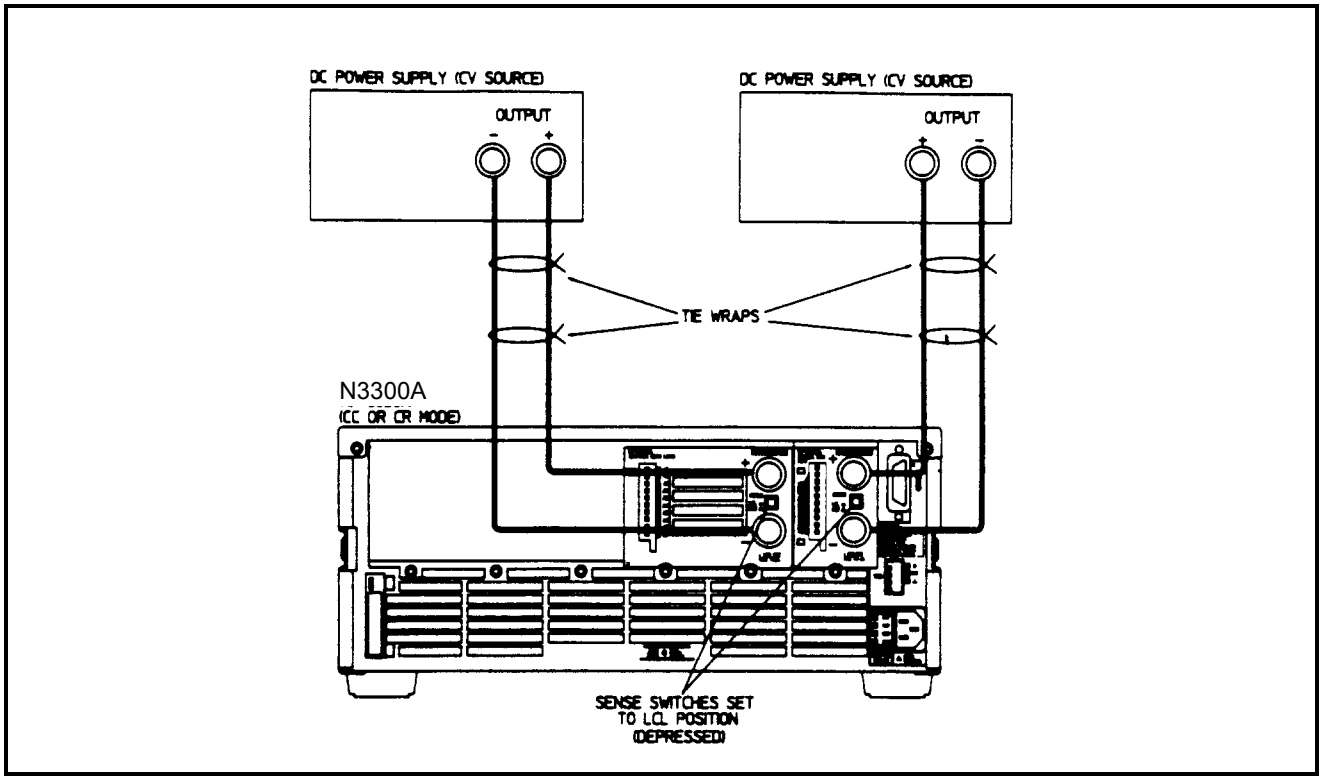


Figure 3-10. Local Sensing

Remote Sense Connections

Figure 3-11 illustrates a typical setup with module number 1 connected for remote sense operation. The remote sense terminals of module 1 are connected to the output of the power supply. Remote sensing compensates for the voltage drop in applications that require long lead lengths. This is only useful when module 1 is operating in CV or CR mode. Remote voltage sensing also provides greater accuracy when using voltage readback in all operating modes. The sense switch must be set to **RMT**. Load leads should be bundled or tie wrapped together to minimize inductance.

Parallel Connections

Figure 3-12 illustrates how modules can be paralleled for increased power dissipation. Up to six modules in one mainframe can be directly paralleled in CC or in CR mode. Modules *cannot* be paralleled in CV mode. Each module will dissipate the power it has been programmed for. For example, if two modules are connected in parallel, with module number 1 programmed for 10 A and module number 2 programmed for 20A, the total current drawn from the source is 30 A.

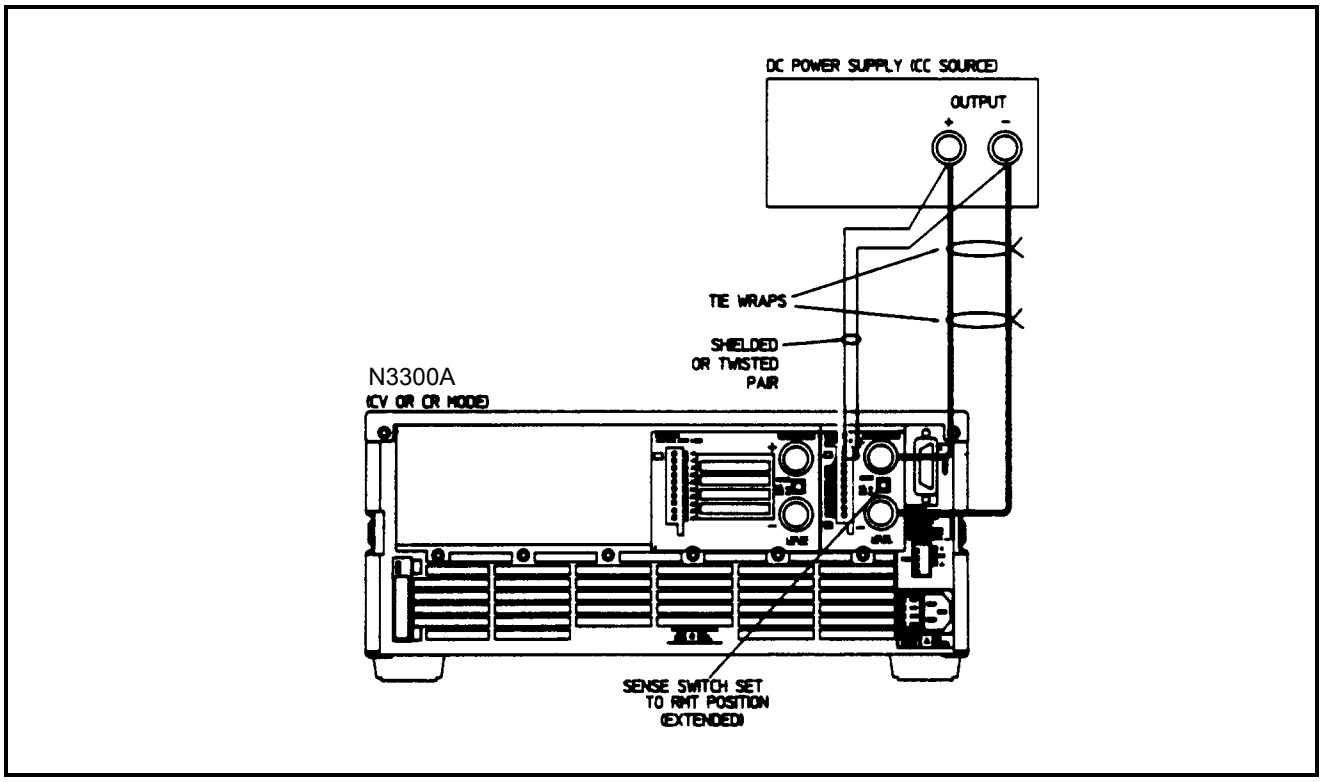


Figure 3-11. Remote Sensing

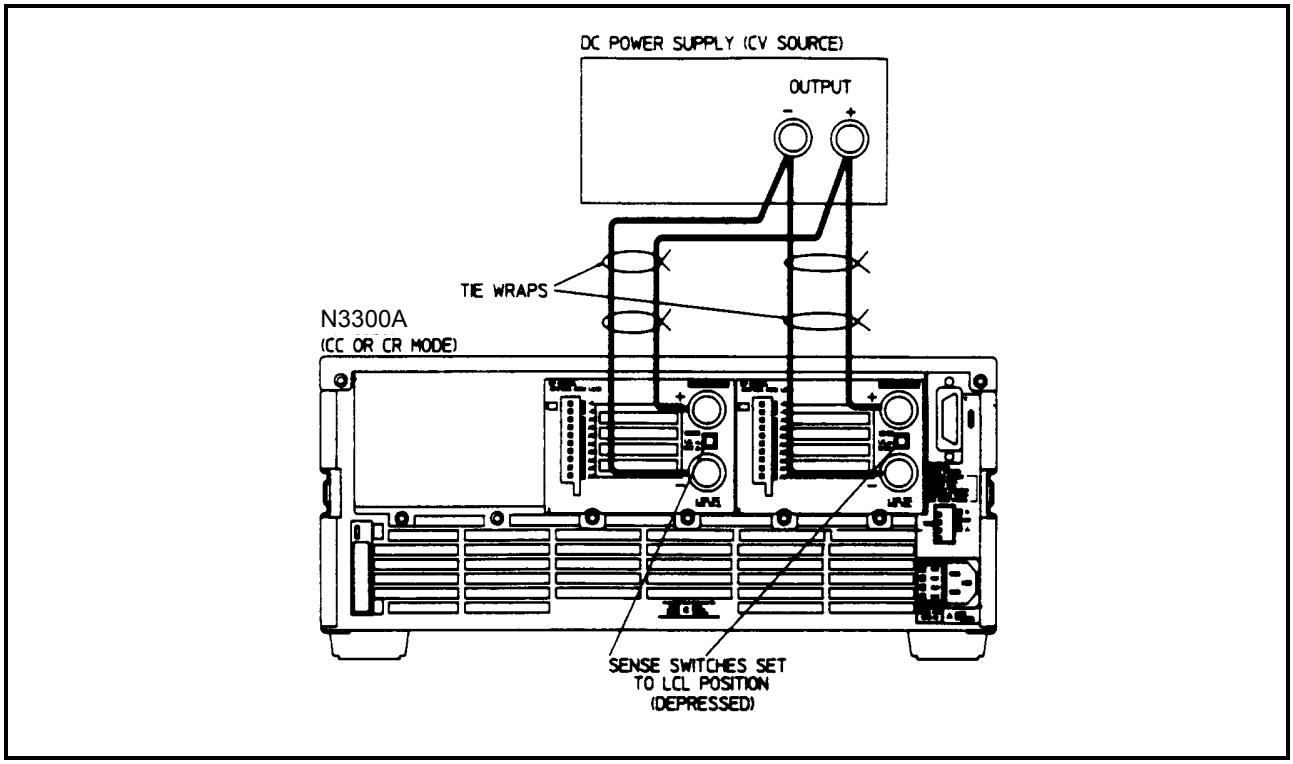


Figure 3-12. Parallel Operation

In Figure 3-12, all lead connections are terminated at the source. Each module is connected to the source using separate wires. Using the source as the current distribution point allows larger wires to be used for each module connection and also reduces the common impedance inherent in daisy-chained configurations.

If because of lead length or other considerations, lead connections cannot be made at the source, a remote distribution terminal may be required. Lead connections can also be daisy-chained across the module input connectors as long as the total current draw is less than the ampere-rating of AWG 8 wire (see Table 3-2). This is because two wires larger than AWG 8 cannot both fit inside the module input connectors.

Low Voltage Operation

When operating below 3 volts, the slew rate and input current are derated, as shown in figure A-1. If these conditions are not acceptable for your application, then it is recommended that you use an external dc power supply to boost the voltage across the load terminals to above 3 volts, as shown in figure 3-13.

Remote sensing is recommended in this configuration, as illustrated in Figure 3-13. The load leads connect to both the boost supply and the DUT, but the remote sense leads connect directly to the DUT. This allows the voltage readback to measure the voltage at the DUT alone, and also improves load regulation in CV and CR modes.

In this configuration, power from both the boost supply and the DUT must be absorbed by the electronic load. A higher power load module may now be needed. Also, the boost supply must have adequate ratings to allow the DUT to produce its full rated current. Finally, and noise generated by the boost supply will affect measurements made on the DUT. A boost supply with suitable noise specifications should be selected.

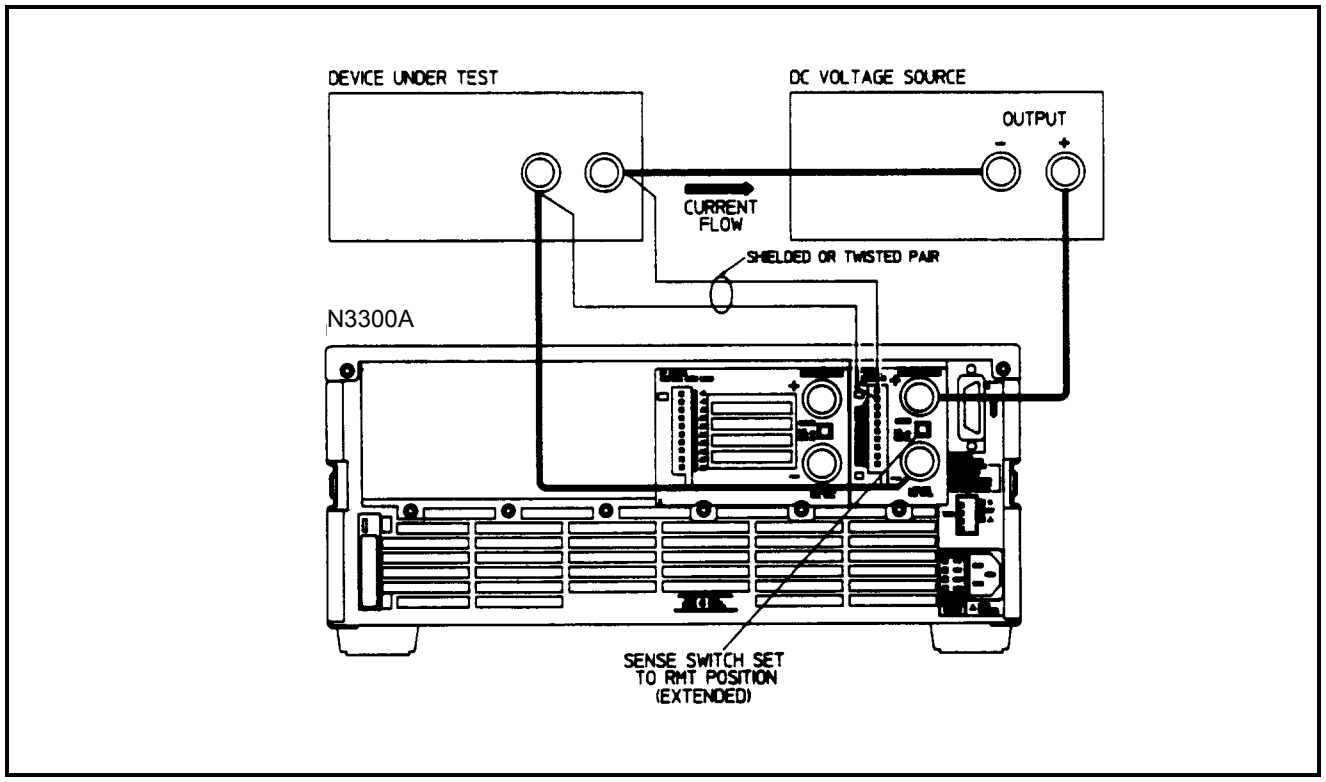


Figure 3-13. Zero Volt Loading

4

Turn-On Checkout

Introduction

Successful tests in this chapter provide a high degree of confidence that the electronic load is operating properly. For verification tests, see Appendix B.

NOTE: This chapter provides a preliminary introduction to the electronic load front panel. See Chapter 5 for more detail.

Checkout Procedure

The tests in this section checks for proper operation of the electronic load. If you have not already done so, connect the power cord to the unit and plug it in.

The following procedure assumes that the unit turns in the factory-default state. If you need more information about the factory default state, refer to the *RST command in Chapter 4 of the Programming Guide. Note that the values shown in the Display column may not exactly match the values that appear on the front panel of your unit.

Table 4-1. Checkout Programming Values

Model	Voltage	Current	Note
All	10V	10A	The settings of the power supply and the values used in the procedure were selected so that they can be used with any module. You can use different settings, but the results of the test will differ from the results shown below.

	Procedure	Display	Explanation
1.	Turn the unit on. The electronic load undergoes a self-test when you first turn it on.	********** 1 0.00 0.00	During selftest, all display segments are briefly lit, followed by the channel number displayed and the CC annunciator on.
2.	Check that the electronic load fan is on.		You should be able to hear the fan and feel the air coming from the back of the unit.
3.	Connect a 10V, 10A power supply to the input connectors of the first channel of the electronic load.		
4.	Set the power supply voltage to 10V and current limit to 10A.	1 10.00 0.00	Observe the front panel. It should display the voltage that the power supply was set to.
5.	Depress the following front panel keys in the indicated order:	1 10.00 4.99	The electronic load is drawing 5A and is operating in the CC mode. The CC

	Current , 5, Enter.			annunciator is on. The power supply should be operating in the CV mode.
6.	Depress the Meter key followed by the scroll key.	1	50 W	The display shows the computed input power for the selected channel.
7.	Repeat steps 3 through 6 for any other modules in the mainframe.			
8.	Turn off electronic load, disconnect power supply and continue with rear panel connections.			

NOTE: If the Err annunciator on the display is on, press the **Shift** key followed by the **Error** key to see the error number. See Table 4-2 for a list of errors.

In Case of Trouble

Error Messages

Electronic load failure may occur during power-on Selftest or during operation. In either case, the display may show an error message that indicates the reason for the failure.

Selftest Errors

Pressing the Shift, Error keys will show the error number. On the front panel, selftest error messages appear as; ERROR <n> where "n" is a number listed in the following table. Some values consist of a number followed by the affected channel. If this occurs, turn the power off and then back on to see if the error persists. If the error message persists, the electronic load requires service. Refer to the list of Keysight Sales and Support Offices at the back of this manual.

Table 4-2 Selftest Error Codes

Error	Failed Test
0	No error
2	Non-volatile RAM CONFIG section checksum failed
4	Non-volatile RAM STATE section checksum failed
5	Non-volatile RAM RST section checksum failed
10	RAM selftest failed
11<channel>	CVDAC selftest 1 failed on specified channel (01 - 06)
12<channel>	CVDAC selftest 2 failed on specified channel (01 - 06)
13<channel>	CCDAC selftest 1 failed on specified channel (01 - 06)
14<channel>	CCDAC selftest 2 failed on specified channel (01 - 06)
15<channel>	CRDAC selftest 1 failed on specified channel (01 - 06)
16<channel>	CRDAC selftest 2 failed on specified channel (01 - 06)
17	ADC buffer failed
18<channel>	LIMIT section checksum failed on specified channel (01 - 06)
19<channel>	CAL section checksum failed on specified channel (01 - 06)
20	Input Down
40	Flash write failed
42	Flash erase failed
80	Digital I/O selftest error

5

Front Panel Operation

Introduction

Here is what you will find in this chapter:

- A complete description of the front panel controls
- Front panel programming examples.

NOTE: The electronic load must be set in Local Mode to use the front panel controls. Press the Local key on the front panel to put the unit in Local Mode.

Front Panel Description

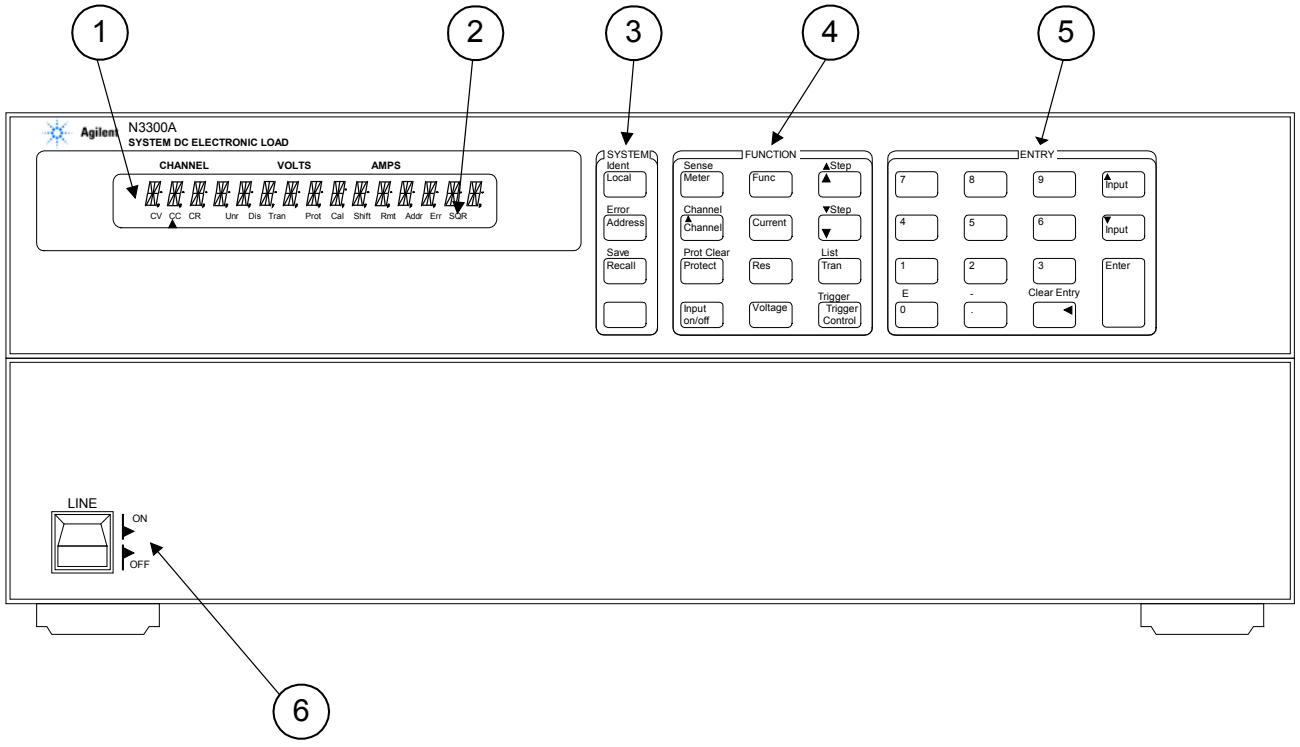


Figure 5-1 Front Panel, Overall View

①Display

15-character fluorescent display for showing measurements and programmed values.

②Annunciators

Annunciators light to indicate operating modes and status conditions:

ϕ1	A list is in progress
CV	The electronic load channel is in constant-voltage mode.
CC	The electronic load channel is in constant-current mode.
CR	The electronic load channel is in constant-resistance mode.
Unr	The electronic load channel is in an unregulated state.
Dis	The electronic load channel measurement is disabled (off).
Tran	The electronic load channel is in transient operation.
Prot	One of the electronic load's channel protection feature is activated.
Cal	The electronic load is in calibration mode.
Shift	The Shift key is pressed to access an alternate key function.
Rmt	The selected interface (GPIB or RS-232) is in a remote state.
Addr	The interface is addressed to talk or to listen.
Err	There is a message in the SCPI error queue.
SQR	The interface is requesting service from the controller.

③System Keys

The system keys let you:
Return to Local mode (front panel control).
Set the electronic load GPIB address.
Set the RS-232 interface communication baud rate and parity bit.
Display SCPI error codes and clear the error queue.
Save and recall up to 10 instrument operating configurations.

④ Function Keys

Function access command menus that let you:
Select CC, CR and CV modes.
Select channel.
Select Current, Resistance and Voltage levels.
Set Trigger and Transient levels.
Set up front panel measurements.

⑤ Entry Keys

Entry keys let you:
Enter programming values.
Increment or decrement programming values.
▲ Enter and **▼ Enter** select the front panel menu parameters.

⑥Line

This turns the electronic load on or off.

System Keys

Refer to the examples later in this chapter for more details on the use of these keys.

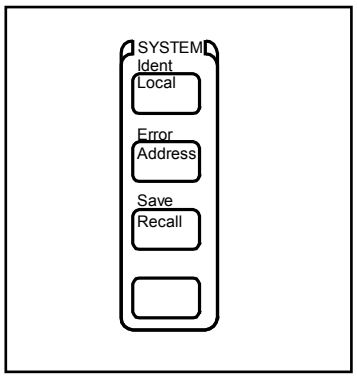


Figure 5-2. System Keys

[ ] This is the blue, unlabeled key, which is also shown as shift in this guide. Pressing this key accesses the alternate or shifted function key (such as ERROR). Release the key after you press it. The Shift annunciator is lit, indicating that the shifted keys are active.

[Local] Press to change the electronic load's selected interface from the remote operation to local (front panel) operation. Pressing the key will have no effect if the interface state is already Local, Local-with-Lockout, or Remote-with-Lockout.

[Address] Press to access the system address menu. This menu lets you configure the electronic load's interface. Address Menu entries are stored in non-volatile memory.

Display	Command Function
ADDRESS <value>	Sets the GPIB address
INTF <char>	Selects an interface (GPIB or RS-232)
BAUDRATE <value>	Selects baud rate (300, 600, 1200, 2400, 4800, 9600)
PARITY <char>	Message parity (NONE, EVEN, ODD, MARK, SPACE)
FLOW <char>	Flow control (RTS-CTS, NONE)

value = numeric value

char = a character string parameter

Use [▲] and [▼] to scroll through the command list

Use [▲Input] and [▼Input] to scroll through the parameter list

[Recall] Press to place the electronic load into a previously stored state. You can recall up to 10 (0 through 9) previously stored states. Only locations 0, 7, 8, and 9 are non-volatile.

[Shift] [Ident] Displays full scale voltage and current for the present channel. It can be used to identify which modules are installed in the selected channel locations.

[Shift] [Error] Press to display the system error codes stored in the SCPI error queue. This action also clears the queue. If there is no error in the queue, 0 is displayed.

[Shift] [Save] Press to store an existing electronic load state in memory. The parameters saved are listed under *SAV in the electronic load Programming Guide. You can save up to 10 states (0 through 9). Only memory locations 0, 7, 8, or 9 are non-volatile. Data saved in locations 1 through 6 will be lost when the unit is turned off.

Function keys

Refer to the examples later in this chapter for more details on the use of these keys.

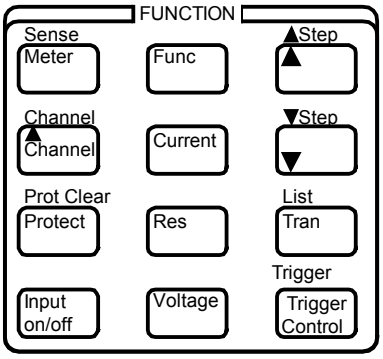


Figure 5-3. Function Keys

Immediate Action Keys

Immediate action keys immediately execute their corresponding function when pressed. Other function keys have commands underneath them that are accessed when the key is pressed.

Input On/Off

This key toggles the input of the electronic load between the on and off states. It immediately executes its function as soon as you press it. When off, the electronic load input is disabled and the **Dis** annunciator is on.

▲ Channel

Selects another channel.

Shift **Trigger**

Causes a trigger to occur. The trigger system must first be initiated by pressing **Trigger Control** and **Enter**. Triggers are used to generate transients or lists.

Protect

Displays any protection functions that are tripped.

Shift **Prot Clear**

Press this key to reset the protection circuit and allow the unit to return to its last programmed state. The condition that caused the protection circuit to become active must be removed prior to pressing this key, or the unit will shut down again and display the **Prot** annunciator again.

Meter

Takes the front panel back to the Metering mode from any other mode.

Scrolling Keys

▲ ▼

Scrolling keys let you move through the commands in the presently selected function menu. Press ▼ to bring up the next command in the list. Press ▲ to go back to the previous command in the list. Function menus are circular; you can return to the starting position by continuously pressing either key

▲ Step ▼ Step

These keys let you scroll through points in a list function. When the display indicates EOL, the end of the list has been reached.

▲ Channel

Press this key to scroll through all channels in the mainframe

Metering Keys

Metering keys control the metering functions of the electronic load. As set from the factory, all front panel measurements are calculated from a total of 1000 readings taken at a 10 microsecond sampling rate. Therefore, the factory default acquisition time for a single front panel measurement is about 10 milliseconds. Refer to "Making Front Panel Measurements" for more information about changing the front panel sampling rate and the number of measurement points.

Meter

Takes the front panel back to the Metering mode from any other mode.

Also accesses the meter menu. This menu lets you measure various parameters of the selected input.

Display	Measurement
<chan> <voltage> <current>	Displays the voltage and current of the selected channel
<chan> <value> V MAX	Displays the maximum voltage
<chan> <value> V MIN	Displays the minimum voltage
<chan> <value> V RMS	Displays the rms voltage
<chan> <value> A MAX	Displays the maximum current
<chan> <value> A MIN	Displays the minimum current
<chan> <value> A RMS	Displays the rms current
<chan> <value> WATTS	Displays the input power
<chan> <value> W MAX	Displays the maximum power
<chan> <value> W MIN	Displays the minimum power

Shift Sense

Specifies the measurement functions and ranges.

Display	Command Function
S:PNT	Defines the number of data points in the measurement
S:TIN	Sets the digitizer sample spacing
S:WIN	Sets the measurement window function
S:OFF	Defines the data offset in the measurement
S:C:RNG	Selects the current measurement range
S:V:RNG	Selects the voltage measurement range

Notes:

Use ▼ and ▲ to scroll through the menu commands
Use ▼ Input and ▲ Input to scroll through the command parameters

Input Control Keys

Input control keys control the input functions of the electronic load.

Shift **Channel**

Press this key to select another channel. Enter the channel number using the Entry Keys. (This key performs the same function as ▼ **Channel**.)

Current

Press this key to access the current menu.

Display	Command Function
CURR <value>	Sets the current of input
C:MODE	Sets the current mode to FIX or LIST
C:RANG	Sets the current range
C:SLEW	Sets the current slew rate for both positive and negative transitions
C:SLW:N	Sets the current slew rate for the negative transitions
C:SLW:P	Sets the current slew rate for the positive transitions
C:TLEV	Sets the current transient input level
C:TRIG	Sets the current trigger input level

Res

Press this key to access the resistance menu.

Display	Command Function
RES <value>	Sets the resistance of input
R:MODE	Sets the resistance mode to FIX or LIST
R:RANG	Sets the resistance range
R:SLEW	Sets the resistance slew rate for both positive and negative transitions
R:SLW:N	Sets the resistance slew rate for the negative transitions
R:SLW:P	Sets the resistance slew rate for the positive transitions
R:TLEV	Sets the resistance transient input level
R:TRIG	Sets the resistance trigger input level

Voltage

Press this key to access the voltage menu.

Display	Command Function
VOLT <value>	Sets the voltage of input
V:MODE	Sets the voltage mode to FIX or LIST
V:RANG	Sets the voltage range
V:SLEW	Sets the voltage slew rate for both positive and negative transitions
V:SLW:N	Sets the voltage slew rate for the negative transitions
V:SLW:P	Sets the voltage slew rate for the positive transitions
V:TLEV	Sets the voltage transient input level
V:TRIG	Sets the voltage trigger input level

Func

Press this key to access the function menu.

Display	Command Function
FUNC <char>	Selects the input regulation mode (CURR, RES, VOLT)
FNC:MODE	Selects what controls the regulation mode (FIX or LIST)
INP:SHOR	Enables or disables the input short (ON, OFF)

Notes

Use ▼ and ▲ to scroll through the menu commands
Use ▼ **Input** and ▲ **Input** to scroll through the command parameters

Transient Control Keys

Transient control keys control the transient functions of the electronic load.

Tran

Press this key to access the function menu.

Display	Command Function
TRAN <value>	Sets the current of input
T:DCYC	Sets the current mode to FIX or LIST
T:FREQ	Sets the current slew rate for both positive and negative transitions
T:MODE	Sets the current slew rate for the negative transitions
T:TWID	Sets the current slew rate for the positive transitions

Trigger Control Keys

Trigger control keys control the trigger functions of the electronic load.

Trigger Control

Press this key to access the function menu.

Display	Command Function
INIT:IMMED	Sets the current of input
ABORT	Sets the current mode to FIX or LIST

List Control Keys

List control keys control the list functions of the electronic load.

List

Press this key to access the function menu.

Display	Command Function
LIST:STEP	Sets the method of incrementing steps (ONCE, AUTO)
LST:CNT	Specifies the number of times the list is cycled
DWEL:0 EOL	Specifies the time period of each step
CURR:0 EOL	Specifies the current setting for each step
C:RANG:0 EOL	Specifies the current range for each step
C:SLEW:0 EOL	Sets the current slew rate for each step
C:SLW:N:0 EOL	Sets the negative current slew rate for each step
C:SLW:P:0 EOL	Sets the positive current slew rate for each step
C:TLEV:0 EOL	Sets the transient input current for each step
FUNC:0 EOL	Sets the list regulation mode (CURR, RES, VOLT)
RES:0 EOL	Specifies the resistance setting for each step
R:RANG:0 EOL	Specifies the resistance range for each step
R:SLEW:0 EOL	Sets the resistance slew rate for each step
R:SLW:N:0 EOL	Sets the negative resistance slew rate for each step
R:SLW:P:0 EOL	Sets the positive resistance slew rate for each step
R:TLEV:0 EOL	Sets the transient input resistance for each step
TRAN:0 EOL	Enables/disables the transient level for each step
T:DCYC:0 EOL	Sets the transient duty cycle for each step
T:FREQ:0 EOL	Sets the transient frequency for each step
T:MODE:0 EOL	Sets the mode of the transient generator (CONT, PULSE)
T:TWID:0 EOL	Sets the transient pulse width for each step
VOLT:0 EOL	Specifies the voltage setting for each step
V:RANG:0 EOL	Specifies the voltage range for each step
V:SLEW:0 EOL	Sets the voltage slew rate for each step
V:SLW:N:0 EOL	Sets the negative voltage slew rate for each step
V:SLW:P:0 EOL	Sets the positive voltage slew rate for each step
V:TLEV:0 EOL	Sets the transient input voltage for each step

Entry Keys

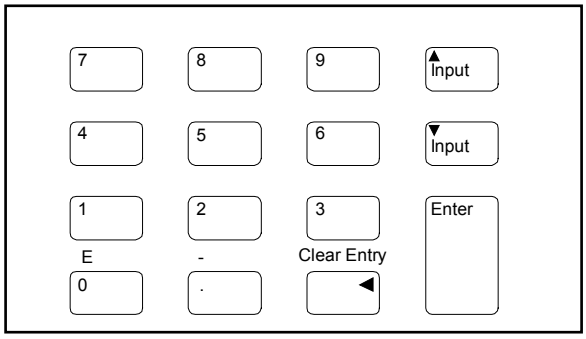


Figure 5-4 Entry Keys

▲ Input **▼ Input**

These keys perform two functions. In Meter mode, these keys can be used to adjust the present input current, voltage, or resistance - depending on which function is presently active (indicated by the CC, CR, or CV annunciator).

In menu mode, these keys let you scroll through choices in a **parameter** list that apply to a specific command. Parameter lists are circular; you can return to the starting position by continuously pressing either key. If the command has a numeric range, these keys increment or decrement the existing numeric value.

◄

The backspace key deletes the last digit entered from the keypad. This key lets you correct one or more wrong digits before they are entered.

0 – **9** , **.**

0 through **9** are used for entering numeric values. **.** is the decimal point. For example, to enter 33.6 press: **3, 3, . , 6, Enter**.

Enter

This key executes the entered value or parameter of the presently accessed command. Until you press this key, the parameters you enter with the other Entry keys are displayed but not entered into the electronic load. Before pressing **Enter**, you can change or abort anything previously entered into the display. After **Enter** is pressed, the electronic load returns to Meter mode.

Shift **E**

This is used to enter an exponent value in the numeric field. Pressing these keys displays an E in the field. Enter the value of the exponent following the E, then press **Enter**.

Shift **-**

This is used to enter either a negative number or a negative exponent value in the numeric field. Pressing these keys displays an - in the field. Enter the numeric value then press **Enter**.

Shift **Clear Entry**

This is used to clear the numeric field of an entered value before the **Enter** key has been pressed. After clearing the field, a new number can be entered.

Examples of Front Panel Programming

You will find these examples on the following pages:

1. Using the front panel display.
2. Programming constant current, voltage, and resistance modes.
3. Programming transient operation.
4. Programming lists.
5. Querying and Clearing Output Protection and Errors
6. Making basic front panel measurements
7. Setting GPIB address or RS-232 parameters.
8. Saving and recalling operating states.

Similar examples are given in the electronic load Programming Guide using SCPI commands.

1 - Using the Front Panel Display

	Action	Display
1.	Press **Meter** to return the display to Meter mode. Press ▲**Channel** to scroll through the channels. The left-most digit of the front panel display identifies the input channel that is presently being controlled by the front panel. You can only select an input when the unit is in metering mode. Once an input has been selected, only the menu commands that apply to that input will appear on the display. The CV, CC, and UNR annunciators apply to the selected channel.	1 7.003V 0.004A

2 - Programming Constant Current, Voltage and Resistance Modes

This example shows you how to set the input voltage, current and resistance modes.

Set the constant current mode input

	Action	Display
1.	On the Function keypad, press ▲ **Channel** to scroll through the channels until channel 1 appears on the display.	1
2.	On the Function keypad, press **Input On/Off** to turn input off.	**Dis** annunciator on
3.	On the Function keypad, press **Func**. On the Entry keypad, press ▲ Input or ▼ Input key until the current function is displayed, then press **Enter.**	FUNC CURR
4.	On the Function keypad, press **Current**. On the Function keypad, press ▲ key until current is displayed.	CURR
5.	On the Entry keypad press **1.25 Enter.**	CURR 1.25
6.	On the Function keypad, press **Current**. On the Function keypad, press ▲ key until current slew is displayed.	C:SLW
7.	On the Entry keypad press **30000 Enter.**	C:SLW 30000
8.	On the Function keypad, press **Current**. On the Function keypad, press ▲ key until current transient is displayed.	C:TLEV
9.	On the Entry keypad press **2 Enter.**	C:TLEV 2

10.	On the Function keypad, press **Input On/Off** to turn input on.	**Dis** annunciator off
11.	To make minor changes to an existing value: On the Function keypad, press **Current**. On the Entry keypad, press **▲Input or ▼ Input** to scroll from 1.25 to 2.25. Then press **Enter**.	CURR 2.25

Set the constant resistance mode input

	Action	Display
1.	On the Function keypad, press ▲ **Channel** to scroll through the channels until channel 1 appears on the display.	1
2.	On the Function keypad, press **Input On/Off** to turn input off.	**Dis** annunciator on
3.	On the Function keypad, press **Func**. On the Entry keypad, press ▲ Input or ▼ Input key until the resistance function is displayed, then press **Enter.**	FUNC:RES
4.	On the Function keypad, press **Res**. On the Function keypad, press ▲ key until resistance is displayed.	RES
5.	On the Entry keypad press **900 Enter.**	RES 900
6.	On the Function keypad, press **Res**. On the Function keypad, press ▲ key until resistance transient is displayed.	R:TLEV
7.	On the Entry keypad press **1000 Enter.**	R:TLEV 1000
8.	On the Function keypad, press **Input On/Off** to turn input on.	**Dis** annunciator off
9.	To make minor changes to an existing value: On the Function keypad, press **Res**. On the Entry keypad, press **▲Input or ▼ Input** to scroll from 900 to 950. Then press **Enter**.	RES 950

Set the constant voltage mode input

	Action	Display
1.	On the Function keypad, press ▲ **Channel** to scroll through the channels until channel 1 appears on the display.	1
2.	On the Function keypad, press **Input On/Off** to turn input off.	**Dis** annunciator on
3.	On the Function keypad, press **Func**. On the Entry keypad, press ▲ Input or ▼ Input key until the voltage function is displayed, then press **Enter.**	FUNC VOLT
4.	On the Function keypad, press **Voltage**. On the Function keypad, press ▲ key until voltage is displayed.	VOLT
5.	On the Entry keypad press **6 Enter.**	VOLT 6
6.	On the Function keypad, press **Voltage**. On the Function keypad, press ▲ key until voltage slew is displayed.	V:SLW
7.	On the Entry keypad press **30000 Enter.**	V:SLW 30000
8.	On the Function keypad, press **Voltage**. On the Function keypad, press ▲ key until voltage transient is displayed.	V:TLEV
9.	On the Entry keypad press **4 Enter.**	V:TLEV 4
10.	On the Function keypad, press **Input On/Off** to turn input on.	**Dis** annunciator off
11.	To make minor changes to an existing value: On the Function keypad, press **Voltage**. On the Entry keypad, press **▲Input or ▼ Input** to scroll from 6.000 to 7.000. Then press **Enter**.	VOLT 7.000

3 - Programming Transient Operation

Transient operation can be used in the CC, CR or CV mode. It causes the selected channel to switch between two load levels.

Set transient operation for Continuous mode

In the following example, assume that the CC mode is active, the slew rate is at the default setting (maximum rate), and the applicable transient operation parameters have been set as follows: continuous mode, main current level = 5A, transient current level = 10 A, transient frequency = 1kHz, transient duty cycle = 40.

The load module starts conduction at the main level (in this case 5 amps). When transient operation is turned on the module input current will slew to and remain at 10 A for 40% of the period (400 μs), then slew to and remain at 5 A for the remaining 60% (600 μs) of that cycle. This cycle is repeated on a continuous basis. Figure 5-5 shows the waveform that would result in this example.

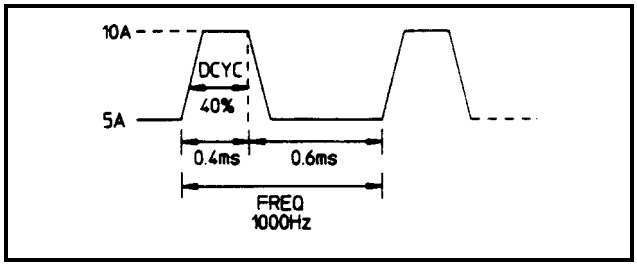


Figure 5-5. Continuous Transient Operation

	Action	Display
1.	On the Function keypad, press **Current**. On the Entry keypad, press **5 Enter** .	CURR 5
2.	On the Function keypad, press **Current**. On the Function keypad, press ▲ key until transient current is displayed.	C:TLEV
3.	On the Entry keypad press **10 Enter.**	C:TLEV 10
4.	On the Function keypad, press **Tran**. On the Function keypad, press ▲ key until transient duty cycle is displayed.	T:DCYC
5.	On the Entry keypad press **40 Enter.**	T:DCYC 40
6.	On the Function keypad, press **Tran**. On the Function keypad, press ▲ key until transient frequency is displayed.	T:FREQ
7.	On the Entry keypad press **1000 Enter.**	1000
8.	On the Function keypad, press **Tran**. On the Function keypad, press ▲ key until transient mode is displayed.	T:MODE
9.	To select the continuous mode, press the **▲Input or ▼ Input** key until the Continuous mode is displayed. Then press **Enter**.	T:MODE CONT
10.	On the Function keypad, press the **Tran** key and select ON to activate the transient mode.	TRAN ON

Set transient operation for Pulse mode

In this example, assume that the CC mode is active, the slew rate is at the factory default setting (maximum rate), and the applicable transient operation parameters have been set as follows: pulse mode, main current level = 5 A, transient current level = 10 A, pulse width = 1 millisecond.

In this example, the electronic load starts conduction at the main current level setting (5 amps). When the transient mode is turned on and an external trigger signal is received, module input current will slew to and remain at 10 A for the remainder of the 10 millisecond time period, then slew to and remain at 5 A until another trigger is received. Any triggers that occur during the time the transient level is in effect will extend the pulse by another 10 milliseconds. Figure 5-6 shows the waveform that would result in this pulsed transient example.

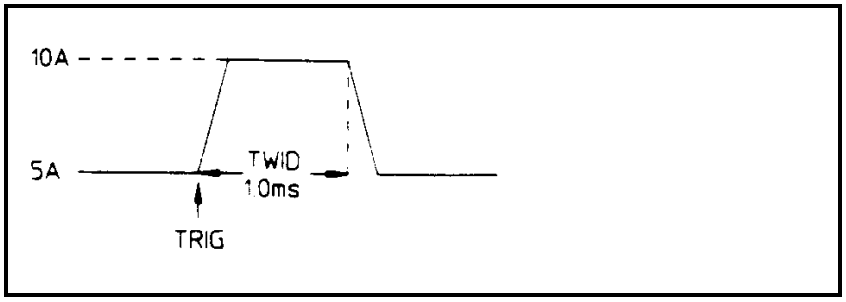


Figure 5-6. Pulsed Transient Operation

	Action	Display
1.	On the Function keypad, press **Current**. On the Entry keypad, press **5 Enter** .	CURR 5
2.	On the Function keypad, press **Current**. On the Function keypad, press ▲ key until transient current is displayed.	C:TLEV
3.	On the Entry keypad press **10 Enter.**	C:TLEV 10
4.	On the Function keypad, press **Tran**. On the Function keypad, press ▲ key until transient pulse width is displayed.	T:TWID
5.	On the Entry keypad press **0.01 Enter.**	T:TWID 0.01
6.	On the Function keypad, press **Tran**. On the Function keypad, press ▲ key until transient mode is displayed.	T:MODE
7.	To select the pulse mode, press the **▲Input or ▼ Input** key until the Pulse mode is displayed. Then press **Enter**.	T:MODE PULS
8.	On the Function keypad, press the **Tran** key and select ON to activate the transient mode.	TRAN ON
9.	On the Function keypad, press **Trigger Control**, then press **Enter**. This initiates the trigger system.	INIT:IMMED
10	Press **Shift** and **Trigger**. This starts the pulse. Repeat this step for additional pulses.	

Set transient operation for Toggled mode

In this example, assume that the CC mode is active, the slew rate is at the factory default setting (maximum rate), and the applicable transient operation parameters have been set as follows: toggle mode, main current level = 5 A, transient current level = 10 A.

The operation of toggled mode is similar to that described for continuous and pulse operation, except that each time a trigger is received the input alternates between the main and transient current levels. Figure 5-7 shows the waveform that would result for this toggled transient operation example

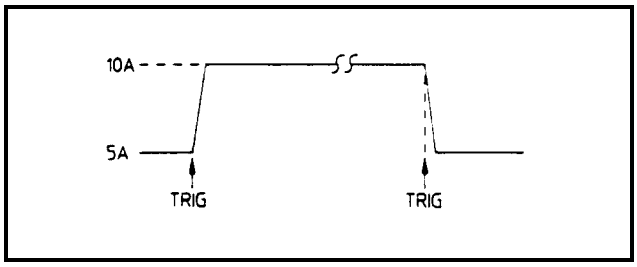


Figure 5-7. Toggled Transient Operation

	Action	Display
1.	On the Function keypad, press **Current**. On the Entry keypad, press **5 Enter** .	CURR 5
2.	On the Function keypad, press **Current**. On the Function keypad, press ▲ key until transient current is displayed.	C:TLEV
3.	On the Entry keypad press **10 Enter.**	C:TLEV 10
6.	On the Function keypad, press **Tran**. On the Function keypad, press ▲ key until transient mode is displayed.	T:MODE
7.	To select the pulse mode, press the **▲Input or ▼ Input** key until the Toggle mode is displayed. Then press **Enter**.	T:MODE TOGG
8.	On the Function keypad, press the **Tran** key and select ON to activate the transient mode.	TRAN ON
9.	On the Function keypad, press **Trigger Control**, then press **Enter**. This initiates the trigger system.	INIT:IMMED
10	Press **Shift** and **Trigger**. This switches to the toggled level. Each time a trigger is sent, the input switches to the alternate level.	

NOTE: The difference between programming a toggled level (C:TLEV) and a triggered level (C:TRIG), is that a toggled level allows you to switch back and forth between the main (or immediate) level and the toggled level. A triggered level, on the other hand, becomes the main level once it is triggered. Subsequent triggers have no effect on the input level.

4 - Programming Lists

Lists are the most flexible means of generating complex input sequences. The following figure shows a current input sequence generated from a list. The input current shown represents three different current pulses (8 A for 2 seconds, 6 A for 5 seconds, and 4 A for 7 seconds) separated by 3-second, 0-ampere intervals.

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

NOTE: From the Recall Menu, execute the *RST command to reset the load module. This is necessary because any previously programmed functions remain in effect until cleared.

	Action	Display
1.	Press **Current** to access the Current Menu. Then press ▼ to access the current mode command.	C:MODE FIXED
2.	On the Entry keypad, press **▲Input** or **▼Input** to scroll through the mode parameters to obtain LIST and press **Enter**.	C:MODE LIST
3.	Access the List Menu by pressing **Shift List**. Press ▼ to scroll to the count command. From the Entry keypad, change the list count from the default (1) to 2. Press **Enter**.	LST:CNT 2

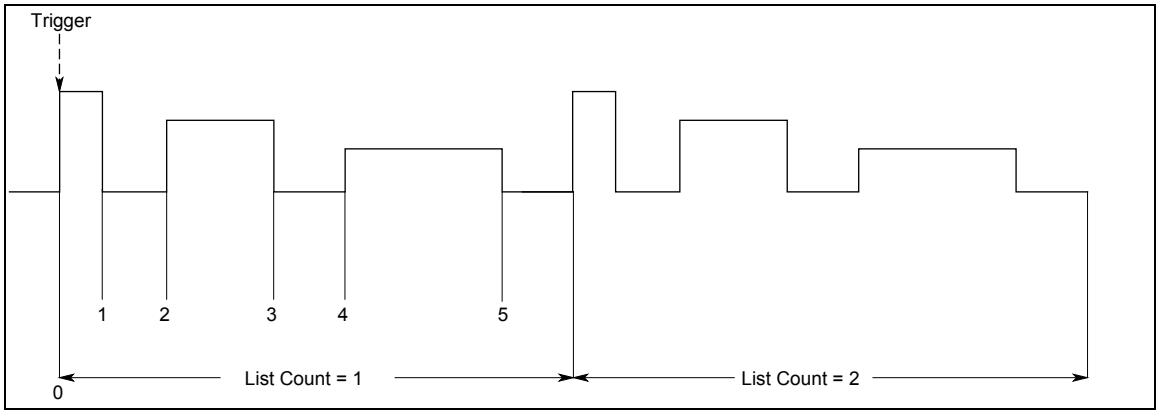


Figure 5-8. List Sequence

	Action	Display
4.	Access the List menu again and press ▼ until you access the dwell time. This specifies the time for each current point, which is effectively its width. The first dwell point (0) appears in the display. On the Entry keypad, press **2** and **Enter**.	DWEL:0 2
5.	Pressing the Enter key automatically advances to the step in the list. Enter the following values for dwell list points 1 through 5: 3, 5, 3, 7, 3. Press **Enter** to enter each value. When you finish, you will be at point 6, which is the end of the list. **Note:** Press **Shift ▲Step** or **Shift ▼Step** to access and edit any list point.	DWEL:1 3 DWEL:2 5 DWEL:3 3 DWEL:4 7 DWEL:5 3 DWEL:6 EOL
6.	Press ▼ until you access the current list. This specifies the value of each current point during its corresponding dwell period. The first current list point (0) appears in the display. On the Entry keypad, press **8** and **Enter**.	CURR:0 8
7.	Pressing the Enter key automatically advances to the step in the list. Enter the following values for current list points 1 through 5: 0, 6, 0, 4, 0. Press **Enter** to enter each value. When you finish, you will be at point 6, which is the end of the list. **Note:** Press **Shift ▲Step** or **Shift ▼Step** to access and edit any list point.	CURR 1 0 CURR 2 6 CURR 3 0 CURR 4 4 CURR 5 0 CURR 6 EOL
8.	Progam at least one list value for the remaining functions in the current list system. Press ▼ until you access the following current list functions: C:RANG C:SLEW C:TLEV The value programmed for C:SLEW will also be applied to C:SLW:P and S:SLW:N. If you will not be programming different values for each list step, you only need to program an initial value in step 0 that will be applied to all the steps for that function.	 C:RANG:0 60 C:SLEW:0 5E6 C:TLEV:0 0
9.	Press ▼ until you access the step command. Check that it is at the default mode (AUTO). This lets a single trigger run your list for the specified count.	STEP AUTO
10.	Press **Trigger Control** and **Enter** to initiate the trigger system. The small ∅1 annunciator on the left of the display comes on to indicate that the list is initialized. If the message LIST LENGTH appears on the display, it usually means that not all current functions have had a list value programmed, or else one of the programmed lists is longer or shorter than the other lists.	INIT:IMMED
11.	Press **Shift Trigger**. This sends the ac source an immediate trigger to generate the output list sequence. The output returns to the immediate value at the end of the list. **Note: To clear a list**, press **Clear Entry**. This truncates or clears the list at the presently displayed list point. Each list must be accessed and cleared separately.	0 V 60 Hz

5 - Querying and Clearing Output Protection and Errors

When overvoltage, overcurrent, or overtemperature condition occurs, the **Prot** annunciator on the front panel will be on and the electronic load will disable its input.

Error messages can occur at any time during the operation of the unit. When the **Err** annunciator on the front panel is on, it means that either an error has occurred on the GPIB bus, or a selftest error has occurred. Appendix B in the *Programming Guide* lists error numbers and descriptions.

Query and clear the electronic load overcurrent protection as follows:

	Action	Display
1.	On the Function keypad, press **Protect**. In this example, an overcurrent condition has occurred.	OC
2.	To restore normal operation *after the cause of the overcurrent condition has been removed*, press **Shift, Prot Clr**. The **Prot** annunciator then will go off.	

Query and Clear Errors as follows:

1.	On the Function keypad, press **Shift, Error**. This displays and clears the error in the error queue. Repeatedly press these keys to clear all errors in the queue. If errors persist, your unit may require service.	ERROR 0

6 - Making Basic Front Panel Measurements

As shipped from the factory, front panel measurements for the input are calculated from a total of 1000 readings taken at a 10 microsecond sampling rate. The unit alternates between voltage and current measurements. Therefore, the data acquisition time for a single front panel voltage or current measurement is 10 milliseconds. It takes an additional 2 milliseconds to calculate the results.

The front panel display updates at a fixed rate of 50 milliseconds per measurement. However, you can program both the sampling rate and the number of data points in each front panel measurement using commands in the Sense menu. With this flexibility, measurement accuracy can be improved for waveforms with frequencies as low as several Hertz. The sample buffer size may be varied from 1 to 4096 data points. The sampling rate may be varied from 10 microseconds to 32 milliseconds. Values are rounded to the nearest 10 microsecond interval.

To have the unit turn on with the reconfigured buffer size and sampling rate, save this state in location 0.

NOTE: If the front panel display indicates OVLD, the input has exceeded the measurement capability of the instrument. This can occur when the measurement has been set to the Low range. If the front panel display indicates -- -- -- -- -- -- , a GPIB measurement is in progress.

Use the Meter menu for making front panel measurements:

	Action	Display
1.	On the Function keypad press **Meter** to access the following measurement parameters:	
	Displays the voltage and current of the selected channel	<chan> <voltage> <current>
	Displays the maximum voltage	<chan> <value> V MAX
	Displays the minimum voltage	<chan> <value> V MIN
	Displays the rms voltage	<chan> <value> V RMS
	Displays the maximum current	<chan> <value> A MAX

	Action	Display
1.	Displays the minimum current	<chan> <value> A MIN
	Displays the rms voltage	<chan> <value> A RMS
	Displays the input power	<chan> <value> WATTS
	Displays the maximum power	<chan> <value> W MAX
	Displays the minimum power	<chan> <value> W MIN

Use ▼ and ▲ to scroll through the measurement selections

7 - Setting the GPIB Address

Your electronic load is shipped with the GPIB address set to 5. This address can only be changed from the front panel using the Address menu located under the **Address** key

Set the GPIB address as follows:

	Action	Display
1.	On the System keypad, press **Address**.	ADDRESS 5
2.	Enter the new address. For example, Press **7, Enter**.	ADDRESS 7

8 - Storing and Recalling Instrument States

You can save up to 10 states in memory and recall them from the front panel. All programmable settings are saved. Only memory locations 0, 7, 8, or 9 are non-volatile. Data saved in locations 1 through 6 will be lost when the unit is turned off.

NOTE: The SAV0 state is the power up state.

Save an instrument state in location 0 as follows:

	Action	Display
1.	Set the instrument to the state that you want to save.	
2.	Save this state to location 0. Press **Shift, Save, 0, Enter**.	*SAV 0

Recall a saved state as follows:

	Action	Display
1.	Recall the state saved in location 0 by pressing **Recall, 0, Enter.**	*RCL 0

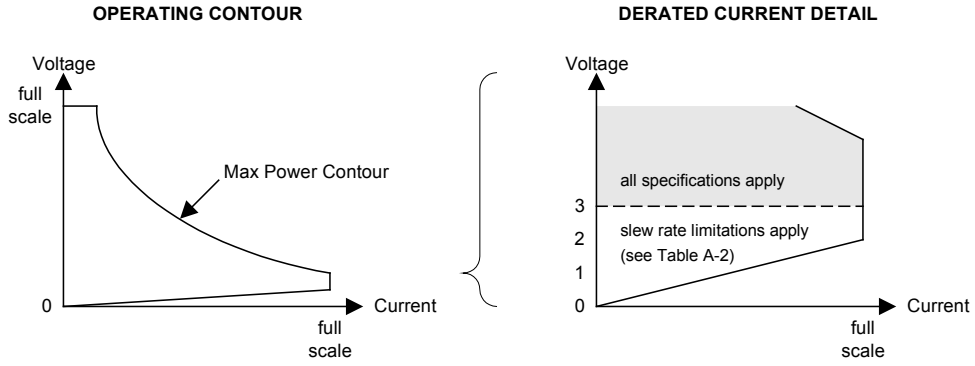
Clear the non-volatile memory of the electronic load as follows:

	Action	Display
1.	On the System keypad, press the **Recall** key and scroll to the reset command. Then press **Enter.** This returns the unit to the factory-default settings.	*RST
2.	Save these settings to location 0. Press **Shift, Save, 0, Enter**.	*SAV 0
3.	Repeat step #2 for memory locations 7 through 9.	*SAV 7 *SAV 8 *SAV 9

Specifications

Table A-1 lists the specifications for the different load models. Specifications indicate warranted performance in the 25°C ±5°C region of the operating temperature range. Specifications apply to normal and transient modes unless otherwise noted.

Table A-1. Specifications

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Input Ratings						
Current	0 - 30 A	0 - 10 A	0 - 60 A	0 - 60 A	0 - 120 A	0 - 30 A
Voltage	0 - 60 V	0 - 240 V	0 - 60 V	0 - 150V	0 - 60V	0 - 150V
Maximum Power @ 40°C [1]	150 W	250 W	300 W	500 W	600 W	250 W
Input Characteristic						
Specified Current @ Low Voltage Operation						
2.0 V	30 A	10 A	60 A	60 A	120 A	30 A
1.5 V	22.5 A	7.5 A	45 A	45 A	90 A	22.5 A
1.0 V	15 A	5 A	30 A	30 A	60 A	15 A
0.5 V	7.5 A	2.5 A	15 A	15 A	30 A	7.5 A
0 V	0 A	0 A	0 A	0 A	0 A	0 A

[1]Maximum continuous power available is derated linearly from 100% of maximum at 40°C, to 75% of maximum at 55°C.

Typical Minimum Operating Voltage @ Full Scale Current

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Table A-1 states that maximum current is available down to 2 volts. Typically, under normal operating conditions, the load can sink the maximum current down to the following voltages:	1.2 V	1.2 V	1.2 V	1.4 V	1.4 V	1.4 V

Table A-1. Specifications (continued)

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Constant Current Mode[2]						
Low Range/High Range	3A / 30A	1A / 10A	6A / 60A	6A / 60A	12A / 120A	3A / 30A
Regulation	10mA	8mA	10mA	10mA	10mA	10mA
Low Range Accuracy	0.1% + 5mA	0.1% + 4mA	0.1% +7.5mA	0.1% +7.5mA	0.1% + 15mA	0.1% +7.5mA
High Range Accuracy	0.1% + 10mA	0.1% +7.5mA	0.1% + 15mA	0.1% + 15mA	0.1% + 37.5mA	0.1% + 15mA
Constant Voltage Mode[2]						
Low Range/High Range	6V / 60V	24V / 240V	6V / 60V	15V / 150V	6V / 60V	15V / 150V
Regulation	5mV	10mV	10mV	10mV	20mV	10mV
Low Range Accuracy	0.1% + 3 mV	0.1% + 10mV	0.1% + 3 mV	0.1% + 10mV	0.1% + 3mV	0.1% + 10mV
High Range Accuracy	0.1% + 8 mV	0.1% + 40mV	0.1% + 8mV	0.1% + 20mV	0.1% + 8mV	0.1% + 20mV
Constant Resistance Mode[2,3]						
Range 1 (I >10% of current rating)	0.067-4 Ω	0.2-48 Ω	0.033-2 Ω	0.033-5 Ω	0.017-1 Ω	0.067-10 Ω
Accuracy up to 25% of range	0.4% ± 24mΩ	1% ± 100mΩ	0.4% ±12mΩ	0.4% ± 24mΩ	0.4% ± 6mΩ	0.75% ± 32mΩ
Accuracy >25% to 50% of range	0.4% ± 24mΩ	2% ± 100mΩ	0.4% ±12mΩ	0.4% ± 24mΩ	0.4% ± 6mΩ	1.5% ± 32mΩ
Accuracy >50% to 100% of range	0.8% ± 24mΩ	3% ± 100mΩ	0.4% ±12mΩ	0.8% ± 24mΩ	0.4% ± 6mΩ	2% ± 32mΩ
Range 2 (I >1% of current rating)	3.6-40 Ω	44-480 Ω	1.8-20 Ω	4.5-50 Ω	0.9-10 Ω	9-100 Ω
Accuracy up to 25% of range	1.5% ±80mΩ	5% ± 500mΩ	1.5% ±40mΩ	1.5% ±80mΩ	1.5% ±20mΩ	3% ±120mΩ
Accuracy >25% to 50% of range	2% ±80mΩ	10% ± 500mΩ	2% ±40mΩ	2% ±80mΩ	2% ±20mΩ	6% ±120mΩ
Accuracy >50% to 100% of range	3% ±80mΩ	20% ± 500mΩ	3% ±40mΩ	3% ±80mΩ	3% ±20mΩ	10% ±120mΩ
Range 3 (I >0.1% of current rating)	36-400 Ω	440-4800 Ω	18-200 Ω	45-500 Ω	9-100 Ω	90-1000 Ω
Accuracy up to 25% of range	8% ±240mΩ	-30%/+50%	6% ±120mΩ	-10%/+25%	6% ±60mΩ	-20%/+20%
Accuracy >25% to 50% of range	16% ±240mΩ	-40%/+133%	10% ±120mΩ	-20%/+50%	10% ±60mΩ	-20%/+66%
Accuracy >50% to 100% of range	32% ±240mΩ	-50%/+600%	20% ±120mΩ	-30%/+150%	20% ±60mΩ	-33%/+200%
Range 4 (I >0.01% of current rating)	360-2000 Ω	4400-12000 Ω	180-2000 Ω	450-2500 Ω	90-1000 Ω	900-2500 Ω
Accuracy up to 25% of range	-25%/+100%	-66%/+800%	-20%/+66%	-35%/+200%	-20%/+66%	-45%/+600%
Accuracy >25% to 50% of range	-25%/+100%	-66%/+800%	-33%/+200%	-45%/+500%	-33%/+200%	-45%/+600%
Accuracy >50% to 80% of range	-40%/+400%	-66%/+800%	-45%/+600%	-50%/+1200%	-45%/+600%	-45%/+600%
Accuracy >80% to 100% of range	-40%/+400%	-66%/+800%	-50%/+2000%	-50%/+2000%	-50%/+2000%	-50%/+2000%
Current Measurement[4,5]						
Low Range / High Range	3A / 30A	1A / 10A	6A / 60A	6A / 60A	12A / 120A	3A / 30A
Low Range Accuracy	0.05% + 3mA	0.05% + 2.5mA	0.05% + 5mA	0.05% + 5mA	0.05% + 10mA	0.05% + 3mA
High Range Accuracy	0.05% + 6mA	0.05% + 5mA	0.05% + 10mA	0.05% + 10mA	0.05% + 20mA	0.05% + 6mA
Voltage Measurement[5]						
Low Range / High Range	6V / 60V	24V / 240V	6V / 60V	15V / 150V	6V / 60V	15V / 150V
Low Range Accuracy	0.05% + 3mV	0.05% + 10mV	0.05% + 3 mV	0.05% + 8mV	0.05% + 3mV	0.05% + 8mV
High Range Accuracy	0.05% + 8mV	0.05% + 20mV	0.05% + 8 mV	0.05% + 16mV	0.05% + 8mV	0.05% + 16mV
Power Measurement[5]						
Accuracy	0.1% + 0.4W	0.1% + 1.2W	0.1% + 0.6W	0.1% + 1.6W	0.1% + 1.3W	0.1% + 0.9W

[2]Accuracy specification is ±(% of programmed value + fixed offset) in those cases where a percentage + fixed term are given. Otherwise, the specification is given as a negative and positive percentage error term. This specification may degrade when the unit is subject to an RF field of 3V/meter, the unit is subject to line spikes of 500V, or an 8kV electrostatic discharge.
[3]For resistance ranges 3 through 4, accuracy specifications apply with input voltages ≥6V.
[4]DC current accuracy specifications apply 30 seconds after input current is applied.
[5]Accuracy specification is ±(% of reading + fixed offset). Measurement is 1000 samples. This specification may degrade when the unit is subject to line spikes of 500V, or an 8kV electrostatic discharge.

Table A-2 lists the supplemental characteristics, which are not warranted but are descriptions of typical performance determined either by design or type testing.

Table A-2. Supplemental Characteristics

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Programming Resolution						
Constant Current Mode	0.05mA/0.5mA	0.02mA/0.2mA	0.1mA/1mA	0.1mA/1mA	0.2 mA / 2 mA	0.05mA/0.5mA
Constant Voltage Mode	0.1mV/1mV	0.4mV/4mV	0.1mV/1mV	0.25mV/2.5mV	0.1mV / 1mV	0.25mV/2.5mV
Constant Resistance	0.07/0.7/7/70mΩ	0.82/8.2/82/ 820mΩ	0.035/0.35/3.5/ 35mΩ	0.085/0.85/8.5/ 85mΩ	0.0175/0.175/ 1.75/17.5mΩ	0.17/1.7/17/ 170mΩ
Readback Resolution						
Current	0.05mA/0.5mA	0.02mA/0.2mA	0.1mA/1mA	0.1mA/1mA	0.2 mA / 2 mA	0.05mA/0.5mA
Voltage	0.1mV/1mV	0.4mV/4mV	0.1mV/1mV	0.25mV/2.5mV	0.1mV / 1mV	0.25mV/2.5mV
Slew Rates[1]						
Current Ranges						
Slow band	500A/s - 25kA/s	167A/s - 8330A/s	1kA/s - 50kA/s	1kA/s - 50kA/s	2kA/s - 100kA/s	500A/s - 25kA/s
Fast band ≥3V	50kA/s - 2.5MA/s	16.7kA/s - 833kA/s	100kA/s - 5MA/s	100kA/s - 5MA/s	200kA/s - 10MA/s	50kA/s - 2.5MA/s
Fast band <3V	50kA/s - 250kA/s	16.7kA/s - 83.3kA/s	100kA/s - 500kA/s	100kA/s - 500kA/s	200kA/s - 1MA/s	50kA/s - 250kA/s
Voltage Ranges						
Slow band	1kV/s - 50kV/s	4kV/s - 200kV/s	1kV/s - 50kV/s	2.5kV/s - 125kV/s	1kV/s - 50kV/s	2.5kV/s - 125kV/s
Fast band ≥3V	100kV/s - 500kV/s	400kV/s - 2MV/s	100kV/s - 500kV/s	250kV/s-1.25MV/s	100kV/s - 500kV/s	250kV/s-1.25MV/s
Fast band <3V	100kV/s - 50kV/s	400kV/s - 200kV/	100kV/s - 50kV/s	250kV/s -125kV/s	100kV/s - 50kV/s	250kV/s -125kV/s
Resistance Range 1						
Slow band	44Ω/s - 1125Ω/s	540Ω/s - 13.5kΩ/s	22Ω/s - 560Ω/s	55Ω/s - 1400Ω/s	11Ω/s - 280Ω/s	110Ω/s - 2800Ω/s
Fast band ≥3V	2250Ω/s - 34kΩ/s	27kΩ/s - 408kΩ/s	1120Ω/s - 17kΩ/s	2800Ω/s -42.5kΩ/s	560Ω/s - 8.5kΩ/s	5600Ω/s - 85kΩ/s
Fast band <3V	2250Ω/s - 3.4kΩ/s	27kΩ/s - 40.8kΩ/s	1120Ω/s - 1.7kΩ/s	2800Ω/s -4.25kΩ/s	560Ω/s - 850Ω/s	5600Ω/s - 8.5kΩ/s
Resistance Range 2						
Slow band	440Ω/s -11.25kΩ/s	5.4kΩ/s - 135kΩ/s	220Ω/s - 5600Ω/s	550Ω/s - 14kΩ/s	110Ω/s - 2800Ω/s	1.1kΩ/s - 28kΩ/s
Fast band ≥3V	22.5kΩ/s -340kΩ/s	270kΩ/s -4.08MΩ/s	11.2kΩ/s - 170kΩ/s	28kΩ/s - 425kΩ/s	5600Ω/s - 85kΩ/s	56kΩ/s - 850kΩ/s
Fast band <3V	22.5kΩ/s - 34kΩ/s	270kΩ/s -408kΩ/s	11.2kΩ/s - 17kΩ/s	28kΩ/s - 42.5kΩ/s	5600Ω/s - 8.5kΩ/s	56kΩ/s - 85kΩ/s
Resistance Range 3						
Slow band	4.4kΩ/s-112.5kΩ/s	54kΩ/s - 1.35MΩ/s	2.2kΩ/s - 56kΩ/s	5.5kΩ/s - 140kΩ/s	1.1kΩ/s - 28kΩ/s	11kΩ/s - 280kΩ/s
Fast band ≥3V	225kΩ/s - 3.4MΩ/s	2.7MΩ/s-40.8MΩ/s	112kΩ/s - 1.7M Ω/s	280kΩ/s 4.25MΩ/s	56kΩ/s - 850kΩ/s	560kΩ/s -8.5MΩ/s
Fast band <3V	225kΩ/s - 340kΩ/s	2.7MΩ/s-4.08MΩ/s	112kΩ/s - 170k Ω/s	280kΩ/s -425kΩ/s	56kΩ/s - 85kΩ/s	560kΩ/s -850kΩ/s
Resistance Range 4						
Slow band	44kΩ/s-1.125MΩ/s	540kΩ/s -13.5MΩ/s	22kΩ/s - 560kΩ/s	55kΩ/s - 1.4MΩ/s	11kΩ/s - 280kΩ/s	110kΩ/s -2.8MΩ/s
Fast band ≥3V	2.25MΩ/s- 34MΩ/s	27MΩ/s - 408MΩ/s	1.12MΩ/s -17MΩ/s	2.8MΩ/s-42.5MΩ/s	560kΩ/s -8.5MΩ/s	5.6MΩ/s - 85MΩ/s
Fast band <3V	2.25MΩ/s-3.4MΩ/s	27MΩ/s -40.8MΩ/s	1.12MΩ/s-1.7MΩ/s	2.8MΩ/s-4.25MΩ/s	560kΩ/s -850kΩ/s	5.6MΩ/s -8.5MΩ/s
Slew Rate Accuracy	within 35% of programmed value					
Programmable Short	66mΩ max. 40mΩ typical	200mΩ max. 100mΩ typical	33mΩ max. 20mΩ typical	33mΩ max. 25mΩ typical	17mΩ max. 12mΩ typical	33mΩ max. 20mΩ typical
Programmable Open	≥20kΩ	≥80kΩ	≥20kΩ	≥80kΩ	≥20kΩ	≥80kΩ
DC Isolation Voltage	±300 Vdc between + or - input binding post and chassis ground					
Command Processing Time						
Discrete commands	3 ms					
List commands	1 ms					
List Dwell Characteristics						
Range	0 - 10 s					
Resolution	1 ms					
Accuracy	5 ms					

[1]Slew rate bands are not programmable. When you program a slew rate value outside the indicated bands, the electronic load will automatically adjust the slew rate to fit within the band that is closest to the programmed value. The slew rate accuracy specification is only applicable to slew rates within the indicated bands. Additionally, when the transition from one setting to another is small, the small signal bandwidth of the load limits the minimum transition time for all programmable slew rates (see chapter 2 for more information).

Below 3 volts, the maximum bandwidth of the electronic load is reduced by a factor of ten to one. For example, in the current range for Model N3302A, the maximum slew rate is specified as 2.5MA/s, below 3 volts the maximum slew rate would be 250kA/s. Any slew rate programmed between 2.5MA/s and 250kA/s would produce a slew rate of 250kA/s. Slew rates programmed slower than 250kA/s would still correctly reflect their programmed value. If you are using transient mode to generate a high frequency pulse train, a reduced slew rate might cause the load to never reach the upper programmed value before beginning the transition to the lower programmed value. So even though the transient mode is still operational at lower voltages, a fast pulse train with large transitions may not be achievable.

Table A-2. Supplemental Characteristics (continued)

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Transient Generator						
Frequency Range	0.25Hz -10kHz					
Frequency Accuracy	0.5%					
Duty Cycle Range	3 to 97% (0.25Hz - 1kHz); 6 to 94% (1kHz - 10kHz)					
Duty Cycle Accuracy	1%					
Pulse Width	50µs ± 1% to 4 seconds ± 1%					
Measurement Time						
1000 samples (default)	20 ms (with specified measurement accuracy)					
200 samples	10 ms (with < 6% additional fixed offset)					
100 samples	9 ms (with < 10% additional fixed offset)					
20 points	7 ms (with < 30% additional fixed offset)					
< 20 points	7 ms (with > 30% additional fixed offset)					
Measurement Bandwidth	10kHz (rms)					
GPIB Capabilities	SH1, AH1, T6, L4, SR1, RL1, DT1, CD1					
Ripple and Noise[2]						
Current (rms/p-p)	2mA / 20mA	1mA / 10mA	4mA / 40mA	4mA / 40mA	6mA / 60mA	2mA / 20mA
Voltage (rms)	5mV rms	12mV rms	6mV rms	10mV rms	8mV rms	10mV rms
Temperature Coefficients						
Current Programming	120ppm/°C + 0.5mA/°C	120ppm/°C+ 0.1mA/°C	120ppm/°C + 1mA/°C	120ppm/°C + 1mA/°C	120ppm/°C + 2mA/°C	120ppm/°C + 0.5mA/°C
Current Readback	100ppm/°C + 0.5mA/°C	100ppm/°C +0.1mA/°C	100ppm/°C + 1mA/°C	100ppm/°C + 1mA/°C	100ppm/°C + 2mA/°C	100ppm/°C + 0.5mA/°C
Voltage Programming	100ppm/°C + 0.5mV/°C	100ppm/°C + 2mV/°C	100ppm/°C+0.5mV/°C	100ppm/°C +1.5mV/°C	100ppm/°C+0.5mV/°C	100ppm/°C + 1.5mV/°C
Voltage Readback	80ppm/°C + 0.33mV/°C	80ppm/°C +1.33mV/°C	80ppm/°C+0.33mV/°C	80ppm/°C + 0.8mV/°C	80ppm/°C+0.33mV/°C	80ppm/°C + 0.8mV/°C
Resistance Programming						
Range 1	800ppm/°C + 0.4mΩ/°C	800ppm/°C + 1.6mΩ/°C	800ppm/°C+0.2mΩ/°C	800ppm/°C + 0.4mΩ/°C	800ppm/°C+0.1mΩ/°C	800ppm/°C+0.8mΩ/°C
Range 2	800ppm/°C + 4mΩ/°C	800ppm/°C + 16mΩ/°C	800ppm/°C + 2mΩ/°C	800ppm/°C + 4mΩ/°C	800ppm/°C + 1mΩ/°C	800ppm/°C + 8mΩ/°C
Range 3	800ppm/°C + 40mΩ/°C	800ppm/°C +160mΩ/°C	800ppm/°C+20mΩ/°C	800ppm/°C + 40mΩ/°C	800ppm/°C +10mΩ/°C	800ppm/°C +80mΩ/°C
Range 4	800ppm/°C + 4Ω/°C	800ppm/°C + 16Ω/°C	800ppm/°C + 2Ω/°C	800ppm/°C + 4Ω/°C	800ppm/°C + 1Ω/°C	800ppm/°C + 8Ω/°C
Remote Sensing:	5Vdc between sense and load input					
Reverse Current Capability						
With input on	50A	20A	100A	60A	120A	50A
With input off	20A	10A	40A	30A	60A	20A
External Analog Programmming						
Programming Voltage	Voltage from 0 to full scale: 0-10V; Current from 0 to full scale: 0-10V (corresponds to 0 to full scale current)					
Bandwidth (all ranges)	10 kHz (-3db frequency)					
Voltage Prog. Accuracy[3]	0.5% + 12mV	0.5% + 48mV	0.5% + 12mV	0.5% + 30mV	0.5% + 12mV	0.5% + 30mV
Temperature Coefficient[3]	100ppm/°C+0.33mV/°C	100ppm/°C+1.33mV/°C	100ppm/°C + 0.33mV/°C	100ppm/°C + 0.8mV/°C	100ppm/°C+0.33mV/°C	100ppm/°C+0.8mV/°C
Current Prog. Accuracy[3]	0.25% + 4.5mA	0.25% + 1.5mA	0.25% + 9mA	0.25% + 9mA	0.25% + 18mA	0.25% + 4.5mA
Temperature Coefficient[3]	120ppm/°C + 0.5mA/°C	120ppm/°C + 0.1mA/°C	120ppm/°C + 1mA/°C	120ppm/°C + 1mA/°C	120ppm/°C + 2mA/°C	120ppm/°C+0.5mA/°C
Monitor Ports						
Monitor Voltage	Voltage from 0 to full scale: 0-10V; Current from 0 to full scale: 0-10V					
Voltage Mon. Accuracy	0.25% + 12mV	0.25% + 48mV	0.25% + 12mV	0.25% + 30mV	0.25% + 12mV	0.25% + 30mV
Temperature Coefficient	100ppm/°C+0.33mV/°C	100ppm/°C+1.33mV/°C	100ppm/°C + 0.33mV/°C	100ppm/°C + 0.8mV/°C	100ppm/°C+0.33mV/°C	100ppm/°C+0.8mV/°C
Current Mon. Accuracy	0.1% + 4.5mA	0.1% + 1.5mA	0.1% + 9mA	0.1% + 9mA	0.1% + 18mA	0.1% + 4.5mA
Temperature Coefficient	120ppm/°C + 0.5mA/°C	120ppm/°C + 0.1mA/°C	120ppm/°C + 1mA/°C	120ppm/°C + 1mA/°C	120ppm/°C + 2mA/°C	120ppm/°C+0.5mA/°C
Drift						
Voltage Programming	2mV	10mV	5mV	5mV	5mV	5mV
Current Programming	1mA	1mA	2mA	2mA	4mA	1mA
Digital/Trigger Inputs	Vil=0.9V max at Iil=-1mA Vih-3.15V min (pull-up resistor on input)					
Digital/Trigger Outputs	Vol=0.72V max at Iol=1mA Voh=3.3V min at Ioh=-20uA					
Calibration Interval	1 year for modules; N3300A and N3301A Electronic Load mainframes do not require calibration					
Weight						
Net	2.7kg (6lb)	2.7kg (6lb)	2.7kg (6lb)	4.6kg (10lb)	4.6kg (10lb)	2.7kg (6lb)
Shipping	4.1kg (9lb)	4.1kg (9lb)	4.1kg (9lb)	6.8kg (15lb)	6.8kg (15lb)	4.1kg (9lb)

[2] From 20Hz-10MHz

[3] Applies to all ranges.

Table A-3. N3300A/N3301A Supplemental Characteristics

	N3300A	N3301A
Operating Temperature Range	0°C to 55°C	
Input Ratings		
Nominal Input	100-120/200-240 Vac 50/60 Hz	
Operating range	90-132 Vac or 180-264 Vac 47-63 Hz	90-264 Vac 47-63 Hz
Input Current	4.2A @ 100-120 Vac ; 2.2 A @ 200-240 Vac	2.3A @ 100-240 Vac
Input VA	440 VA	230 VA
Inrush Current	38A	18A @ 115 Vac 36A @ 230 Vac
Dimensions		
Height	178 mm (7 in.), add 10 mm (0.4 in.) for removable feet	
Depth	625 mm (24.6 in.), including input connectors on modules	
Width	425.5mm (16.75in.)	213 mm (8.4 in.)
Weight		
Net	13.2kg (29lb)	7.3kg (16lb)
Shipping	17.3kg (38lb)	9.1kg (20lb)

B

Performance Test and Calibration Procedures

Introduction

This appendix contains test procedures for checking the operation and calibration of the Keysight N330xA Series Electronic Load Modules. The tests are performed using the front panel keypad of the N3300A or N3301A Mainframes. The required test equipment is listed in Table B-1 and sample performance test record cards are included at the end of the performance test section. The performance tests confirm the Keysight N330xA Series Electronic Load Modules meet all their published specifications.

The calibration (adjustment) procedures create new calibration constants to bring the current, voltage and resistance values within specifications. Calibration cannot be performed using the front panel keypad, an IEEE-488 (GPIB) controller is required. **Note that the Electronic Load Mainframe does not require calibration**.

Important Perform the verification procedures before calibrating your Electronic Load Module. If the Electronic Load Module passes the verification procedures, the unit is operating within its calibration limits and does not need to be re-calibrated.

If the electronic load requires service, refer to the list of Keysight Sales and Support Offices at the back of this manual.

Equipment Required

The equipment listed in the following table, or the equivalent to this equipment, is required for verification and calibration. An IEEE-488.2 controller is not required for verification.

Table B-1. Equipment Required

Equipment	Characteristics	Recommended Models
Current Shunts[1]	0.1 Ohms @ 15 Amps, 0.015% @ 25 watts 0.01 Ohms @ 100 Amps, 0.015% @ 100 watts 0.001 Ohms @ 300 Amps, 0.015% @ 100 watts	Guildline 9230/15 Guildline 9230/100 Guildline 9230/300
Cooling Fan	A fan is recommended to keep the current shunts cool during the calibration procedures.	Any model
Voltmeter	DC accuracy 0.01% 5 digit	Keysight 34401A or 3458A
Oscilloscope		Keysight 54520A
Power Source	61Vdc / 61A minimum (N3302A, N3304A, N3306A) 20Vdc / 122A minimum (N3305A, N3306A) 151V dc / 5A minimum (N3305A, N3307A) 241Vdc / 10A minimum (N3303A)	6031A, 6032A, 6033A, 6035A or equivalent
Controller	GPIB (IEEE 488.2)	HP Series 200/300 or PC with HP 82341 IEEE 488.2 Interface card and Basic for Windows or equivalent

[1] A 4-terminal resistor (current shunt) is required to eliminate output current measurement errors caused by voltage drops in the load leads and connections.

Performance Tests

IMON Zero Verification

This test verifies that IMON Zero is within calibration. IMON zero must be in calibration to perform the tests in this section. If the IMON value is not within calibration, go to the calibration section of this appendix and calibrate IMON zero, IPROG, current programming and readback and resistance programming and readback. See figure B-1 for IMON Zero test setup.

	Action	Normal Result
1.	Turn off load module and connect DVM to IMON as per figure B-1. Input terminals must be open (no power source connected)	
2.	Turn on Load – press [Recall } – scroll to *RST – press [Enter]	
3.	Read IMON voltage from DVM.	Voltage reading less than 0.166mV for models N3302A - N3305A, and N3307A. Voltage reading less than 0.320mV for model N3306A
4.	If IMON in step 3 in not within specification then calibrate IMON zero, IPROG, Current mode and Resistance mode.	

CC Mode Tests

These tests verify that the module operates in the CC mode and that IMON, current programming, and readback to the front panel display are within specification. Values read back over the GPIB are the same as those displayed on the front panel. To read back the current value via the GPIB, use MEAS:CURR:ACDC?

Current Programming and Measurement Accuracy Test

This test verifies that the current programming and measurement accuracy are within specification. If the test readings are out of tolerance the module may require calibration. If the test readings significantly disagree with the specified values or no readings can be obtained go to the Turn-On Checkout procedure to verify module operation.

Make a copy of the module test card for the model to be tested to record test values.

1. Connect the Electronic Load, power source, DVM and current shunt as shown in figure B-2.
2. Turn on the Electronic Load and press [Recall]. Scroll until display reads *RST and press [Enter].
3. Turn on the power source. Set the power source voltage and current to the values listed in the following table.

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Power Source Voltage Setting	5V	20V	5V	8V	5V	5V
Power Source Current Setting	33A	12A	61A	61A	122A	33A

4. Checking high current range, low current point. Press [CURR] [1] then [Enter]. Wait 10 seconds then record the actual input current (DVM reading / current shunt resistance) and front panel current reading on the test record card under high current range low current.
5. Checking high current range, high current point. Press [CURR] [select current from following table] [Enter].

N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
30A	10A	60A	60A	120A	30A

6. Wait 30 seconds, then record the actual input current (DVM reading / current shunt resistance) and front panel current reading on the test record card under high current range high current.

7. Checking low current range, low current point. Press [CURR] [1] (for N3303A press [CURR] [0.1]) [Enter]. Press [CURR]. Scroll until display reads C:RANG, press [1] [Enter]. Press shift key then [Sense]. Scroll until display reads S:C:RNG press [1] [Enter]. Wait 10 seconds then record the actual input current (DVM reading / current shunt resistance) and front panel current reading on the test record card under low current range low current.
8. Checking low current range, high current point. Press [CURR] [select current from following table] [Enter].

N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
3A	1A	6A	6A	12A	3A

9. Wait 30 seconds then record the actual input current (DVM reading / current shunt resistance) and front panel current reading on the test record card under high current range high current.

CC Mode Regulation Test

This test verifies the Input Current remains within specification when the input voltage is changed from a low voltage to rated voltage.

1. Connect the Electronic Load, power source, DVM and current shunt as shown in figure B-2.
2. Turn on the Electronic Load and press [Recall]. Scroll until display reads *RST and press [Enter].
3. Press [CURR] [select current from following table] [Enter].

N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
2.5A	1A	5A	3.3A	10A	1.6A

4. Turn on the power source. Set the power source voltage and current to the values listed in following table.

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Power Source Voltage Setting	4V	4V	4V	4V	4V	4V
Power Source Current Setting	5A	5A	10A	10A	20A	5A

5. Wait 10 seconds, then record input current reading (DVM reading / current shunt).
6. Reset the power source voltage level to value listed in following table.

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Power Source Voltage Setting	60V	240V	60V	150V	60V	150V

7. Wait 10 seconds, then record input current reading (DVM reading / shunt resistance).
8. Subtract reading in step ‘7’ from step ‘5’. Absolute value of difference should be less than specification.

CV Mode Tests

These tests verify that the module operates in the CV mode and that voltage programming and readback to the front panel display are within specification. Values read back over the GPIB are the same as those displayed on the front panel. To read back the voltage value via the GPIB, use the command MEAS:VOLT:ACDC?

Voltage Programming and Measurement Accuracy Test

This test verifies that voltage programming and voltage measurement accuracy are within specification. Make a copy of the module test card for the model being tested to record test values.

1. Connect the Electronic Load, Power source and DVM as shown in figure B-3. **Be sure + sense and – sense are connected to the +/- input terminals and the remote/local button is in the remote position.**
2. Turn on the Electronic Load and press [Recall]. Scroll until display reads *RST and press [Enter].
3. Press [Func]. Scroll until display reads FUNC VOLT then press [Enter].
4. Turn on the power source. Set the power source voltage and current to the values listed in the following table.

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Power Source Voltage Setting	61V	246V	61V	152V	61V	152V
Power Source Current Setting	2A	0.6A	3A	2A	3A	2A

5. Checking high voltage range, low voltage point. Press [VOLT] [3] [Enter]. Wait 10 seconds, then record actual input voltage (DVM reading) and front panel readings on test record card under high voltage range, low voltage.
6. Checking high voltage range, high voltage point. Press [VOLT] [select voltage from the following table] [Enter].

N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
60V	240V	60V	150V	60V	150V

7. Wait 10 seconds, then record the actual input voltage (DVM reading) and front panel voltage reading on the test record card under high voltage range, high voltage.
8. Checking low voltage range, low voltage point. Press [VOLT] [3] [Enter]. Press [VOLT]. Scroll until display reads V:RANG, press [3] [Enter]. Press shift key then [Sense]. Scroll until display reads S:V:RNG, press [3] [Enter]. Wait 10 seconds then record actual input voltage (DVM reading) and front panel readings on test record card under low voltage range, low voltage.
9. Checking low voltage range, high voltage point. Press [VOLT] [select voltage from following table] [Enter].

N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
6V	24V	6V	15V	6V	15V

10. Wait 10 seconds then record actual input voltage (DVM reading) and front panel readings on test record card under low voltage range, low voltage.

CV Mode Regulation Test

This test verifies the Input Voltage remains within specification when the input current is changed from a low current to rated current.

1. Connect Electronic Load, power source and DVM as shown in figure B-3. **Be sure + sense and – sense are connected to the +/- input terminals and the remote/local button is in the remote position.**
2. Turn on the Electronic Load and press [Recall]. Scroll until display reads *RST and press [Enter].
3. Press [Func]. Scroll until display reads FUNC VOLT, then press [Enter].
4. Press [Volt] [select voltage from following table] [Enter].

N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
5V	25V	5V	8.3V	5V	8.3V

5. Turn on power source. Set power source voltage and current to values listed in following table.

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Power Source Voltage Setting	6V	30V	6.5V	10V	6.6V	10V
Power Source Current Setting	1A	0.4A	1A	1A	1A	1A

6. Wait 10 seconds and record input voltage reading.
7. Reset power source current level to value listed in following table.

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Power Source Current Setting	30A	10A	60A	60A	120A	30A

8. Wait 10 seconds and record input voltage reading.
9. Subtract reading in step ‘8’ from reading in step ‘6’. Absolute value of difference should be less than specification.

CR Mode Tests

These tests verify that the module operates in CR mode and the resistance programming is within specification. The programmed resistance values are checked by recording the voltage across the current monitor resistor and the input voltage (voltage at the modules + and – sense terminals), then calculating the resistance as follows;

Load Resistance = Input Voltage / (voltage across current monitor / monitor resistor value)

Resistance Range 1 Programming Accuracy

1. Connect Electronic Load, Power source and DVM's as shown in figure B-4. **Be sure + sense and – sense are connected to the +/- input terminals and the remote/local button is in the remote position.**
2. Turn on the Electronic Load and press [Recall], scroll till display reads *RST and press [Enter].
3. Press [Func]. Scroll until display reads FUNC RES then press [Enter].
4. Press [RES]. Scroll until display reads RES:RANG, press [1] then [Enter].
5. Turn on the power source. See power source voltage and current values as listed in following table.

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Power Source Voltage Setting	24V	48V	12V	30V	15V	30V
Power Source Current Setting	7A	7A	10A	10A	20A	7A

6. Wait 30 seconds. Checking resistance range 1, high resistance point. Calculate and record resistance on test card. Input resistance = Input Voltage / (DVM voltage reading from current shunt/ current shunt resistance).
7. Checking resistance range 1, low resistance point. Reset power source voltage to following values.

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Power Source Voltage Setting	4V	6V	10V	5V	6V	5V
Power Source Current Setting	25A	10A	30A	50A	70A	25A

8. Press [RES] [select resistance from following table] [Enter].

N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
0.2 Ω	1.2 Ω	0.5 Ω	0.125 Ω	0.100 Ω	0.250 Ω

9. Wait 30 seconds. Calculate and record resistance range 1, low resistance point.

Resistance Range 2 Programming Accuracy

1. Press [RES]. Scroll until display reads RES:RANG. For models N3302A, N3304A, N3305A, and N3306A press [9] then [Enter]. For models N3303A and N3307A press [5] [0] then [Enter].
2. Checking resistance range 2, low resistance point. Press [RES] [select resistance from following table] [Enter].

N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
3.6 Ω	44 Ω	1.8 Ω	4.5 Ω	0.9 Ω	9 Ω

3. Set power source voltage and current values as listed in following table.

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Power Source Voltage Setting	20V	96V	6V	30V	6V	30V
Power Source Current Setting	7A	3A	7A	15A	8A	7A

4. Wait 15 seconds. Calculate and record resistance range 2 low resistance point.
5. Checking resistance range 2, high resistance point. Press [RES] [select resistance from following table] [Enter].

N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
40 Ω	480 Ω	20 Ω	50 Ω	10 Ω	100 Ω

6. Set power source voltage and current values as listed in following table.

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Power Source Voltage Setting	24V	96V	12V	30V	12V	30V
Power Source Current Setting	7A	3A	7A	15A	8A	7A

7. Wait 15 seconds. Calculate and record resistance range 2 high resistance point

Resistance Range 3 Programming Accuracy

1. Press [RES]. Scroll until display reads RES:RANG. For models N3302A, N3304A, N3305A, and N3306A press [1] [0] [0] then [Enter]. For models N3303A and N3307A press [5] [0] [0] then [Enter].
2. Checking resistance range 3, low resistance point. Press [RES] [select resistance from following table] [Enter].

N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
36 Ω	440 Ω	18 Ω	45 Ω	9 Ω	90 Ω

3. Set power source voltage and current values as listed in following table.

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Power Source Voltage Setting	40V	96V	20V	50V	20V	50V
Power Source Current Setting	3.5A	1A	3A	3.5A	3.5A	3.5A

4. Wait 7 seconds. Calculate and record resistance range 3 low resistance point.
5. Checking resistance range 3, high resistance point. Press [RES] [select resistance from following table] [Enter].

N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
400 Ω	4800 Ω	200 Ω	500 Ω	100 Ω	1000 Ω

6. Set power source voltage and current values as listed in following table.

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Power Source Voltage Setting	40V	96V	20V	50V	20V	50V
Power Source Current Setting	3.5A	1A	3A	3.5A	3.5A	3.5A

7. Wait 7 seconds. Calculate and record resistance range 3 high resistance point.

Resistance Range 4 Programming Accuracy

1. Press [RES]. Scroll until display reads RES:RANG. For models N3302A, N3304A, N3305A, and N3306A press [1] [0] [0] [0] then [Enter]. For model N3303A press [5] [0] [0] [0] then [Enter]. For model N3307A press [2] [0] [0] [0] then [Enter].
2. Checking resistance range 4 low resistance point. Press [RES] [select resistance from following table] [Enter].

N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
360 Ω	4400 Ω	180 Ω	450 Ω	90 Ω	900 Ω

3. Set power source voltage and current values as listed in following table.

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Power Source Voltage Setting	50V	96V	20V	50V	20V	50V
Power Source Current Setting	3.5A	1A	3A	3.5A	3.5A	3.5A

4. Wait 3 seconds. Calculate and record resistance range 3 low resistance point.
5. Checking resistance range 4, high resistance point. Press [RES] [select resistance from following table] [Enter].

N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
2000 Ω	12,000 Ω	2000 Ω	2500 Ω	1000 Ω	2500 Ω

6. Set power source voltage and current values as listed in following table.

	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
Power Source Voltage Setting	50V	96V	20V	50V	20V	50V
Power Source Current Setting	3.5A	1A	3A	3.5A	3.5A	3.5A

7. Wait 3 seconds. Calculate and record resistance range 4 high resistance point.

Keysight N3302A Verification Test Record

Test Description	Minimum Specification	Results	Maximum Specification
Constant Current Mode Tests			
30 Ampere Range Programming and Readback			
Low Current (1 A)	0.989 A	_____A	1.011 A
Front Panel Display	Aout – 6.5mA	_____A	Aout + 6.5mA
High Current (30 A)	29.960 A	_____A	30.040 A
Front Panel Display	Aout – 21mA	_____A	Aout + 21mA
3 Ampere Range Programming and Readback			
Low Current (1 A)	0.994 A	_____A	1.006 A
Front Panel Display	Aout – 3.5mA	_____A	Aout + 3.5mA
High Current (3 A)	2.992 A	_____A	3.008 A
Front panel Display	Aout – 4.5mA	_____A	Aout + 4.5mA
Constant Current Regulation Test			
2.5 Amp Regulation at input voltage delta 4V to 60V		_____ mA	Less than 10mA
Voltage Mode Tests			
60 Volt Range Programming and Readback			
Low Voltage (3 V)	2.989 V	_____V	3.011 V
Front Panel Display	Vout – 9.5mV	_____V	Vout + 9.5mV
High Voltage (60 V)	59.932 V	_____V	60.068 V
Front Panel Display	Vout – 38mV	_____V	Vout + 38mV
6 Volt Range Programming and Readback			
Low Voltage (3 V)	2.994 V	_____V	3.006 V
Front Panel Display	Vout – 4.5mV	_____V	Vout + 4.5mV
High Voltage (6 V)	5.991 V	_____V	6.009 V
Front Panel Display	Vout – 6mV	_____V	Vout + 6mV
Voltage Mode Regulation Test			
5V regulation with input current delta 1A to 30A		_____mV	Less than 5mV
Resistance Mode Tests			
Resistance Range 1			
High Resistance Point 4 Ω	3.944 Ω	_____ Ω	4.056 Ω
Low Resistance Point 0.2 Ω	0.1752 Ω	_____ Ω	0.2248 Ω
Resistance Range 2			
Low Resistance Point 3.6 Ω	3.466 Ω	_____Ω	3.734 Ω
High Resistance Point 40 Ω	38.720 Ω	_____Ω	41.280 Ω
Resistance Range 3			
Low Resistance Point 36 Ω	32.880 Ω	_____Ω	39.120 Ω
High Resistance Point 400 Ω	271.76 Ω	_____ Ω	528.24 Ω
Resistance Range 4			
Low Resistance Point 360 Ω	270 Ω	_____Ω	720 Ω
High Resistance Point 2000 Ω	1200 Ω	_____Ω	10,000 Ω

Keysight N3303A Verification Test Record

Test Description	Minimum Specification	Results	Maximum Specification
Constant Current Mode Tests			
10 Ampere Range Programming and Readback			
Low Current (1 A)	0.9915 A	_____A	1.0085 A
Front Panel Display	Aout – 5.5mA	_____A	Aout + 5.5mA
High Current (10 A)	9.9825 A	_____A	10.0175 A
Front Panel Display	Aout – 10mA	_____A	Aout + 10mA
1 Ampere Range Programming and Readback			
Low Current (0.1 A)	0.0959 A	_____A	0.1041 A
Front Panel Display	Aout – 2.55 mA	_____A	Aout + 2.55mA
High Current (1 A)	0.995 A	_____A	1.005 A
Front panel Display	Aout – 3mA	_____A	Aout + 3mA
Current Regulation test			
1.0 Amp Regulation at input voltage delta 4V to 240V		_____mA	Less than 8mA
Voltage Mode Tests			
240 Volt Range Programming and Readback			
Low Voltage (3 V)	2.957 V	_____V	3.043 V
Front Panel Display	Vout – 21mV	_____V	Vout + 21mV
High Voltage (240 V)	239.720 V	_____V	240.280 V
Front Panel Display	Vout – 140mV	_____V	Vout + 140mV
24 Volt Range Programming and Readback			
Low Voltage (3 V)	2.987 V	_____V	3.013 V
Front Panel Display	Vout – 11mV	_____V	Vout + 11mV
High Voltage (24 V)	23.966 V	_____V	24.034 V
Front Panel Display	Vout – 22mV	_____V	Vout + 22mV
Voltage Mode Regulation Test			
25V regulation with input current delta 0.4A to 10A		_____mV	Less than 10mV
Resistance Mode Tests			
Resistance Range 1			
High Resistance Point 48 Ω	46.46 Ω	_____ Ω	49.54 Ω
Low Resistance Point 1.2 Ω	1.088 Ω	_____ Ω	1.312 Ω
Resistance Range 2			
Low Resistance Point 44 Ω	41.30 Ω	_____Ω	46.70 Ω
High Resistance Point 480 Ω	383.50 Ω	_____Ω	576.5 Ω
Resistance Range 3			
Low Resistance Point 440 Ω	308 Ω	_____Ω	660 Ω
High Resistance Point 4800 Ω	2400 Ω	_____Ω	33,600 Ω
Resistance Range 4			
Low Resistance Point 4400 Ω	1496 Ω	_____Ω	39,600 Ω
High Resistance Point 12,000 Ω	4080 Ω	_____Ω	108,000 Ω

Keysight N3304A Verification Test Record

Test Description	Minimum Specification	Results	Maximum Specification
Constant Current Mode Tests			
60 Ampere Range Programming and Readback			
Low Current (1 A)	0.984 A	_____A	1.016 A
Front Panel Display	Aout –10.5mA	_____A	Aout + 10.5mA
High Current (60 A)	59.925 A	_____A	60.075 A
Front Panel Display	Aout – 40mA	_____A	Aout +40mA
6 Ampere Range Programming and Readback			
Low Current (1 A)	0.9915	_____A	1.0085
Front Panel Display	Aout – 5.5mA	_____A	Aout + 5.5mA
High Current (6 A)	5.9865 A	_____A	6.0135 A
Front panel Display	Aout – 8mA	_____A	Aout + 8mA
Current Regulation Test			
5 Amp Regulation at input voltage delta 4V to 60V		_____mA	Less than 10 mA
Voltage Mode Tests			
60 Volt Range Programming and Readback			
Low Voltage (3 V)	2.989 V	_____V	3.011 V
Front Panel Display	Vout – 9.5mV	_____V	Vout + 9.5mV
High Voltage (60 V)	59.932 V	_____V	60.068 V
Front Panel Display	Vout – 38mV	_____V	Vout + 38mV
6 Volt Range Programming and Readback			
Low Voltage (3 V)	2.994 V	_____V	3.006 V
Front Panel Display	Vout – 4.5mV	_____V	Vout + 4.5mV
High Voltage (6 V)	5.991 V	_____V	6.009 V
Front Panel Display	Vout – 6mV	_____V	Vout + 6mV
Voltage Mode Regulation Test			
5V regulation with input current delta 1A to 60A		_____mV	Less than 10mV
Resistance Mode Tests			
Resistance Range 1			
High Resistance Point 2 Ω	1.980 Ω	_____ Ω	2.020 Ω
Low Resistance Point 0.50 Ω	0.486 Ω	_____ Ω	0.514 Ω
Resistance Range 2			
Low Resistance Point 1.8 Ω	1.733 Ω	_____Ω	1.867 Ω
High Resistance Point 20 Ω	19.360 Ω	_____ Ω	20.640 Ω
Resistance Range 3			
Low Resistance Point 18 Ω	16.800 Ω	_____Ω	19.20 Ω
High Resistance Point 200 Ω	159.88 Ω	_____Ω	240.12 Ω
Resistance Range 4			
Low Resistance Point 180 Ω	144 Ω	_____Ω	298.8 Ω
High Resistance Point 2000 Ω	1000 Ω	_____Ω	42,000 Ω

Keysight N3305A Verification Test Record

Test Description	Minimum Specification	Results	Maximum Specification
Constant Current Mode Tests			
60 Ampere Range Programming and Readback			
Low Current (1A)	0.984 A	_____A	1.016 A
Front Panel Display	Aout – 10.5mA	_____A	Aout + 10.5mA
High Current (60 A)	59.925 A	_____A	60.075 A
Front Panel Display	Aout – 40mA	_____A	Aout + 40mA
6 Ampere Range Programming and Readback			
Low Current (1A)	0.9915 A	_____A	1.0085 A
Front Panel Display	Aout – 5.5mA	_____A	Aout + 5.5mA
High Current (6 A)	5.9865 A	_____A	6.0135 A
Front panel Display	Aout – 8mA	_____A	Aout + 8mA
Current Regulation Test			
3.3 Amp Regulation at input voltage delta 4V to 150V		_____mA	Less than 10mA
Voltage Mode Tests			
150 Volt Range Programming and Readback			
Low Voltage (3 V)	2.977 V	_____V	3.023 V
Front Panel Display	Vout – 17.5mV	_____V	Vout + 17.5mV
High Voltage (150 V)	149.830 V	_____V	150.170 V
Front Panel Display	Vout – 91mV	_____V	Vout + 91mV
15 Volt Range Programming and Readback			
Low Voltage (3 V)	2.987 V	_____V	3.013 V
Front Panel Display	Vout – 9.5mV	_____V	Vout + 9.5mV
High Voltage (15 V)	14.975 V	_____V	15.025 V
Front Panel Display	Vout – 15.5mV	_____V	Vout + 15.5mV
Voltage Regulation Test			
8.3V regulation with input current delta 1A to 60A		_____mV	Less than 10mV
Resistance Mode Tests			
Resistance Range 1			
High Resistance Point 5 Ω	4.936 Ω	_____ Ω	5.064 Ω
Low Resistance Point 0.125 Ω	0.1005 Ω	_____ Ω	0.1495 Ω
Resistance Range 2			
Low Resistance Point 4.5 Ω	4.352 Ω	_____Ω	4.647 Ω
High Resistance Point 50 Ω	48.42 Ω	_____Ω	51.58 Ω
Resistance Range 3			
Low Resistance Point 45 Ω	40.50 Ω	_____Ω	56.25 Ω
High Resistance Point 500 Ω	350 Ω	_____Ω	1250 Ω
Resistance Range 4			
Low Resistance Point 450 Ω	292 Ω	_____Ω	1350 Ω
High Resistance Point 2500 Ω	1250 Ω	_____Ω	52.5 kΩ

Keysight N3306A Verification Test Record

Test Description	Minimum Specification	Results	Maximum Specification
Constant Current Mode Tests			
120 Ampere Range Programming and Readback			
Low Current (1A)	0.9615 A	_____A	1.0385 A
Front Panel Display	Aout – 20.5mA	_____A	Aout + 20.5mA
High Current (120 A)	119.8425 A	_____A	120.1575 A
Front Panel Display	Aout – 80mA	_____A	Aout + 80mA
12 Ampere Range Programming and Readback			
Low Current (1A)	0.9840A	_____A	1.0160 A
Front Panel Display	Aout – 10.5mA	_____A	Aout + 10.5mA
High Current (12 A)	11.973 A	_____A	12.027 A
Front panel Display	Aout – 16mA	_____A	Aout + 16mA
Current Regulation Test			
10 Amp Regulation at input voltage delta 4V to 60V		_____mA	Less than 10mA
Voltage Mode Tests			
60 Volt Range Programming and Readback			
Low Voltage (3 V)	2.989 V	_____V	3.011 V
Front Panel Display	Vout – 9.5mV	_____V	Vout + 9.5mV
High Voltage (60 V)	59.932 V	_____V	60.068 V
Front Panel Display	Vout – 38mV	_____V	Vout + 38mV
6 Volt Range Programming and Readback			
Low Voltage (3 V)	2.994 V	_____V	3.006 V
Front Panel Display	Vout – 4.5m	_____V	Vout + 4.5m
High Voltage (6 V)	5.991 V	_____V	6.009 V
Front Panel Display	Vout – 6mV	_____V	Vout + 6mV
Voltage Regulation Test			
5V regulation with input current delta 1A to 120A		_____mV	Less than 20mV
Resistance Mode Tests			
Resistance Range 1			
High Resistance Point 1 Ω	0.990 Ω	_____ Ω	1.010 Ω
Low Resistance Point 0.100 Ω	0.0936 Ω	_____ Ω	0.1064 Ω
Resistance Range 2			
Low Resistance Point 0.9 Ω	0.8665 Ω	_____Ω	0.9335 Ω
High Resistance Point 10 Ω	9.680 Ω	_____Ω	10.32 Ω
Resistance Range 3			
Low Resistance Point 9 Ω	8.400 Ω	_____Ω	9.60 Ω
High Resistance Point 100 Ω	79.940 Ω	_____Ω	120.06 Ω
Resistance Range 4			
Low Resistance Point 90 Ω	72 Ω	_____Ω	149.4 Ω
High Resistance Point 1000 Ω	500 Ω	_____ Ω	21,000 Ω

Keysight N3307A Verification Test Record

Test Description	Minimum Specification	Results	Maximum Specification
Constant Current Mode Tests			
30 Ampere Range Programming and Readback			
Low Current (1 A)	0.984 A	_____A	1.016 A
Front Panel Display	Aout – 6.5mA	_____A	Aout + 6.5mA
High Current (30 A)	29.955 A	_____A	30.045 A
Front Panel Display	Aout – 21mA	_____A	Aout + 21mA
3 Ampere Range Programming and Readback			
Low Current (1 A)	0.9915 A	_____A	1.0085 A
Front Panel Display	Aout – 3.5mA	_____A	Aout + 3.5mA
High Current (3 A)	2.9895 A	_____A	3.0105 A
Front panel Display	Aout – 4.5mA	_____A	Aout + 4.5mA
Constant Current Regulation Test			
1.6 Amp Regulation at input voltage delta 4V to 150V		_____ mA	Less than 10mA
Voltage Mode Tests			
150 Volt Range Programming and Readback			
Low Voltage (3 V)	2.977 V	_____V	3.023 V
Front Panel Display	Vout – 17.5mV	_____V	Vout + 17.5mV
High Voltage (150 V)	149.830 V	_____V	150.170 V
Front Panel Display	Vout – 91mV	_____V	Vout + 91mV
15 Volt Range Programming and Readback			
Low Voltage (3 V)	2.987 V	_____V	3.013 V
Front Panel Display	Vout – 9.5mV	_____V	Vout + 9.5mV
High Voltage (15 V)	14.975 V	_____V	15.025 V
Front Panel Display	Vout – 15.5mV	_____V	Vout + 15.5mV
Voltage Regulation Test			
8.3V regulation with input current delta 1A to 30A		_____mV	Less than 10mV
Resistance Mode Tests			
Resistance Range 1			
High Resistance Point 10 Ω	9.768 Ω	_____ Ω	10.232 Ω
Low Resistance Point 0.250 Ω	0.2161 Ω	_____ Ω	0.2839 Ω
Resistance Range 2			
Low Resistance Point 9.0 Ω	8.61 Ω	_____Ω	9.390 Ω
High Resistance Point 100 Ω	89.88 Ω	_____Ω	110.12 Ω
Resistance Range 3			
Low Resistance Point 90 Ω	72 Ω	_____Ω	108 Ω
High Resistance Point 1000 Ω	670 Ω	_____Ω	3000 Ω
Resistance Range 4			
Low Resistance Point 900 Ω	495 Ω	_____Ω	6300 Ω
High Resistance Point 2500 Ω	1250 Ω	_____ Ω	52.5k Ω

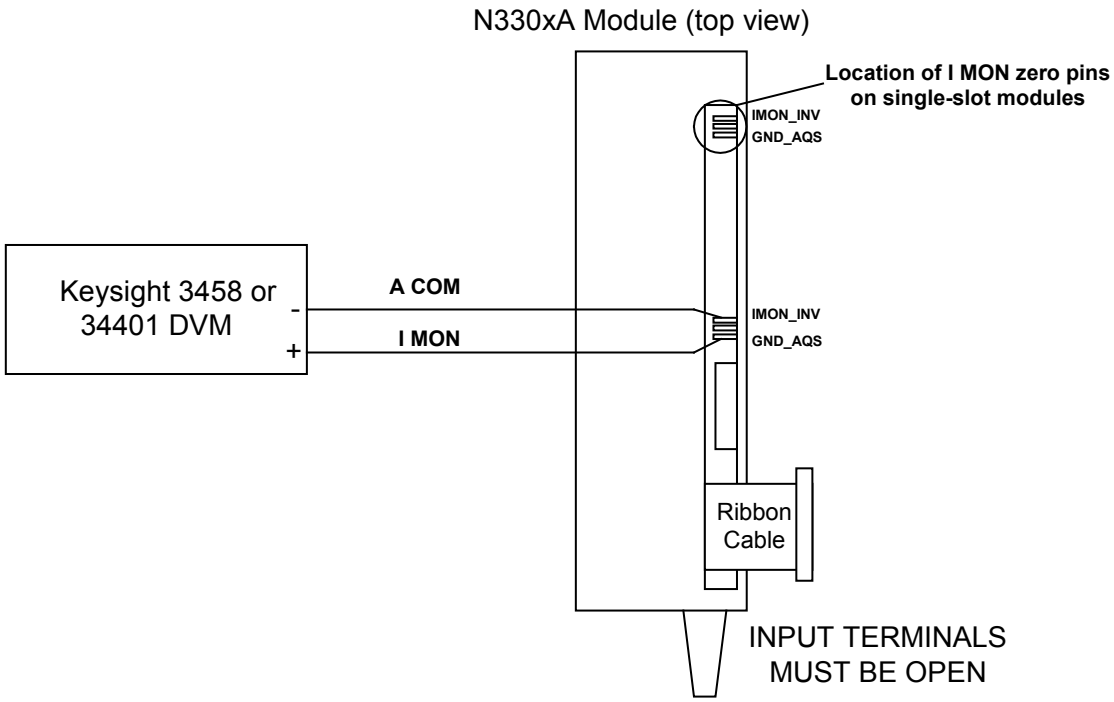


Figure B-1. I MON ZERO CALIBRATION

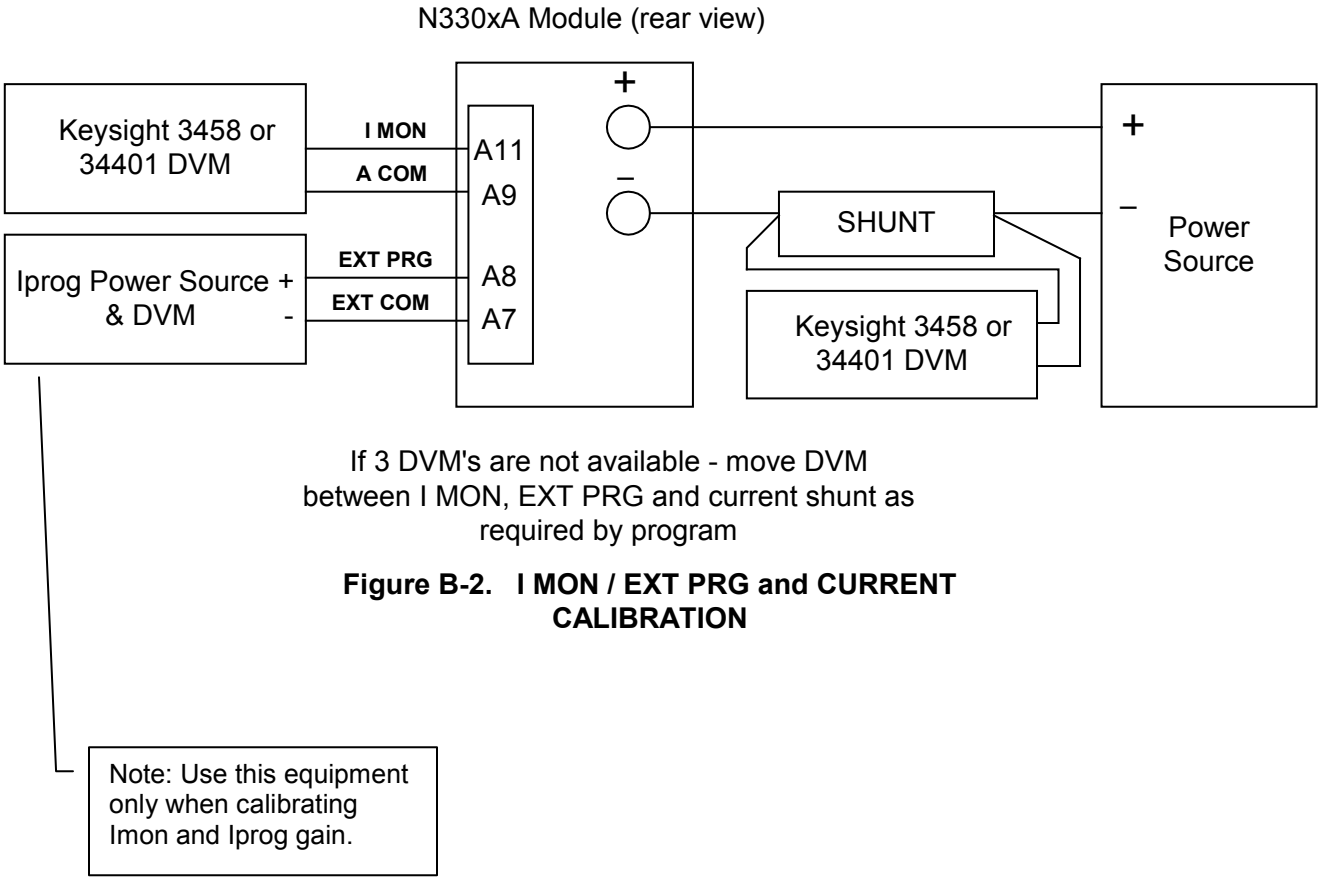
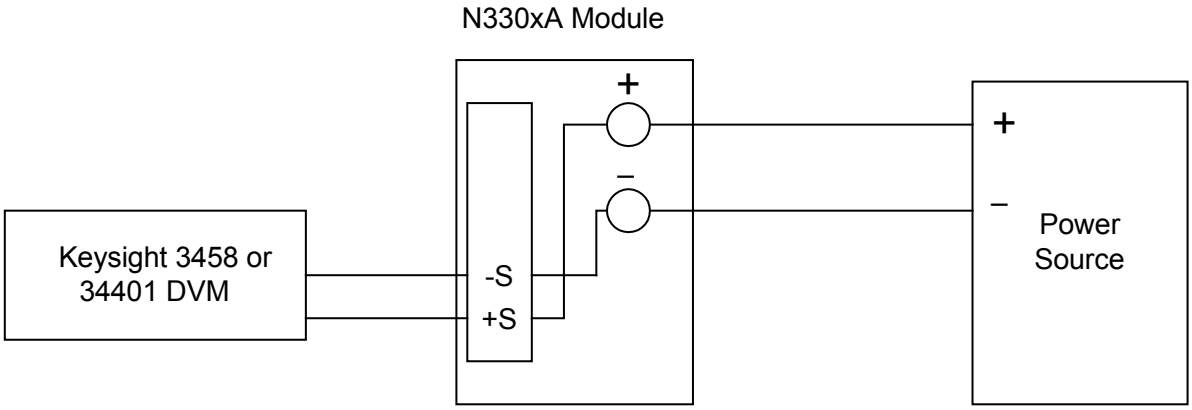
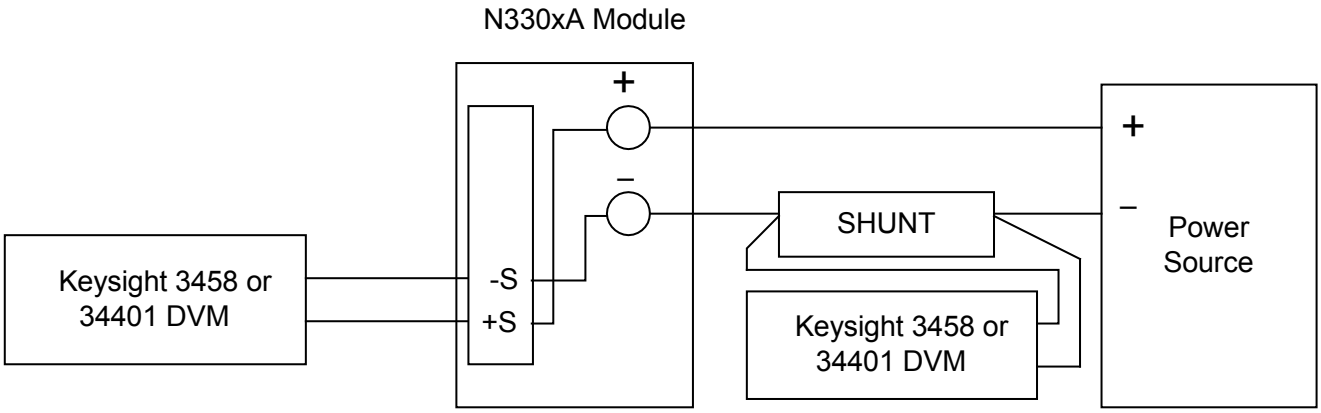


Figure B-2. I MON / EXT PRG and CURRENT CALIBRATION



Be sure sense switch is in RMT position

Figure B-3. VOLTAGE CALIBRATION



If 2 DVM's are not available - move DVM between
+/- sense and shunt as required by program

Be sure sense switch is in RMT position

Figure B-4. RESISTANCE CALIBRATION

Calibration

Parameters Calibrated

The following parameters may be calibrated:

- External Current Monitor (Imon)
- External Current Programming (Iprog)
- Input Current
- Input Voltage
- Input Resistance

You do not have to do a complete calibration each time. If appropriate, you may calibrate only the current, voltage or resistance and proceed to "Saving Calibration Constants". However, Imon and Iprog must be calibrated before Input Current is calibrated and both Imon and Input Current must be calibrated before Input Resistance can be calibrated.

The following section lists calibration programs to re-calibrate (adjust) those parameters that are not within specification. The programs listed are for use with either an HP Series 200/300 computer using BASIC (RMB) or a PC equipped with an IEEE-488.2 interface card and BASIC for Windows.

The variables to be used in the programs are listed in **Table B-2 Variables**. The connections for the test equipment, current shunts and DVMs are shown in Figures B-1 for IMON ZERO calibration, B-2 for IMON, IPROG and CURRENT calibration, B-3 for VOLTAGE calibration and B-4 for RESISTANCE calibration. A listing of all programming commands and their explanations can be found in the Programming Guide, part number 5964-8198.

Table B-2 Variables and Power Source Settings

VARIABLE	N3302A	N3303A	N3304A	N3305A	N3306A	N3307A
CURRENT MODE VOLTAGE / CURRENT SETTINGS						
Power source voltage setting	5V	20	5V	8V	5V	8V
Power source current setting	33A	12A	61A	61A	130A	33A
VOLTAGE MODE VOLTAGE / CURRENT SETTINGS						
Power source voltage setting	61V	246 V	61V	152V	61V	152V
Power source current setting	2 A	0.6 A	3 A	2 A	3 A	2A
RESISTANCE MODE VARIABLE and VOLTAGE / CURRENT SETTINGS						
Resistance Range 1						
< resistance range 1 variable >	4 Ω	48 Ω	2 Ω	5 Ω	1 Ω	10 Ω
Power source voltage setting for P1	24V	80V	12V	28V	12V	27V
Power source voltage setting for P2	6V	15V	6V	4.5V	6V	9V
Power source current setting	20A	7A	40A	15A	80A	15A
Resistance Range 2						
< resistance range 2 variable >	40 Ω	480 Ω	20 Ω	50 Ω	10 Ω	100 Ω
Power source voltage setting for P1	15V	50V	18V	39V	18V	45V
Power source voltage setting for P2	12V	30V	7V	16V	9V	24V
Power source current setting	3.5A	3.5A	15A	3.5A	15A	3.5A
Resistance Range 3						
< resistance range 3 variable >	400 Ω	2400 Ω	200 Ω	500 Ω	100 Ω	1000 Ω
Power source voltage setting for P1	30V	150V	25V	45V	20V	100V
Power source voltage setting for P2	18V	75V	12V	15V	11V	75V
Power source current setting	3.5A	3.5A	3.5A	3.5	7A	3.5
Resistance Range 4						
< resistance range 4 variable >	2000 Ω	12000 Ω	2000 Ω	2500 Ω	1000 Ω	2500 Ω
Power source voltage setting for P1	60V	150V	60V	150V	17V	150V
Power source voltage setting for P2	30V	150V	12V	115V	11V	150V
Power source current setting	3.5A	3.5A	3.5A	3.5A	3.5A	3.5A

IMON, IPROG and CURRENT Calibration Program

```
10    !  This program will calibrate Imon, Iprog and Current for load
20    !  modules N3302A, N3303A, N3304A, N3305A, N3306A and N3307A.
30    !
40    !  last update 1/11/02
50    !
60    !  Edit the interface address on line 100 if different then 705
70    !
80    ASSIGN @Ld TO 705
90    !
100   OUTPUT @Ld;"*RST"
110   OUTPUT @Ld;"CAL:STAT ON"
120   OUTPUT @Ld;"FUNC CURR"
130   OUTPUT @Ld;"CURR:RANG MAX"
140   OUTPUT @Ld;"SENS:CURR:RANG MAX"
150   OUTPUT @Ld;"INP:STAT ON"
160   !
170   ! *******     Calibrating Imon Zero  *******
180   !
190   PRINT TABXY(10,8),"See figure B-1 for Imon calibration"
200   PRINT TABXY(10,10),"Module Input Terminals must be open - disconnect power
      source"
210   PRINT TABXY(10,12),"Connect DVM to IMON terminals"
220   DISP "Press CONT when ready to calibrate Imon"
230   PAUSE
240   CLEAR SCREEN
250   !
260   OUTPUT @Ld;"CAL:IMON:LEV P1"
270   PRINT TABXY(20,20);"Calibrating IMON P1 - 5 SECOND WAIT"
280   WAIT 5
290   CLEAR SCREEN
300   INPUT "Measure IMON and enter value in volts - OBSERVE VOLTAGE
      POLARITY",Vimonp1
310   !
320   OUTPUT @Ld;"CAL:DATA ";Vimonp1
330   !
340   OUTPUT @Ld;"CAL:IMON:LEV P2"
350   PRINT TABXY(20,20);"Calibrating IMON P2 - 5 SECOND WAIT"
360   WAIT 5
370   CLEAR SCREEN
380   INPUT "Measure IMON and enter value in volts - OBSERVE VOLTAGE
      POLARITY",Vimonp2
390   !
400   OUTPUT @Ld;"CAL:DATA ";Vimonp2
410   !
420   ! *******   Calibrating Imon and Iprog gain  *******
430   !
440   PRINT TABXY(10,8),"See figure B-2 for Imon and Iprog calibration"
450   PRINT TABXY(10,10),"Connect module input terminals to power source"
460   PRINT TABXY(10,12),"See Table B-2 Current Mode Voltage /Current Settings"
470   PRINT TABXY(10,14),"Set power source voltage and current for model to be
      calibrated"
480   PRINT TABXY(10,16),"Set IPROG power source to 1 volt"
490   !
500   DISP "Press CONT when ready to calibrate Imon and Iprog"
510   PAUSE
520   CLEAR SCREEN
530   !
```

```
540   INPUT "Enter value of high range current shunt in ohms",Rshunt
550   DISP "You have entered ";Rshunt;" ohms"
560   INPUT "If correct enter 'Y' or press CONT, if wrong enter 'N' or 'n'",Y$
570   IF UPC$(Y$)="Y" OR Y$="" THEN 590
580   IF UPC$(Y$)="N" OR Y$="n" THEN 520
590   CLEAR SCREEN
600   !
610   OUTPUT @Ld;"CAL:IPR:LEV P1"
620   PRINT TABXY(20,20),"Calibrating IMON & IPROG P1 - 30 SECOND WAIT"
630   WAIT 30
640   CLEAR SCREEN
650   !
660   INPUT "Measure voltage across current shunt and enter in volts",Ip1
670   !
680   INPUT "Measure Imon voltage and enter in volts",Vimonp1
690   !
700   INPUT "Measure Iprog voltage and enter in volts",Viprogp1
710   !
720   Ip1=Ip1/Rshunt
730   !
740   OUTPUT @Ld;"CAL:DATA ";Ip1,Vimonp1,Viprogp1
750   !
760   OUTPUT @Ld;"CAL:IPR:LEV P2"
770   !
780   PRINT TABXY(20,20),"Calibrating IMON & IPROG P2 - 30 SECOND WAIT"
790   WAIT 30
800   CLEAR SCREEN
810   !
820   INPUT "Measure voltage across current shunt and enter in volts",Ip2
830   !
840   INPUT "Measure Imon voltage and enter in volts",Vimonp2
850   !
860   INPUT "Measure Iprog voltage and enter in volts",Viprogp2
870   !
880   Ip2=Ip2/Rshunt
890   !
900   OUTPUT @Ld;"CAL:DATA ";Ip2,Vimonp2,Viprogp2
910   !
920   PRINT "Set IPROG power source to 8.5 volts"
930   DISP "Press CONT when ready"
940   PAUSE
950   CLEAR SCREEN
960   !
970   OUTPUT @Ld;"CAL:IPR:LEV P3"
980   PRINT TABXY(20,20),"Calibrating IMON & IPROG P3 - 30 SECOND WAIT"
990   WAIT 30
1000  CLEAR SCREEN
1010  !
1020  INPUT "Measure voltage across current shunt and enter in volts",Ip3
1030  !
1040  INPUT "Measure Imon voltage and enter in volts",Vimonp3
1050  !
1060  INPUT "Measure Iprog voltage and enter in volts",Viprogp3
1070  !
1080  Ip3=Ip3/Rshunt
1090  !
1100  OUTPUT @Ld;"CAL:DATA ";Ip3,Vimonp3,Viprogp3
```

```
1110  !
1120  OUTPUT @Ld;"CAL:IPR:LEV P4"
1130  !
1140  PRINT TABXY(20,20),"Calibrating IMON & IPROG P4 - 30 SECOND WAIT"
1150  WAIT 30
1160  CLEAR SCREEN
1170  !
1180  INPUT "Measure voltage across current shunt and enter in volts",Ip4
1190  !
1200  INPUT "Measure Imon voltage and enter in volts",Vimonp4
1210  !
1220  INPUT "Measure Iprog voltage and enter in volts",Viprogp4
1230  !
1240  Ip4=Ip4/Rshunt
1250  !
1260  OUTPUT @Ld;"CAL:DATA ";Ip4,Vimonp4,Viprogp4
1270  !
1280  !  *******   Calibrating Main Current DAC    ********
1290  !
1300  PRINT TABXY(10,10),"Disconnect instruments from IMON and IPROG terminals"
1310  DISP "Press CONT when ready to calibrate main current ADC"
1320  PAUSE
1330  !
1340  CLEAR SCREEN
1350  OUTPUT @Ld;"CAL:LEV P1"
1360  PRINT TABXY(10,20),"Calibrating high current range P1 - 30 SECOND WAIT"
1370  WAIT 30
1380  CLEAR SCREEN
1390  !
1400  INPUT "Measure voltage across current shunt and enter in volts",Ip1
1410  !
1420  Ip1=Ip1/Rshunt
1430  !
1440  OUTPUT @Ld;"CAL:DATA ";Ip1
1450  !
1460  OUTPUT @Ld;"CAL:LEV P2"
1470  !
1480  PRINT TABXY(10,10),"Calibrating high current range P2 - 30 SECOND WAIT"
1490  WAIT 30
1500  CLEAR SCREEN
1510  !
1520  INPUT "Measure voltage across current shunt and enter in volts",Ip2
1530  !
1540  Ip2=Ip2/Rshunt
1550  !
1560  OUTPUT @Ld;"CAL:DATA ";Ip2
1570  !
1580  OUTPUT @Ld;"INP:STAT OFF"
1590  OUTPUT @Ld;"CURR:RANG MIN"
1600  OUTPUT @Ld;"SENS:CURR:RANG MIN"
1610  !
1620  CLEAR SCREEN
1630  !
1640  INPUT "Disconnect high range current shunt. Connect low range current shunt.
      Enter value of low range current shunt in ohms",Rshuntl
1650  DISP "You have entered ";Rshuntl;" ohms"
1660  INPUT "If correct enter 'Y' or press CONT, if wrong enter 'N' or 'n'",Y$
1670  IF UPC$(Y$)="Y" OR Y$="" THEN 1690
1680  IF UPC$(Y$)="N" OR Y$="n" THEN 1620
```

```
1690  CLEAR SCREEN
1700  !
1710  OUTPUT @Ld;"INP:STAT ON"
1720  OUTPUT @Ld;"CAL:LEV P1"
1730  !
1740  PRINT TABXY(10,10),"Calibrating low current range P1 - 30 SECOND WAIT"
1750  WAIT 30
1760  CLEAR SCREEN
1770  !
1780  INPUT "Measure voltage across current shunt and enter in volts",Ip1
1790  !
1800  Ip1=Ip1/Rshuntl
1810  !
1820  OUTPUT @Ld;"CAL:DATA ";Ip1
1830  !
1840  OUTPUT @Ld;"CAL:LEV P2"
1850  !
1860  PRINT TABXY(10,10),"calibrating low current range P2 - 30 SECOND WAIT"
1870  WAIT 30
1880  CLEAR SCREEN
1890  !
1900  INPUT "Measure voltage across current shunt and enter in volts",Ip2
1910  !
1920  Ip2=Ip2/Rshuntl
1930  !
1940  OUTPUT @Ld;"CAL:DATA ";Ip2
1950  !
1960  OUTPUT @Ld;"CAL:SAVE"
1970  OUTPUT @Ld;"CAL:STAT OFF"
1980  !
1990  PRINT "IMON, IPROG and Current calibration adjustments complete"
2000  PRINT "Verify Current Adjustments"
2010  !
2020  END
```

VOLTAGE Calibration Program

```
10    !  This program calibrates the voltage mode for load modules
20    !  N3302A, N3303A, N3304A, N3305A, N3306A and N3307A.
30    !
40    !  last update  1/11/02
50    !
60    !  Edit the interface address on line 100 if different then 705
70    !
80    ASSIGN @Ld TO 705
90    !
100   OUTPUT @Ld;"*RST"
110   OUTPUT @Ld;"CAL:STAT ON"
120   OUTPUT @Ld;"FUNC VOLT"
130   OUTPUT @Ld;"VOLT:RANG MAX"
140   OUTPUT @Ld;"SENS:VOLT:RANG MAX"
150   OUTPUT @Ld;"INP:STAT ON"
160   !
170   ! *******     Calibrating high volt range    *******
180   !
190   PRINT TABXY(10,8),"See figure B-3 for voltage calibration"
200   PRINT TABXY(10,10),"Connect power leads to input terminals"
210   PRINT TABXY(10,12),"Connect + sense to + input terminal"
220   PRINT TABXY(10,14),"Connect - sense to - input terminal"
230   PRINT TABXY(10,16),"Connect DVM to +/- sense terminals"
240   PRINT TABXY(10,18),"See Table B-2 Voltage Mode Voltage / Current Settings"
250   PRINT TABXY(10,20),"Set power source to voltage and current for model to be
      calibrated"
260   PRINT TABXY(10,24),"BE SURE REMOTE BUTTON ON REAR PANEL IS IN REMOTE
      POSITION"
270   DISP "Press CONT when ready to calibrate voltage "
280   PAUSE
290   CLEAR SCREEN
300   !
310   PRINT TABXY(9,15);"CALIBRATING HIGH VOLTAGE RANGE"
320   OUTPUT @Ld;"CAL:LEV P1"
330   WAIT 1
340   INPUT "Measure voltage at +/- sense terminals and enter value in volts",Vp1
350   !
360   OUTPUT @Ld;"CAL:DATA";Vp1
370   !
380   OUTPUT @Ld;"CAL:LEV P2"
390   WAIT 1
400   INPUT "Measure voltage at +/- sense terminals and enter value in volts",Vp2
410   !
420   OUTPUT @Ld;"CAL:DATA";Vp2
430   !
440   ! *******   Calibrating low voltage range  *******
450   !
460   OUTPUT @Ld;"VOLT:RANG MIN"
470   OUTPUT @Ld;"SENS:VOLT:RANG MIN"
480   !
490   CLEAR SCREEN
500   PRINT TABXY(9,15);"CALIBRATING LOW VOLTAGE RANGE"
510   !
520   OUTPUT @Ld;"CAL:LEV P1"
530   WAIT 1
```

```
540   !
550   INPUT "Measure voltage at +/- sense terminals and enter value in volts",Vp1
560   !
570   OUTPUT @Ld;"CAL:DATA";Vp1
580   !
590   OUTPUT @Ld;"CAL:LEV P2"
600   WAIT 1
610   !
620   INPUT "Measure voltage at +/- sense terminals and enter value in volts",Vp2
630   !
640   OUTPUT @Ld;"CAL:DATA";Vp2
650   !
660   OUTPUT @Ld;"CAL:SAVE"
670   OUTPUT @Ld;"CAL:STAT OFF"
680   !
690   CLEAR SCREEN
700   PRINT "Voltage calibration adjustments complete"
710   PRINT "Verify Voltage Adjustments"
720   !
730   END
```

RESISTANCE Calibration Program

```
10    !  This program calibrates the resistance mode for load modules
20    !  N3302A, N3303A, N3304A, N3305A, N3306A and N3307A.
30    !
40    !  last update  1/11/02
50    !
60    !  The variables for the module to be calibrated must be inserted
70    !  in the program where a < variable > is encountered. See Table B-2
80    !  for variables for the module you are calibrating.
90    !
100   !  NOTE: Delete lines 1540 to 1940 for module Model N3303
110   !
120   !  Edit the interface address on line 100 if different then 705
130   !
140   ASSIGN @Ld TO 705
150   !
160   OUTPUT @Ld;"*RST"
170   OUTPUT @Ld;"CAL:STAT ON"
180   OUTPUT @Ld;"FUNC RES"
190   OUTPUT @Ld;"INP:STAT ON"
200   !
210   PRINT TABXY(10,8);"See figure B-4 for resistance calibration set-up"
220   PRINT TABXY(10,10);"Connect power leads to input terminals"
230   PRINT TABXY(10,12);"Connect +/- sense to +/- input terminal"
240   PRINT TABXY(10,14);"Connect one DVM to +/- sense terminals"
250   PRINT TABXY(10,16);"Connect second DVM across current shunt"
260   DISP "Press CONT when ready to continue"
270   PAUSE
280   !
290   !    ********   CALIBRATING RANGE 1 ****************
300   !
310   CLEAR SCREEN
320   INPUT "Enter value of current shunt for range 1 in OHMS",Rshunt1
330   PRINT TABXY(10,10);"You have entered ";Rshunt1;" ohms"
340   INPUT "If correct enter 'Y' or press CONT, if wrong enter 'N' or 'n'",Y$
350   IF UPC$(Y$)="Y" OR Y$="" THEN 370
360   IF UPC$(Y$)="N" OR Y$="n" THEN 310
370   CLEAR SCREEN
380   !
390   PRINT TABXY(10,12);"Turn on and set power source to voltage and current
      settings from"
400   PRINT TABXY(10,13);"Table B-2 for resistance range 1 - Point P1"
410   DISP "Press CONT when ready to calibrate resistance range 1"
420   PAUSE
430   CLEAR SCREEN
440   PRINT TABXY(9,15);"CALIBRATING RESISTANCE RANGE 1 - P1 - 30 SECOND WAIT"
450   OUTPUT @Ld;"RES:RANG 1"
460   OUTPUT @Ld;"CAL:LEV P1"
470   WAIT 30
480   INPUT "Measure voltage across current shunt - enter value in volts",Vp1
490   Ip1=Vp1/Rshunt1
500   INPUT "Measure voltage across +/- sense terminals and enter value in
      volts",Vt1
510   Rp1=Vt1/Ip1
520   OUTPUT @Ld;"CAL:DATA";Rp1
530   !
540   CLEAR SCREEN
```

```
550   PRINT TABXY(10,12);"Set power source to voltage and current settings from
      Table B-2"
560   PRINT TABXY(10,13);"for resistance range 1 - Point P2"
570   DISP "Press Cont to continue resistance range 1 calibration"
580   PAUSE
590   OUTPUT @Ld;"CAL:LEV P2"
600   CLEAR SCREEN
610   PRINT TABXY(9,15);"CALIBRATING RESISTANCE RANGE 1 - P2 - 30 SECOND WAIT”
620   WAIT 30
630   INPUT "Measure voltage across current shunt - enter value in volts",Vp2
640   Ip2=Vp2/Rshunt1
650   INPUT "Measure voltage across +/- sense terminals and enter value in
      volts",Vt2
660   Rp2=Vt2/Ip2
670   OUTPUT @Ld;"CAL:DATA";Rp2
680   OUTPUT @Ld;"INP:STAT OFF"
690   !
700   !       **********  CALIBRATING RANGE 2   *****************
710   !
720   CLEAR SCREEN
730   INPUT "Enter value of current shunt for range 2 in OHMS",Rshunt2
740   PRINT TABXY(10,10);"You have entered ";Rshunt2;" ohms"
750   INPUT "If correct enter 'Y' or press CONT, if wrong enter 'N' or 'n'",Y$
760   IF UPC$(Y$)="Y" OR Y$="" THEN 780
770   IF UPC$(Y$)="N" OR Y$="n" THEN 720
780   CLEAR SCREEN
790   !
800   PRINT TABXY(10,12);"Set power source to voltage and current settings from"
810   PRINT TABXY(10,13);"Table B-1 for resistance range 2 - Point P1"
820   DISP "Press CONT when ready to calibrate resistance range 2"
830   PAUSE
840   CLEAR SCREEN
850   PRINT TABXY(9,15);"CALIBRATING RESISTANCE RANGE 2 - P1 - 15 SECOND WAIT"
860   OUTPUT @Ld;"INP:STAT ON"
870   OUTPUT @Ld;"RES:RANG 20"  !< resistance range 2 variable from table B-1
880   OUTPUT @Ld;"CAL:LEV P1"
890   WAIT 15
900   INPUT "Measure voltage across current shunt - enter value in volts",Vp1
910   Ip1=Vp1/Rshunt2
920   INPUT "Measure voltage across +/- sense terminals and enter value in
      volts",Vt1
930   Rp1=Vt1/Ip1
940   OUTPUT @Ld;"CAL:DATA";Rp1
950   !
960   CLEAR SCREEN
970   PRINT TABXY(10,12);"Set power source to voltage and current settings from
      Table B-2"
980   PRINT TABXY(10,13);"for resistance range 2 - Point P2"
990   DISP "Press Cont to continue resistance range 2 calibration"
      1000  PAUSE
1010  OUTPUT @Ld;"CAL:LEV P2"
1020  CLEAR SCREEN
1030  PRINT TABXY(9,15);"CALIBRATING RESISTANCE RANGE 2 - P2 - 15 SECOND WAIT"
1040  WAIT 15
1050  INPUT "Measure voltage across current shunt - enter value in volts",Vp2
1060  Ip2=Vp2/Rshunt2
1070  INPUT "Measure voltage across +/- sense terminals and enter value in
      volts",Vt2
```

```
1080  Rp2=Vt2/Ip2
1090  OUTPUT @Ld;"CAL:DATA";Rp2
1100  OUTPUT @Ld;"INP:STAT OFF"
1110  !
1120  !          ************  CALIBRATING RANGE 3  ******************
1130  !
1140  CLEAR SCREEN
1150  INPUT "Enter value of current shunt for range 3 in OHMS",Rshunt3
1160  PRINT TABXY(10,10);"You have entered ";Rshunt3;" ohms"
1170  INPUT "If correct enter 'Y' or press CONT, if wrong enter 'N' or 'n'",Y$
1180  IF UPC$(Y$)="Y" OR Y$="" THEN 1200
1190  IF UPC$(Y$)="N" OR Y$="n" THEN 1140
1200  CLEAR SCREEN
1210  !
1220  PRINT TABXY(10,12);"Set power source to voltage and current settings from"
1230  PRINT TABXY(10,13);"Table B-1 for resistance range 3 - Point P1"
1240  DISP "Press CONT when ready to calibrate resistance range 3"
1250  PAUSE
1260  CLEAR SCREEN
1270  PRINT TABXY(9,15);"CALIBRATING RESISTANCE RANGE 3 - P1 - 7 SECOND WAIT"
1280  OUTPUT @Ld;"INP:STAT ON"
1290  OUTPUT @Ld;"RES:RANG 200" !< resistance range 3 variable from table B-1
1300  OUTPUT @Ld;"CAL:LEV P1"
1310  WAIT 7
1320  INPUT "Measure voltage across current shunt - enter value in volts",Vp1
1330  Ip1=Vp1/Rshunt3
1340  INPUT "Measure voltage across +/- sense terminals and enter value in
      volts",Vt1
1350  Rp1=Vt1/Ip1
1360  OUTPUT @Ld;"CAL:DATA";Rp1
1370  !
1380  CLEAR SCREEN
1390  PRINT TABXY(10,12);"Set power source to voltage and current settings from
      Table B-2"
1400  PRINT TABXY(10,13);"for resistance range 3 - Point P2"
1410  DISP "Press Cont to continue resistance range 3 calibration"
1420  PAUSE
1430  OUTPUT @Ld;"CAL:LEV P2"
1440  CLEAR SCREEN
1450  PRINT TABXY(9,15);"CALIBRATING RESISTANCE RANGE 3 - P2 - 7 SECOND    WAIT"
1460  WAIT 7
1470  INPUT "Measure voltage across current shunt - enter value in volts",Vp2
1480  Ip2=Vp2/Rshunt3
1490  INPUT "Measure voltage across +/- sense terminals and enter value in
      volts",Vt2
1500  Rp2=Vt2/Ip2
1510  OUTPUT @Ld;"CAL:DATA";Rp2
1520  OUTPUT @Ld;"INP:STAT OFF"
1530  !
1540  !      ************   CALIBRATING RANGE 4   ********************
1550  !
1560  CLEAR SCREEN□F1570  INPUT "Enter value of current shunt for range 4 in
      OHMS",Rshunt4
1580  PRINT TABXY(10,10);"You have entered ";Rshunt4;" ohms"
1590  INPUT "If correct enter 'Y' or press CONT, if wrong enter 'N' or 'n'",Y$
1600  IF UPC$(Y$)="Y" OR Y$="" THEN 1620
1610  IF UPC$(Y$)="N" OR Y$="n" THEN 1560
```

```
1620  CLEAR SCREEN
1630  !
1640  PRINT TABXY(10,12);"Set power source to voltage and current settings from"
1650  PRINT TABXY(10,13);"Table B-1 for resistance range 4 - Point P1"
1660  DISP "Press CONT when ready to calibrate resistance range 4"
1670  PAUSE
1680  CLEAR SCREEN
1690  PRINT TABXY(9,15);"CALIBRATING RESISTANCE RANGE 4 - P1 - 3 SECOND WAIT"
1700  OUTPUT @Ld;"INP:STAT ON"
1710  OUTPUT @Ld;"RES:RANG 2000"!< resistance range 4 variable from table B-1
1720  OUTPUT @Ld;"CAL:LEV P1"
1730  WAIT 3
1740  INPUT "Measure voltage across current shunt - enter value in volts",Vp1
1750  Ip1=Vp1/Rshunt4
1760  INPUT "Measure voltage across +/- sense terminals and enter value in
      volts",Vt1
1770  Rp1=Vt1/Ip1
1780  OUTPUT @Ld;"CAL:DATA";Rp1
1790  !
1800  CLEAR SCREEN
1810  PRINT TABXY(10,12);"Set power source to voltage and current settings from
      Table B-2"
1820  PRINT TABXY(10,13);"for resistance range 4 - Point P2"
1830  DISP "Press Cont to continue resistance range 4 calibration"
      1840  PAUSE
1850  OUTPUT @Ld;"CAL:LEV P2"
1860  CLEAR SCREEN
1870  PRINT TABXY(9,15);"CALIBRATING RESISTANCE RANGE 4 - P2 - 3 SECOND   WAIT"
1880  WAIT 3
1890  INPUT "Measure voltage across current shunt - enter value in volts",Vp2
1900  Ip2=Vp2/Rshunt4
1910  INPUT "Measure voltage across +/- sense terminals and enter value in
      volts",Vt2
1920  Rp2=Vt2/Ip2
1930  OUTPUT @Ld;"CAL:DATA";Rp2
1940  OUTPUT @Ld;"INP:STAT OFF"
1950  !
1960  OUTPUT @Ld;"CAL:SAVE"
1970  OUTPUT @Ld;"CAL:STAT OFF"
1980  !
1990  CLEAR SCREEN
2000  PRINT TABXY(10,10);"Resistance calibration adjustments complete"
2010  PRINT TABXY(10,12);"Verify Resistance Adjustments"
2020  END
```

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