KEITHLEY

Series 3700 System Switch/Multimeter

User's Manual

3700S-900-01 Rev. A / August 2007

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WARRANTY

Keithley Instruments, Inc. warrants this product to be free from defects in material and workmanship for a period of one (1) year from date of shipment.

Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, software, rechargeable batteries, diskettes, and documentation.

During the warranty period, Keithley Instruments will, at its option, either repair or replace any product that proves to be defective.

To exercise this warranty, write or call your local Keithley Instruments representative, or contact Keithley Instruments headquarters in Cleveland, Ohio. You will be given prompt assistance and return instructions. Send the product, transportation prepaid, to the indicated service facility. Repairs will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days.

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from product modification without Keithley Instruments' express written consent, or misuse of any product or part. This warranty also does not apply to fuses, software, non-rechargeable batteries, damage from battery leakage, or problems arising from normal wear or failure to follow instructions.

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Series 3700

System Switch/Multimeter

User's Manual

Manual Print History

The print history shown below lists the printing dates of all Revisions and Addenda created for this manual. The Revision Level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between Revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new Revision is created, all Addenda associated with the previous Revision of the manual are incorporated into the new Revision of the manual. Each new Revision includes a revised copy of this print history page.

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The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the user documentation for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product warranty may be impaired.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the user documentation. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, perform safe installations, and repair products. Only properly trained service personnel may perform installation and service procedures.

Keithley Instruments products are designed for use with electrical signals that are rated Measurement Category I and Measurement Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Measurement Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Measurement Category II connections require protection for high transient over-voltages often associated with local AC mains connections. Assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the user documentation.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000V, no conductive part of the circuit may be exposed.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance-limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, ensure that the line cord is connected to a properly-grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

The instrument and accessories must be used in accordance with its specifications and operating instructions, or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with the same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a ⏚ screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The ⚠ symbol on an instrument indicates that the user should refer to the operating instructions located in the user documentaion.

The ⚡ symbol on an instrument shows that it can source or measure 1000V or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The ♨ symbol on an instrument shows that the surface may be hot. Avoid personal contact to prevent burns.

The �⊥ symbol indicates a connection terminal to the equipment frame.

If this (Hg) symbol is on a product , it indicates that mercury is present in the display lamp. Please note that the lamp must be properly disposed of according to federal, state, and local laws.

The **WARNING** heading in the user documentation explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in the user documentation explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits - including the power transformer, test leads, and input jacks - must be purchased from Keithley Instruments. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. Other components that are not safety-related may be purchased from other suppliers as long as they are equivalent to the original component (note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water-based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., a data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

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Introduction

If you have any questions after reviewing this information, please contact your local Keithley Instruments representative or call one of our Applications Engineers at 1-888-KEITHLEY (1-888-534-8453). You can also contact us through our website at www.keithley.com.

In this section:

Overview

The Series 3700 instruments offer scalable, instrument grade switching and multi-channel measurement solutions that are optimized for automated testing of electronic products and components. The Series 3700 includes four versions of the Model 3706 system switch mainframe along with a growing family of plug-in switch and control cards. When the Model 3706 mainframe is ordered with the high performance multimeter, you receive a tightly integrated switch and measurement system that can meet the demanding application requirements in a functional test system or provide the flexibility needed in stand-alone data acquisition and measurement applications.

Measure and switching capabilities

The basic measurement capabilities of Series 3700 systems are summarized in the following figure.

Figure 1-1: DMM measurement capabilities
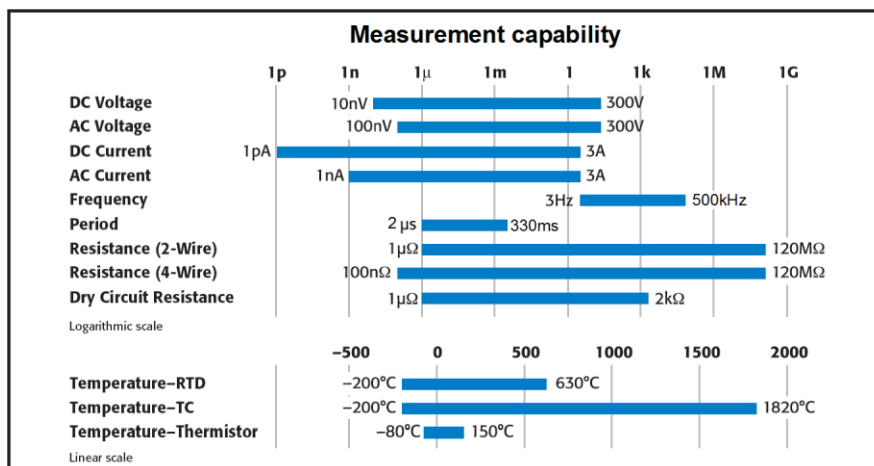
Reference manual content

Refer to the Series 3700 Reference Manual for specific listing of advanced operation including:

- Range
- Digits
- Rate Bandwidth
- Filter
- Relative
- Math
- dB
- Buffer
- Scanning
- Calibration

Also included in the reference manual is a detailed listing of the Instrument Control Library (ICL) commands.

Warranty information

Detailed warranty information is located at the front of this manual. Should your Series 3700 require warranty service, contact the Keithley Instruments representative or authorized repair facility in your area for further information. When returning the instrument for repair, be sure to complete the service form at the back of this manual and give it to the repair facility with all relevant information.

NOTE	The service form requires the serial number of the Series 3700. The serial number label is located inside the unit on the bottom panel. The serial number can be viewed by removing the slot covers and/or switching modules from the mainframe.

WARNING	*Before removing (or installing) switching modules, make sure you turn off the Series 3700 and disconnect the line cord. Also, remove any other external power connected to the instrument or switching module(s).*
	Failure to remove power before removing (or installing) switching modules may result in personal injury or death due to electric shock.

Displaying the unit's serial number

To display the serial number on the front panel:

NOTE	If the Series 3700 is in remote mode, press the **EXIT** key once to place the unit in local mode.

1. When in local mode, press the **MENU** key.

2. Scroll to the SYSTEM-INFO menu and press the **ENTER** key.

3. On the SYSTEM INFORMATION menu, scroll to the SERIAL# and press the **ENTER** key. The Series 3700 serial number will be displayed.

Safety symbols and terms

The following symbols and terms may be found on the System Switch/Multimeter or used in this manual:

The ⚠ symbol indicates that the user should refer to the operating instructions located in the manual.

The ⚠ symbol shows that high voltage may be present on the terminal(s). Use standard safety precautions to avoid personal contact with these voltages.

The ⚠ symbol on an instrument shows that the surface may be hot. Avoid personal contact to prevent burns.

The **WARNING** heading used in this manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading used in this manual explains hazards that could damage the unit. Such damage may invalidate the warranty.

Specifications

Full specifications can be found in Appendix A of this manual. Also, refer to the product data sheet for System Switch/Multimeter specifications. Check the Keithley Instruments website at www.keithley.com for the latest updates to the specifications.

Using the Front Panel

In this section:

Front panel introduction

Typical Series 3700 front panels are shown below.

> **NOTE** Not all models will have a DMM installed. All DMM related documentation is not applicable to those models.

Figure 2-1: Model 3706 System Switch/Multimeter
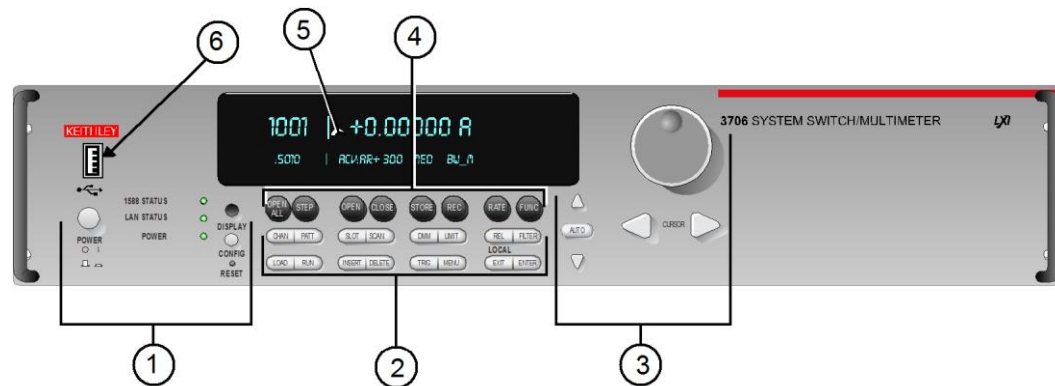
Item	Description
1	*Special keys and power switch* (on page 2-6)
2	*Operation keys* (on page 2-7)
3	*Range, multifunction keys, and wheel* (on page 2-17)
4	*Function keys* (on page 2-17)
5	*Display* (on page 2-3)
6	*USB connector* (see "USB connectors" on page 3-4)

Figure 2-2: Model 3706-S System Switch (no DMM)
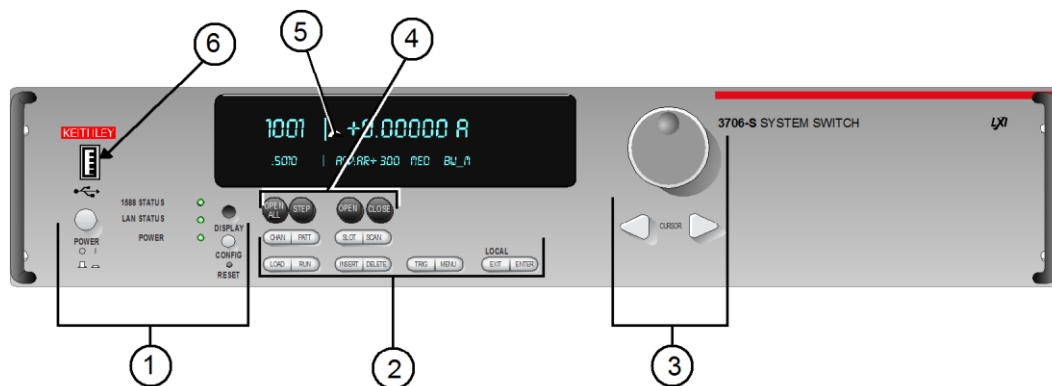
NOTE	If your model does not have a front panel, please refer to the reference manual for information on how to change: 1. GPIB address with gpib.address command. 2. LAN configuration using LAN functions. To see current settings for LAN, see the applicable lan.status.* commands (for example, to see the present IP address of the Series 3700, send the following command: lan.status.ipaddress.

Figure 2-3: Model 3706-NFP System Switch/Multimeter
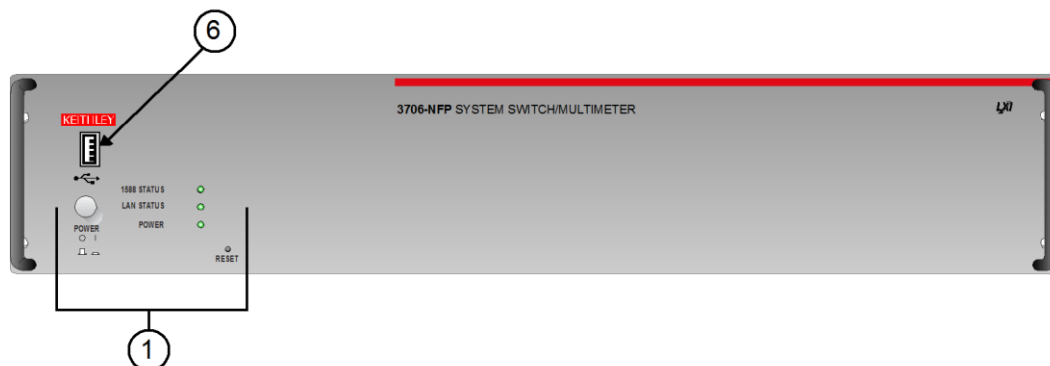
Figure 2-4: Model 3706-SNFP System Switch (no DMM)
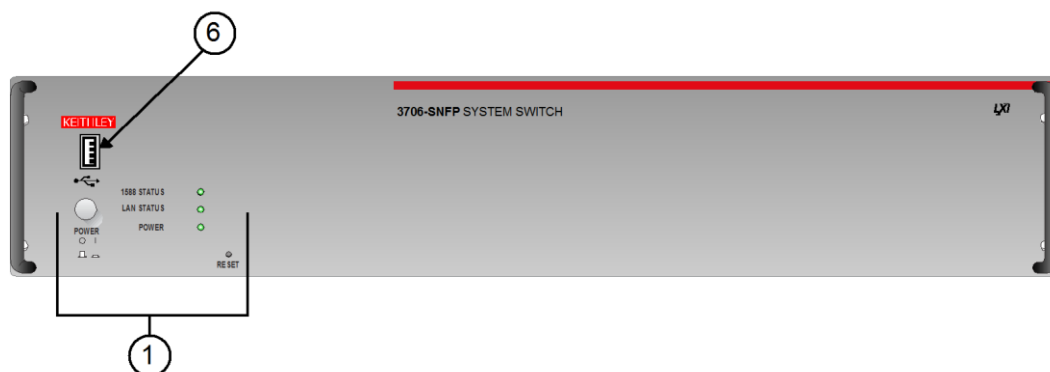
Display

The Series 3700 display provides visual information on the present active channel. The display, with the wheel, provides a means to change the active channel or channel ranges, as well as access to view and edit the various menus and menu items.

See the following figure for an active channel example. The display has the 4WΩ and AUTO range annunciators lit (1). Also, the active channel is 1004 (Slot 1 Channel 004). The present state of the channel is open, and it has two poles (3). The present state of the attributes for this channel (4) are: 4WΩ function set for AUTO range, dry-circuit ohms disabled (DRY-), offset compensation off (OC-). Other attributes, such as NPLC, are available for this specific active channel (1004) as indicated by arrow (5) being lit. These may be viewed by turning the wheel (6) to scroll through the attribute list.

NOTE	Attribute lists, as well as menu lists, that are larger than the display, can be accessed by turning the wheel (6). Displayed arrows (5) indicate additional attributes (or menu items, as applicable) are available for access by turning the wheel (6) in the direction the arrow points. If an arrow (5) is not displayed, there are no additional menu choices in that direction.

Figure 2-5: Active channel display example
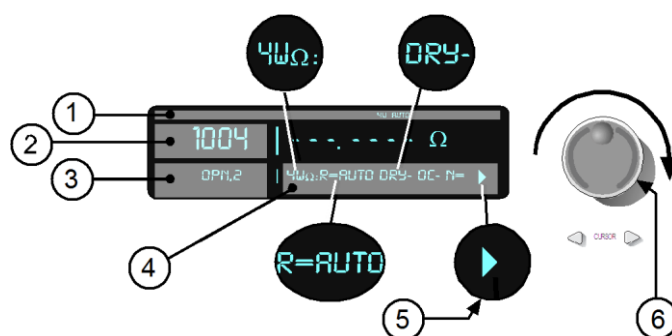
The top line of the display (1) contains the following annunciators:

Annunciator	Description
* (asterisk)	Front panel readings are being stored in the selected reading buffer.
4W	4-wire resistance or RTD temperature reading displayed.
ARM	Unit armed and ready to use.
AUTO	Auto range enabled for the selected DMM function.
EDIT	Unit in edit mode (for front panel).
FILT	Filter enabled for the selected DMM function.
LSTN	Instrument addressed to listen over GPIB.
MATH	mX+b, percent, or reciprocal (1/X) calculation enabled for the selected DMM function.
REL	Relative enabled for selected DMM function.
REM	Instrument in bus remote mode or web control mode (all interfaces, LAN, GPIB, or USB).
SMPL	Flashes whenever the DMM has completed a reading.
SRQ	Service request over GPIB.
TALK	Instrument addressed to talk over GPIB bus.
TRIG	External triggering selected. The TRIG annunciator will blink if taking continuous triggered readings on front panel.

The bottom line of the display (4) contains the attribute symbols. The symbols that appear are dependent on whether the attribute exists for the selected function. If the symbol has also contains a value, the third column in the table indicates the value definition. The following table indicates the DMM attribute symbols that may appear on the front panel.

Front panel DMM attribute	Symbol	Values
range	R=	AUTO or n, here n equals the range
nplc	N=	n, where n equals the nplc
auto delay	AD	+ for ON, 1 for ONCE, or 0 for OFF
auto zero	AZ	+ for ON or – for OFF
line sync	LS	+ for ON or – for OFF
limit	LIM	+ for a limit enabled or – for limits disabled
detector bandwidth	DBW	3, 30, or 300
threshold	THR=	n, where n indicates the threshold
aperture	A=	n, where n indicates the aperture setting
dry circuit	DRY	+ for ON or – for OFF
offset compensation	OC	+ for ON or – for OFF
thermocouple sensor K	K_T/C	N/A
thermocouple sensor T	T_T/C	N/A
thermocouple sensor E	E_T/C	N/A
thermocouple sensor R	R_T/C	N/A
thermocouple sensor S	S_T/C	N/A
thermocouple sensor B	B_T/C	N/A
thermocouple sensor N	N_T/C	N/A
thermistor	THRM	N/A
three-wire RTD	3RTD	N/A
four-wire RTD	4RTD	N/A
simulated reference junction	RJ_SIM	N/A
internal reference junction	RJ_INT	N/A
external reference junction	RJ_EXT	N/A

NOTE   To access the main menu, press the **MENU** key.

See the following figure for a menu example. In the example, the MAIN MENU is displayed. Turn the wheel (6) or press the cursor keys, to scroll through the available menu items. In the following figure's first display, there is a right arrow indicator. This indicates there are additional menu items to the right. In figure's second display, both right and left arrows are active indicating there are additional items in both directions. To select the highlighted (flashing) menu item, press the wheel (or press the **ENTER** key).

Figure 2-6: MAIN MENU display
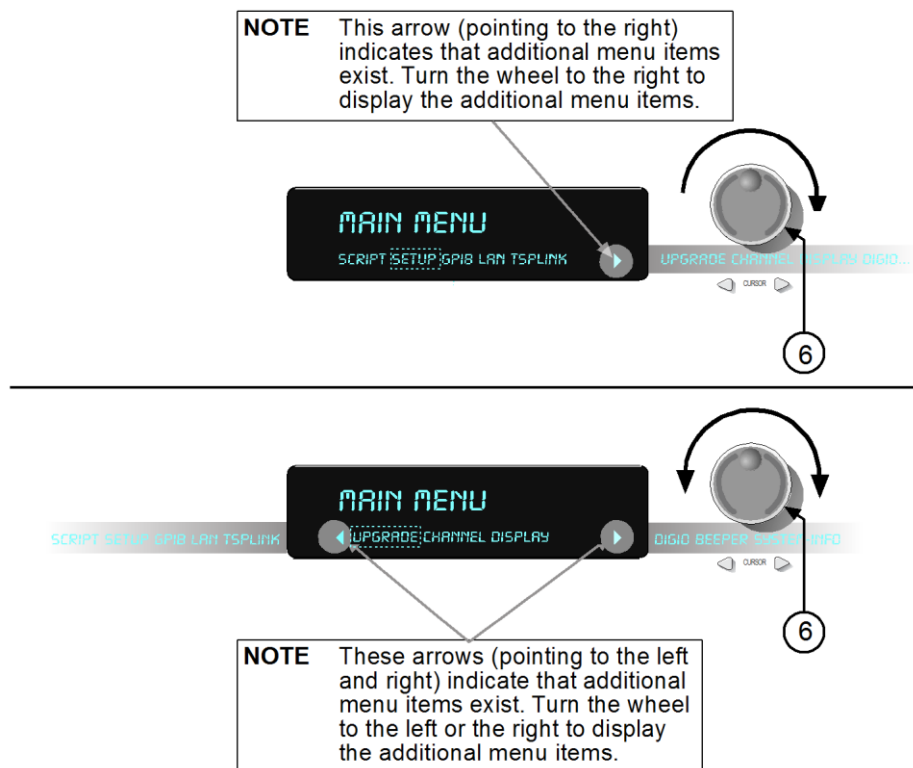
Front panel keys

Special keys and power switch

POWER switch

Press this switch to turn the Series 3700 on (I); press it again to turn it off (O).

DISPLAY key

Press this key to toggles between main and user display modes.

CONFIG key

Use this key to access the an attribute menu that enables you to configure channels, channel patterns, DMM functions, or settings, reading buffer, scans, and other operations. Refer to the following for additional information:

- *CHAN key configuration* (on page 2-8)
- *PATT key configuration* (on page 2-9)
- *SCAN key configuration* (on page 2-10)
- *DMM key configuration* (on page 2-11)
- *LIMIT key configuration* (on page 2-14)
- *REL key configuration* (on page 2-14)
- *FILTER key configuration* (on page 2-15)

RESET switch

Use this switch to restore the Series 3700 factory default LAN settings. Refer to the reference manual LAN functions (lan.config.x, where x represents the specific command) for factory default information.

Operation keys

CHAN key

Pressing this key opens the CHANNEL ACTION MENU that contains the following menu items:

- **OPEN:** This menu item opens the specified channels for switching aspects. Related Instrument Control Library (ICL) command: channel.open
- **CLOSE:** This menu item closes specified channels. These closures are appended to the already closed channels. Related ICL command: channel.close
- **EXCLOSE:** This menu item closes the specified items so they are exclusively closed. Related ICL commands: channel.exclusiveclose, channel.exclusiveslotclose
- **EXSLOTCLOSE:** This menu item exclusively closes specified channels on the specified slots. Related ICL command: channel.exclusiveslotclose
- **RESET:** This menu item resets channel and channel pattern aspects of the system to factory default settings. Related ICL command: channel.reset

CHAN key configuration

Pressing the **CONFIG** key and then the **CHAN** key opens the CHANNEL ATTRibute MENU. This menu contains:

- **LABEL:** This menu item sets the label associated with the channels specified. Related ICL command: channel.setlabel. From the front panel, the label can be up to 12 characters. Remotely, the label may be up to 20 characters.

- **BACKPLANE:** This menu item opens the BACKPLANE MENU. Use this menu to add or remove backplane channels from the channels specified. Related ICL command: channel.setbackplane

- **FORBID:** This menu item prevents the closing of the channels specified. Related ICL command: channel.setforbidden

- **POLE:** This menu item sets the number of poles for the channels specified. Related ICL command: channel.setpole

- **DELAY:** This menu sets additional delay time for channels specified. Related ICL command: channel.setdelay

- **COUNT:** This menu item displays closure cycles for the channels specified. Related ICL command: channel.getcount

- **DMM_CONFIG:** This menu item sets the DMM configuration associated with the channels specified. Related ICL command: dmm.setconfig

PATT key

Pressing this key opens the PATTERN ACTION MENU that contains the following menu items:

- **OPEN:** This menu item opens the specified channel pattern for switching aspects. Related ICL command: channel.open

- **CLOSE:** This menu item closes specified channel pattern. These closures are appended to the already closed channels. Related ICL command: channel.close

- **EXCLOSE:** This menu item closes the specified items so they are exclusively closed. Related ICL command: channel.exclusiveclose

- **EXSLOTCLOSE:** This menu item exclusively closes specified channels on the specified slots. Related ICL command: channel.exclusiveslotclose

- **CREATE:** This menu item creates a channel pattern from a snapshot and associates it with the specified name. From the front panel, the pattern name can be up to 12 characters. Remotely, the pattern name may be up to 20 characters. Note that if no patterns exist in the system when the PATT key is pressed, then CREATE will be the only menu item displayed. Related ICL commands: channel.pattern.snapshot

- **VIEW:** This menu item shows the channels associated with the pattern. Note that if no patterns exist in the system when the PATT key is pressed, then this will be the only menu item displayed in the PATTERN ACTION MENU. Related ICL command: channel.pattern.getimage

- **DELETE:** This menu item deletes a channel pattern. Related ICL command: channel.pattern.delete

- **RESET:** This menu item resets channel pattern aspects of the system to factory default settings. Resetting a channel pattern will cause each channel and backplane relay of the pattern image to be reset back to factory default settings. Also, the pattern will be deleted because resetting a channel causes any patterns that contain a channel being reset will be deleted. Related ICL command: channel.reset

If patterns (or a pattern) have already been created, pressing this key once will allow you to scroll through and select a pattern. Pressing this key a second time opens the PATTERN ACTION MENU (as described above).

PATT key configuration

Pressing the **CONFIG** key and then the **PATT** key opens the PATTERN ATTRibute MENU. This menu contains the following item:

- DMM_CONFIG: This menu item sets the DMM configuration associated with the channels specified. Related ICL command: dmm.setconfig

SLOT key

Press this key to display installed card(s) and instrument information, as well as main system information. The information displayed includes firmware revisions of both main and installed components. After pressing this key, scroll through all available instruments, including the internal DMM.

SCAN key

If a scan list is present, this key opens the SCAN ACTION MENU that contains the following menu items:

NOTE   Use the **INSERT** key to create and add the present active channel to the scan list.

- **EXECUTE:** This menu item runs the scan. Related ICL command: scan.execute

- **CREATE:** This menu item displays following message: Use <INSERT> key

- **LIST:** This menu item displays the scan list (turn the wheel to scroll). Related ICL command: scan.list

- **CLEAR:** This menu item clears the scan list. Related ICL command: scan.create (send with an empty string)

- **RESET:** This menu item resets the scan settings to factory default values. Related ICL command: scan.reset

SCAN key configuration

Pressing the **CONFIG** key and then the **SCAN** key opens the "SCAN ATTR MENU" that contains:

- **ADD:** This menu item instructs how to add an additional list of channels and/or channel patterns to scan. When it displays "Use <INSERT> key", with selected channel or channel pattern for adding to scan list on front panel, press the INSERT key when on the main display. Related ICL command: scan.add

- **BYPASS:** This menu item enables or disables bypassing the first item in the scan. Related ICL command: scan.bypass

- **MODE:** This menu item sets the scan.mode value to one of the following: scan.MODE_OPEN_ALL or 0 (default setting), scan.MODE_OPEN_SELECTIVE or 1 scan.MODE_FIXED_ABR or 2. See related ICL command for definitions. Related ICL command: scan.mode

- **MEAS_CNT:** This menu item sets the measure count value. Related ICL command: scan.measurecount

- **SCAN_CNT:** This menu item sets the scan count value. Related ICL command: scan.scancount

DMM key

Opens the DMM ACTION MENU that contains the following menu items:

- **MEASURE:** This menu item takes measurements on the digital multimeter (DMM) without using the trigger model. Related ICL command: dmm.measure

- **COUNT:** This menu item indicates the number of measurements to take when a measurement is requested. Related ICL command: dmm.measurecount

- **LOAD:** This menu item recalls a user or factory DMM configuration. Related ICL command: dmm.configure.recall

- **SAVE:** This menu item creates a DMM configuration with the pertinent attributes based on the selected function and associates it with the specified name. Related ICL command: dmm.configure.set

- **OPEN:** This menu item opens the specified channel and/or channel pattern. Related ICL command: dmm.open

- **CLOSE:** This menu item closes the specified channel or channel pattern in preparation for a DMM measurement. Related ICL command: dmm.close

- **RESETFUNC:** This menu item returns DMM aspects of the system for the active function only. Related ICL command: dmm.reset

- **RESETALL:** This menu item returns the DMM functions instruments to the default settings. Related ICL command: dmm.reset

DMM key configuration

Pressing the **CONFIG** key and then the **DMM** key opens a DMM attribute menu for the active function. For example, if the DCV function is active, pressing the **CONFIG** key and then the **DMM** key opens the DC VOLT ATTR MENU.

Each function only has access to the applicable attributes for that function. Brief definitions of the available attributes are contained in the following paragraphs. Refer to the appropriate ICL contained in the reference manual for additional attribute information (Instrument Control Library (ICL)).

APERTURE

Configures the aperture setting for the active DMM function in seconds. Related ICL command: dmm.aperture

AUTODELAY

Configures the auto delay setting for the active DMM function. Related ICL command: dmm.autodelay

AUTORANGE

Configures the auto range setting for the DMM. Related ICL command: dmm.autorange

AUTOZERO

Configures the auto zero setting for the DMM. Related ICL command: dmm.autozero

DBREF

Configures the DB reference setting for the DMM in volts. Related ICL command: dmm.dbreference

DIGITS

Configures the display digits setting for the selected DMM function. Related ICL command: dmm.displaydigits

DRYCIRCUIT

Configures the dry circuit setting for the selected DMM function. Related ICL command: dmm.drycircuit

FILTER

Opens the FILTER MENU for the selected DMM function. See *FILTER key configuration* (on page 2-15).

FUNC

Pressing this key selects the active DMM function for the channel. Related ICL command: dmm.func

INPUTDIV

Enables or disables the 10M ohm input divider. Related ICL command: dmm.inputdivider

LIMIT

Opens the LIMIT MENU for the selected DMM function. See *LIMIT key configuration* (on page 2-14).

LINESYNC

Attribute configuring whether line sync is used during the measurement. Related ICL command: dmm.linesync

MATH

Selecting the MATH menu item opens the MATH MENU. Items contained in this menu are as follows:

- **ENABLE:** Enable or disable math operation on measurements. Related ICL command: dmm.math.enable
- **FORMAT:** Specifies the math operation to perform on measurements. Related ICL command: dmm.math.format
- **BFACTOR:** Specifies the offset for the y = mx + b operation. Related ICL command: dmm.math.mxb.bfactor
- **MFACTOR:** Specifies the scale factor for the y = mx + b operation. Related ICL command: dmm.math.mxb.mfactor
- **MXBUNITS:** Specifies the unit character for the y = mx + b operation. Related ICL command: dmm.math.mxb.units
- **PERCENT:** Specifies the constant to use for the percent operation. Related ICL command: dmm.math.percent

NPLC

Configures the integration rate in line cycles for the DMM. Related ICL command: dmm.nplc

OFFSETCOMP

Configures the offset compensation setting for the DMM. Related ICL command: dmm.offsetcompensation

OPENDETECT

Configures the state of the thermocouple or four-wire ohms open detector being used. Related ICL command: dmm.opendetector

RANGE

Configures the range of DMM for the selected function. Related ICL command: dmm.range

REL

Opens the REL MENU for the selected DMM function. See *REL key configuration* (on page 2-14).

THERMO

Selecting the THERMO menu item opens the THERMO MENU. Items contained in this menu are as follows:

- REF JUNCTION: Allows selection of the Reference Junction to use. Available choices are: SIMULATED, EXTERNAL, or INTERNAL. Related ICL command: dmm.refjunction
- SIMREF: Specifies the simulated reference temperature for thermocouples. Related ICL command: dmm.simreftemperature
- THERMISTOR: Specifies the type of thermistor. Related ICL command: dmm.thermistor
- COUPLE: Specifies the thermocouple type. Related ICL command: dmm.thermocouple
- TRANSDUCER: Selects the transducer type (THERMOCOUPLE, THERMISTOR, 3RTD, or 4RTD). Related ICL command: dmm.transducer
- THREERTD: Specifies the type of 3-wire RTD. Related ICL command: dmm.threertd
- FOURRTD: Specifies the type of 4-wire RTD. Related ICL command: dmm.fourrtd
- USER: Specifies USER type of RTD (ALPHA, BETA, DELTA, or ZERO). Related ICL commands: dmm.rtdalpha, dmm.rtdbeta, dmm.rtddelta, dmm.rtdzero

THRESHOLD

Configures the threshold range. Related ICL command: dmm.threshold

UNITS

Configures the units for voltage and temperature measurements. Related ICL command: dmm.units

LIMIT key

Pressing this key will cycle through the four combinations of limit state settings (Limit1 and Limit2 off, Limit1 on and Limit2 off, Limit1 off and Limit2 on, Limit1 and Limit2 on).

LIMIT key configuration

Pressing the **CONFIG** key and then the **LIMIT** key opens the LIMIT MENU. Select LIMIT 1 or LIMIT 2 to open the desired LIMIT 1 or 2 MENU. These menus contain the following menu items:

- **ENABLE:** This menu item enables or disables limit testing. Related ICL command: dmm.limit[Y].enable

- **CLEAR:** This menu item clears the test results of the limit. Related ICL command: dmm.limit[Y].clear

- **AUTOCLEAR:** This menu item sets indicates if the limit should be cleared automatically or not. Related ICL command: dmm.limit[Y].autoclear

- **LOWVAL:** This menu item sets the low limit value. Related ICL command: dmm.limit[Y].low.value

- **LOWFAIL:** This menu item queries for the low test results of the limit. Related ICL command: dmm.limit[Y].low.fail

- **HIGHVAL:** This menu item sets the high limit value. Related ICL command: dmm.limit[Y].high.value

- **HIGHFAIL:** This menu item queries for the high test results of limit. Related ICL command: dmm.limit[Y].high.fail

REL key

Pressing this key enables/disables relative for selected function. Causes REL annunciator to light when enabled. Also see Relative in the reference manual.

REL key configuration

Pressing the **CONFIG** key and then the **REL** key opens the RELATIVE OFFSET MENU. This menu contains the following menu items:

- **ACQUIRE:** This menu item acquires an internal measurement to store as the REL level value. Related ICL command: dmm.rel.acquire

- **ENABLE:** This menu item enables or disables relative measurement control for the DMM. Related ICL command: dmm.rel.enable

- **LEVEL:** This menu item sets a specific offset value to use for relative measurements for the DMM. Related ICL command: dmm.rel.level

FILTER key

Pressing this key enables/disables filter for selected function. When the filter is enabled, the FILT annunciator will light. Also see Filter in the reference manual.

FILTER key configuration

Pressing the **CONFIG** key and then the **FILTER** key opens the FILTER MENU. This menu contains the following menu items:

- ENABLE: This menu item enables or disables filtered measurements for the selected DMM function. Related ICL command: dmm.filter.enable
- COUNT: This menu item indicates the filter count setting for the selected DMM function. Related ICL command: dmm.filter.count
- TYPE: This menu item indicates the filter averaging type for the DMM measurements on the selected DMM functions (MOVING or REPEAT). Related ICL command: dmm.filter.type
- WINDOW: This menu item indicates the filter window for the DMM measurements (0-10% in 0.1% increments). Related ICL command: dmm.filter.window

FUNC

Pressing this key selects the active DMM function for the channel. Related ICL command: dmm.func

FUNC key configuration

Pressing the **CONFIG** key and then the **FUNC** key allows viewing of the available functions and then selection of the active function. Turn the wheel (or press the cursor keys) to scroll through available functions. Press the wheel (or the **ENTER** key) to make the displayed function active.

NOTE	When using just the **FUNC** key (not in configuration mode of the **FUNC** key as this topic is describing), the selected function takes effect immediately as you scroll though the available functions. While in the configuration mode of the **FUNC** key, the function takes effect for the highlighted function only when **ENTER** key is pressed (the function does not change while scrolling).

LOAD key

Loads scripts, along with Lua chunks added with display.loadmenu.add for execution. This key opens the LOAD TEST menu which contains the following menu items:

- **USER:** This menu item provides access to Lua chunks specified by display.loadmenu.add (not scripts).
- **SCRIPTS:** This menu item provides access to scripts created by the user. The scripts can be directly executed.

RUN key

Pressing this key runs last selected script or load menu item.

INSERT key

Pressing this key appends the present channel to the scan list.

DELETE key

Pressing this key deletes the present channel (including function) from the scan list. If the present channel is not contained in the scan list, no error is reported.

TRIG key

Pressing this key triggers a measurement equivalent to the dmm.measure command.

MENU key

Pressing this key opens the MAIN MENU that contains the following menu items:

- **SCRIPT:** Opens the SCRIPT menu that contains LOAD and SAVE menu items.
- **SETUP:** Opens the SETUP MENU that contains SAVE, RECALL, POWERON, and RESET menu items.
- **GPIB:** Opens the GPIB MENU that contains ADDRESS and ENABLE menu items.
- **LAN:** Opens the LAN MENU that contains STATUS, CONFIG, APPLY, RESET, and ENABLE menu items.
- **TSPLINK:** Opens the TSPLINK MENU that contains NODE and RESET menu items.
- **UPGRADE:** Questions whether or not the unit is to be upgraded.
- **CHANNEL:** This menu item opens the CONNECT MENU that allows you to select a rule (BBM, MBB, or OFF), or to connect sequentially (ON or OFF setting). Related ICL command: channel.connectrule
- **DISPLAY:** Opens the DISPLAY menu. Selecting the TEST item opens the DISPLAY TESTS MENU which contains KEYS and DISPLAY-PATTERNS menu items. Use KEYS to verify the operation of the keys. Use DISPLAY-PATTERNS to verify each segment of the display.
- **DIGIO:** Opens the DIGIO I/O menu that is used to set DIGIO-OUTPUT and WRITE-PROTECT menu items.
- **BEEPER:** Use to enable or disable the beeper, along with selection KEYCLICK option.
- **SYSTEM-INFO:** Opens the SYSTEM INFORMATION menu that can query FIRMWARE, SERIAL#, and CAL information.

EXIT key

Cancels the selection and moves back to the measurement display.

ENTER key

Pressing this key accepts selection, moves to next choice, or back to measurement display.

NOTE	Pressing the wheel performs the same function as the **ENTER** key.

Range, multifunction keys, and wheel

Range keys

▲▼ Selects the next higher or lower measurement range for the selected function when on measurement display.

To set the range, use the **RANGE** keys ▲ or ▼. If the Series 3700 displays the overflow message on a particular range, select a higher range until an on-range reading is displayed. Use the lowest range possible without causing an overflow to ensure best accuracy and resolution. For details see Auto ranging over the front panel in the reference manual.

AUTO key

Enables or disables autorange for the selected function, and causes the AUTO annunciator to light when enabled.

CURSOR keys

◄ CURSOR ► Use the CURSOR arrows in a menu to control cursor position for making selections or changing values.

Wheel

Turn the wheel to scroll to the desired menu option or to change the value of the selected numeric parameter. Also, press the wheel to cause the same function as pressing the **ENTER** key. Also see *ENTER key* (on page 2-16). Turn the wheel to scroll to the desired digit location to edit, press the wheel to enter edit mode, and then turn the wheel to increase or decrease the value.

NOTE	When changing a multiple character value, such as an IP address or channel pattern name, press the wheel to enter edit mode, rotate the wheel to change the characters value as desired, but do not leave edit mode. Use the cursor keys to scroll to the other characters and use the wheel to change their value as needed. Press the **ENTER** key when finished changing all the characters.

Function keys

OPEN ALL key

Opens all closed channels.

STEP key

Steps through channels associated with the defined scan list; sends a trigger after each channel.

OPEN key

Opens selected channels or channel pattern.

CLOSE Key

Closes specified channels or channel pattern.

STORE key

Opens the RD BUFF ACTION MENU. This menu contains:

- **CREATE:** Allows creation of a reading buffer, or allows you to select a previously created reading buffer. When a new buffer is created, you can set the number of readings to store and then select the buffer. Related Instrument Control Library (ICL) command: dmm.makebuffer

- **SELECT:** Allows you to select a previously created reading buffer. Related Instrument Control Library (ICL) command: dmm.measure

- **CLEAR:** Removes readings from a previously created buffer.

- **SAVE:** Allows you to save a previously created reading buffer to a USB flash drive (flash drive must be installed and have enough available space).

- **DELETE:** Allows you to delete a previously created reading buffer from the system. All data associated with deleted buffer will be lost. Equivalent to setting the reading buffer variable name to nil over bus (ICL command).

STORE key configuration

With a buffer selected, pressing the **CONFIG** key and then the **STORE** key opens the RD BUFFER ATTR MENU. This menu contains the following menu items:

- **CAPACITY:** Maximum number of readings that can be stored.

- **COUNT:** Actual number of readings stored.

- **APPEND:** Places readings buffer in append mode.

RECall key

Displays stored readings and buffer statistics for selected reading buffer. Use the ◄ CURSOR ► keys or turn the wheel to navigate through buffer.

RATE key

Sets measurement speed (fast, medium, or slow) for the active or selected function.

FUNCtion key

This key select the active function by cycling through the following list as listed. Each press of the **FUNC** key has the DMM and configured to the next function in the list:

- **dcvolts:** DC voltage
- **acvolts:** AC voltage
- **dccurrent:** DC current
- **accurrent:** AC current
- **twowireohms:** Two-wire ohm (resistance)
- **fourwireohms:** Four-wire ohm (resistance)
- **commonsideohms:** Common-side ohm (resistance)
- **frequency:** Frequency
- **period:** Period
- **continuity:** Continuity
- **temperature:** Temperature

Rear Panel

In this section:

Rear panel summary

Figure 3-1: Rear panel features

Item	Description
1	*Analog backplane fuse* (see "Analog backplane AMPS fuse" on page 3-2)
2	*Slots (6 places)* (see "Slots" on page 3-2)
3	*TSP-link® connectors (2 places)* (see "TSP-Link connector" on page 3-2)
4	*Instrument fuse* (on page 3-2)
5	*Power connector* (on page 3-2)
6	*Digital I/O port* (on page 3-3)
7	*GPIB connector* (on page 3-4)
8	*Ethernet connector* (see "Ethernet connector (RJ-45)" on page 3-4)
9	*USB connector* (see "USB connectors" on page 3-4)
10	*Analog backplane connector* (on page 3-5)

Rear panel connections

Analog backplane AMPS fuse

FOR CONTINUED PROTECTION AGAINST FIRE HAZARD, REPLACE FUSE WITH SAME TYPE AND RATING (3A / 250V). See *Fuse replacement* (on page 8-1) for details.

Slots

Use any of the six slots of the Keithley Instruments Series 3700 for the switching modules. When a module is not installed, make sure to cover the slot with a slot cover. For additional information on an installed module, press the *SLOT key* (on page 2-9).

TSP-Link connector

Use with TSP-link cable to expand system.

Instrument fuse

FOR CONTINUED PROTECTION AGAINST FIRE HAZARD, REPLACE FUSE WITH SAME TYPE AND RATING (1.25A / 250V). See *Fuse replacement* (on page 8-1) for details.

Power connector

Using the supplied line cord, connect to a grounded AC power outlet. See *Line power connection* (on page 3-11) for connection details.

Digital I/O port

The Series 3700 has a digital input/output port that can be used to control external digital circuitry. For example, a handler that is used to perform binning operations can be used with a Digital I/O port. The Digital I/O port is a standard female DB-25 connector.

Figure 3-2: Digital I/O port
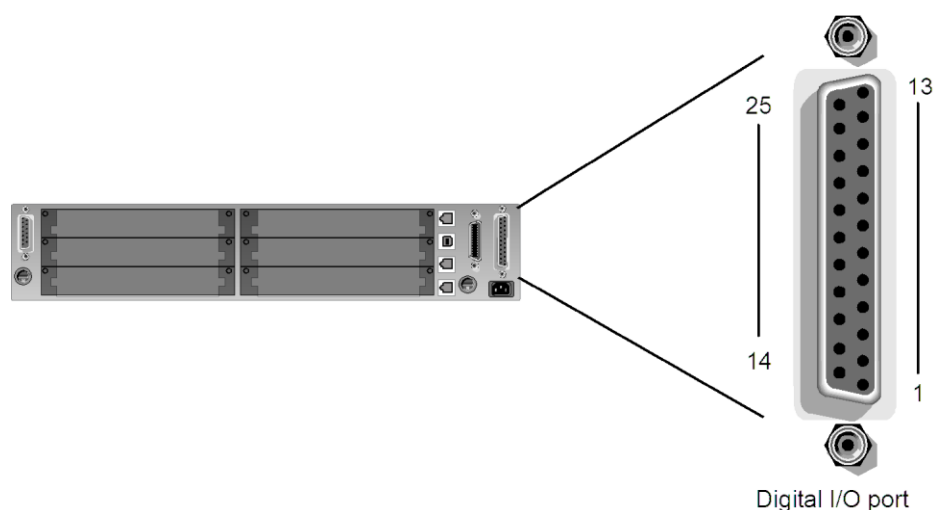
Digital I/O port

Pin	Description
1	Digital I/O #1
...	...
9	Digital I/O #9
10	Digital I/O #10 (High Current Pins see Note)
...	...
14	Digital I/O #14 (High Current Pins see Note)
15-21	Ground
22	V EXT
23	V EXT
24	NC (no connection)
25	V EXT

NOTE   High Current Pins (10-14) can be used for binning applications or for external relays.

Connecting cables

Use a cable equipped with a standard male DB-25 connector (Keithley Instruments part number CA-126-1).

Digital I/O lines (pins 1 through 14)

The port provides 14 digital I/O lines. Each output is set high (+5V) or low (0V) and can read high or low logic levels.

+5V output (pins 22, 23, and 25)

The Digital I/O Port provides a +5V output that is used to drive external logic circuitry. Maximum current output for this line is 600mA. This line is protected by a self-resetting fuse (one hour recovery time).

GPIB connector

For GPIB communication, connect to GPIB port of computer using an IEEE-488 cable (Keithley Instruments Model 7007).

Ethernet connector (RJ-45)

For Ethernet communication, connect to Ethernet port of a computer, or to a hub or receptacle of an Ethernet system.

To connect the Series 3700 directly to a computer, use an Ethernet cross-over cable (RJ-45, male/male).

To connect the Series 3700 to an Ethernet system hub or receptacle, use a standard Ethernet cable (RJ-45, male/male).

USB connectors

The downstream USB-2.0 receptacle (Type B) located on the rear panel connects to a host. The front panel has an upstream USB-2.0 connector (Type A) that connects to a user supplied USB flash drive.

Use the rear connector to communicate with the instrument over USB by sending the desired commands. Use the front panel connector to insert a USB flash drive for saving or loading reading buffers, user setups, or scripts. See the Reference Manual for more information on reading buffers, user setups and scripts.

Figure 3-3: USB connectors

Pin number	Function
1	VBUS (5 volts)
2	D-
3	D+
4	Ground
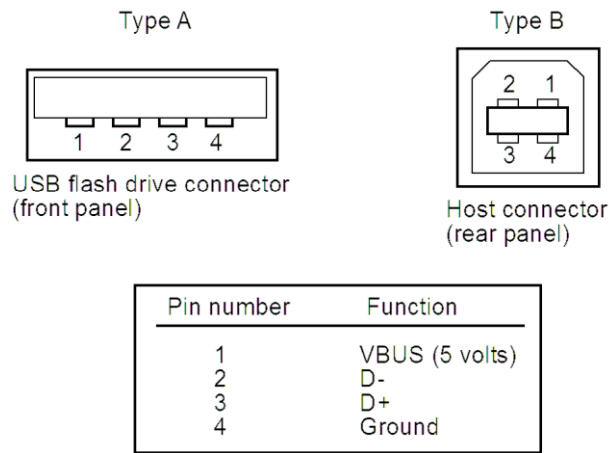
Analog backplane connector

Refer to the following figure for analog backplane connector information. See *Connections* (on page 3-8) before making any connections.

Figure 3-4: Analog backplane connector
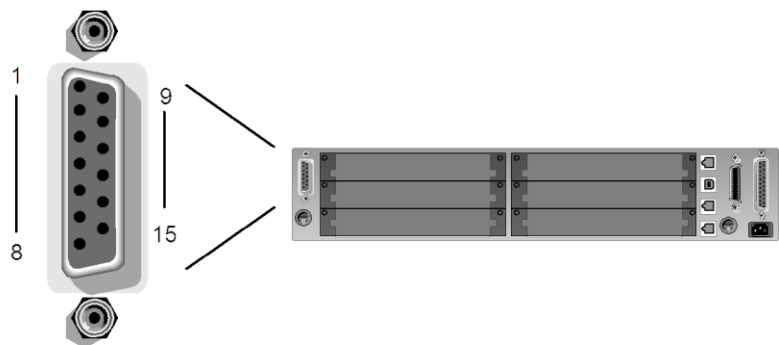
Analog backplane connector

The table below contains pin numbers and descriptions for the analog backplane connector.

Description	Pin	Description	Pin
Analog backplane 3-HI	5	DMM-SLO	4
Analog backplane 3-LO	6	DMM-SHI	3
Analog backplane 4-HI	7	DMM-LO	2, 9
Analog backplane 4-LO	8	DMM-HI	1
Analog backplane 5-HI	12	AMP-LO	2, 9
Analog backplane 5-LO	13	AMP	10, 11
Analog backplane 6-HI	14		
Analog backplane 6-LO	15		

Switching module installation and connections

In order to exercise close/open operations explained in this section, a switching module (or pseudocard) must be installed in the mainframe. A switching module can be installed by the user, however external connections to the switching module are only to be performed by qualified service personnel.

WARNING	*To prevent electric shock that could result in injury or death, NEVER handle a switching module that has power applied to it:*
	• Before installing (or removing) a switching module, make sure the Series 3700 is turned off and disconnected from line power.
	• If the switching module is already connected to a device under test (DUT), make sure power is removed from all external circuitry.

NOTE	For inexperienced users, it is recommended that DUT and external circuitry not be connected to switching modules. This will allow you to exercise safe close/open operations without the dangers associated with live test circuits.

Module installation

WARNING	*Slot covers must be installed on unused slots to prevent personal contact with high voltage circuits.*

Perform the following steps to install a switching module into the Series 3700 mainframe:

1. Turn the Series 3700 off and disconnect the power line cord and any other cables connected to the rear panel.

2. Position the Series 3700 so that you are facing the rear panel.

3. Remove the slot cover plate from the desired mainframe slot. Retain the plate and screws for future use.

4. With the top cover of the switching module facing up, align the module's card edge into the slot's card guide and slide in the module. For the last ¼ inch or so, press in firmly to mate the module connector to the mainframe connector.

5. On each side of the module, there is a mounting screw. Tighten these two screws to secure the module to the mainframe. Do not overtighten.

6. Reconnect the power line cable and any other cables to the rear panel.

7. Press the **SLOT** *key* (on page 2-9) to see the model numbers, description, and the firmware revision of the installed switching module(s), along with the mainframe firmware and DMM (if present).

Figure 3-5: Typical module installation
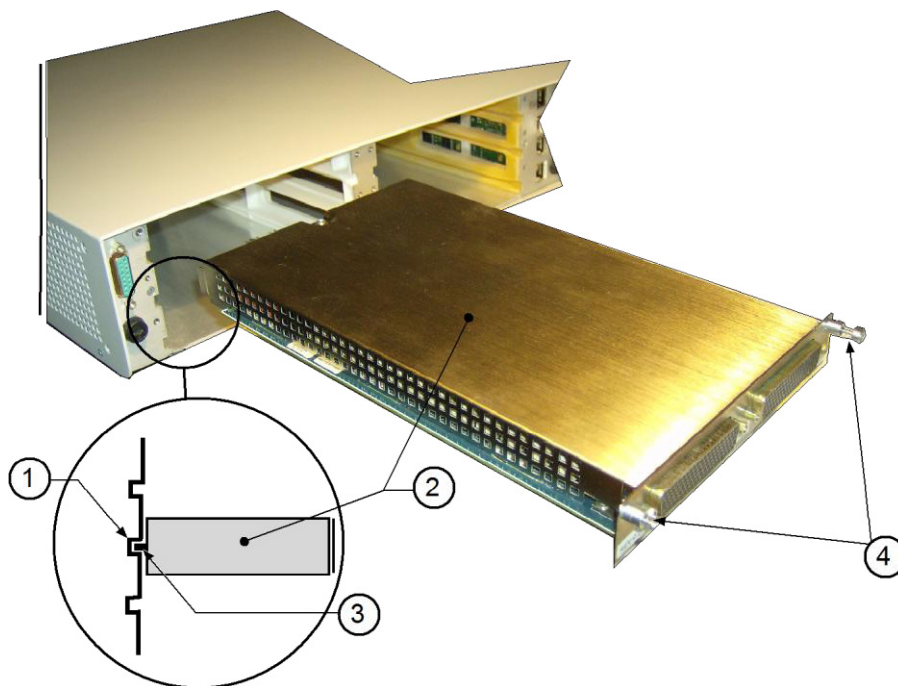
Item	Description
1	Card guide (part of Series 3700)
2	Module
3	Card edge (part of module)
4	Mounting screw (part of module)

Connections

WARNING	*Connection information for switching modules is intended for qualified service personnel. Do not attempt to connect DUT or external circuitry to a switching module unless qualified to do so.*
	To prevent electric shock that could result in serious injury or death, comply with these safety precautions:
	Before making or breaking any connections to the switching module, make sure the Series 3700 is turned off and power is removed from all external circuitry.
	Do not connect signals that will exceed the maximum specifications of any installed switching module.
	If both the rear analog backplane connector of the Series 3700 and the switching module terminals are connected at the same time, the test lead insulation must be rated to the highest voltage that is connected. For example, if 300V is connected to the analog backplane connector, the test lead insulation for the switching module must also be rated for 300V.
	Dangerous arcs of an explosive nature in a high energy circuit can cause severe personal injury or death. If the multimeter is connected to a high energy circuit when set to a current range, low resistance range, or any other low impedance range, the circuit is virtually shorted.
	Dangerous arcing can result (even when the multimeter is set to a voltage range) if the minimum voltage spacing is reduced in the external connections. For details about how to safely make high energy measurements, see High-energy circuit safety precautions *(on page 5-2).*
	As described in the International Electrotechnical Commission (IEC) Standard IEC 664, the Series 3700 is Installation Category I and must not be connected to mains.

Pseudocards

You can perform open/close/scan operations and configure your system without having an actual switching module installed in your Series 3700. Using remote programming, you can assign a pseudocard to an empty switching module slot, allowing the Model 3700S to operate as if a switching module were installed.

A pseudocard, which is essentially a "virtual switching module," cannot be installed from the front panel. However, once the remote installation is complete, you can take the Series 3700 out of remote mode and use the front panel. Pressing the **LOCAL** or **EXIT** key takes the Series 3700 out of remote mode.

When the instrument is turned off, the pseudocard will be lost (uninstalled). In order to recall a pseudocard, make it part of a saved setup.

NOTE	A saved setup retains the model number of the module installed in each slot. The model number of a pseudocard is the same as the model number of an actual module. This allows a saved setup to be recalled provided the installed card (or pseudocard) matches the model number for the slot in the saved setup.

Pseudocards programming example

Use the following command line to set the pseudocard of Slot 6 for 3720 Dual 1 x 30 Multiplexer card simulation:

```
slot[6].pseudocard = slot.PSEUDO_3720
```

Channel assignments

Each switching module has a certain number of channels. For example, the Model 3720 switching module has 60 channels (1 through 60). When you encounter a 1 to 3-digit channel number in this manual, the switching module channel is the point of discussion. A four-digit channel number includes the slot followed by the 3-digit channel number.

A switching module can be installed in any of the mainframe's six slots. Therefore, to close, open, or scan a channel, it is necessary to specify the slot location and channel number of the switching module. This is accomplished by using a four-digit channel number for the mainframe. The first digit (1, 2, 3, 4, 5, or 6) indicates the slot number, and the next three digits indicate one of the following:

- The *channel number of a switching module* (see "Mux (multiplexer) channel notation" on page 4-11)

- The *row and column of a matrix card* (see "Matrix card notation" on page 4-12)

- The modules' *backplane relay* (see "Backplane relay notation" on page 4-10)

Bus operation

The Series 3700 supports bus operation over USB, Ethernet and GPIB. The GPIB settings may be set from the front panel, or once controlled by the bus, over the bus.

1. Viewing or configuration using the front panel:

   a)   Press the **MENU** key to bring up the main menu,

   b)   Turn the wheel to scroll to "GPIB" menu item and press the **ENTER** key.

   c)   Select setting to change ADDRESS or ENABLE

2. Viewing or configuration over the bus:

   a)   gpib.address to change the address

   b)   gpib.enable to change the enable setting.
         ON: GPIB will respond to bus commands.
         OFF: GPIB will not respond to bus commands.

USB is always connected and available to send bus commands. There are no unique USB settings. To use USB, make sure have installed the Test Script Builder application. The applicable USB driver is available after installing this software.

NOTE For your Series 3700 to be recognized by your computer over the USB interface, the proper driver must be installed. Installing the Test Script Builder application also installs the applicable USB driver (it becomes available after installing this software). To complete the USB driver installation, after installing the Test Script Builder application, connect the Series 3700 USB connector (rear panel) to the computer.

Ethernet supports various settings. The LAN logical device has options that show the current status under lan.status commands while it has pending configuration settings under lan.config. The config settings will take effect when lan.applysettings is executed. Using the lan.reset command is equivalent to doing a lan.restoredefaults followed by a lan.applysettings. To only restore defaults without resetting to them, use the lan.restoredefaults command by itself. Please refer to the LAN ICLs directly for individual settings that may be controlled with the LAN logical device. From the front panel, the LAN (Ethernet) options may be enabled or disabled collectively under MAIN MENU and LAN settings. From the bus, one may enable or disable certain aspects of LAN with:

1. comm.lan.telnet.enable

2. comm.lan.web.enable

3. comm.lan.vxi11.enable

4. comm.lan.rawsockets.enable

The following list contains the four LAN default port numbers (along with corresponding ICLs to query for these values):

1. telnet is 23 (ICL: lan.status.port.telnet)

2. rawsocket is 5025 (ICL: lan.status.port.rawsocket)

3. vxi11 is 1024 (ICL: lan.status.port.vxi11)

4. dead socket termination is 5030 (ICL: lan.status.port.dst)

When changing between the various bus interfaces, send the abort command to have that interface become the active one for receiving and processing bus commands. For example, if changing from communicating with instrument over GPIB and to send ICLs with a telnet session (assuming both interfaces are enabled):

1. Connect via telnet.

2. Send abort to leave the GPIB interface and switch over to telnet.

3. Send commands as desired.

Any of the enable settings will take effect the next time the unit powers up. Therefore, after making changes to these settings, power cycle the unit.

Power-up

Line power connection

Follow the procedure below to connect the Series 3700 to line power and turn on the instrument. The Series 3700 operates from a line voltage of 100V to 240V at a frequency of 50Hz or 60Hz. Line voltage is automatically sensed. There are no switches to set. Make sure the operating voltage in your area is compatible.

WARNING	***The power cord supplied with the Series 3700 contains a separate ground wire for use with grounded outlets. When proper connections are made, instrument chassis is connected to power line ground through the ground wire in the power cord. Failure to use a grounded outlet may result in personal injury or death due to electric shock.***

CAUTION	Operating the instrument on an incorrect line voltage may cause damage to the instrument, possibly voiding the warranty.

1. Before plugging in the power cord, make sure that the front panel power switch is in the off (O) position. See *Rear panel summary* (on page 3-1) for connector location.

2. Connect the female end of the supplied power cord to the (5) Power Connector (AC receptacle) on the rear panel. Connect the other end of the power cord to a grounded AC outlet.

3. Turn on the instrument by pressing the front panel power switch to the on (I) position. See
    Front panel introduction (on page 2-1) for switch location.

Line frequency

NOTE	Line frequency only applies to models with a DMM installed.

The Series 3700 will operate at line frequencies of either 50Hz or 60Hz. The line frequency is
auto-detected at startup.

Use the localnode.linefreq bus command to see the line frequency. For example:

```
print(localnode.linefreq)
```

Fuse replacement

Refer to the *Fuse replacement* (on page 8-1) topic contained in the user's manual for fuse
replacement information.

Power-up sequence

On power-up, the Series 3700 performs self-tests on its ROM, NVRAM, and RAM and
momentarily lights all segments and annunciators. If a failure is detected, the instrument
momentarily displays an error message and the ERR annunciator turns on. (Error messages are
listed in Error and status messages contained in the Reference manual.)

NOTE	If a problem develops while the instrument is under warranty, return it to Keithley Instruments, Inc., for repair.

Assuming no errors occur, the Series 3700 will power-up as follows:

1. "No Comm Link" is briefly displayed.

2. "Initializing" is displayed for several seconds.

3. Nearing the end of initialization, the 1588 and LAN status LEDs light.

4. All of the display pixels briefly light.

5. The display shows:
    KEITHLEY
    Series 3700

6. Main display appears.

System identification

Serial number, firmware revision, and calibration dates can be displayed by selecting the SYSTEM-INFO item of the main menu (press MENU > SYSTEM-INFO).

Select FIRMWARE, SERIAL#, or CAL as desired.

For remote programming, use the `*IDN?` query to read system information.

Beeper

With the beeper enabled, a beep will be issued to acknowledge the following actions:

- A short beep, emulating a keyclick, is issued when a front panel key is pressed.
- A short beep, emulating a keyclick is also issued when the wheel is turned or pressed.

To control the beeper from the front panel, select MENU > BEEPER > KEYCLICK, then ENABLE or DISABLE the keyclick as desired.

For remote programming, use the `beeper.enable` command to control the beeper. For example, the following enables the beeper:

```
beeper.enable = 1
```

Closing and Opening Switching Module Channels

In this section:

Close/open overview

NOTE	This section provides basic close/open information for switching module channels. Operating characteristics unique to a specific Series 3700 switching module are provided in an instruction sheet provided with the specific switching module.
	Terminology used throughout this manual is detailed in the applicable sections of the user's and reference manuals.

The switching channels of a Series 3700 support a concept of "duality." This means that each channel has specific settings for switching and specific settings for switching with DMM operations. The location of the specific operation request determines the setting that activates. An operation request residing in the channel logical device causes the switching settings to be used (example commands are channel.close, channel.open, channel.exclusiveclose); an operation request residing in the DMM logical device such as dmm.close or dmm.open, causes the DMM settings to be used. Refer to the reference manual for more information on logical devices (TSP section).

Open a Microsoft web-browser and type in the IP address (see How do I connect to the internal web page? located in the Quick Start Guide). The Series 3700 home page will appear. Use this home page to see a visual representation of the present channel status (select the desired slot or model contained under "Cards").

NOTE	Java application may need to be installed.

The Series 3700 supports opening and closing channels through either **Channel operation** or through **Channel pattern operation**:

Channel operation (non-channel pattern operation): This mode of operation should be used exclusively by most (if not all) users. When you close a channel for a measurement operation, other channels on the switching module close automatically to internally connect it through the backplane to the DMM of the Series 3700. When you close a channel for a switching operation, the channel (and possibly the channel pair) will close but, no backplane relays are closed unless associated with the channel.

Channel pattern operation: This mode of operation provides additional flexibility by providing individual control of each switching module and backplane channel. Careless operation in this mode could create a safety hazard and/or damage the switching module and other equipment. Channel pattern operation should only be used by experienced test engineers.

WARNING   ***Careless channel pattern operation could create an electric shock hazard that could result in severe injury or death. Improper operation can also cause damage to the switching modules and external circuitry. Controlling multiple channels using channel patterns should be restricted to experienced test engineers who recognize the dangers associated with multiple channel closures.***

CAUTION   To prevent damage to a switching module, do not exceed the maximum signal level input for that module. Most switching modules are rated for 300V.

NOTE   The Series 3700 is capable of scanning switching module channels. Each channel in the scan can have its own unique DMM configuration.

Channel operation (non-channel pattern operation)

NOTE   Channel operation includes closing and opening individual channels as well as channel ranges and backplane relays, but does not include channel patterns. *Channel pattern operation* (on page 4-2) includes channels and backplane relays that have been specifically associated together as a single-pattern image.

When closing/opening a channel (or range of channels), the configuration of the channel's attributes control how the channel is closed/opened. Additional channels or analog backplane relays that are affected by the channel's attribute settings are also controlled. The Series 3700 verifies the operation being requested for a channel is supported by the specified channel and that the channels specified to open or close exist in the system.

A channel represents a single channel unless it is being paired with its corresponding 4-pole channel. Channels are configured at power up based on the card contained in each slot. Even if a range of channels is specified in the command, each channel is treated individually as a channel or channel pair and not as a channel pattern. If a slot has no card installed, only a few attributes may be populated such as card type which will be set to indicate no card is in the slot like "empty slot."

Channel pattern operation

For channel patterns, only channels and analog backplane relays included in the image are controlled (no additional backplane relays or channel pairs other than those specifically contained in the channel pattern image are closed/opened). Unlike *channel operation* (see "Channel operation (non-channel pattern operation)" on page 4-2), no verification occurs during the operation if a channel pattern is specified. The user must ensure the requested operation is safe for a channel pattern. The system will verify that the items specified exist in the system.

NOTE	Matrix and multiplexer channels, along with backplane relays, may be part of a channel pattern image.

A channel pattern is comprised of multiple channels and/or backplane relays (minimum of two). The channels may be mux (multiplexer), matrix, or analog backplane relay channels and is created by the user. If the user desires only a single channel then, use a single channel notation (*Channel operation (non-channel pattern operation)* (see "Channel operation (non-channel pattern operation)" on page 4-2)).

Reference a channel pattern by its alphanumeric name.

NOTE	The first character of a channel pattern name must be alphabetical (uppercase or lowercase letter). Pattern names are case sensitive.

Channel pattern content

Channel patterns are:

- lists of channels
- comprised of multiple channels (at least 2) and created by the user. If a single channel is desired, use single channel notation
- reference a channel pattern by it's alphanumeric name
- may contain analog backplane relays

NOTE	The first character of a channel pattern name must be alphabetical (uppercase or lowercase letter). Pattern names are case sensitive.

To send a <ch_list> parameter that includes

- Slot 1, channels 1 through 5
- Slot 3, Channel 3,
- Slots/channels represented by the channel pattern "mychans"

send the following string:

```
("1001:1005", 3003, mychans")
```

Channel patterns may be created and controlled over the bus using *channel.pattern.** (see "channel functions and attributes" on page 6-2) ICLs or over the front panel.

NOTE	Labels and Channel Patterns cannot have the same name.

Channel pattern storing

Channel patterns:

- are part of saved setup data and restored when a setup is recalled.
- are deleted with a system reset or reset of a channel associated with a pattern.
- have 32K of memory available for each channel pattern to store data.

The number of channel patterns 32K will hold varies with the number of characters stored. If a given channel pattern name is 5 characters long, and each pattern is comprised of 5 channels each, with the string image only being comma delimited (for example, "2003,4003,2005,4005,2915"), then the number of channel patterns capable of being stored is 642. Decreasing the number of characters in each channel pattern name or the number of channels in the channel pattern image allows room for additional patterns to be stored. Conversely, increasing the number of characters in the channel pattern name or number of channels in the channel pattern image will take up additional space, thereby allowing fewer channel patterns to be stored.

Pole settings and channel patterns

NOTE	Changing a channel's pole setting deletes all patterns containing that channel.

When creating a channel pattern image, set the pole setting first (when the pole setting for a channel is changed, patterns that contain the channel are deleted). For example, assume a channel pattern called 'myimage' has channels 2004, 2008 and 2012 associated with it while 'myimage2' has channels 2005, 2009 and 2011. Now, if pole setting of Channel 2004 changes then the channel pattern 'myimage' is deleted and no longer exist in system. However, the pattern called 'myimage2' still exists.

NOTE	Matrix channels have fixed pole settings. Multiplexer channels pole settings may be changed.

While creating channel pattern images, the paired channel will automatically be accounted for based on pole setting. Therefore, the paired channel does not need to be specified in the channel image manually. For example, assume Slot 1 has a 3720 card installed and all channels are set to 4-pole operation. With all channels configured for 4-pole, the available channels are 1001 to 1030. To create a channel pattern called 'one4wire' with Channel 1001 and backplane relays 1911 and 1922, the corresponding bus command is:

```
channel.pattern.setimage('1001, 1911, 1922', 'one4wire')
```

To see the image associated with a channel pattern, use the `channel.pattern.getimage` command. For example to see the image of the pattern just created called 'one4wire':

```
print(channel.pattern.getimage('one4wire')) → 1001(1031),1911,1922
```

NOTE	Paired channel are indicated in parenthesis *<ch_list> queries* (on page 4-13).

Close/open commands and operation

NOTE	When the Series 3700 is powered up, all switch cards present in the system will have all their relays opened. This includes all switching and all backplane relays.

The command or operation used to request the close or open will specify how the action should be completed. The open/close action may be executed to achieve a switching or measuring application.

Available commands for switching:

- channel.close
- channel.exclusiveclose
- channel.exclusiveslotclose
- channel.open
- scanning (only with function of DMM configuration set to 'nofunction')

ICL	Action performed
channel.close	Close items in an append operation (no channels will be opened).
channel.exclusiveclose	Close items such that only those specified are closed. This will open any closed item that is not specified in list. If a specified item is already closed, it will remain closed during the operation.
channel.exclusiveslotclose	Close items for specified slots such that only those specified are closed. Other items on those slots will open. Items closed on other slots will not be affected. If a specified item is already closed, it will remain closed during the operation.
channel.open	For a channel, it will open the channels and backplane relays that would get closed with channel.close. For channel patterns, it would open items associated with the image of the pattern.

Available commands for measuring:

- dmm.close
- dmm.open
- scanning (only with function of DMM configuration set to anything other than 'nofunction')

ICL	Action performed
dmm.close	Equivalent of channel.exclusiveslotclose except it also prepares the DMM for taking a measurement on the function associated with the item. For a channel, it will make sure the DMM is connected through the backplane. However, it will not do this for a channel pattern. It will close any needed backplane relays and paired channel. It will open channels and backplane relays that will interfere with measuring on the specified channel.
dmm.open	For a channel, it will open the channels that would get closed with dmm.close. For channel pattern, it will open the items associated with the image of the pattern.

Close/open bus operation

Use the following commands to control switches over the bus. For detailed information specifying what happens with each of these commands, see the reference manual.

ICL	Description	Usage
channel.close	Function: Closes specified items in ch_list without opening any channels.	`channel.close(ch_list)` **ch_list:** string listing the items to close. Items can include channels, backplane relays, and channel patterns.
channel.open	Function: Opens items specified in ch_list.	`channel.open(ch_list)` **ch_list:** string listing the items to open. Items can include channels, backplane relays, and channel patterns.
dmm.close	Function: Closes the specified channel or channel pattern in preparation for a DMM measurement.	`dmm.close(ch_list)` **ch_list**: string listing the channel or channel pattern to close
dmm.open	Function: Opens the specified channel and/or channel pattern.	`dmm.open(ch_list)` **ch_list**: string listing the channel or channel pattern to open

Close/open key operation

The front panel **CLOSE** and **OPEN** keys operate in the same manner as one of the following:

- channel.close and channel.open commands
- dmm.close and dmm.open commands

The operation of the keys depend on the selected channel or channel patterns function association.

To have the keys work as channel.close and channel.open:

- Make sure the DMM function of the DMM configuration associated with the selected channel or channel pattern is "nofunction."

To have the keys work as dmm.close and dmm.open:

- Make sure the DMM function of the DMM configuration associated with the selected channel or channel pattern is not "nofunction" (for example, DC volts).

Channel attributes

NOTE	Unless noted, attributes are not common to backplane relays or channel patterns.

Each switching channel has the following set of associated attributes:

label: a string representing the channel (maximum length: 20 characters). Once a unique label is assigned to a channel, it may be used to refer to that channel. The label for a channel cannot match the name of an existing pattern.

delay setting: additional delay to incur after the relay settles. Therefore, the total delay for channel operation is user delay + relay settling time.

backplane relays: list of backplane relays to control when performing a switching (channel logical device action) close or open operation on a single channel. For channel patterns, the image must include the backplane relays that need to be controlled during the channel operation since patterns don't have a separate attribute setting for backplane relays (*Channel pattern operation* (on page 4-2)).

pole setting: pole setting for mux (multiplexer) channels that indicates if the paired mux channel should be included when doing a close or open operation on channel. Changing the pole setting on a channel deletes any existing channel patterns containing that channel. Putting a channel in 4-pole operation will cause the associated paired channel to become unavailable for switching operation. For example, assume 3003 is set to 4-pole and its paired channel is 3033. Now, 3033 is unavailable for its own channel attribute settings and doing switching (channel logical device action) closes and opens. If Channel 3033 is specified it will generate a settings conflict with paired channel specified error message.

forbidden setting: indicates if the channel is forbidden to close. A backplane relay may be marked as forbidden to close. Marking a channel as 'forbidden to close' deletes any existing channel patterns containing that channel.

close count: indicates how many times the relay for a channel has closed. A backplane relay has a close count associated with it as well.

DMM configuration: indicates the DMM function tied to a mux channel along with that function's pertinent attributes. This is the only attribute that is available to channel patterns (*Channel pattern operation* (on page 4-2)). As long as the channel is not opened or closed through a channel pattern, verification that the channel supports the function associated with the DMM configuration will take place. No verification will occur for a channel pattern, therefore the user must be sure that the channel pattern and DMM configuration are safe to be associated together.

The system will allow for the pole setting and DMM configuration of a channel to contradict each other without causing an error. This means that the DMM configuration may have a channel configured for 2-pole measuring operation (for example, DC volts) while the pole setting may be configured for 4-pole. Or, a channel may have a DMM configuration of 4-wire ohms while the pole settings is at 2-pole. The operation being requested indicates the setting used. For DMM operations (dmm.close or dmm.open), the DMM configuration will be used, but for channel operations (channel.close, channel.open, channel.exclusiveclose and channel.exclusiveslotclose), the pole configuration setting will be used.

DMM configurations:

- are part of saved setup data and restored when a setup is recalled.

- are deleted with a system reset but, not affected by a DMM reset alone (dmm.reset ICL)

- have 32K of memory available for each channel pattern to store data.

The number of DMM configurations 32K can store varies with the number of characters stored. If each DMM configuration is 6 characters long, 78 temperature configurations can be stored (temperature has 41 unique DMM associated attribute settings). However, with the function set to DC volts, with each name still being 6 characters long, 99 DMM configurations can fit in 32K (DC volts only has 31 unique DMM associated attribute settings). Use the DMM configuration query command to determine how many attributes are associated with a function (see dmm.configure.query).

Duality with example

Since the switching channels of a Series 3700 support the concept of "duality", each channel has specific settings for switching and specific settings for switching with DMM operations. Recall that to achieve the duality, the location of the specific operation request determines the setting that activates. An operation request residing in the channel logical device causes the switching settings to be used; an operation request residing in the DMM logical device causes the DMM settings to be used. The following example illustrates this concept.

Assume the following channel attributes:

Channel	Backplane relays	Pole setting	DMM configuration
3001	none	2	'fourwireohms'
3002	3915	2	'fourwireohms'
3031	3921	2	N/A (paired channel)
3032	3921	2	N/A (paired channel)

NOTE   The reason that 3031 and 3032 are paired channels (in this is example) is that the channels 3001 and 3002 are configured with a DMM setting of "fourwireohms" (which is a four-wire function). Two poles are supplied from the called channels, and two poles from the channels associated by the "fourwireohms" configuration.

For this example, the following numbered operations are executed either from the front panel or over the bus. Bulleted items that immediately follow the numbered operation indicate actions that can occur with the operation:

1. channel open all

2. channel exclusive close 3001

   - only 3001 closes (since no backplane relays have been associated with channel and channel is not paired, in other words, not 4-pole)

3. channel exclusive close 3002

   - open 3001 (no longer being requested as closed)

   - close 3002 and 3915 (no channel pair since 2-pole and 3915 is backplane relay attribute setting)

4. channel exclusive close 3031

   - open 3002 and 3915

   - close 3031 and 3921

5. channel exclusive close 3032

   - open 3031

   - keep 3921 close

   - close 3032

6. dmm close 3001

   - open 3032, 3921

   - close 3001, 3031, 3911, 3922 (prepare for a 4-wire measurement, need paired channel and corresponding backplane relays)

7. dmm close 3002

- open 3001, 3031
- keep 3911, 3922 close
- close 3002, 3032

When creating a channel pattern, make sure to:

- include all of the channels and backplane relays that are needed for that channel pattern image.
- check that channels and backplane relays contained in the image are correct.
- check that channels and backplane relays contained in the image create the desired path connection.
- check that DMM configuration associated with pattern is valid based on pattern connections the image makes.

The system will verify that the channels exist for a pattern, but will not verify that the connection is correct or that a good measurement will result for using the pattern based on the assigned DMM configuration.

NOTE	Channel patterns inherit the delay times of the individual channels that comprise the pattern.

Channel and backplane notation

There are three different notations used to control relays: Backplane relay notation, Mux (multiplexer) channel notation, and Matrix card notation.

Backplane relay notation

To control analog backplane relays for slots with analog backplane relay channels, use S9BX where:

S: Slot number

9: Backplane notation designation (always 9 when referencing a backplane relay)

B: Bank number

X: Analog backplane relay number

Analog backplane relays (bank 2 of Slot 1) examples:

Reference	Analog backplane relay
1921	analog backplane relay 1
1922	analog backplane relay 2
1923	analog backplane relay 3
1924	analog backplane relay 4
1925	analog backplane relay 5
1926	analog backplane relay 6

Mux (multiplexer) channel notation

To control channels using mux channel notation, use SCCC where:

S: Slot number

CCC: Channel number (always use 3 digits)

Multiplexer examples:

Reference	Slot	Channel
1004	1	004
1020	1	020
2100	2	100
3003	3	003

Figure 4-1: Multiplexer card display
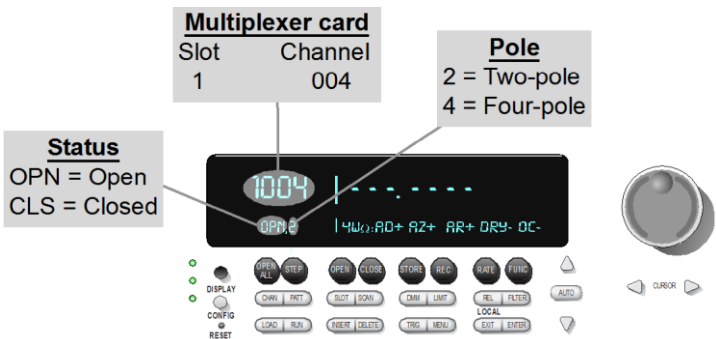
Matrix card notation

To control channels using matrix card notation, use SRCC where:

S: Slot number

R: Row number

CC: Column number (always use 2 digits)

Matrix channel examples:

Reference	Slot	Row	Column
1104	1	1	04
1203	1	2	03
2305	2	3	05
3112	3	1	12
6101	6	1	01

Figure 4-2: Matrix card display
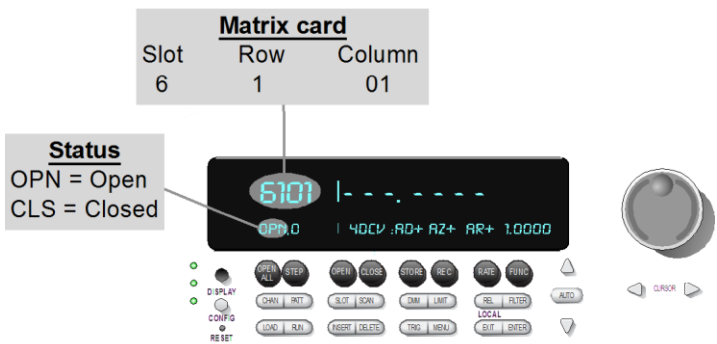
Channel list parameter <ch_list>

The channel list parameter <ch_list>, used when controlling the Series 3700's relays over the bus, is a string-type parameter. An example:

- Channel 1 (of Slot 1) is associated with analog backplane relays 3 and 4, while Channel 3 (of the same slot) has analog backplane relays 5 and 6. The <ch_list> used in this example is ("1001, 1003"). The response to a channel.getbackplane("1001, 1003") will be "1913, 1914;1915,1916". To associate the backplane relays as indicated with Channel 1, the corresponding command would be channel.setbackplane('1001', '1913, 1914').

Therefore, when sending this parameter:

- Enclose the contents of the channel list in either single (') or double (") quotes, but the quote style must match.

- Use a comma or semicolon to separate the channel list or channel patterns.

- The string may contain a single channel, channel pattern or analog backplane relay as well as multiple ones that are indicated by a range or comma separated.

- Use a colon to specify a range of channels. Example: channel.getbackplane("1001:1003") responds with the range of Slot 1 channels from 1 to 3.

Although a parameter string may be valid, the command that calls it will determine the string's ultimate validity. For example, only channels have a pole setting (channel patterns do not). If a channel pattern is passed to the poles setting command, an error would be generated.

Channel patterns may be included as a <ch_list> parameter.

<ch_list> queries

For queries that return a channel list parameter, a channel configured for 4-pole operations will indicate the paired channel in parenthesis. For example, Channel 3003 on a 60-channel card is configured for 4-pole, then sending:

```
channel.close('3003')

print(channel.getclose('slot3') → 3003(3033)
```

NOTE   In the above examples output →, the paired channel associated with 3003 is 3033 and is in included in parenthesis.

Channel operation

The channel number is displayed on the Series 3700's front panel. For a 4-wire function (in other words, Ω4), the paired channel is internally connected to DMM sense, but not displayed. When triggered, the DMM performs a measurement and displays it on the Series 3700.

When a measurement channel is closed (measurement channel meaning that a function other than 'no function' is associated with the channel), the input backplane isolation channel also closes to connect the channel to DMM input. For a 4-wire function, the paired channel and the sense backplane isolation channel also close to make the sense connections to the DMM.

2-wire functions

The following figure shows an example of how the channel is connected to the DMM Input of the Series 3700 with regards to a 2-wire function, such as DC volts. Assume a switching module with 20 channels is installed in Slot 1 of the mainframe. When Channel 1001 is closed using the channel **Close** key, both the Channel 1 relay and the backplane isolation relay (Channel 1911) close to connect the channel to the DMM.

Figure 4-3: Two-wire function
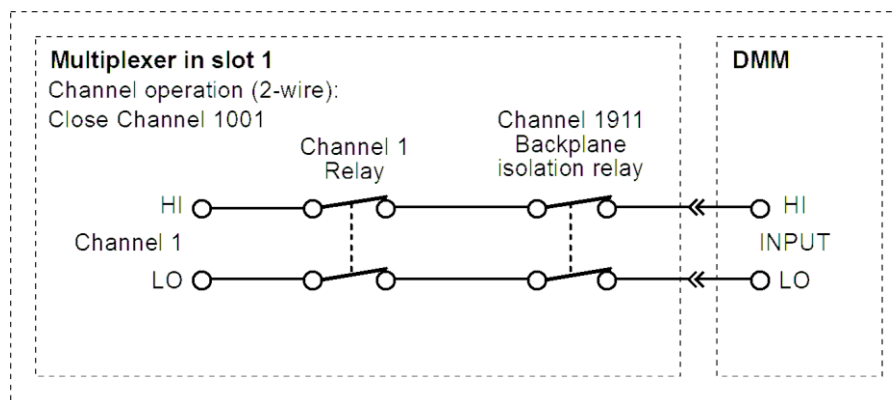
4-wire functions (paired channels)

A 4-wire function, such as Ω4, requires that another measurement channel (SENSE) be paired to the channel (INPUT). For example, in a switching module that has 20 measurement channels, Channels 1 through 10 can be used as the calling channels (channels that are sent with the commands or closed from the front panel), while Channels 11 through 20 are used as the paired channel. For a switching module that has 20 measurement channels, Channel 1 is paired to Channel 11, Channel 2 is paired to Channel 12, Channel 3 is paired to Channel 13, and so on.

The following figure shows an example of channel connections for a 4-wire function.

Assume a switching module is installed in Slot 1 of the mainframe, and a 4-wire function, such as Ω4, is selected. When Channel 1001 is closed using the **Close** key, the Channel 1 relay and the input backplane isolation relay (Channel 1911) closes to connect the channel to DMM Input. Also, the Channel 11 relay and the sense backplane isolation relay (Channel 1922) closes to connect the paired channel to DMM Sense.

Figure 4-4: Four-wire function
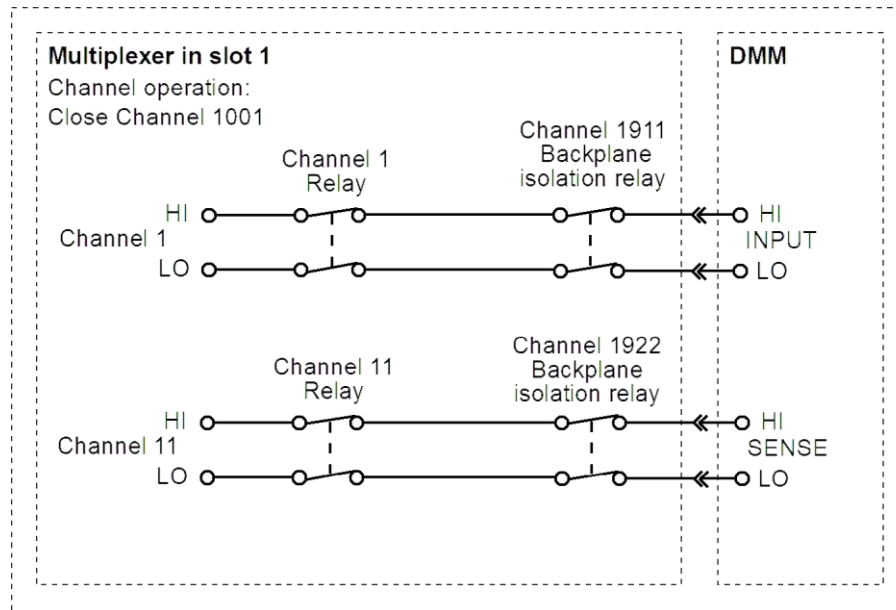
Identifying installed modules and viewing closed channels

Use the **SLOT** key to scroll through the model numbers, description, as well as the firmware revision of the installed switching module(s).

Switching module queries (remote operation)

Use `print(slot[x].idn)` to query and identify installed switching modules and channels that are closed:

```
print(slot[x].idn)
```

where: x = slot number (from 1 to 6)

The following example uses the `print(slot[x].idn)` to determine which switching modules (or pseudocards) are installed in the Series 3700.

Example

Assume a Model 3722 is installed in Slot 1, a Model 3721 is installed in Slot 2 and the other 4 slots are empty. Sending the following command line over the bus:

```
for x=1,6 do print (slot[x].idn) end
```

The response would be:

```
3722, Dual 1x48 Multiplexer, 01.00a, <Module Serial Number>

3721, Dual 1x20 Multiplexer, 01.02a, <Module Serial Number>

Empty Slot

Empty Slot

Empty Slot

Empty Slot
```

Break Before Make and connecting sequentially

Break Before Make (BBM) or Make Before Break (MBB) is a user settable channel attribute. This attribute is applicable for EMR, reed, and solid state relay cards. The same attribute setting for BBM and MBB applies to all applicable channels in the system.

To set the rule as Break Before Make over the bus, send the following ICL command:

```
channel.connectrule = channel.BREAK_BEFORE_MAKE
```

When sequential connecting is enabled, the list of channels or analog backplane relays close sequentially. To set the connect sequential to ON over the bus, send the following ICL command:

```
channel.connectsequential = channel.ON
```

Both of these attributes can be set using the front panel keys. To set from the front panel, use the following procedure as a guide:

NOTE　　If the Series 3700 is in remote mode (controlled over the bus) press the **EXIT** key to place it in local mode to control the unit using the front panel keys.

NOTE　　Front panel keys are not available on all models.

1.　Press the **MENU** key.

2.　Use the wheel to scroll to the CHANNEL menu item.

3.　Press the **ENTER** key (or the wheel) to display the CONNECT MENU.

---

4. From this menu, select one of the following:

    *   RULE: Use this menu item to set the rule to BBM, MBB, or OFF.

    *   SEQUENTIAL. Use this menu item connect sequentially (ON or OFF setting).

5. Use the **EXIT** key to leave the menu.

Relay closure count

The Series 3700 keeps an internal count of the number of times each module relay has been closed. The total number of relay closures are stored in nonvolatile memory on the module. This count will help you determine if and when any relays require replacement (see the specific module's contact life specifications).

Relay closures are counted only when a relay cycles from open to closed state. If you send multiple close commands to the same channel without sending an open command, only the first closure will be counted.

To see the close counts for channels 1 to 5 on Slot 2, send the following ICL command:

```
count=channel.getcount("2001:2005")

print(count)
```

This would output a comma delimited list of the five close counts (2001 through 2005). See the ICL channel.getcount for more information.

To see the close counts for channels 3 to 5 on the card in Slot 1 using the front panel keys:

NOTE	If the Series 3700 is in remote mode (controlled over the bus) press the **EXIT** key to place it in local mode to control the unit using the front panel keys.

NOTE	Front panel keys are not available on all models.

1. Select the channel range 1003:1005 using the wheel.

    *   To change the present slot, press the wheel. The first digit of the four digit channel number will flash indicating edit mode. Turn the wheel to change the number (any slot that has a module or a pseudocard installed can be selected). For this example, change the digit to a 1.

    *   Press the wheel a second time. This accepts the slot selection (above) and selects edit mode for the channel. Digits two through four of the four digit channel number will flash indicating edit mode. Turn the wheel to change the number (any channel available for the selected slot's module can be selected). For this example, change the digit to a 003.

    *   Press the wheel a third time. This accepts the channel selection (above) and selects edit mode for the channel range. Digits two through four of the smaller four digit channel number will flash indicating edit mode. Turn the wheel to change the number (any channel available for the selected slot's module can be selected). For this example, change the digit to a 005.

    *   Press the wheel a fourth time to accept the channel selection.

    *   Press the wheel a fifth time to return to the main display.

2. Press the **CONFIG** key.

3. Press the **CHAN** key.

4. Use the wheel (3) to scroll to the "COUNT" menu item.

5. Press the **ENTER** key (or the wheel) to display the close counts for Channel 1003 through 1005.

6. Use the **EXIT** key to leave the menu.

NOTE   The backplane relay closure count may be queried using this same method.

Basic Digital Multimeter (DMM) Operation

In this section:

DMM measurement capabilities

The DMM of the Series 3700 can make the following measurements:

DCV: DC voltage measurements from -303V to 303V

ACV: AC voltage measurements from 0V to 303V

DCI: DC current measurements from -3.1A to 3.1A

ACI: AC current measurements from 0A to 3.1A

Ω2: 2-wire resistance measurements from 0Ω to 120MΩ.

Ω4: 4-wire resistance measurements from 0Ω to 120MΩ.

CSΩ: Common side ohms resistance measurements from 0Ω to 120MΩ.

FREQ: Frequency measurements from 3Hz to 500kHz.

PERIOD: Period measurements from 2μs to 333ms.

TEMP: Temperature measurements from -200°C to 1820°C.

CONT: Continuity testing using the 1kΩ range.

| CAUTION | When using a switching module, do not exceed the maximum signal levels of the module. |

High-energy circuit safety precautions

To optimize safety when measuring voltage in high-energy distribution circuits, read and use the directions in the following warning:

WARNING   *Dangerous arcs of an explosive nature in a high-energy circuit can cause severe personal injury or death. If the multimeter is connected to a high-energy circuit when set to a current range or low resistance range, the circuit is virtually shorted. Dangerous arcing can result even when the multimeter is set to a voltage range if the minimum voltage spacing is reduced in the external connections.*

As described in the International Electrotechnical Commission (IEC) Standard IEC 664, the Series 3700 is Installation Category I and signal lines must not be directly connected to AC mains.

When making measurements in high-energy circuits, use test leads that meet the following requirements:

- Test leads should be fully insulated.
- Only use test leads that can be connected to the circuit (for example, alligator clips, spade lugs, etc.) for hands-off measurements.
- Do not use test leads that decrease voltage spacing. These diminish arc protection and create a hazardous condition.

Use the following procedure when testing power circuits:

1. De-energize the circuit using the regular installed connect-disconnect device. For example, remove the device's power cord or by turning off the power switch.

2. Attach the test leads to the circuit under test. Use appropriate safety rated test leads for this application. If over 42V, use double-insulated test leads or add an additional insulation barrier for the operator.

3. Set the multimeter to the proper function and range.

4. Energize the circuit using the installed connect-disconnect device and make measurements without disconnecting the multimeter.

5. De-energize the circuit using the installed connect-disconnect device.

6. Disconnect the test leads from the circuit under test.

Performance considerations

Warm-up

After the Series 3700 is turned on, it must be allowed to warm up for at least two hours to allow the internal temperature to stabilize. If the instrument has been exposed to extreme temperatures, allow extra warm-up time.

Autozero

To help maintain stability and accuracy over time and changes in temperature, the Series 3700 periodically measures internal voltages corresponding to offsets (zero) and amplifier gains. These measurements are used in the algorithm to calculate the reading of the input signal. This process is known as autozeroing.

When autozero is disabled, the offset and gain measurements are not performed. This increases the measurement speed. However, the zero and gain reference points will eventually drift resulting in inaccurate readings of the input signal. It is recommended that autozero only be disabled for short periods of time. The internal temperature references used for thermocouple measurements are performed regardless of the autozero state because they do not have a significant effect on measurement speed.

When autozero is enabled after being off for a long period of time, the internal reference points will not be updated immediately. This will initially result in inaccurate measurements, especially if the ambient temperature has changed by several degrees.

NOTE	To force a rapid update of the internal reference points, set the AUTOZERO attribute for the channel to ONCE. This will update the internal reference points once and stop. Querying the AUTOZERO setting will show it set to OFF. The Instrument Control Library (ICL) command to set AUTOZERO is covered in dmm.autozero.
	To force a rapid update of the internal reference points for a long period of time and also to remain on, is to change the dmm.nplc to 0.0005 and then back to the desired NPLC. Autozero reference will be rapidly updated but continue to be collected.
	For example:

	```dmm.autozero = dmm.ON```
	
	```dmm.nplc = 0.0005```
	
	```dmm.nplc = 1.0```

Remote programming can be used to enable or disable autozero. Autozero can be configured from the front panel by pressing the **CONFIG** key, then the **DMM** key (configuration includes: OFF, ON, or ONCE). See dmm.autozero for remote programming information.

Line cycle synchronization

Synchronizing A/D conversions with the frequency of the power line increases common mode and normal mode noise rejection. When line cycle synchronization is enabled, the measurement is initiated at the first positive-going zero crossing of the power line cycle after the trigger.

The following figure shows a measurement process that consists of two A/D conversions. If the trigger occurs during the positive cycle of the power line (Trigger #1), the A/D conversion starts with the positive-going zero crossing of the power line cycle. If the next trigger (Trigger #2) occurs during the negative cycle, then the measurement process also starts with the positive-going zero crossing.

NOTE	Line synchronization is not available for the AC functions (ACV, ACI, FREQ, or PERIOD). Line synchronization can be enabled for ≤ 1.0PLC measurement, increasing NMRR and CMRR.

See dmm.linesync contained in the reference manual for remote programming information.

Figure 5-1: Line cycle synchronization
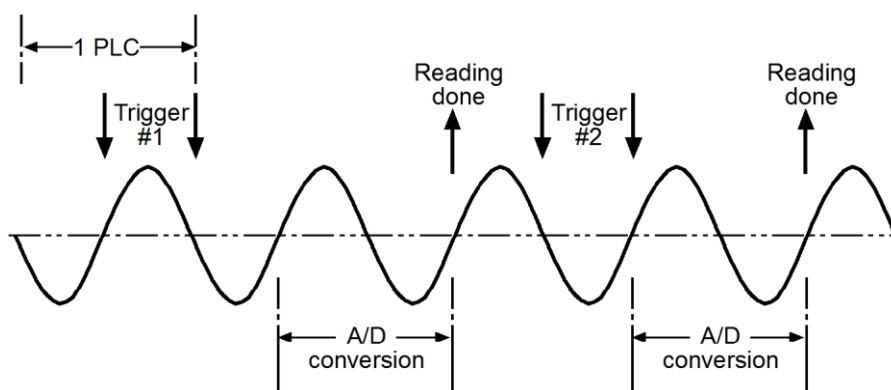
Voltage measurements (DCV and ACV)

The Series 3700 can make DCV measurements from 0.01µV to 300V and ACV measurements from 0.1µV to 300V RMS (425V peak for AC waveforms).

- DCV input resistance: 100mV through 10V ranges: >10GΩ
- 100V and 300V ranges: ≥10MΩ

Refer to the specifications for complete and updated information and tolerances.

DCV input divider

Normally, the input resistance for the 100mVDC, 1VDC, and 10VDC ranges is >10GΩ, while the input resistance of the 100VDC and 300VDC ranges is 10MΩ. However, the input resistance for the three lower DCV ranges can also be set to 10MΩ by enabling the input divider.

With the input divider enabled, the measurement INPUT HI is connected to INPUT LO. Also, some external devices (such as a high voltage probe) must be terminated to a 10MΩ load. The input divider maintains the measurement of open leads near 0V. Also, internal I_{BIAS} through the 10M causes an open input to read <-4.4mV. With a short circuit (and the input divider on or off), the short circuit to read < $\pm0.9\mu$V.

The input divider can be enabled from the front panel when function is "dcvolts" by pressing the **CONFIG** key, then the **DMM** key. To control the divider over the bus, use the dmm.inputdivider remote programming command.

Connections

WARNING	***Even though the Series 3700 can measure up to 300V, the maximum input to a switching module may be less. Exceeding the voltage rating of a switching module may cause damage and create a safety hazard.***

WARNING	Make sure the insulation and wire sizes used are appropriate for the voltages and current being applied to the Series 3700 analog backplane connector. Use supplementary insulation as needed. Exceeding the voltage rating of a wiring may cause damage and create a safety hazard.

Figure 5-2: DCV connection
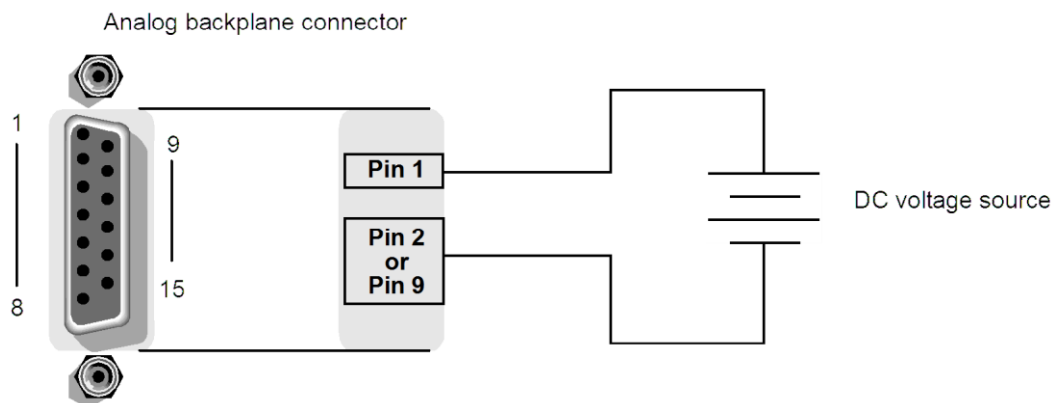
Figure 5-3: ACV connection
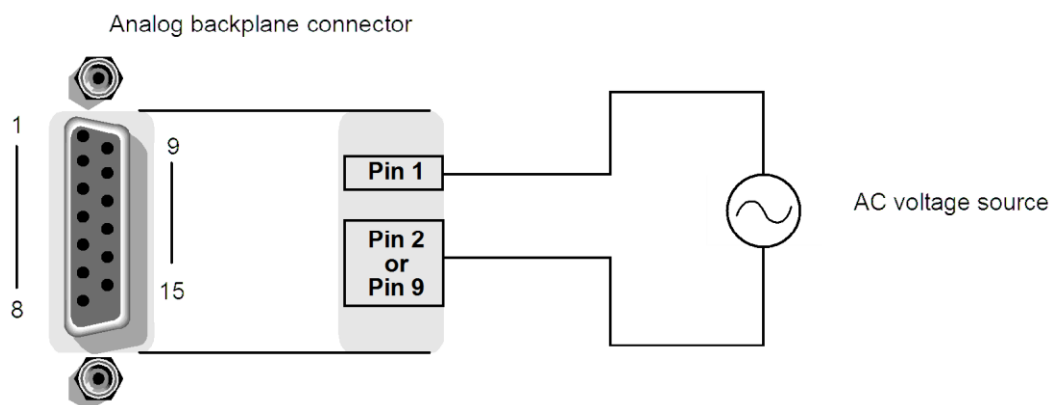
Schematic

Refer to the following figure for a schematic of the rear panel, backplane, and DMM connect relays with a typical card.

Figure 5-4: Rear panel to backplane to DMM connect relays schematic
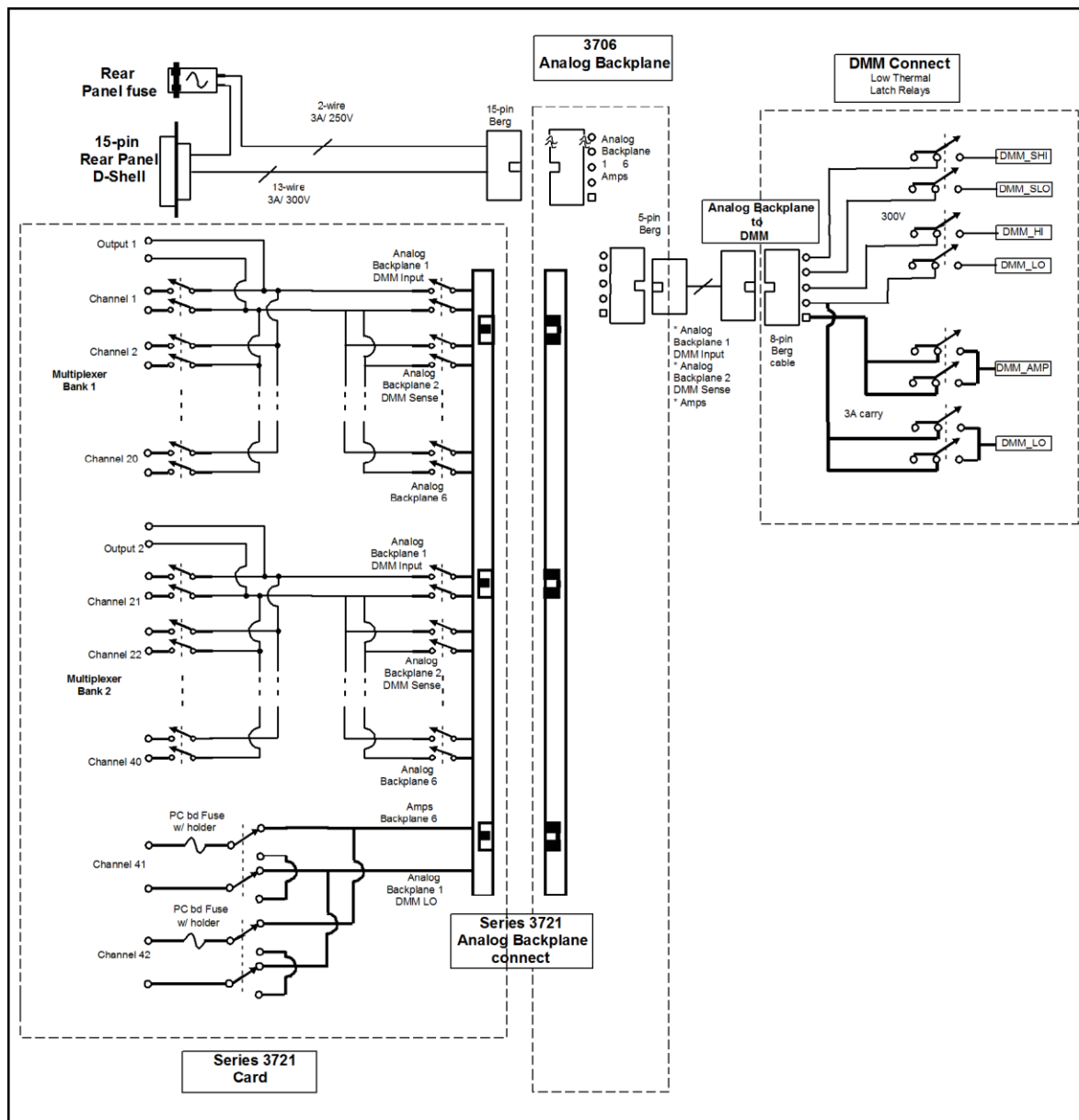
Voltage measurement procedure

WARNING	*If both the analog backplane connector and a switching module's terminals are connected at the same time, all wiring and connections must be rated to the highest voltage that is connected. For example, if 300V is connected to the analog backplane connector, the test lead insulation for the switching module must also be rated for 300V.*

CAUTION	Do not apply more than maximum input levels indicated or instrument damage may occur. The voltage limit is subject to the 8×10^7 VHz product.

Perform the following steps to measure voltage:

1. Press the **OPENALL** key to open all switching channels.

2. Select the voltage measurement function by pressing the **FUNC** key until "DCV" or "ACV" (as applicable) is displayed.

3. Use the **RANGE ▲ and ▼** keys to select a measurement range consistent with the expected voltage, or press the **AUTO** key to select autoranging (AUTO annunciator turns on).

4. Apply the voltage(s) to be measured.

5. If using a switching module, perform the following steps to close the desired channel:

    a)   Use the wheel to dial in the channel number.

    b)   Press the **CLOSE** key.

6. Press the **TRIG** key and observe the displayed reading. If the "Overflow" message is displayed, select a higher range until a normal reading is displayed (or press the **AUTO** key for autoranging). For manual ranging, use the lowest possible range for the best resolution.

7. To measure other switching channels, repeat steps 5 and 6.

8. When finished, press the **OPENALL** key to open all channels.

AC voltage measurements and crest factor

The root-mean-square (RMS) value of any periodic voltage or current is equal to the value of the DC voltage or current which delivers the same power to a resistance as the periodic waveform does. Crest factor is the ratio of the peak value to the RMS value of a particular waveform. This is represented by the following equations:

$$CF = \frac{V_P}{V_{RMS}} \quad \text{or} \quad CF = \frac{I_P}{I_{RMS}}$$

The crest factor of various waveforms is different, since the peak-to-RMS ratios are variable. For example, the crest factor for a pulse waveform is related to the duty cycle; as the duty cycle decreases, the crest factor increases. The RMS calculations and crest factor (CF) for various waveforms are shown in the following figures.

Figure 5-5: ACV measurements: sine waves
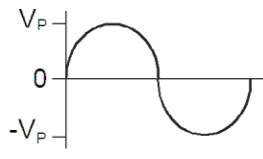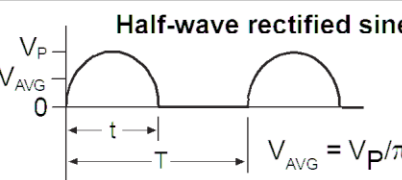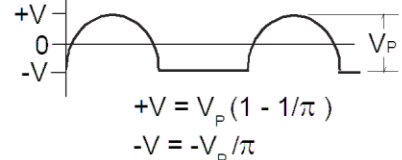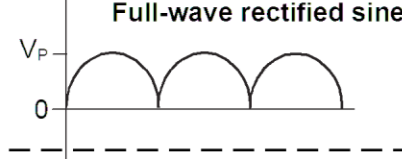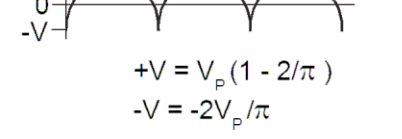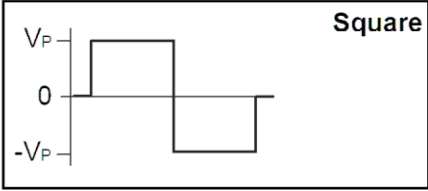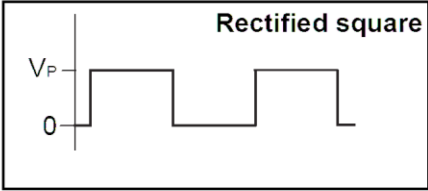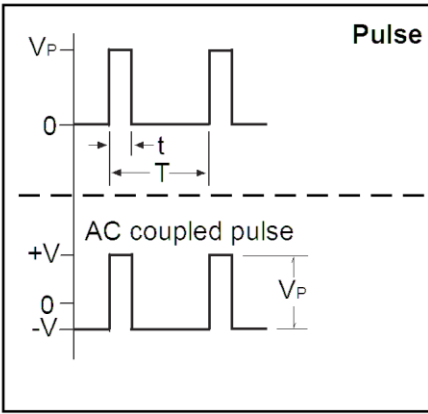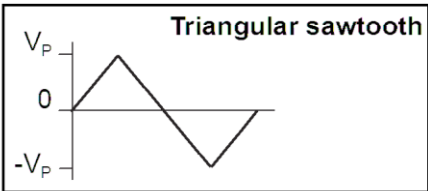
Sine

AC coupled RMS:

$$V_{RMS} = \frac{V_P}{\sqrt{2}}$$

Crest Factor:

$$CF = \sqrt{2}$$

Half-wave rectified sine

$$V_{AVG} = V_P/\pi$$

RMS:

$$V_{RMS} = V_P \sqrt{D/2}$$

where: D (duty cycle) = t/T

Crest Factor:

$$CF = \frac{1}{\sqrt{D/2}}$$

$$+V = V_P(1 - 1/\pi)$$
$$-V = -V_P/\pi$$

AC coupled RMS:

$$V_{RMS} = \sqrt{(V_P\sqrt{D/2})^2 - (V_P/\pi)^2}$$
$$= V_P \sqrt{(D/2) - (1/\pi^2)}$$

Crest Factor:

$$CF = \frac{1}{\sqrt{(D/2) - (1/\pi^2)}}$$

Full-wave rectified sine

RMS:

$$V_{RMS} = \frac{V_P}{\sqrt{2}}$$

Crest Factor:

$$CF = \sqrt{2}$$

$$+V = V_P(1 - 2/\pi)$$
$$-V = -2V_P/\pi$$

AC coupled RMS:

$$V_{RMS} = \sqrt{(V_P/\sqrt{2})^2 - (2V_P/\pi)^2}$$
$$= V_P \sqrt{(1/2) - (4/\pi^2)}$$

Crest Factor:

$$CF = \frac{1}{\sqrt{(1/2) - (4/\pi^2)}}$$

Figure 5-6: ACV measurements: square, pulse, and sawtooth waves

Square

V_P, 0, $-V_P$

AC coupled RMS:

$$V_{RMS} = V_P$$

Crest Factor:

$$CF = 1$$

Rectified square

V_P, 0

AC coupled RMS:

$$V_{RMS} = \frac{V_P}{2}$$

Crest Factor:

$$CF = 2$$

Pulse

V_P, 0, $\leftarrow t$, $\leftarrow T$

AC coupled RMS:

$$V_{RMS} = V_P\sqrt{D(1-D)}$$

where: D (duty cycle) = t/T

Crest Factor:

$$CF = \frac{1}{\sqrt{D(1-D)}}$$

AC coupled pulse

$+V$, 0, $-V$, V_P

AC coupled peak:

$$+V = V_P(1-D)$$
$$-V = -V_P D$$

when: $0 < D \leq 0.5$

$$CF = \sqrt{\frac{1}{D} - 1}$$

when: $0.5 < D \leq 1$

$$CF = \sqrt{\frac{1}{1-D} - 1}$$

Triangular sawtooth

V_P, 0, $-V_P$

RMS:

$$V_{RMS} = 0.557 V_P$$

Crest Factor:

$$CF = 1.733$$

The Series 3700 is an AC-coupled RMS meter. For an AC waveform with DC content, the DC component is removed before the RMS is calculated. This affects the crest factor because the peak value for the DC-coupled waveform is different than the peak value for the AC-coupled waveform. In an AC-coupled waveform, the peak value is measured from the original DC average value, not DC zero. For example, if a voltage pulse is measured on the AC function of the Series 3700 with a peak voltage of VP and a low voltage of zero volts, the AC-coupled peak value will be calculated as follows:

ACPEAK = VP • (1 - duty cycle)

Therefore, the AC-coupled crest factor will differ from the DC-coupled waveform. The RMS function will calculate the RMS value based on the pulsed waveform with an average value of zero.

The reason to consider crest factor in accuracy of RMS measurements is because the meter has a limited bandwidth. Theoretically, a sine wave can be measured with a finite bandwidth because all of its energy is contained in a single frequency. Most other common waveforms have a number of spectral components requiring an almost infinite bandwidth above the fundamental frequency to measure the signal exactly. Because the amount of energy contained in the harmonics becomes smaller with increasing frequency, very accurate measurements can be made with a limited bandwidth meter, as long as enough spectral components are captured to produce an acceptable error.

Crest factor is a relative measurement of the harmonic content of a particular waveform and reflects the accuracy of the measurement. For a rectangular pulse train, the higher the crest factor, the higher the harmonic content of the waveform. This is not always true when making spectral comparisons between different types of waveforms. A sine wave, for example, has a crest factor of 1.414, and a square wave has a crest factor of 1. The sine wave has a single spectral component and the square wave has components at all odd harmonics of the fundamental.

The Series 3700 RMS AC volts and AC amps accuracies are specified for sine waves of different frequency ranges.

Additional error uncertainties are also specified for non-sinusoidal waveforms of specific crest factors and frequencies. The Series 3700 has capabilities of measuring AC waveforms of crest factors up to 5.

Speed, accuracy, and settling times for AC current and voltage

The Series 3700 is an AC-coupled RMS meter. For an AC waveform with a DC content, the DC component is removed before the RMS is calculated. The RMS converter rectifies the AC waveform and creates a proportional DC level. The amount of the DC level is dependent on input level, frequency, and dmm.detectorbandwidth setting.

When detectorbandwidth is between 3 and 30

For dmm.detectorbandwidth=3 or 30, the A/D uses a multi-sampling algorithm to measure the DC and AC output of the RMS converter. These settings have been optimized for inputs from 3-300kHz, dmm.detectorbandwidth=3 (SLOW) and 30Hz to 300kHz for dmm.detectorbandwidth=30 (MED). The number of samples taken and the intervals vary with the settings as follows:

Setting	Number of samples taken	Interval per measurement
SLOW	2000	1msec
MED	200	1msec

Also, for varying input levels, a 330msec delay is required to properly settle the RMS converter's filter capacitor.

When detectorbandwidth = 300

For dmm.detectorbandwidth=300, the Series 3700 DMM is optimized for inputs from 300kHz, (FAST). For ACI or ACV inputs ≥300Hz, the RMS converter is ≈ DC output. The A/D takes a single measurement to determine the RMS measurement. For varying input signal levels, only an 80msec delay is require to properly settle the RMS converter's filter capacitor. The Series 3700 DMM default detector bandwidth is 300.

Auto delay

Each DMM function and range has a unique auto delay. Auto delay is applied at the start of measurement, allowing cables, Series 3700 cards, or internal DMM circuitry to settle for best measurement accuracy. For ACI and ACV, the auto delay includes both the RMS filter and AC coupling capacitor settling times.

Auto delay modes

Auto delay supports 3 modes:

- dmm.OFF or 0
- dmm.ON or 1
- dmm.AUTODELAY_ONCE or 2.

For **Off**, the zero delay is applied at the start of measurement. For **On**, every start of measurement delays the same amount of time. For **Once**, only the start of the first measurement has the delay and each measurement there after has no additional delay. When dmm.measurecount =1, ONCE acts similarly to On, applying a delay at the start of every measurement.

Autodelay and Auto range settings

The following table provides times for autodelay and auto range time for the Series 3700 DMM functions.

Function	Range and delays							
DCV	Ranges	100mV	1V	10V	100V	300V		
	Autodelay	1ms	1ms	1ms	5ms	5ms		
	Auto Range	1ms	1ms	1ms	5ms	5ms		
ACV	Ranges	100mV	1V	10V	100V	300V		
	Autodelay	1s	1s	1s	1s	1s		
	Auto Range	1s	1s	1s	1s	1s		
Freq and Period	Ranges	100mV	1V	10V	100V	300V		
	Autodelay	100ms	100ms	100ms	100ms	100ms		
	Auto Range	100ms	100ms	100ms	100ms	100ms		
DCI	Ranges	10µA	100µA	1mA	10mA	100mA	1A	3A
	Autodelay	2ms	2ms	2ms	2ms	2ms	2ms	2ms
	Auto Range	2ms	2ms	2ms	2ms	2ms	2ms	2ms

Function	Range and delays							
ACI	Ranges			1mA	10mA	100mA	1A	3A
	Autodelay			200ms	200ms	200ms	200ms	200ms
	Auto Range			300ms	300ms	300ms	300ms	300ms
Ω2 and Ω4	Ranges	1- 100Ω	1kΩ	10kΩ	100kΩ	1MΩ	10MΩ	100MΩ
	Autodelay	3ms	3ms	13ms	25ms	100ms	150ms	250ms
	Auto Range	2.5ms	2.5ms	12.5ms	25ms	100ms	150ms	250ms
Continuity DCV	Ranges		1kΩ					
	Autodelay		3ms					
	Auto Range		2.5ms					
Temp	RTDs	Autodelay 3ms and Auto Range 2.5ms.						
	T/C	Autodelay and Auto Range 1ms.						
	Thermistor	For the selected sensor type, the appropriate Ω2 delays will be applied.						

Measure count

The Series 3700 supports multi-sample measurements by using the dmm.measurecount ICL command. For a single ICL trigger, such as `print(dmm.measure())`, the DMM will take "n" measurements. This is useful in channel closures or a scanlist where multiple measurements are required per channel. With a measurecount >1 and autodelay set to **once**, measurements can be optimized for accuracy and fast throughput. For example, for a 10-channel scanlist requiring twenty 10V ACV readings per channel at detectorbandwidth = 3, the measurements can be optimized as follows:

```
dmm.func="acvolts"
dmm.range=10
dmm.detectorbandwidth=3
dmm.autodelay=dmm.AUTODELAY_ONCE
dmm.configure.set("myacv")
dmm.setconfig("4001:4010", "myacv")
scan.create("4001:4010")
scan.measurecount=20
buf=dmm.makebuffer(200)
buf.clear()
buf.appendmode=1
scan.execute(buf)
```

Low level considerations

For sensitive measurements, external considerations beyond the Series 3700 affect the accuracy. Effects not noticeable when working with higher voltages are significant in microvolt signals. The Series 3700 reads only the signal received at its input; therefore, it is important that this signal be properly transmitted from the source. The following paragraphs indicate factors that affect accuracy, including stray signal pick-up and thermal offsets.

Shielding

AC voltages that are extremely large compared with the DC signal to be measured may produce an erroneous output. Therefore, to minimize AC interference, the circuit should be shielded with the shield connected to the Series 3700 input low (particularly for low level sources). Improper shielding can cause the Series 3700 to behave in one or more of the following ways:

- Unexpected offset voltages.
- Inconsistent readings between ranges.
- Sudden shifts in reading.

To minimize pick-up, keep the voltage source and the Series 3700 away from strong AC magnetic sources. The voltage induced due to magnetic flux is proportional to the area of the loop formed by the input leads. Therefore, minimize the loop area of the input leads and connect each signal at only one point.

Thermal EMFs

Thermal EMFs (thermoelectric potentials) are generated by temperature differences between the junctions of dissimilar metals. These can be large compared to the signal that the Series 3700 can measure. Thermal EMFs can cause the following conditions:

- Instability or zero offset is much higher than expected.
- The reading is sensitive to (and responds to) temperature changes. This effect can be demonstrated by touching the circuit, by placing a heat source near the circuit, or by a regular pattern of instability (corresponding to changes in sunlight or the activation of heating and air conditioning systems).

To minimize the drift caused by thermal EMFs, use copper leads to connect the circuit to the Series 3700.

A clean, oxidized-free, copper conductor such as #10 bus wire is ideal for this application. For switching modules, use #20 AWG copper wire to make connections. The leads to the Series 3700 may be shielded or unshielded, as necessary.

Widely varying temperatures within the circuit can also create thermal EMFs. Therefore, maintain constant temperatures to minimize these thermal EMFs. A shielded enclosure around the circuit under test also helps by minimizing air currents.

The REL control can be used to null out constant offset voltages.

AC voltage offset

The Series 3700, at 5½ digits resolution, will typically display 100 counts of offset on AC volts with the input shorted. This offset is caused by the offset of the TRMS converter. This offset will not affect reading accuracy and should not be zeroed out using the REL feature. The following equation expresses how this offset (VOFFSET) is added to the signal input (V_{IN}):

$$Displayed\ reading = \sqrt{(V_{IN})^2 + (V_{OFFSET})^2}$$

Example:
Range= 1VAC, Offset = 100 counts (1.0mV), Input = 100mV RMS

$$Displayed\ reading = \sqrt{(100mV)^2 + (1.0mV)^2}$$

Therefore, the displayed reading is 0.100005V.

The offset is seen as the last digit, which is not displayed. Therefore, the offset is negligible. If REL were used to zero the display, the 100 counts of offset would be subtracted from V_{IN}, resulting in an error of 100 counts in the displayed reading.

Current measurements (DCI and ACI)

The Series 3700 can make DCI measurements from 1pA to 3A and ACI measurements from 1mA to 3A RMS.

> *WARNING*   ***To prevent electric shock, never make or break connections while power is present in the test circuit.***

NOTE	Also see crest factor information contained in *AC voltage measurements and crest factor* (on page 5-9).

Amps measurement procedure

1. Press the **OPENALL** key to open all switching channels.

2. Select the amps measurement function by pressing the **FUNC** key until "DCI" or "ACI" (as applicable) is displayed.

3. Use the **RANGE ▲ and ▼** keys to select a measurement range consistent with the expected current, or press the **AUTO** key to select autoranging (AUTO annunciator turns on).

4. Apply the current(s) to be measured.

5. If using a switching module, perform the following steps to close the desired channel:

    a)   Use the wheel to dial in the channel number.

    b)   Press the **CLOSE** key.

6. Press the **TRIG** key and observe the displayed reading. If the "Overflow" message is displayed, select a higher range until a normal reading is displayed (or press the **AUTO** key for autoranging). For manual ranging, use the lowest possible range for the best resolution.

7. To measure other switching channels, repeat steps 5 and 6.

8. When finished, press the **OPENALL** key to open all channels.

NOTE   When you have an amps-only channel closed, you cannot select a non-amps function.

NOTE   When making measurements < 1µA, to minimize 50/60Hz noise, use a twisted pair for AMP and DMM connections.

AMPS analog backplane fuse replacement

WARNING   *Make sure the instrument is disconnected from the power line and other equipment before replacing the AMPS fuse.*

CAUTION   Do not use a fuse with a higher current rating than specified or instrument damage may occur. If the instrument repeatedly blows fuses, locate and correct the cause of the trouble before replacing the fuse.

NOTE   Model 3721 card supports both AC and DC current measurements. Refer to the *Schematic* (on page 5-7) contained in the User's manual. The Model 3721 card has replaceable fuses. For replacement information, refer to *Model 3721: AMPS channels fuse replacement* (on page 9-17).

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1. Turn off the power and disconnect the power line and connections.

2. From the rear panel, gently push in the AMPS fuse holder with a flat blade screwdriver and rotate the fuse holder one-quarter turn counterclockwise.

3. Remove the fuse and replace it with the same type (3A, 250V, fast-blow, 5 × 20mm). The Keithley Instruments part number is FU-99-1.

4. Install the new fuse by reversing the procedure above.

Resistance measurements

The Series 3700 uses the constant-current method to measure resistance ranges from 1Ω to $1M\Omega$. The Series 3700 sources a constant current (I) to the resistance and measures the voltage (V). Resistance (R) is then calculated (and displayed) using the known current and measured voltage (R = V/I). For the $10M\Omega$ and $100M\Omega$ ranges, the ratiometric method is used to measure resistance.

Basic resistance measurements

The Series 3700 can make resistance measurements from $0.1\mu\Omega$ to $120M\Omega$. For resistances $>1k\Omega$, the 2-wire ($\Omega2$) method is typically used for measurements. For resistances $\leq1k\Omega$, the 4-wire ($\Omega4$) measurement method should be used to cancel the effect of test lead (and channel path) resistances.

Offset compensated ohms (OC+)

The presence of thermal EMFs (voltages) can adversely affect low-resistance measurement accuracy. To overcome these unwanted offset voltages, you can use offset-compensated ohms on the 1Ω, 10Ω, 100Ω, $1k\Omega$, and $10k\Omega$ ranges for the $\Omega4$ function.

Dry circuit testing (DRY+)

For power and low-glitch resistance measurements requiring a low open-circuit voltage (20mV), dry circuit ohms can be used on the 1Ω, 10Ω, 100Ω, $1k\Omega$, and $10k\Omega$ ranges (maximum of $2.4k\Omega$) for the $\Omega4$ function.

Connections

Analog backplane connector (rear panel)

Connections for resistance measurements are shown below.

For 2-wire resistance measurements (Ω2), connect the leads to INPUT HI and LO.

Figure 5-7: Two-wire resistance measurements
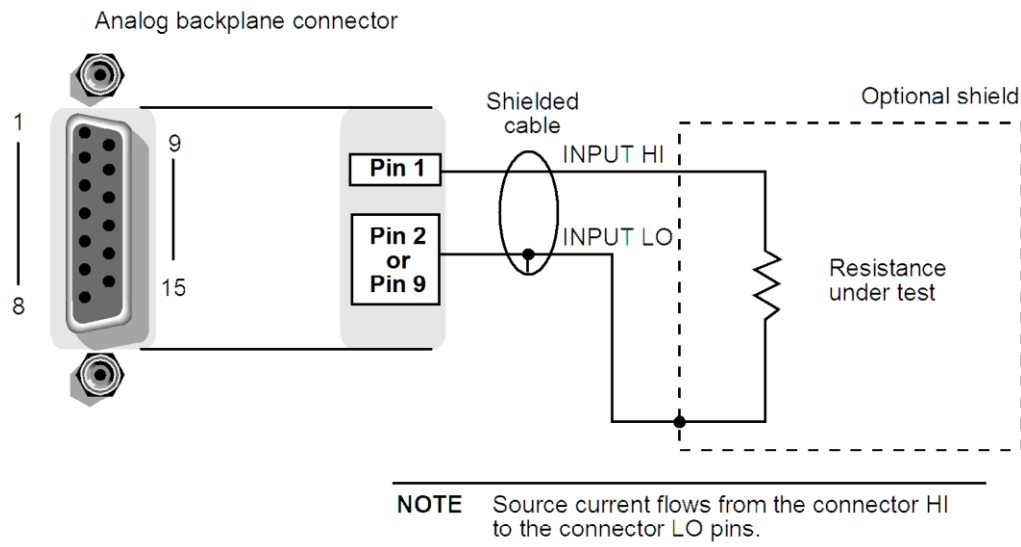
For 4-wire resistance (Ω4), connect the leads to INPUT HI and LO, and sense Ω4 HI and LO.

Figure 5-8: Four-wire resistance measurement
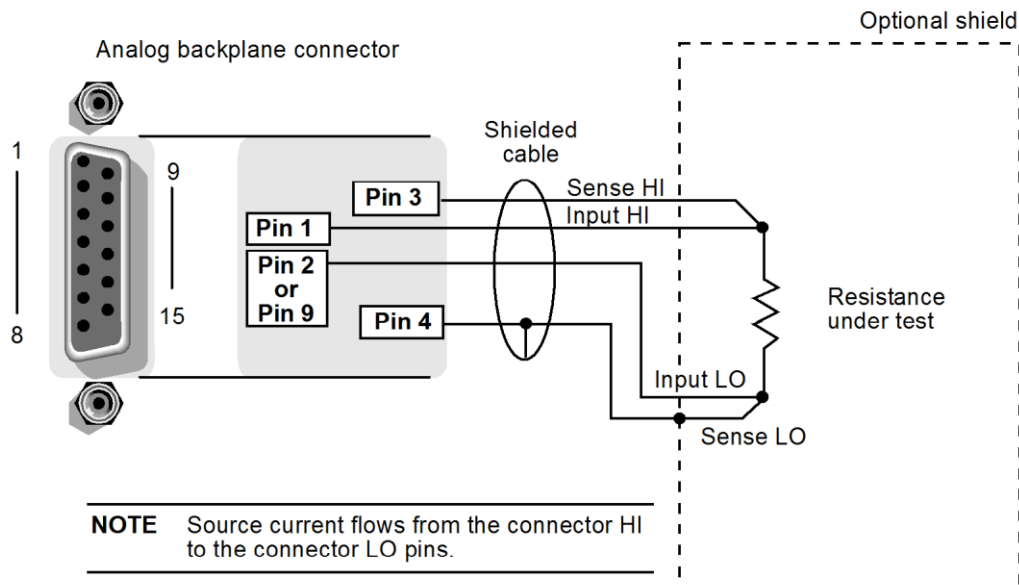
Switching module

Connections for the switching module are shown below. As shown, each of the 40 channels can be used to perform 2WΩ measurements.

Figure 5-9: Two-wire switching module resistance connection
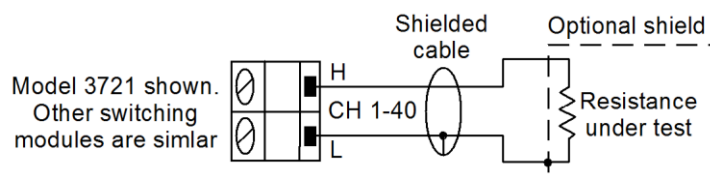
For 4WΩ measurements, a channel pair is used for each 4-wire measurement as shown. For 4WΩ connections on a 40-channel switching module, Channels 1 through 20 (which are used as the INPUT terminals) are paired to Channels 21 through 40 (which are used as the SENSE terminals). Channel 1 is paired to Channel 21, Channel 2 is paired to Channel 22, and so on.

Figure 5-10: Four-wire switching module resistance connection
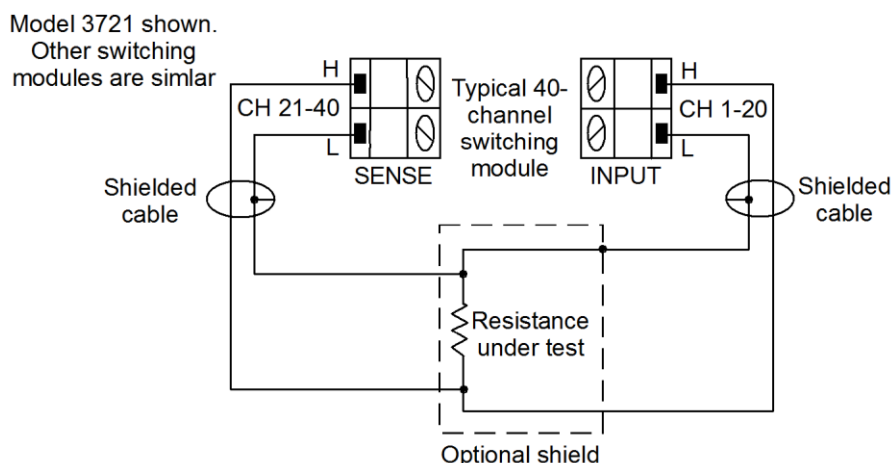
NOTE Source current flows from input high (H) to input low (L).

Shielding

To achieve a stable reading, it helps to shield resistances greater than 100kΩ. As shown in *analog backplane connector (rear panel)* (on page 5-17), place the resistance in a shielded enclosure and connect the shield to the INPUT LO terminal of the instrument electrically.

Cable leakage

For high resistance measurements in a high humidity environment, use Teflon™ insulated cables to minimize errors due to cable leakage.

Standard resistance measurements

CAUTION	Inputs: Do not apply more than 425V peak between INPUT HI and LO, or instrument damage may occur.

CAUTION	Switching cards: Do not apply more than 300V DC or 300V RMS (425V peak) for AC waveforms between any two pins, or switching module damage may occur.
	For example, if INPUT Channel 1 HI is 300VDC from Channel 1 LO, Channel 1 LO must be $\approx$ 0VDC from chassis ground.

Perform the following steps to measure resistance:

1. Press the **OPENALL** key to open all switching channels.

2. Select the ohms measurement function by pressing the **FUNC** key until 2WΩ or 4WΩ (as applicable) is displayed.

3. Use the **RANGE ▲ and ▼** keys to select a measurement range consistent with the expected resistance, or press the **AUTO** key to select autoranging (AUTO annunciator turns on).

4. Connect the resistance(s) to be measured.

5. If using a switching module, perform the following steps to close the desired channel:

    a)   Use the wheel to dial in the channel number.

    b)   Press the **CLOSE** key.

6. Press the **TRIG** key and observe the displayed reading. If the "Overflow" message is displayed, select a higher range until a normal reading is displayed (or press the **AUTO** key for autoranging). For manual ranging, use the lowest possible range for the best resolution.

7. To measure other switching channels, repeat steps 5 and 6.

8. When finished, press the **OPENALL** key to open all channels.

Offset-compensated ohms

The presence of thermal EMFs (V_{EMF}) can adversely affect low-resistance measurement accuracy. To overcome these unwanted offset voltages, you can use offset-compensated ohms (OCOMP). Offset-compensated ohms measurements can be performed on the 1Ω, 10Ω, 100Ω, 1kΩ, and 10kΩ ranges for the Ω4 function. It cannot be done on the Ω2 function.

NOTE	The various instrument operations, including OCOMP, are performed on the input signal in a sequential manner.

For a normal resistance measurement, the Series 3700 sources a current (I) and measures the voltage (V). The resistance (R) is then calculated (R=V/I) and the reading is displayed.

For offset-compensated ohms, two measurements are performed: one normal resistance measurement, and one using the lowest current source setting.

The offset-compensated ohms reading is then calculated as follows:

Offset-compensated ohms reading = ΔV/ΔI

where:

Δ**V** = V2 - V1

Δ**I** = I2 - I1

V1 is the voltage measurement with the current source at its normal level.

V2 is the voltage measurement using the lowest current source setting.

The above 2-point measurement process and reading calculation eliminates the resistance contributed by the presence of V_{EMF}.

Enabling/disabling offset-compensated ohms

Offset-compensated ohms is an attribute set on the 4-wire ohms (4WΩ) function. To enable or disable it from the front panel:

NOTE	To enable offset-compensated ohms, the Series 3700 must be in 4WΩ mode (see figure).

Figure 5-11: Enabling offset-compensated ohms
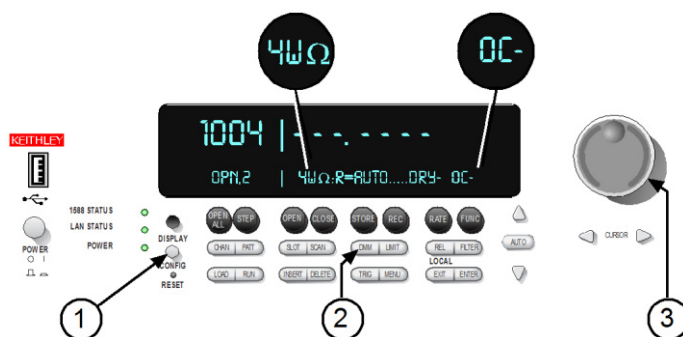
NOTE	The Series 3700 is in four-wire ohm mode when the 4WΩ is displayed. Offset compensation is active when the OC+ is displayed (OC- is shown in the above figure).

1. Press the **CONFIG** key (1).

2. Press the **DMM** key (2).

3. Turn the wheel (3) to scroll to the "OFFSETCOMP" menu item and press the wheel to select.

4. Turn the wheel to select the ON/OFF settings for Offset Compensation as desired and press the wheel to set.

5. Press the **EXIT** key to leave the menu.

Figure 5-12: Four-wire Ohm ATTR MENU: OFFSETCOMP

NOTE When enabled, the Offset Compensation annunciator is on (OC+).

Performing offset-compensated ohms measurements

Offset-compensated ohms can only be performed on the $\Omega 4$ function using the 1Ω, 10Ω, 100Ω, 1kΩ, or 10kΩ ranges. Make sure you use 4-wire connections to the DUT as detailed in *analog backplane connector (rear panel)* (on page 5-17) or if using a module for switching, the connections specific to the module.

1. Press the **OPENALL** key to open all switching channels.

2. If not already on, enable offset compensated ohms (OC+ annunciator is lit). See *Enabling/disabling offset-compensated ohms* (on page 5-21).

3. Use the **RANGE ▲ and ▼** keys to select the 1Ω, 10Ω, 100Ω, 1kΩ, or 10kΩ range, or press the **AUTO** key to enable auto range. If using auto range, offset-compensated ohms measurements will not be performed if the instrument goes to the 100kΩ (or higher) range.

4. Perform steps 4 through 8 of the "*Standard resistance measurements* (on page 5-20)" procedure.

NOTE   If an invalid offset-compensated ohms range is selected (100kΩ through 100MΩ ranges), normal ohms measurements will be performed instead.

With dry circuit ohms enabled, the 10kΩ range (measuring a maximum resistance of 2.4kΩ) is the highest offset-compensated ohms range that can be selected.

For buffer recall, there is no way to distinguish between a normal ohms reading and an offset-compensated ohms reading. The OC annunciator (- or +) has no significance for recalled resistance readings that are displayed.

With offset-compensated ohms enabled, it will be "remembered" by the 4WΩ function after you change measurement functions (i.e., DCV). When 4WΩ is again selected, offset-compensated ohms will be enabled.

dmm.offsetcompensation is a common ICL command and is shared with fourwireohms, dryciruit, threertd and fourrtd. To activate dmm.offsetcompensation, select the available function desired, set `dmm.offsetcompensation = dmm.ON` or `OFF`. The function will retain the dmm.offsetcompensation state even if the function is changed.

Dry circuit ohms (DRY+)

Standard resistance measurements have open-circuit voltage levels from 6.4V to 14.7V, depending on the selected range. Dry circuit ohms limits open-circuit voltage to between 20mV and 27mV. This allows you to perform resistance measurements that require low open-circuit voltage. Dry circuit ohms can be used on the 1Ω, 10Ω, 100Ω, 1kΩ, and 10kΩ ranges (maximum resistance of 2.4kΩ) for the 4WΩ function only. Also, offset-compensated ohms (OC+) can be used with dry circuit ohms to cancel the effect of thermal EMFs.

Measuring contact resistance (oxide film build-up)

The ideal resistance between switch connectors, or relay contacts is 0Ω. However, an oxide film may be present on the switch or relay contacts. This oxide film could add resistance on the order of several hundred milli-Ωs. Also, this oxide film changes the contact resistance over time and with changes in the environmental conditions (such as temperature and humidity).

Typically, the Ω4 function of the Series 3700 or a standard DMM is used to measure low resistance. However, if standard resistance measurements are performed, the relatively high open-circuit voltage may puncture the oxide film, and render the test meaningless.

Dry circuit ohms limits voltage to 20mV to minimize any physical and electrical changes in a measured contact junction. This low open-circuit voltage will not puncture the film, and will therefore provide a resistance measurement that includes the resistance of the oxide film.

Oxide films may also build up in connections on a semiconductor wafer. In order to accurately measure the resistance introduced by the oxide film, dry circuit ohms should be used to prevent oxide film puncture.

Measuring resistance of voltage-sensitive devices

Dry circuit ohms should be used for any device that could be damaged by high open circuit voltage. If you are not sure the slightly degraded accuracy is a consideration, it is good practice to use dry circuit ohms to measure low resistance.

Enabling/disabling dry circuit ohms

Dry circuit ohms is an attribute set on the 4-wire ohms (4WΩ) function.

NOTE   When dry circuit ohms is enabled, offset-compensated ohms is automatically enabled (OC+ annunciator). If you do not wish to use offset-compensated ohms, after setting dry circuit ohms, disable offset-compensated ohms using the information in *Enabling/disabling offset-compensated ohms* (see "Enabling/disabling offset-compensated ohms" on page 5-21).

NOTE   If the Series 3700 is in remote mode (controlled over the bus) press the **EXIT** key to place it in local mode to control the unit using the front panel keys. The front panel keys are not available on all models.

NOTE   To enable offset-compensated ohms, the Series 3700 must be in 4WΩ mode.

To enable/disable dry circuit ohms from the front panel:

Figure 5-13: Enabling dry-circuit ohms
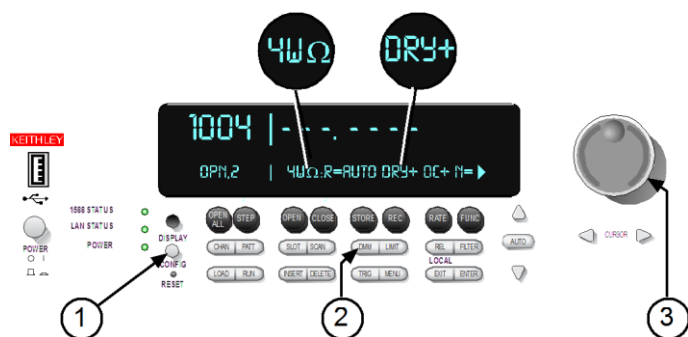
NOTE   The Series 3700 is in four-wire ohm mode when the 4WΩ is displayed. Dry Circuit is active when the DRY+ is displayed (see the above figure).

1. Press the **CONFIG** key (1).

2. Press the **DMM** key (2).

3. Turn the wheel (3) to scroll to the "DRYCIRCUIT" menu item.

4. Press the wheel (3) to display ON/OFF settings for dry circuit ohms.

5. Select "ON" or "OFF" and press the wheel (3) again.

6. Press the **EXIT** key to leave the menu.

Figure 5-14: Four-wire Ohm ATTR MENU: DRYCIRCUIT

NOTE	When enabled, the dry circuit ohms annunciator is on (DRY+).

Performing dry circuit ohms measurements

Dry circuit ohms can only be performed on the 4WΩ function using the 1Ω, 10Ω, 100Ω, 1kΩ, or 10kΩ ranges (maximum resistance of 2.4kΩ). Make sure you use 4-wire connections to the DUT as detailed in *Analog backplane connector (rear panel)* (on page 5-17) or specific to the module used for switching.

NOTE	Do not make connections to the device under test (DUT) until after dry circuit ohms is enabled in step 2.

1. Press the **OPENALL** key to open all switching channels.

2. If not already on, enable dry circuit ohms (see *Enabling/disabling dry circuit ohms* (on page 5-23)).

    - Dry circuit ohms enabled: DRY+

    - Dry circuit ohms disabled: DRY-

NOTE	When dry circuit measurement is enabled (DRY+), offset-compensated ohms will also enable (OC+ annunciator turns on). If you do not wish to use offset-compensated ohms, disable it (see *Enabling/disabling offset-compensated ohms* (on page 5-21)).

3. Make 4-wire connections to the DUT. See 4-wire connection information contained in *analog backplane connector (rear panel)* (on page 5-17) and *Switching module* (on page 5-19).

4. Use the **RANGE ▲ and ▼** keys to select the 1Ω, 10Ω, 100Ω, 1kΩ, or 10kΩ range, or press the **AUTO** key to enable auto range.

5. If using a switching module, perform the following steps to close the desired channel:

    a) Use the wheel to dial in the channel number.

    b) Press the **CLOSE** key.

6. Press the **TRIG** key and observe the displayed reading. If the "Overflow" message is displayed, select a higher range until a normal reading is displayed (or press the **AUTO** key for autoranging). For manual ranging, use the lowest possible range for the best resolution.

7. To measure other switching channels, repeat steps 5 and 6.

8. When finished, press the **OPENALL** key to open all channels.

NOTE	The states (on or off) of dry circuit ohms and offset-compensated ohms are "remembered" by the 4WΩ function after you select a different measurement function (i.e., DCV). When 4WΩ is again selected, the previous states of dry circuit ohms and offset-compensated ohms will be restored. The accuracy specifications for dry circuit ohms is for offset-compensated ohms and line synchronization enabled.

Dry circuit ohms measurement considerations

Dry circuit ohms uses a constant current source with voltage monitoring that is used to clamp the current source voltage. The current source will remain constant as long as the monitoring voltage is <20mV. When the voltage exceeds 20mV, the current source shunts current internal to the DMM until 20mV is maintained at the DUT.

The voltage is measured at the SENSE HI terminal. There is a secondary voltage monitoring circuit on INPUT HI. This is needed if SENSE HI or INPUT HI have different voltages. This could occur if measuring 4-wire resistance and INPUT HI becomes an open circuit. In this condition, SENSE HI would indicate no voltage and the secondary voltage monitor would clamp the current source to <20mV for 10Ω to $10k\Omega$ at less than $27mV/\Omega$, $99k\Omega||$ < $1.0\mu F$ for the 1Ω to 100Ω ranges, and $10M\Omega \, ||$< $0.015\mu F$ for the $1k\Omega$ to $10k\Omega$ ranges.

When using dry circuit ohms, the DUT is shunted by $100k\Omega$ and $0.9\mu F$. This allows the current source to have minimal overshoot voltage under transient conditions. When used with a switching system, the overshoot is <40mV in $20\mu sec$.

Measurement methods

The Series 3700 uses two methods to measure resistance:

- **Constant-current source method** (1Ω through $1M\Omega$ ranges): Sources a constant-current to the DUT. Voltage is measured by the Series 3700 and resistance is then calculated (R = V/I).
- **Ratiometric method** ($10M\Omega$ and $100M\Omega$ ranges): Test current is generated by a 6.4V reference through a $10M\Omega$ reference resistor.

Constant-current source method

For the 1Ω to $1M\Omega$ ranges, the Series 3700 uses the constant-current method to measure resistance. The Series 3700 sources a constant current (I_{SOUR}) to the device under test (DUT) and measures the voltage (V_{MEAS}). Resistance (R_{DUT}) is then calculated (and displayed) using the known current and measured voltage ($R_{DUT} = V_{MEAS}/I_{SOUR}$).

The constant-current method is shown below. The test current sourced to the DUT depends on the selected measurement range. For example, for the 100Ω range the test current is 1mA. Since the voltmeter of the Series 3700 has very high input impedance (>$10G\Omega$), virtually all the test current (1mA) flows through the DUT. For DUT $\leq 1k\Omega$, 4-wire ohms measurements should be used as shown. Since, the voltage is measured at the DUT, voltage drop in the test leads is eliminated (this voltage could be significant when measuring low-ohm DUT).

The two-wire constant-current method is shown below.

Figure 5-15: Two-wire constant-current source method
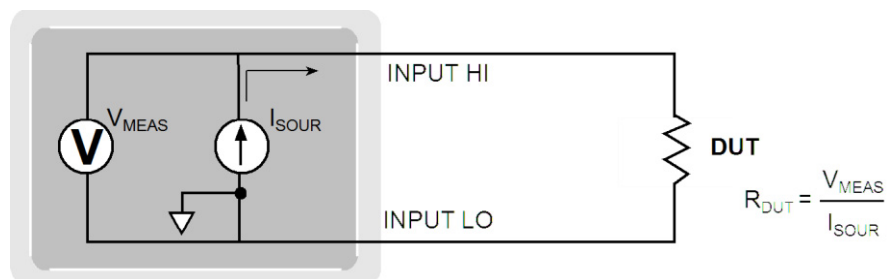
The four-wire constant-current method is shown below.

Figure 5-16: Four-wire constant-current source method
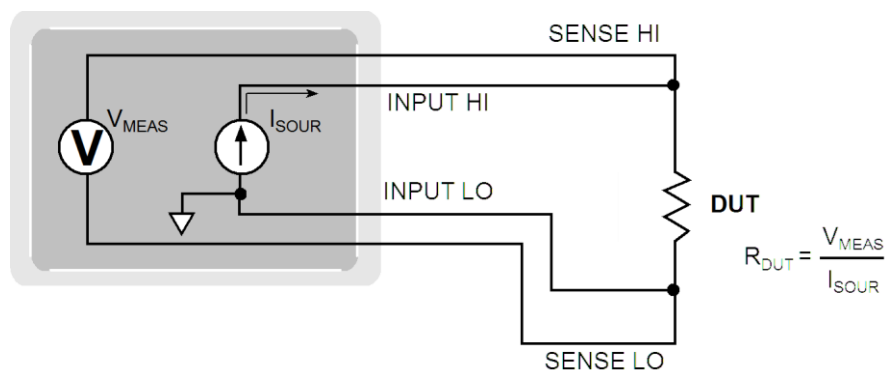
Ratiometric method

For the 10MΩ and 100MΩ ranges, the ratiometric method is used to measure resistance. Test current for this method is generated by a 6.4V voltage source through a 10MΩ reference resistance (R_{REF}), as shown.

Basic circuit theory dictates that I_{REF} is equal to the I_{DUT}. Since the voltmeter of the Series 3700 (V_{MEAS}) has very high input impedance (>10GΩ), current through the voltmeter branch is insignificant and can be discounted. Therefore, as shown in the following Figures Equation 1, I_{REF} = I_{DUT}

Figure 5-17: Two-wire ratiometric method

Equation 1:

$$I_{REF} = I_{DUT}$$

$$\frac{V_{SOUR} - V_{MEAS}}{R_{REF}} = \frac{V_{MEAS}}{R_{DUT}}$$

$$R_{DUT} = \frac{V_{MEAS}}{V_{SOUR} - V_{MEAS}} \times R_{REF}$$

Equation 2:

For $R_{DUT} \approx 0\Omega$

$$I_{REF} = \frac{V_{SOUR}}{R_{REF}}$$

R_{DUT} Example

For $R_{DUT} \approx 10M\Omega$

$$I_{REF} = \frac{V_{SOUR}}{R_{REF} + R_{DUT}}$$
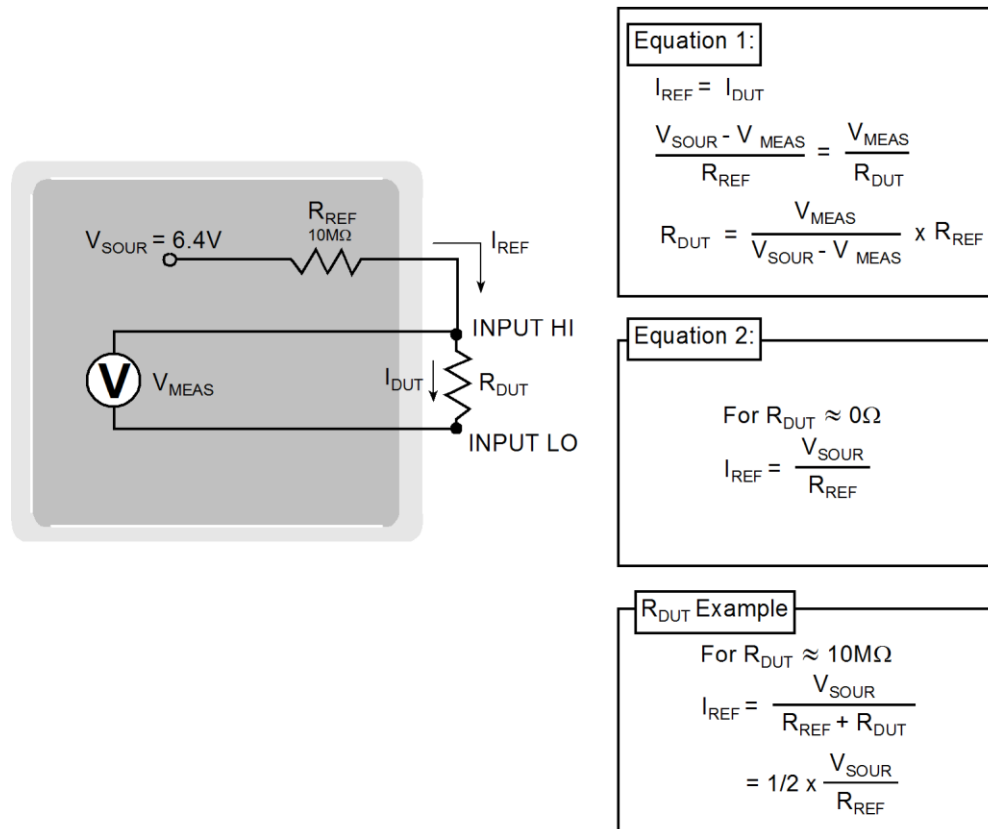
$$= 1/2 \times \frac{V_{SOUR}}{R_{REF}}$$

Since I = V/R, Equation 1 is modified using the V/R equivalents in place of I_{REF} and I_{DUT}. Therefore:

$I_{SOUR} = (V_{MEAS} / R_{REF}) + (V_{MEAS} / R_{DUT})$

Keep in mind that V_{MEAS} is measured by the Series 3700. With V_{MEAS}, I_{SOUR}, R_{REF} known, the Series 3700 calculates the resistance of the DUT and displays the result. R_{REF} is learned during calibration and V_{SOUR} is routinely self-calibrated when the dmm.autozero attribute is enabled (`dmm.autozero = dmm.ON`).

As shown, the 4WΩ function can also be used to measure ohms for the 10MΩ and 100MΩ ranges. To minimize the effects of charge injection when dmm-autozero is enabled, the 10MΩ to 100MΩ is actually a 3-wire ohm measurement. SENSE HI is not used. SENSE HI is connected to the DUT but is not required (it can be left open). The measurement method is similar to the ratiometric method for 2WΩ, but it performs an extra voltage measurement (V_{LEAD}) to compensate for voltage drop in the input test leads.

Keep in mind that V_{MEAS} includes the voltage drops of the input test leads (Input HI and Input LO). Therefore, the actual voltage drop across the DUT is V_{MEAS} minus the two voltage drops in the test leads. Since matched inputs are used, the voltage drop is 2 x V_{LEAD}. Therefore:

$V_{DUT} = V_{MEAS} - 2(V_{LEAD})$.

Figure 5-18: Four-wire ratiometric method
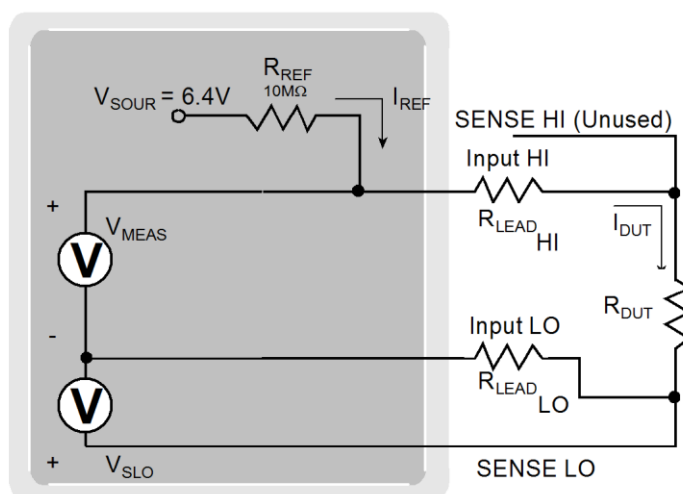
Open lead detection

The Series 3700 has four methods to detect open lead conditions:

- ISOUR open voltage
- VMEAS open voltage
- Calculated measurement
- dmm.opendetector

The following figures contains open lead detection schematics for various measurements.

Figure 5-19: Simplified Dry-Circuit open lead detection schematic
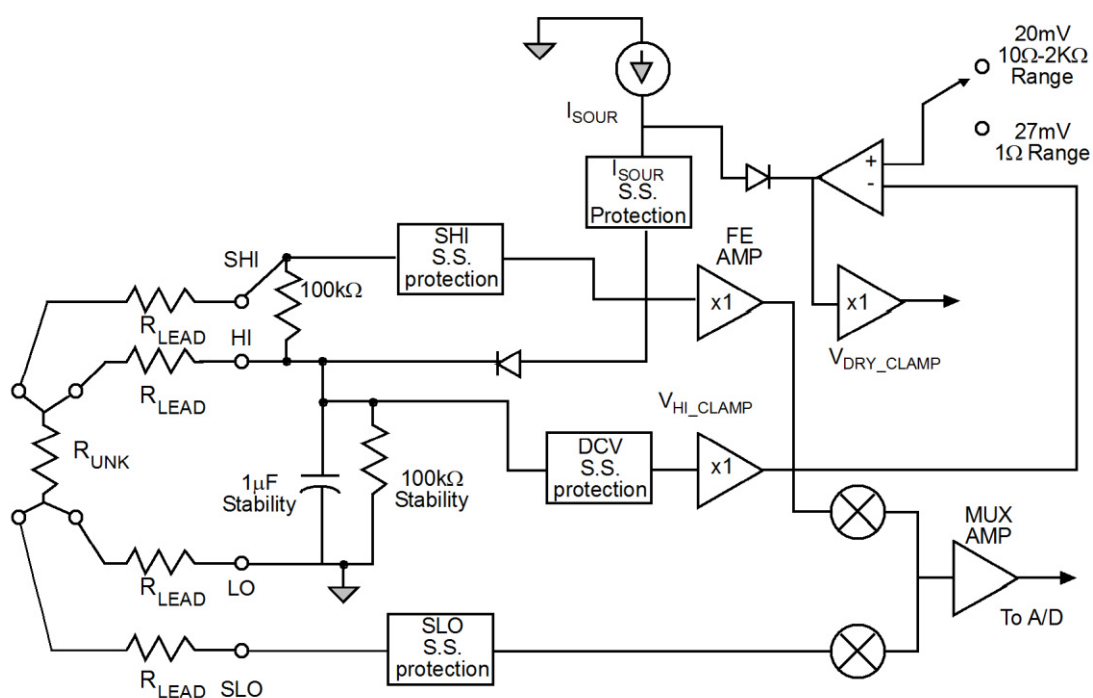
Figure 5-20: Simplified normal four-wire open lead detection schematic
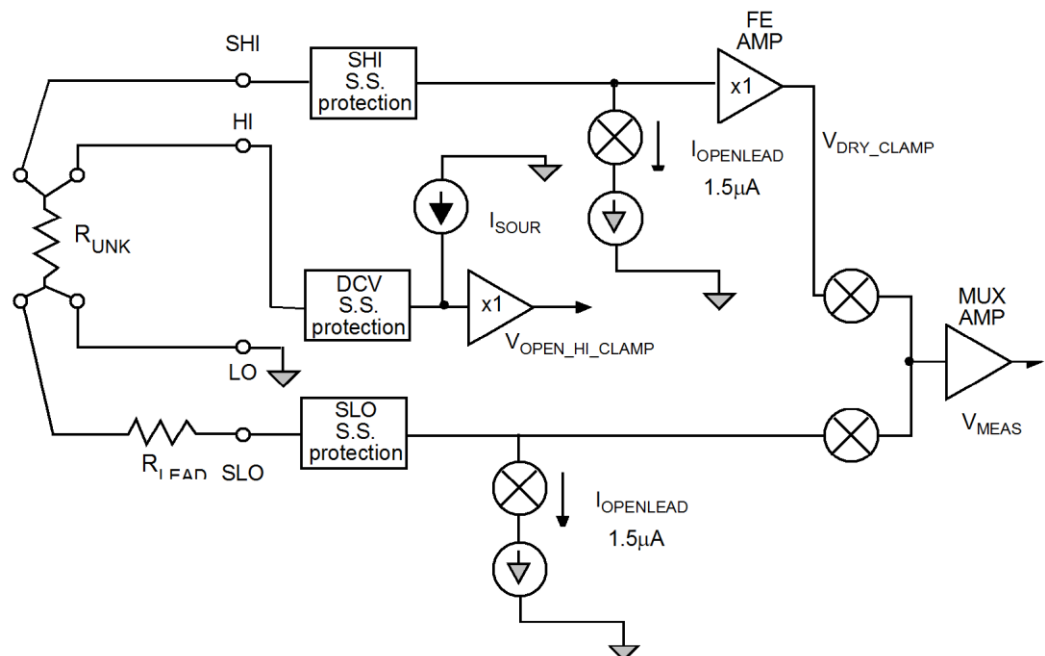
ISOUR open voltage

1Ω through $1M\Omega$ ranges: A hardware detector is used to detect an open input lead. The hardware detector uses a comparator circuit to monitor the voltage on the ohm I_{SOUR} $V_{OPEN-HI-LEAD}$ terminal.

- For the lower ohms ranges (1Ω, 10Ω, and $10k\Omega$), open circuit voltage on the ohm I_{SOUR} $V_{OPEN-HI-LEAD}$ terminal is >7.1V.

- For the higher ohms ranges ($100k\Omega$ through $1M\Omega$), open circuit voltage on the ohm I_{SOUR} $V_{OPEN-HI-LEAD}$ terminal is >12.8V.

When an input lead (HI or LO) is open, as shown, voltage rises to the open-circuit level, then the A/D will abort in <100μsec and the "Overflow" message is displayed.

VMEAS open voltage

If either Input Sense HI or Sense LO V_{MEAS} is outside the enclosed table voltages, the A/D will abort in <100μsec and return an overflow reading.

Range	V_{MEAS} SHI or SLO High Limit Open Lead Detection	V_{MEAS} SHI or SLO Low Limit Open Lead Detection
1Ω-100Ω	> 128mV	< -10mV
$1k\Omega$-$100k\Omega$	> 1.28V	< -100mV
$1M\Omega$	> 12.8V	< -1.0V

Calculated measurement open voltage

A calculated measurement, which exceed 120% of the range, will return an overflow reading.

dmm.opendetector open voltage

With dmm.opendetector = dmm.ON, a separate -1.5 A $I_{OPENLEAD}$ SHI and a separate SLO current source, will pulse on and off before the start of each measurement while I_{SOUR} remains enabled. The A/D will monitor SHI for 2msec then switch to SLO for an additional 2msec. During either phase, if the input voltage exceeds the above table, the A/D will abort in <100μsec and return an overflow reading. If there are no open leads detected during the $I_{OPENLEAD}$ phase, the $I_{OPENLEAD}$ is disabled and standard 4-wire is enabled.

V_{MEAS} with open input:

If Sense HI is disconnected, V_{MEAS} will droop less than -1V, causing an A/D overflow.

V_{MEAS} with valid connections:

For valid connections, INPUT Sense HI, V_{MEAS}, will dip during the 4msec $I_{OPENLEAD}$ phase. The amount of the voltage dip is the sum of $I_{OPENLEAD}$ and the range I_{SOUR} and R_{DUT} load. For example, if measuring a 100kΩ on the 100kΩ range, the **V_{MEAS}** across the 100kΩ will be 0.85V (10 A - 1.5μA) x 100KΩ during $I_{OPENLEAD}$ and 1V during measurement phase.

The tables below notes timing with dmm.opendetector = dmm.ON:

Range	SHI and SLO IOPENLEAD Phase (msec)1	SHI Settle Time (msec)	Line Freq (Hz)	SHI Measurement Time (msec)	
				min	max
1-10kΩ	4.0	0.5	60	0.0083	250
			50	0.010	240
100kΩ	4.0	2.0	60	0.0083	250
			50	0.010	240
1MΩ	4.0	30.0	60	0.0083	250
			50	0.010	240
10MΩ-100MΩ	4.0	5.01	60	0.0083	250

Range	Internal DMM Comm. (msec)	SLO Settle Time (msec)	SLO Measurement Time (msec)		Internal DMM Comm.
1-10kΩ	0.06	0.5	min	max	0.06
			0.0083	250	
			0.010	240	
100kΩ	0.06	1.0	0.0083	250	0.06
			0.010	240	
1MΩ	0.06	1.0	0.0083	250	0.06
			0.010	240	
10MΩ-100MΩ	0.06	1.0	0.0083	250	0.06
			0.010	240	

1. For 10MΩ and 100MΩ, $V_{measurement}$ is made on Input HI. Input Sense HI is unused.

2. Default condition for 4-wire is dmm.opendetector=dmm.ON.

3. For dmm.drycircuit=dmm.ON, $I_{OPENLEAD}$ is disable, but print(dmm.opendetector) returns 1.0.

4. Additional cable and 3700 card capacitance can increase settle times, resulting additional measurement uncertainty. Keithley Instruments recommend the use of Teflon or other low-dielectric absorption wire insulation for these measurements.

Four-wire dry-circuit open lead detection

The Series 3700 dry-circuit resistance measurement circuitry was designed for low power, low glitch, and low open voltage applications such as GMRR head testing and air bag / squib test that require low energy resistance sourcing. For this reason, dmm.opendetecor = dmm.ON is disabled when dmm.drycircuit = dmm.ON. The $I_{OPENLEAD}$ current pulse would exceed the dry-circuit voltage application.

The follow schematic provides a simplified view of the Series 3700 four-wire dry-circuit open lead detection.

Figure 5-21: Simplified Dry-Circuit open V-clamp feedback loop schematic
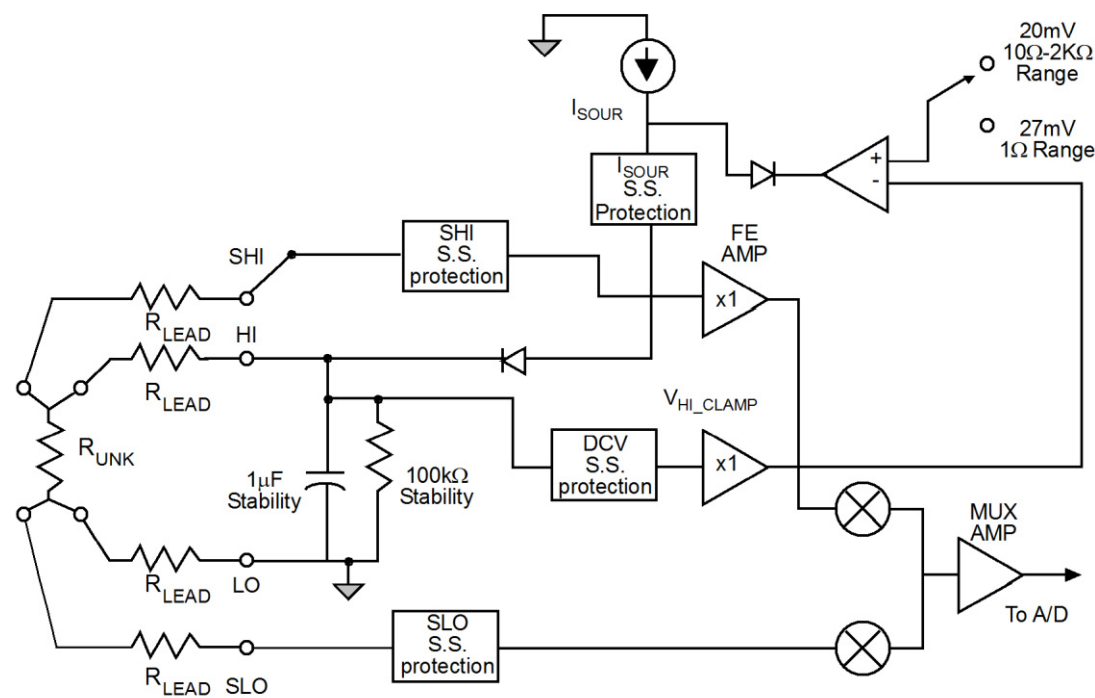
Dry-clamp open lead detector (dry-circuit)

A hardware detector is used to detect an open input lead. The hardware detector uses a internal circuit to monitor the voltage on the $V_{DRY-CLAMP}$ terminal. The circuit will abort the A/D in < 100μsec and return an overflow reading if the voltage is greater than 1V.

VMEAS open voltage (dry-circuit)

If either Input Sense HI or Sense LO V_{MEAS} is outside the enclosed table voltages, the A/D will abort in <100μsec and return an overflow reading.

Range	V_{MEAS} SHI or SLO High Limit Open Lead Detection	V_{MEAS} SHI or SLO Low Limit Open Lead Detection
1Ω	> 27mV	< -10mV
10Ω-2kΩ	> 20mV	< -10mV

Calculated measurement open voltage (dry-circuit)

A calculated measurement, which exceed 120% of the range, will return an overflow reading.

NOTE	1. INPUT Sense HI is internally connector to INPUT HI. The connection allows proper open circuit voltage, even with Sense HI disconnected. With INPUT Sense HI disconnected, and the other inputs properly connected, the measurement will read the V_{DUT} and $R_{LEADVOLTAGE}$ drop.
	2. For dmm.drycircuit = dmm.ON and dmm.opendetector = dmm.ON, IOPENLEAD will be disabled, but a print(dmm.opendetector) will still return 1.0.

Temperature measurements

The Series 3700 can measure temperature using various thermoelectric transducers including: thermocouples, thermistors, and 3 or 4-wire resistance temperature detectors (RTDs). When deciding which type to use, keep in mind that the thermocouple is the most versatile and useful for significant distances between the sensor and the instrument, the thermistor is the most sensitive, the 4-wire RTD is the most stable, and the 3-wire RTD minimizes the number of conductors per sensor (3).

Thermocouples

For thermocouples, temperature measurement range depends on which type of thermocouple is being used. Thermocouples that are supported include types J, K, N, T, E, R, S, and B.

Type	Range	Resolution
J	-200°C to +760°C	0.001°C
K	-200°C to +1372°C	0.001°C
N	-200°C to +1300°C	0.001°C
T	-200°C to +400°C	0.001°C
E	-150°C to +1000°C	0.001°C
R	0°C to +1768°C	0.1°C
S	0°C to +1786°C	0.1°C
B	+350°C to +1820°C	0.1°C

When two wires made up of dissimilar metals are joined together, a voltage is generated. The generated voltage is a function of temperature. As temperature changes, the voltage changes. The thermocouple voltage equates to a temperature reading. This is the basic operation principle of the thermocouple.

When you connect a thermocouple directly to the input of the Series 3700, at least one of those connections will be a junction made up of two dissimilar metals. Hence, another voltage is introduced and is algebraically added to the thermocouple voltage. The result will be an erroneous temperature measurement.

To cancel the affects of the unwanted thermal voltage, the thermocouple circuit requires a reference junction that is at a known temperature.

Reference junctions

A reference junction is the cold junction in a thermocouple circuit that is held at a stable, known temperature. The cold junction is where dissimilar wire connections must be made. As long as the temperature of the cold junction is known, the Series 3700 can factor in the reference temperature to calculate the actual temperature reading at the thermocouple.

The standard reference temperature is the ice point (0°C). The ice point can be precisely controlled, and the National Institute of Standards and Technology (NIST) uses it as the fundamental reference for its voltage-to-temperature conversion tables. However, other known temperatures can be used.

There are two ways for the Series 3700 to acquire the cold junction temperature. It can measure the cold junction using a thermistor or 4-wire RTD, or the known temperature value can be entered by the user.

There are two reference junction types supported by the Series 3700:

- Simulated reference junction
- Internal reference junction

These reference junctions are explained in the following paragraphs.

Simulated reference junction

An example of a simulated reference junction is an ice bath as shown in the paragraph titled *Thermocouple connections* (on page 5-39). The copper wire to thermocouple wire connections are immersed (but electrically isolated) in the ice bath, and the user enters the 0°C simulated reference temperature into the Series 3700. The simulated reference temperature for the Series 3700 can be set from 0° to 65°C.

The Series 3700 measures the input voltage and factors in the simulated reference temperature to calculate the temperature reading at the thermocouple.

NOTE	The most accurate temperature measurements are achieved by using a simulated reference junction using an ice point reference.

Internal reference junction

"Internal" implies that a temperature transducer(s) is used to measure the cold junction. For specific switching modules, the cold junction can be the switching module's screw terminals with voltage temperature sensors strategically placed to measure the temperature of the cold junction (see *Thermocouple connections* (on page 5-39)).

The Series 3700 measures the temperature of the cold junction (screw terminals), measures the input voltage, and then calculates the temperature reading at the thermocouple.

To help maintain stability and accuracy over time and changes in temperature, the Series 3700 periodically measures internal voltages corresponding to offsets (zero) and amplifier gains. For thermocouple temperature measurements using the internal reference junction, the internal temperature is also measured. These measurements are used in the algorithm to calculate the reading of the input signal. This process is known as autozeroing. Note that internal temperature references are collected regardless of whether or not autozero is enabled.

Open thermocouple detection

Long lengths of thermocouple wire can have a large amount of capacitance that is seen at the input of the DMM. If an intermittent open occurs in the thermocouple circuit, the capacitance can cause an erroneous on-scale reading. The Series 3700 has an open thermocouple detection circuit. When enabled, a 100μA pulse of current is applied to the thermocouple before the start of each temperature measurement.

NOTE	Default condition is dmm.opendetector = dmm.ON.

The Series 3700 open thermocouple detection works in similar fashion to the open lead detection. Refer to *Effects of open inputs on ohms readings* (see "Open lead detection" on page 5-30). The open thermocouple detection performs as follows:

- VMEAS open voltage: If Input HI V_{MEAS} is outside ±120mV, the A/D will abort in <100μsec and return an overflow reading.

- A calculated measurement, outside of the ranges contained in the following table, will cause the "Overflow" message to be displayed.

Type	Range
J	-200°C to +760°C
K	-200°C to +1372°C
N	-200°C to +1300°C
T	-200°C to +400°C
E	-150°C to +1000°C
R	0°C to +1768°C
S	0°C to +1786°C
B	+350°C to +1820°C

- If during a measurement cycle, with dmm.opendetector = dmm.ON, the ohm's function 100μA I_{SOUR} is pulsed on and off before the start of each measurement. The A/D will monitor V_{MEAS} for 0.8msec. During the $I_{ONPHASE}$, if the resistance >1.15kΩ is detected, or the input voltage is greater than 120mV, the A/D will abort in <100μsec and return an overflow reading. If <1.15kΩ is detected and the input voltage is in the range of ±120mV, the open lead detection current is turned off and a normal thermocouple temperature measurement is performed (see *Thermocouple connections* (on page 5-39)).

- I_{SOUR} open voltage with dmm.opendetector. A hardware detector is used to continuously detect for open input lead. The hardware detector uses a comparator circuit to monitor the voltage on the ohm I_{SOUR} $V_{OPEN-HI-LEAD}$ terminal. If during a measurement cycle, the input voltage on I_{SOUR} $V_{OPEN-HI-LEAD}$ terminal is greater than 7.1V, the A/D will abort in <100μsec and return an overflow reading. The following table notes timing with dmm.opendetector = dmm.ON.

The thermocouple open detection times are listed in the following table.

Ion Source Settle (msec)	IOPENL EAD Measure (msec)	Phase Internal DMM Comm. (msec)	Ioff Source Settle (msec)	Line Freq (Hz)	T/C Measurement Time (msec)		Internal DMM Comm. (msec)
					min	max	
1.0	0.8	0.4	1.0	60	0.0083	250	0.06
				50	0.010	240	

1. Default condition is `dmm.opendetector=dmm.ON` or 1.

2. For `dmm.transducer=dmm.TEMP_THERMISTOR`, `dmm.TEMP_THREERTD`, and `dmm.TEMP_FOURRTD`, $I_{OPENLEAD}$ phase is disabled, but `print(dmm.opendetector)` returns 1.0.

3. dmm.opendetector is a common ICL command, shared with fourwireohms. To enable or disable dmm.opendetector for either function, the appropriate function must be selected before applying the new dmm.opendetector state. For example, to disable thermocouple open detection, send `dmm.func="temperature"` then `dmm.opendetector=0`.

The following figure provides a schematic representation of the Series 3700 open thermocouple detection.

Figure 5-22: Simplified T/C open lead detection schematic
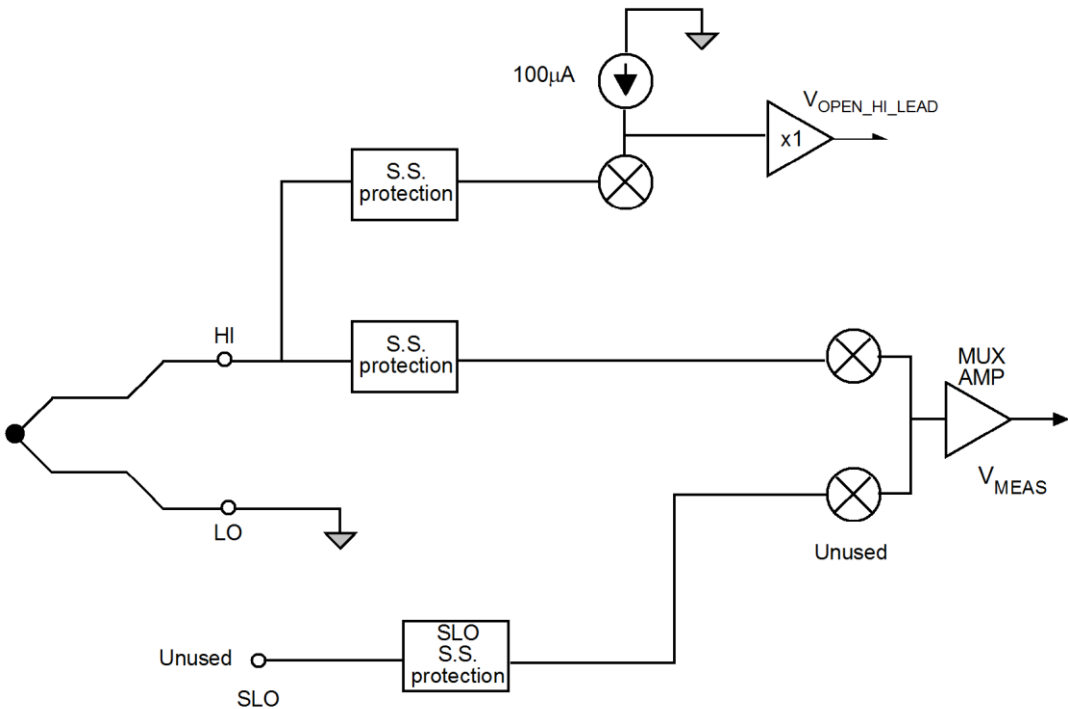
Thermocouple connections

Connections for thermocouples are shown below. Thermocouples are color coded to identify the positive (+) and negative (-) leads (see the table). Note that the negative (-) lead for U.S. type T/Cs is red.

T/C type		Positive (+)	Negative (-)		T/C type		Positive (+)	Negative (-)
J	U.S.	White	Red		E	U.S.	Purple	Red
	British	Yellow	Blue			British	Brown	Blue
	DIN	Red	Blue			DIN	Red	Black
	Japanese	Red	White			Japanese	Red	White
	French	Yellow	Black			French	Yellow	Blue
K	U.S.	Yellow	Red		R	U.S.	Black	Red
	British	Brown	Blue			British	White	Blue
	DIN	Red	Green			DIN	Red	White
	Japanese	Red	White			Japanese	Red	White
	French	Yellow	Purple			French	Yellow	Green
N	U.S.	Orange	Red		S	U.S.	Black	Red
	British	--	--			British	White	Blue
	DIN	--	--			DIN	Red	White
	Japanese	--	--			Japanese	Red	White
	French	--	--			French	Yellow	Green
T	U.S.	Blue	Red		B	U.S.	Gray	Red
	British	White	Blue			British	--	--
	DIN	Red	Brown			DIN	Red	Gray
	Japanese	Red	White			Japanese	Red	Gray
	French	Yellow	Blue			French	--	--

When using the Series 3700 analog backplane connector, use a simulated reference junction for thermocouple temperature measurements. An ice bath, as shown below, serves as an excellent cold junction since it is relatively easy to hold the temperature to 0°C. Notice that copper wires are used to connect the thermocouple to the Series 3700 input.

Figure 5-23: Simulated reference junction
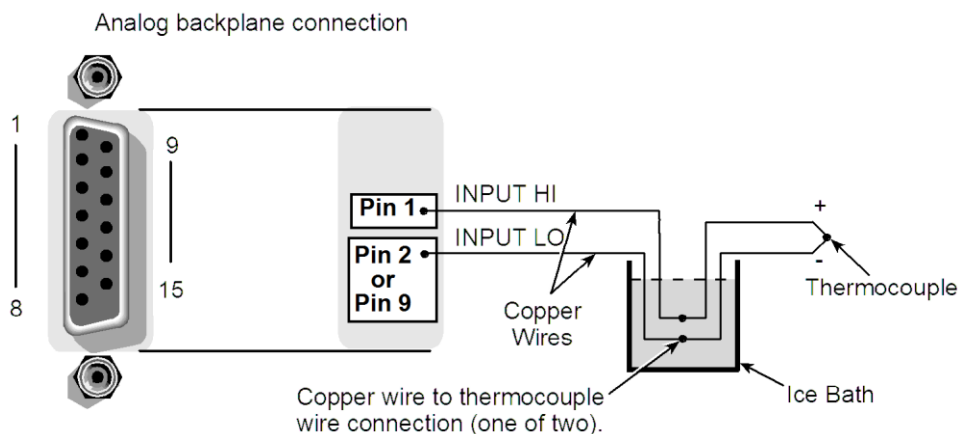
NOTE   The positive lead of the type T thermocouple is made of copper. Therefore, that lead can be connected directly to the input of the switching module (it does not have to be maintained at the simulated reference temperature, in other words, immersed in an ice bath).

For the thermocouple-capable switching modules, you can also use a simulated reference junction as shown, or you can connect the thermocouple wires directly to the screw terminals (internal reference junction). Using a simulated reference junction may be inconvenient, but it will provide more accurate temperature measurements (assuming the user enters a precise reference temperature).

Figure 5-24: Simulated reference junction switching module
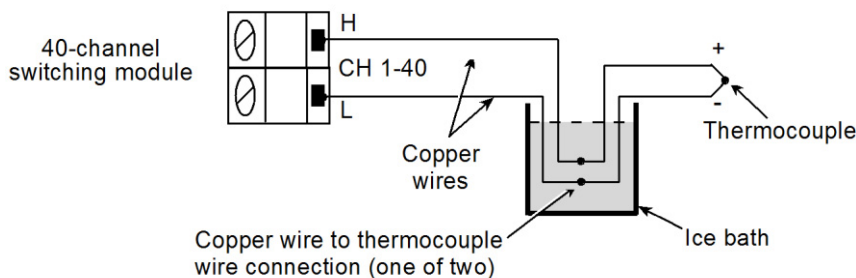
Figure 5-25: Internal reference junction (40 channel switching module)
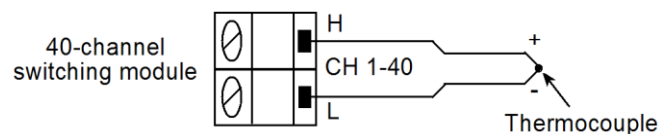
Thermocouple temperature measurement configuration

To configure temperature measurements from the front panel:

1. If needed, change to the temperature function ("TMP" is displayed) by pressing the **FUNC** key.

2. Press the **CONFIG** key and then the **DMM** key. The "TEMP ATTR MENU" will open.

3. Set units of measurement degrees:

   - Using the wheel, scroll to the "UNITS" menu item (right most menu item) and press the **ENTER** key.

   - Turn the wheel to select desired units (Celsius, Kelvin, or Fahrenheit) and press the **ENTER** key.

4. Set thermocouple device attributes:

   - Turn the wheel to scroll to the "THERMO" menu item and press the **ENTER** key.

   - Turn the wheel to scroll to the "COUPLE" temperature connection and press the **ENTER** key.

   - Turn the wheel to select the desired thermocouple type (J, K, T, E, R, S, B, or N) and press the **ENTER** key.

5. Set thermocouple device reference junction type:

   - Turn the wheel to scroll to the "REFJUNCT" menu item and press the **ENTER** key.

   - Select the desired Reference Junction: SIMULATED, INTERNAL, or EXTERNAL. See *Reference junctions* (on page 5-36) for more information.

   - Press the **ENTER** key to set the selection.

6. If a SIMULATED reference junction was selected in step 5:

   - Turn the wheel to scroll to the "SIMREF" menu item and press the **ENTER** key.

   - Using the wheel, dial in the desired reference temperature (default values are units dependent: 023.00°C, 296.15°K, and 073.40°F).

   - Press the **ENTER** key to set the selection.

7. Press the **EXIT** key twice to leave the "TEMP ATTR MENU."

Alternatively, use the bus command dmm.thermocouple to set attributes.

Thermistors

The temperature measurement range for thermistors is -80°C to 150°C (0.01° resolution). Thermistor types that are supported include the 2.2kΩ, 5kΩ, and 10kΩ types.

The thermistor is a temperature sensitive resistor. Its resistance changes non-linearly with changes in temperature. Most thermistors have a negative temperature coefficient. As temperature increases, the resistance decreases. The Series 3700 measures the resistance of the thermistor and calculates the temperature reading.

Of all the temperature transducers, the thermistor is the most sensitive. It can detect minute changes in temperature. It is a good choice when measuring slight changes in temperature. The downside for this increased sensitivity is the loss of linearity. Since they are especially non-linear at high temperatures, it is best to use them for measurements below 100°C.

NOTE	Curve fitting constants are used in the equation to calculate thermistor temperature. The thermistor manufacturer's specified curve fitting may not be exactly the same as the ones used by the Series 3700.

Thermistor connections

A thermistor can be connected directly to the analog backplane connector (or to any of the applicable input channels of a thermistor capable switching module).

Figure 5-26: Thermistor analog backplane connection
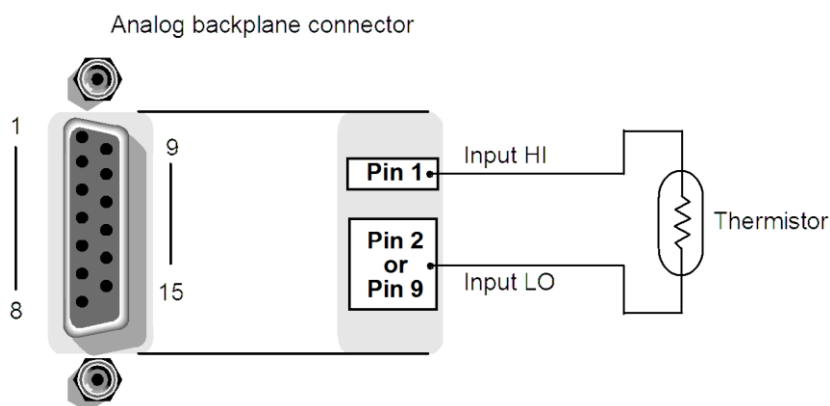
Figure 5-27: Thermistor switching module connection
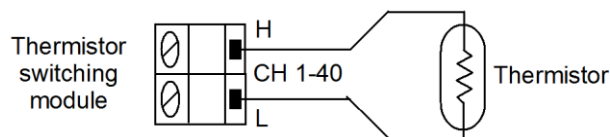
Thermistor measurement configuration

To configure thermistor measurements from the front panel:

1. If needed, change to the temperature function ("TMP" is displayed) by pressing the **FUNC** key.

2. Press the **CONFIG** key and then the **DMM** key. The "TEMP ATTR MENU" will open.

3. Set units of measurement degrees:

    •   Turn the wheel to scroll to the "UNITS" menu item (right most menu item) and press the **ENTER** key.

    •   Turn the wheel to select desired units (Celsius, Kelvin, or Fahrenheit) and press the **ENTER** key.

4. Set THERMO device attributes:

- Turn the wheel to scroll to the "THERMO" menu item and press the **ENTER** key.

- Turn the wheel to scroll to the "THERMISTOR" temperature connection and press the **ENTER** key.

- Turn the wheel to select desired resistance (2252Ω, 5000Ω, or 10000Ω) and press the **ENTER** key.

5. Press the **EXIT** key twice to leave the "TEMP ATTR MENU."

Also see bus command dmm.thermistor for more information on setting thermistor measurement attributes.

RTDs (Resistance Temperature Detector)

For 4-wire resistance temperature detectors (RTDs) the temperature measurement range is -200°C to 630°C (0.01°C resolution). The Series 3700 supports 4-wire RTD types including: PT100, D100, F100, PT385, and PT3916. A USER type is also available to modify RTD parameters, such as the resistance at 0°C. Like the other supported 4-wire types, the USER type can be enabled from the front panel, but the settings can only be changed using remote programming.

The RTD has a metal construction (typically platinum). The resistance of the RTD changes with change in temperature. The Series 3700 measures the resistance and calculates the temperature reading. When using default RTD parameters, the resistance of the RTD will be 100Ω at 0°C.

Of all the temperature transducers, the RTD exhibits the most stability and linearity. By default the Series 3700 performs the 4-wire measurement using offset-compensated ohms, which provides the most accurate way to measure the low resistance of the RTD. For faster RTD measurements when the most accurate measurements are not required, offset-compensation may be disabled for 3-wire or 4-wire RTD measurements.

Use of a 3-wire RTD requires a special math capability to compensate for lead resistance on the 3rd wire. As for 3-wire RTDs, the Series 3700 supports RTD types including: PT100, D100, F100, PT385, and PT3916. A USER type is available to modify RTD parameters, such as the resistance at 0°C. Like the other supported 3-wire types, the USER type can be enabled from the front panel, but the settings can only be changed using remote programming.

3-wire RTD connections

Shown below are 3-wire RTD connections to the Series 3700. For a 3-wire RTD capable 40-channel switching module, paired channels are used to perform the 3-wire measurement. For example, the two input leads of the RTD are connected to a primary channel (1 through 20), while only the LO sense lead is connected to its paired channel (21 through 40)(see Note). Channel 1 is paired to Channel 21, Channel 2 is paired to Channel 22, and so on.

NOTE   The HI sense of the paired channels are not used (3-wire RTD).

NOTE	dmm.offsetcompensation is a common command, shared with fourwireohms and drycircuit. To enable or disable RTD offset compensation, first select the temperature function, next the transducer, and lastly, the offset compensation state.

Figure 5-28: Three-wire RTD connections
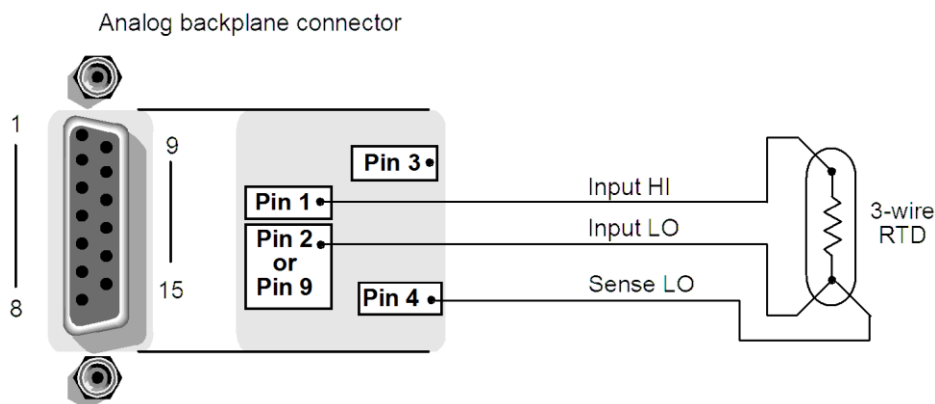
Figure 5-29: Three-wire RTD switching module connections
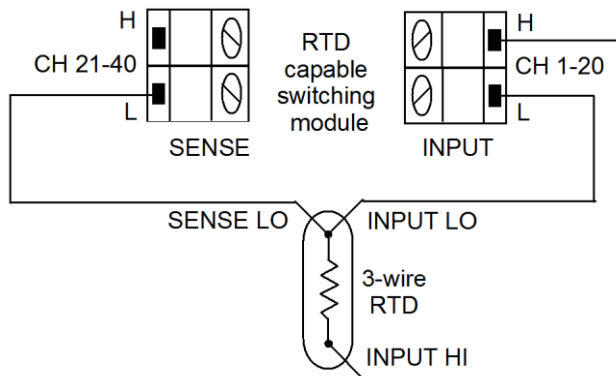
4-wire RTD connections

Shown below are 4-wire RTD connections to the Series 3700. For a 4-wire RTD capable 40-channel switching module, paired channels are used to perform the 4-wire measurement. For example, the two input leads of the RTD are connected to a primary channel (1 through 20), while the two sense leads are connected to its paired channel (21 through 40). Channel 1 is paired to Channel 21, Channel 2 is paired to Channel 22, and so on.

Figure 5-30: Four-wire RTD connections
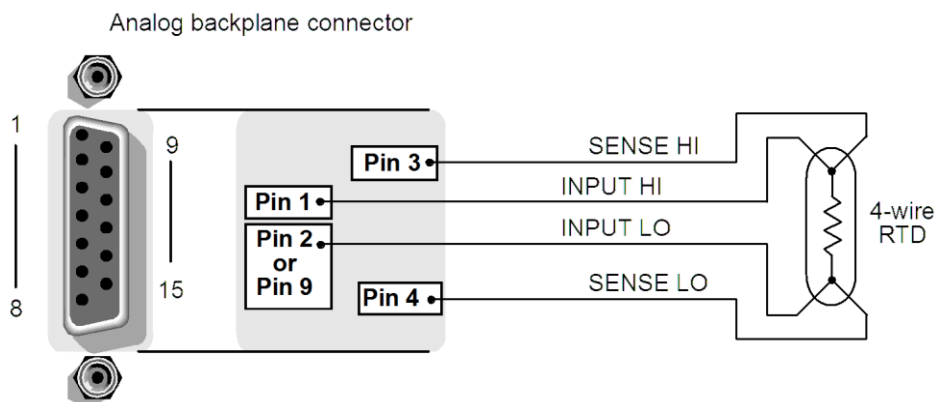
Figure 5-31: Four-wire RTD switching module connections
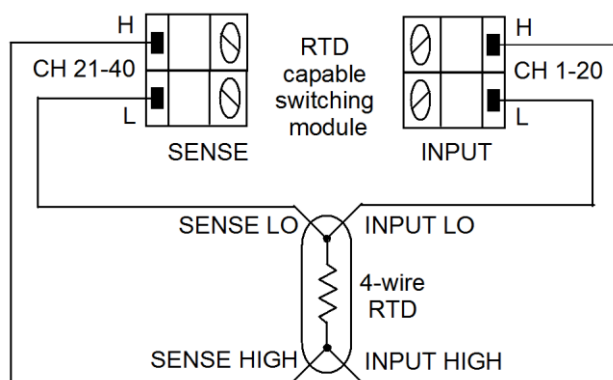
RTD temperature measurement configuration

The Alpha, Beta, Delta, and Ω at 0°C parameters for the five basic RTD types are provided in the table below.

NOTE   These parameters can be modified using remote programming for USER type RTDs.

Type	Standard	Alpha	Beta	Delta	Ω at 0°C
PT100	ITS-90	0.00385055	0.10863	1.49990	100Ω
D100	ITS-90	0.003920	0.10630	1.49710	100Ω
F100	ITS-90	0.003900	0.11000	1.49589	100Ω
PT385	IPTS-68	0.003850	0.11100	1.50700	100Ω
PT3916	IPTS-68	0.003916	0.11600	1.50594	100Ω

RTD configuration

To configure 3 or 4-wire RTD measurements from the front panel:

1. If needed, change to the temperature function ("TMP" is displayed) by pressing the **FUNC** key.

2. Press the **CONFIG** key and then the **DMM** key. The "TEMP ATTR MENU" will open.

3. Set units of measurement degrees:

    - Turn the wheel to scroll to the "UNITS" menu item (right most menu item).
    - Press the **ENTER** key.
    - Using the wheel, select desired units (Celsius, Kelvin, or Fahrenheit).
    - Press the **ENTER** key.

4. Set four wire RTD device attributes:

    - Turn the wheel to scroll to the "THERMO" menu item and press the **ENTER** key.
    - Turn the wheel to scroll to the "THREERTD" or "FOURRTD" temperature connection and press the **ENTER** key.
    - Turn the wheel to select desired RTD type (PT100, D100, F100, PT3916, PT385, or USER) and press the **ENTER** key.

5. Press the **EXIT** key twice to leave the "TEMP ATTR MENU."

Alternatively, use the bus command dmm.fourrtd or dmm.threertd (as applicable) to set attributes.

Temperature measurement configuration

The Series 3700 is configured to measure temperature from the temperature measurement configuration menu. Use the following general rules to navigate through the front panel menu structure:

NOTE	If the Series 3700 is in remote, place the unit in local by pressing the **LOCAL (EXIT)** key.

- The temperature measurement can be configured from the front panel when the present function is "TMP" by pressing the **CONFIG** key, then the **DMM** key.

- Front panel cursor position is indicated by a flashing menu item or parameter and is controlled by the◄ CURSOR ► keys or by turning the wheel.

- With the cursor on a menu item or parameter, use the wheel to scroll through the available options.

- A displayed menu item and parameter is selected by pressing the **ENTER** key.

- You can exit from the menu structure by pressing the **EXIT** key. However, any ENTERed selections will apply.

NOTE When using ICL commands such as dmm.nplc, filter, REL, etc.,. first select the function, then the transducer type, before sending the temperature measurement configuration commands.

To select the active thermoelectric transducer, while in temperature measurement function (TMP is displayed):

1. Press **CONFIG** key and then the **DMM** key.

2. Turn the wheel to scroll to the "THERMO" menu item and press the **ENTER** key.

3. Turn the wheel to scroll to the "TRANSDUCER" menu item and press the **ENTER** key.

4. Turn the wheel to scroll to the desired thermoelectric transducer: THERMOCOUPLE, THERMISTOR, TEMP_THREERTD, or TEMP_FOURRTD. Press the **ENTER** key to select.

5. Configure the selected transducer as appropriate. For configuration information, see the following: *Thermocouple temperature measurement configuration* (on page 5-41), *Thermistor temperature measurement configuration* (see "Thermistor measurement configuration" on page 5-42), or *RTD temperature measurement configuration* (on page 5-45).

Temperature measurement procedure

NOTE If the Series 3700 is in remote, place the unit in local by pressing the **EXIT** key.

---

1. Press the **OPENALL** key to open all switching channels.

2. Select the temperature measurement function by pressing the **FUNC** key until "TMP" is displayed.

3. Configure the temperature measurement as explained in "*Temperature measurement configuration* (on page 5-46)."

4. Connect the temperature transducer(s) to be measured.

5. If using a switching module, perform the following steps to close the desired channel. Keep in mind, that for 3 or 4-wire RTD measurements, you will close the primary (INPUT) channel (1 through 10). The channel that it is paired to will close automatically.

   a)   Use the wheel to dial in the channel number.

   b)   Press the **CLOSE** key.

6. Press the **TRIG** key and observe the displayed reading.

7. To measure other switching channels, repeat steps 5 and 6.

8. When finished, press the **OPENALL** key to open all channels.

Frequency and period measurements

NOTE	Frequency or period measurements as low as 0.5Hz (2 seconds) and < greater than 1MHz (1μs) are possible but range dependent.

The Series 3700 is specified for frequency measurements from 3Hz to 500kHz on voltage ranges of 100mV, 1V, 10V, 100V, and 300V. Period (1 / frequency) measurements can be taken from 2μs to 333ms on the same voltage ranges as the frequency.

Input impedance: 1MΩ || <100pF, AC coupled.

The instrument uses the volts input to measure frequency. The AC voltage range can be changed with the **RANGE ▲ and ▼** keys. The signal voltage must be greater than 10% of the full-scale range.

CAUTION	The voltage limit is subject to the 8• $\times 10^7$ VHz product.

Trigger level

Frequency and period use a zero-crossing trigger, meaning that a count is taken when the frequency crosses the zero level. The Series 3700 uses a reciprocal counting technique to measure frequency and period. This method generates constant measurement resolution for any input frequency. The multimeter's AC voltage measurement section performs input signal conditioning. If the input signal voltage exceeds the selected voltage range, a 000.0000mHz (0.000000μs) will be returned.

Gate time

The gate time is the amount of time the Series 3700 uses to sample frequency or period readings. Use the **RATE** key to set the gate time; SLOW sets the gate time to 0.25 sec, MED sets it to 0.1 sec, and FAST sets it to 0.01 sec. For remote programming, the gate time can be set from 0.01 to 0.273 sec by setting the `dmm.aperture` attribute.

The Series 3700 completes a reading when it receives its first positive zero-crossing after the gate time expires. For example, for any arbitrary frequency, you may wait up to the gate time plus two times the period of the input waveform before the Series 3700 returns a reading.

Frequency connections

Frequency connections for the Series 3700 as well as a switching module are shown below.

Figure 5-32: FREQ and PERIOD input connections
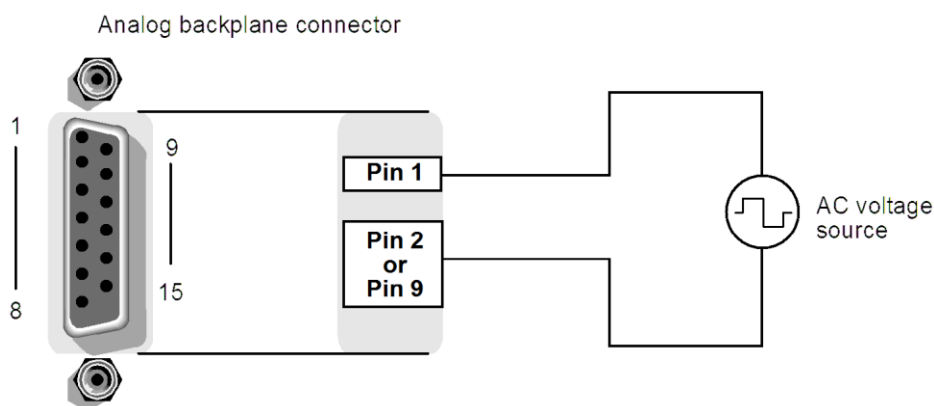
Figure 5-33: FREQ and PERIOD connections (switching module)
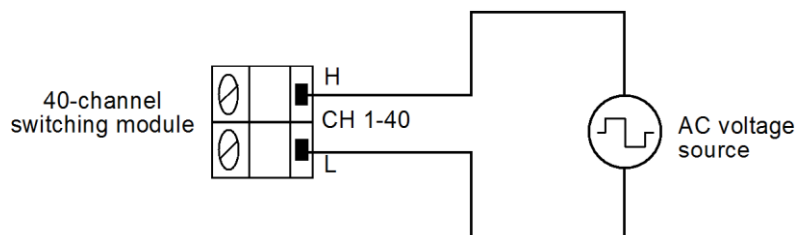
Frequency and period measurement procedure

CAUTION	Do not apply more than the maximum input levels for the Series 3700 or installed switching module (whichever is lower) or instrument damage may occur.

NOTE	If the Series 3700 is in remote, place the unit in local by pressing the **LOCAL** or **EXIT** key.

1. Press the **OPENALL** key to open all switching channels.

2. Select the frequency measurement function by pressing the **FUNC** key until "FRQ" is displayed.

3. Press the **CONFIG** key and then the **DMM** key. The "CONT ATTR MENU" will open.

4. Set threshold voltage:

    - Turn the wheel to scroll to the "THRESHOLD" menu item (right most menu item) and press the **ENTER** key.

    - Using the wheel, dial in the desired voltage to be used as a threshold (0V–303V).

    - Press the **ENTER** key to set.

    - Press the **EXIT** key to leave the "FREQ ATTR MENU."

5. Apply the AC voltage(s) to be measured (see CAUTION).

NOTE	When observing the displayed readings, if the "Overflow" message is displayed, select a higher range until a normal reading is displayed. Use the lowest possible range for the best resolution.

6. Press the **TRIG** key and observe the displayed reading.

7. To measure other switching channels, repeat steps 5 and 6.

8. When finished, press the **OPENALL** key to open all channels.

NOTE	Also see the bus command dmm.threshold for more information on threshold attributes.

Continuity testing

The Series 3700 can test continuity using the 2-wire 1kΩ range with a user selectable threshold resistance level (1 to 1000Ω). When the measured circuit is below the set threshold level, the instrument will display the resistance readings. When the measured circuit is above the threshold level, the instrument will display the message "OPEN."

NOTE	The reading rate for continuity is fixed at FAST (0.01 PLC). Limits and digital outputs cannot be used when testing continuity with the continuity (CONT) function. If you need to use these operations, use the Ω2 function to test continuity.

NOTE	The continuity function does not support REL. Use mx + b, with b as an offset, to compensate for losses due to cable lead resistance.

Continuity testing connections

When using the rear analog backplane connector, connect the test leads to the INPUT HI and LO terminals as shown below.

Figure 5-34: Continuity connections

Analog backplane connector
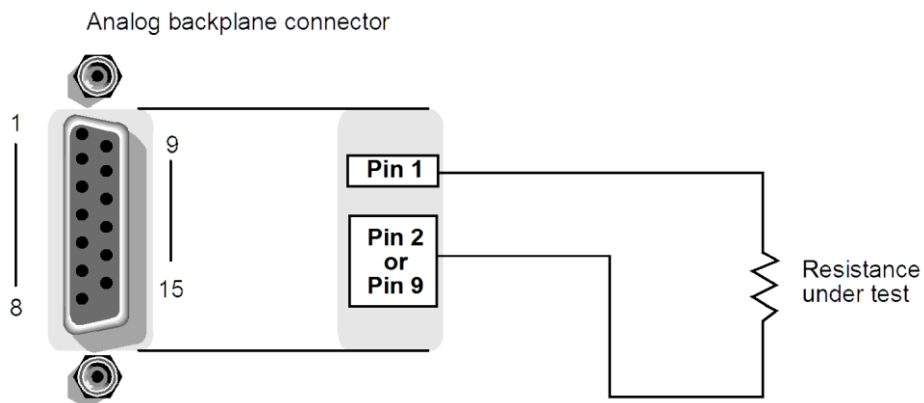
Connections to test continuity using a switching module are shown below. Since this is a 2-wire ohms measurement, Channels 1 through 20 of a 40-channel switching module can be used.

Figure 5-35: Continuity connections using a switching module
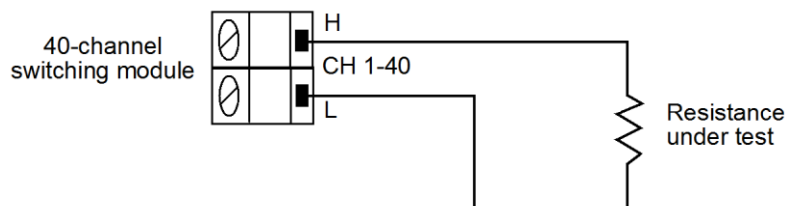
Continuity testing procedure

> **NOTE**　　If the Series 3700 is in remote, place the unit in local by pressing the **LOCAL** key (or the **EXIT** key).

1. Press the **OPENALL** key to open all switching channels.

2. Select the continuity testing function by pressing the **FUNC** key until "CNT" is displayed.

3. Press the **CONFIG** key and then the **DMM** key. The "CONT ATTR MENU" will open.

4. Set threshold resistance:

    - Turn the wheel to scroll to the "THRESHOLD" menu item (right most menu item) and press the **ENTER** key.

    - Using the wheel, dial in the desired resistance to be used as a threshold (1Ω–1000Ω).

    - Press the **ENTER** key to set.

    - Press the **EXIT** key to leave the "CONT ATTR MENU."

5. Apply the resistance to be tested. If using a switching module, perform the following steps to close the appropriate channel.

    a)   Use the wheel to dial in the channel number.

    b)   Press the **CLOSE** key.

6. Press the **TRIG** key and observe the displayed reading.

7. To measure other switching channels, repeat steps 5 and 6.

NOTE	If the measured circuit is below the set threshold level, the instrument will display the resistance readings. If the measured circuit is above the threshold level, the instrument will display the message "OPEN."

8. To disable continuity testing, select a different function (for example, DCV).

9. When finished, press the **OPENALL** key to open all channels.

NOTE	Limits and digital outputs cannot be used when testing continuity with the continuity (CNT) function. If you need to use these operations, use the 2WΩ function to test continuity.
NOTE	Also see the bus command dmm.threshold for more information on threshold attributes.
NOTE	`dmm.threshold` is a common ICL command. To enable a unique continuity threshold, first select the function `dmm.func = "continuity"`, then select the threshold value. The threshold value will be remembered after exiting when returning to the function (unless reset).

ICL Command List

This section provides a listing of Instrument Control Library commands, descriptions, and usage. Refer to the reference manual for complete ICL usage information.

In this section:

beeper

The beeper generates a beep tone. It is typically used to announce the start and/or completion of a test or operation. Available commands:

```
beeper.enable

beeper.beep()
```

bit functions

The bit functions are used to perform bitwise logic operations on two given numbers, and bit operations on one given number. Logic and bit operations truncate the fractional part of given numbers to make them integers. Available commands:

```
bit.bitand()

bit.bitor()

bit.bitxor()

bit.clear()

bit.get()

bit.getfield()

bit.set()

bit.setfield()

bit.test()

bit.toggle()
```

channel functions and attributes

Use the functions and attributes in this group to control and query switching channels. Unless specifically noted, ch_list specifies the channels or backplane relays in a comma-delimited format on which the function is to be performed. Available commands:

```
channel.clearforbidden()

channel.close()

channel.connectrule
```

```
channel.connectsequential

channel.exclusiveclose()

channel.exclusiveslotclose()

channel.getbackplane()

channel.getclose()

channel.getcount()

channel.getdelay()

channel.getforbidden()

channel.getimage()

channel.getlabel()

channel.getpole()

channel.getstate()

channel.open()

channel.pattern.catalog()

channel.pattern.delete()

channel.pattern.getimage()

channel.pattern.setimage()

channel.pattern.snapshot()

channel.reset()

channel.setbackplane()

channel.setdelay()

channel.setforbidden()

channel.setlabel()

channel.setpole()
```

delay function

This function is used to postpone system operation for a specified period of time. Available command:

```
delay()
```

digio functions and attributes

Use the functions and attributes in this group to control read/write and trigger operations for the digital I/O Port. Available commands:

```
digio.readbit()
```

```
digio.readport()
```

```
digio.trigger[N].assert()
```

```
digio.trigger[N].clear()
```

```
digio.trigger[N].mode
```

```
digio.trigger[N].overrun
```

```
digio.trigger[N].pulsewidth
```

```
digio.trigger[N].release()
```

```
digio.trigger[N].triggerstimulus
```

```
digio.trigger[N].wait()
```

```
digio.writebit()
```

```
digio.writeport()
```

```
digio.writeprotect
```

display functions and attributes

The functions and attributes in this group are used for various display operations. Available commands:

```
display.clear()
```

```
display.getannunciators()
```

```
display.getcursor()

display.getlastkey()

display.gettext()

display.inputvalue()

display.loadmenu.add

display.loadmenu.delete()

display.locallockout

display.menu()

display.prompt()

display.screen

display.sendkey()

display.setcursor()

display.settext()

display.waitkey()
```

dmm functions

Use the functions and attributes in this group to control DMM operation, set limits, and perform calibration. Default configuration names like 'dcvolts', 'temperature', 'fourwireohms', etc., imply the reset conditions for the corresponding function. For example, sending `dmm.setconfig('slot1', 'dcvolts')` sets all channels on Slot 1 to use DC volts factory default settings. To make a channel use one setting that is different, create a user DMM configuration with `dmm.configure.set('mydcv')` and then set `'mydcv'` to the desired channels. Available commands:

```
dmm.adjustment.count

dmm.adjustment.date

dmm.aperture

dmm.autodelay

dmm.autorange

dmm.autozero

dmm.calibration.ac()
```

```
dmm.calibration.dc()

dmm.calibration.lock()

dmm.calibration.password

dmm.calibration.save()

dmm.calibration.unlock()

dmm.calibration.verifydate

dmm.close()

dmm.configure.catalog()

dmm.configure.delete()

dmm.configure.query()

dmm.configure.recall()

dmm.configure.set()

dmm.connect

dmm.dbreference

dmm.detectorbandwidth

dmm.displaydigits

dmm.drycircuit

dmm.filter.count

dmm.filter.enable

dmm.filter.type

dmm.filter.window

dmm.fourrtd

dmm.func

dmm.getconfig()

dmm.inputdivider

dmm.limit[Y].autoclear

dmm.limit[Y].enable
```

```
dmm.limit[Y].high.fail

dmm.limit[Y].high.value

dmm.limit[Y].low.fail

dmm.limit[Y].low.value

dmm.linesync

dmm.makebuffer()

dmm.math.enable

dmm.math.format

dmm.math.mxb.bfactor

dmm.math.mxb.mfactor

dmm.math.mxb.units

dmm.math.percent

dmm.measure()

dmm.measurecount

dmm.measurewithtime()

dmm.nplc

dmm.offsetcompensation

dmm.open()

dmm.opendetector

dmm.range

dmm.refjunction

dmm.rel.acquire()

dmm.rel.enable

dmm.rel.level

dmm.reset()

dmm.rtdalpha

dmm.rtdbeta
```

```
dmm.rtddelta

dmm.rtdzero

dmm.savebuffer()

dmm.setconfig()

dmm.simreftemperature

dmm.thermistor

dmm.thermocouple

dmm.threertd

dmm.threshold

dmm.transducer

dmm.units
```

eventlog functions and attributes

Use the functions and attributes in this group to control (read, write, enable, count, etc.,) the event log. Available commands:

```
eventlog.enable

eventlog.count

eventlog.clear()

eventlog.next()

eventlog.all()
```

errorqueue functions and attribute

Use the functions and attributes in this group to read the entries in the error queue. Available commands:

```
errorqueue.clear

errorqueue.count

errorqueue.next
```

exit function

Use this function to terminate a script that is presently running. Available command:

```
exit()
```

format attributes

Use the format attributes to configure the output formats used by the printnumber and printbuffer functions. These attributes can set the data format (ASCII or binary), ASCII precision (number of digits), and binary byte order (normal or swapped).

NOTE	All of the responses are ASCII data.

Available commands:

```
format.asciiprecision
```

```
format.byteorder
```

```
format.data
```

gpib attribute

Use the following attribute to set or get the GPIB address. Available command:

```
gpib.address
```

makegetter functions

Use the functions in this group to set and retrieve a value for an attribute. Available commands:

```
makegetter()
```

```
makesetter()
```

LAN commands

Use the functions and attributes in this group to set/read the LAN triggers. Available commands:

```
lan.applysettings()
```

```
lan.config.autonegotiate
```

```
lan.config.dns.address[N]

lan.config.dns.domain

lan.config.dns.dynamic

lan.config.dns.verify

lan.config.duplex

lan.config.gateway

lan.config.ipaddress

lan.config.method

lan.config.speed

lan.config.subnetmask

lan.status.dns.address[index]

lan.status.dns.hostname

lan.status.duplex

lan.status.gateway

lan.status.ipaddress

lan.status.macaddress

lan.status.port.dst

lan.status.port.rawsocket

lan.status.port.telnet

lan.status.port.vxi11

lan.status.reset()

lan.status.speed

lan.status.subnetmask

lan.trigger[N].assert()

lan.trigger[N].clear()

lan.trigger[N].overrun

lan.trigger[N].stimulus
```

```
lan.trigger[N].wait()
```

localnode attributes

Use the attributes in this group to set the power line frequency, control (on/off) prompting, control (hide/show) error messages on the display, to save/recall setup and other related local node capabilities. Available commands:

```
localnode.define.MAX_TIMERS
```

```
localnode.define.MAX_DIO_LINES
```

```
localnode.define.MAX_TSPLINK_TRIGS
```

```
localnode.define.MAX_BLENDERS
```

```
localnode.define.MAX_BLENDER_INPUTS
```

```
localnode.define.MAX_LAN_TRIGS
```

```
localnode.linefreq
```

```
localnode.model
```

```
localnode.reset()
```

```
localnode.prompts
```

```
localnode.revision
```

```
localnode.showerrors
```

opc function

Use this function to set the OPC bit in the status register when all overlapped commands are completed.

```
opc()
```

printbuffer

Use this function to print buffer information.

```
printbuffer()
```

reset function

Use this function to return all logical instruments to the default settings.

```
reset()
```

scan functions

Use the functions in this group to specify and configure channels and/or channel patterns to scan, as well as associated buffers, triggers, or other scanning aspects. Available commands:

```
scan.abort()
```

```
scan.add()
```

```
scan.background()
```

```
scan.bypass()
```

```
scan.create()
```

```
scan.execute()
```

```
scan.list()
```

```
scan.measurecount
```

```
scan.mode
```

```
scan.nobufferbackground()
```

```
scan.nobufferexecute()
```

```
scan.reset()
```

```
scan.scancount
```

```
scan.state()
```

```
scan.stepcount()
```

```
scan.trigger.arm.clear()
```

```
scan.trigger.arm.set()
```

```
scan.trigger.arm.stimulus
```

```
scan.trigger.channel.clear()
```

```
scan.trigger.channel.set()

scan.trigger.channel.stimulus

scan.trigger.clear()

scan.trigger.measure.clear()

scan.trigger.measure.set()

scan.trigger.measure.stimulus

scan.trigger.sequence.clear()

scan.trigger.sequence.set()

scan.trigger.sequence.stimulus
```

setup functions and attribute

Use the functions and attributes in this group to save and recall setups, and to set the power-on setup. Available commands:

```
setup.poweron

setup.recall()

setup.save()

setup.cards()
```

slot[X] attributes

The attributes in this group indicate whether a card in slot X (where X = 1 to 6) supports different features (for example, pole settings, voltage or 2-wire measurements, etc.,). To query an attribute, use the print command sending the attribute as an argument.

For example:

```
print(slot[1].idn)
```

This command will output a comma separated string that contains the model number, description, firmware revision and serial number of the card installed in Slot 1. Available commands:

```
slot[X].commonsideohms

slot[X].endchannel.amps
```

```
slot[X].endchannel.isolated

slot[X].endchannel.voltage

slot[X].idn

slot[X].interlock.override

slot[X].interlock.state

slot[X].isolated

slot[X].matrix

slot[X].maxsettlingtime

slot[X].maxvoltage

slot[X].multiplexer

slot[X].poles.four

slot[X].poles.one

slot[X].poles.two

slot[X].pseudocard

slot[X].startchannel.amps

slot[X].startchannel.isolated

slot[X].startchannel.voltage

slot[X].tempsensor

slot[X].thermal.state
```

status function and attributes

Refer to the reference manual for complete status ICL command information. Available commands:

```
status.condition

status.measurement.condition

status.measurement.enable

status.measurement.event
```

```
status.measurement.ntr

status.measurement.ptr

status.node_enable

status.node_event

status.operation.condition

status.operation..enable

status.operation.event

status.operation.ntr

status.operation.ptr

status.operation.user.condition

status.operation.user.enable

status.operation.user.event

status.operation.user.ntr

status.operation.user.ptr

status.questionable.condition

status.questionable.enable

status.questionable.event

status.questionable.ntr

status.questionable.ptr

status.request_enable

status.request_event

status.reset()

status.standard.condition

status.standard.enable

status.standard.event

status.system.condition

status.system.enable
```

```
status.system.event

status.system2.condition

status.system2.enable

status.system2.event

status.system3.condition

status.system3.enable

status.system3.event

status.system4.condition

status.system4.enable

status.system4.event

status.system5.condition

status.system5.enable

status.system5.event
```

timer functions

Use the functions in this group to control the trigger timer. Available commands:

```
trigger.timer[N].clear()

trigger.timer[N].count

trigger.timer[N].delay

trigger.timer[N].overrun

trigger.timer[N].passthrough

trigger.timer[N].stimulus

trigger.timer[N].wait()
```

trigger functions

Use the functions in this group to control triggering. Available commands:

```
trigger.blender[N].clear()
```

```
trigger.blender[N].orenable

trigger.blender[N].overrun

trigger.blender[N].stimulus[M]

trigger.blender[N].wait()

trigger.clear()

trigger.wait()
```

tsplink functions and attributes

Use the functions and attributes in this group to assign node numbers to Series 3700 instruments and initialize the TSP-Link system, and to control the TSP-link's trigger event detector. Available commands:

```
tsplink.node

tsplink.reset()

tsplink.state

tsplink.trigger[N].assert()

tsplink.trigger[N].clear()

tsplink.trigger[N].mode

tsplink.trigger[N].overrun

tsplink.trigger[N].release()

tsplink.trigger[N].stimulus

tsplink.trigger[N].wait()
```

upgrade function

Use this function to upgrade the Series 3700 firmware. Available command:

```
upgrade.unit()
```

userstring functions

Use the functions in this group to store and retrieve user-defined strings in nonvolatile memory. Available commands:

```
userstring.add()

userstring.catalog()

userstring.delete()

userstring.get()
```

waitcomplete function

This function waits for all overlapped commands to complete.

```
waitcomplete()
```

Upgrade Procedure Using USB Flash Drive

Use this procedure to upgrade the Series 3700 firmware directly from a USB flash drive using a *.cab file. The upgrade process should take approximately 5 minutes.

CAUTION	Do not turn off unit or remove flash drive during the upgrade procedure unless specifically instructed to do so.

1. Copy upgrade *.cab file to a blank USB flash drive (make sure drive size is large enough for the size of the upgrade file).

2. Power on the Series 3700.

3. Install a USB flash drive in the front panel connector.

4. To upgrade over the bus:

    - Send the following command: upgrade.unit()

To upgrade from the front panel:

    - Press the **MENU** key.

    - Turn the wheel to scroll to "UPGRADE" and press the wheel.

    - Answer YES to the question UPGRADE UNIT? (select "Yes" and press the wheel).

5. The Series 3700 upgrade status will be displayed, including the percentage. When the file has been unpacked, the upgrade status will be displayed as it is upgraded (first units installed in the slots including the DMM if installed, and then the Main Series 3700).

6. The Series 3700 reboots automatically when the upgrade is complete.

Maintenance

In this section:

Introduction

The information in this section deals with routine maintenance that can be performed by the operator.

Fuse replacement

The analog backplane AMPS fuse (see item 1, in Fuse location figure) is accessible from the rear panel, just below the Analog Backplane Connector. The instrument fuse (see item 2, in Fuse location figure) is accessible from the rear panel, below the GPIB Connector.

WARNING	*Disconnect all external power from the equipment and the line cord before performing any maintenance on the Series 3700.*
	Failure to disconnect all power may expose you to hazardous voltages, that if contacted, could cause personal injury or death. Use appropriate safety precautions when working with hazardous voltages.

Figure 8-1: Fuse location
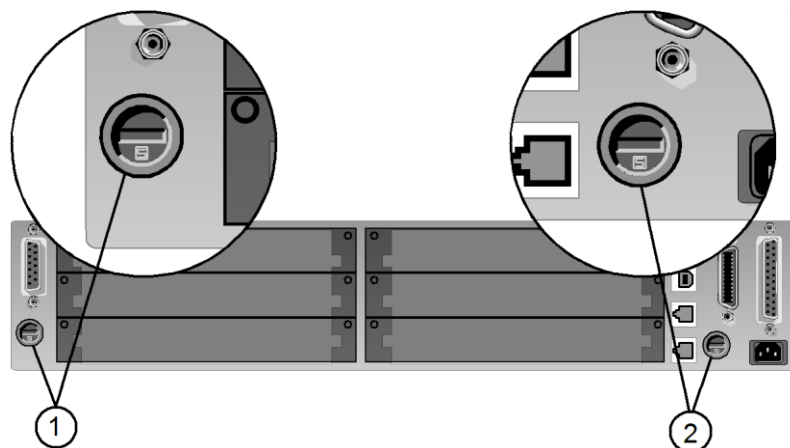
Fuse Location	Rating	Keithley Instruments part number
(1) Analog backplane fuse	250V, 3A fast blow 5x20mm	FU-99-1
(2) Instrument fuse	250V / 1.25A slow blow 5x20mm	FU-106-1.25

To replace a fuse:

1. Using a flathead screwdriver, disengage the fuse holder by rotating it counter-clockwise.

2. Pull out the fuse holder and replace the fuse with the correct type (see table).

3. Reinstall the fuse holder.

If the fuse continues to blow, a circuit malfunction exists and must be corrected. Return the unit to Keithley Instruments for repair.

Front panel tests

There are two front panel tests: one to test the functionality of the front panel keys and one to test the display.

Test procedure

The keys test lets you check the functionality of each front panel key.

To run the test:

1. Display the MAIN MENU by pressing the **MENU** key.

2. Turn the wheel to scroll to the DISPLAY menu item and press the **ENTER** key to select.

3. Press the **ENTER** key to select TEST.

4. Select KEYS or DISPLAY-PATTERNS and press the **ENTER** key to run the test.

   - **KEYS**: When a key is pressed, the label name for that key will be displayed to indicate that it is functioning properly. When the key is released, the message "No keys pressed" is displayed. Press the **Exit key** twice to end the test.

   - **DISPLAY-PATTERNS**: There are three parts to the display patterns test. Each time ENTER or Rotary Knob is pressed, the next part of the test sequence is selected. The three parts of the test sequence are as follows:
     a. Checkerboard pattern and the annunciators that are on during normal operation.
     b. Checkerboard pattern (alternate pixels on) and all annunciators.
     c. Each digit (and adjacent annunciator) is sequenced. All of the pixels of the selected digit are on.

5. Press the **Exit** key to end the test.

6. Continue pressing the **EXIT** key to back out of the menu structure.

Series 3700 Module Schematics and Connections

The Series 3700 series offers a growing family of high-density and general-purpose plug-in cards that accommodates a broad range of signals at very competitive pricing. The Series 3700 supports applications as diverse as design validation, accelerated stress testing, data acquisition, and functional testing. This section provides information on the following:

In this section:

Maximum power usage with Series 3700 cards

Plug in modules are capable of switching many relays at once which can take a substantial amount of system power. There is a limited amount of system power available for switching relays. Therefore, use care in order that Series 3700 maximum available power is not exceeded. The maximum power available is limited on a per bank basis as follows:

Bank 1	Bank 2
SLOT 1	SLOT 4
SLOT 2	SLOT 5
SLOT 3	SLOT 6
12300 mW (max)	12300mW (max)

From the table, the total power available for slots #1, 2 and 3 is 12,300mW (12.3W). Similarly, the total power available for slots #4, 5 and 6 is 12.3W. Attempting to exceed these power levels will result in the system performing as many of the operations as possible until these power limits are reached. An error message will then be created and the remaining operations will not be performed.

Power budgeting and calculation

Individual relay power consumption generally depends on the type of relay. Latching type relays consume power only briefly in order to open or close. These types of relays are not of concern for power budgeting purposes. Non-latching types of relays consume power in a sustained fashion in order to maintain their state. These types of relays must be considered for power budgeting purposes.

Another power consideration is the fact that each plug in card consumes an amount of system power in order to operate. This sustained (and roughly constant) power draw is known as quiescent power. Quiescent power directly takes away from the power available to operate relays. So it must also be taken into account when budgeting for power consumption.

The following table shows the power consumption of channel and backplane relays for various Series 3700 plug-in cards. The quiescent power is also shown. For latching type relays an "NA" is shown.

Model	Quiescent Power (Milliwatts)	Channel Relay Power Consumption (Milliwatts) Each	Backplane Relay Power Consumption (Milliwatts) Each
3720	975	NA	100
3721	1350	NA	100
3722	475	NA	100
3723	700	100 (2 Pole)	100
		50 (1 Pole)	100
3730	780	NA	100
3740	1000	NA (Independent)	100
		200 (High Current)	100

In order to determine whether or not a given quantity of relay operations can be performed, the tables above must be used to calculate the total power required by applying the example equations given below:

$$P_{TS} = P_Q + (N_{CC} \times P_{CR}) + (N_{BC} \times P_{BR})$$

Where:

P_{TS} = Total Slot Power

P_Q = Quiescent power

N_{CC} = Number of closed channels

N_{BC} = Number of closed backplane channels

P_{CR} = Power per channel relay

P_{BR} = Power per backplane relay

$$Total\ Bank\ \#1\ Power = Slot\ 1\ P_{TS} + Slot\ 2\ P_{TS} + Slot\ 3\ P_{TS}$$

$$Total\ Bank\ \#2\ Power = Slot\ 4\ P_{TS} + Slot\ 5\ P_{TS} + Slot\ 6\ P_{TS}$$

To check power consumption, each slot power must be computed. The slot power for slots 1 through 3 are added. Also, slot power for slots 4 through 6 are added. The results are called bank powers, and should be compared with the maximum limits. Some example calculations follow.

Power budgeting examples

Example 1

This example is for a fully loaded Model 3706-S with Model 3723 cards (all 2 pole mode).

Slot #	Card	Channel relays closed	Backplane relays closed
SLOT 1	3723	30	4
SLOT 2	3723	30	4
SLOT 3	3723	30	4
SLOT 4	3723	30	4
SLOT 5	3723	30	4
SLOT 6	3723	30	4

This produces the following power consumption:

Slot #1 Power Consumed =	700	+	30 x 100	+	4 x 100	=	4100
Slot #2 Power Consumed =	700	+	30 x 100	+	4 x 100	=	4100
Slot #3 Power Consumed =	700	+	30 x 100	+	4 x 100	=	4100
Slot #4 Power Consumed =	700	+	30 x 100	+	4 x 100	=	4100
Slot #5 Power Consumed =	700	+	30 x 100	+	4 x 100	=	4100
Slot #6 Power Consumed =	700	+	30 x 100	+	4 x 100	=	4100

Totals for each bank can then be calculated as follows:

	Slot 1		Slot 2		Slot 3		Total
Bank #1 Power Consumed =	4100	+	4100	+	4100	=	12300

	Slot 4		Slot 5		Slot 6		Total
Bank #2 Power Consumed =	4100	+	4100	+	4100	=	12300

Result: Since each bank has not exceeded maximum power, this is OK.

Example 2

This example is for a partially loaded Model 3706 with Model 3723 cards (all 1 pole mode).

Slot #	Card	Channel relays closed	Backplane relays closed
SLOT 1	3723	107	1
SLOT 2	3723	107	1
SLOT 3	EMPTY	0	0
SLOT 4	3723	107	1
SLOT 5	3723	107	1
SLOT 6	EMPTY	0	0

This produces the following power consumption:

Slot 1 Power Consumed =	700	+	107 x 50	+	1 x 100	=	6150
Slot 2 Power Consumed =	700	+	107 x 50	+	1 x 100	=	6150
Slot 3 Power Consumed =	0	+	0	+	0	=	0
Slot 4 Power Consumed =	700	+	107 x 50	+	1 x 100	=	6150
Slot 5 Power Consumed =	700	+	107 x 50	+	1 x 100	=	6150
Slot 6 Power Consumed =	0	+	0	+	0	=	0

Totals for each bank can then be calculated as follows:

	Slot 1		Slot 2		Slot 3		Total
Bank #1 Power Consumed =	6150	+	6150	+	0	=	12300

	Slot 4		Slot 5		Slot 6		Total
Bank #2 Power Consumed =	6150	+	6150	+	0	=	12300

Result: Since each bank has not exceeded maximum power, this is OK.

Example 3

This example is for a fully loaded Model 3706-S with Model 3723 cards (all 2 pole mode).

Slot #	Card	Channel relays closed	Backplane relays closed
SLOT 1	3723	60	4
SLOT 2	3723	60	4
SLOT 3	3723	60	4
SLOT 4	3723	60	4
SLOT 5	3723	60	4
SLOT 6	3723	60	4

This produces the following power consumption:

Slot #1 Power Consumed =	700	+	60 x 100	+	4 x 100	=	7100
Slot #2 Power Consumed =	700	+	60 x 100	+	4 x 100	=	7100
Slot #3 Power Consumed =	700	+	60 x 100	+	4 x 100	=	7100
Slot #4 Power Consumed =	700	+	60 x 100	+	4 x 100	=	7100
Slot #5 Power Consumed =	700	+	60 x 100	+	4 x 100	=	7100
Slot #6 Power Consumed =	700	+	60 x 100	+	4 x 100	=	7100

Totals for each bank can then be calculated as follows:

	Slot 1		Slot 2		Slot 3		Total
Bank #1 Power Consumed =	7100	+	7100	+	7100	=	21300

	Slot 4		Slot 5		Slot 6		Total
Bank #2 Power Consumed =	7100	+	7100	+	7100	=	21300

Result: Each bank has exceeded maximum power. Some operations will not be performed and an error will generated.

Example 4

This example is for a fully loaded 3706-S with mix of cards.

Slot #	Card	Channel relays closed	Backplane relays closed
SLOT 1	3720	20	2
SLOT 2	3721	20	2
SLOT 3	3722	15 (2-pole)	4
SLOT 4	3723	25 (HI Current)	2
SLOT 5	3730	10	4
SLOT 6	3740	2	4

This produces the following power consumption:

Slot #1 Power Consumed =	975	+	0	+	2 x 100	=	1175
Slot #2 Power Consumed =	1350	+	0	+	2 x 100	=	1550
Slot #3 Power Consumed =	475	+	0	+	4 x 100	=	875
Slot #4 Power Consumed =	700	+	25 x 100	+	2 x 100	=	3400
Slot #5 Power Consumed =	780	+	0	+	4 x 100	=	1180
Slot #6 Power Consumed =	1000	+	2 x 200	+	4 x 100	=	1800

Totals for each bank can then be calculated as follows:

	Slot 1		Slot 2		Slot 3		Total
Bank #1 Power Consumed =	1175	+	1550	+	875	=	3600

	Slot 4		Slot 5		Slot 6		Total
Bank #2 Power Consumed =	3400	+	1180	+	1800	=	6380

Result: Since each bank has not exceeded maximum power, this is OK.

Model 3720 dual 1x30 multiplexer card

The Model 3720 offers two independent banks of 1×30 two-pole multiplexers. It is ideal for general-purpose switching, including temperature measurements. The two banks can automatically be connected to the Series 3700 mainframe backplane and optional DMM through the analog backplane connection relays. This connection allows the mainframe to reconfigure the card to a single 1×60 two-pole multiplexer or to enable card-to-card expansion for even larger configurations.

Other features of the Model 3720 include its ability to be reconfigured to coordinated four-pole operation for additional measurement flexibility. Furthermore, the Model 3720 supports thermocouple-type temperature measurements with the Model 3720-ST (screw terminal) accessory providing automatic cold junction compensation (CJC).

The Model 3720 uses two 78-pin male D-sub connectors for signal connections. For screw terminal or automatic CJC, use the detachable Model 3720-ST accessory.

Figure 9-1: Model 3720
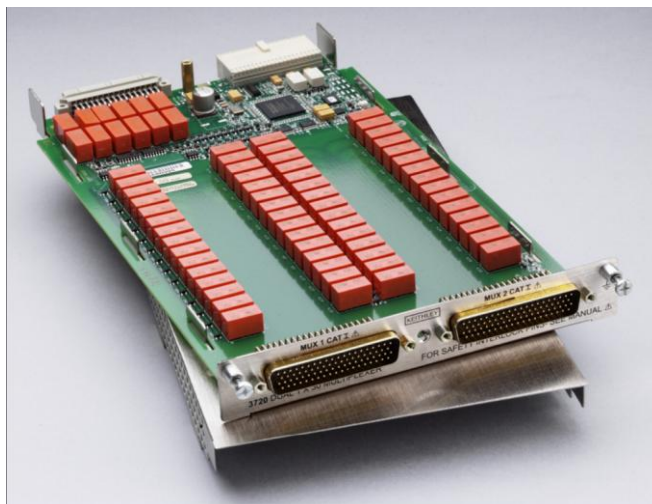
Available accessories: Model 3720

3720-MTC-1.5:   78-pin female-to-male D-sub cable assembly, 1.5m (4.9ft)

3720-MTC-3:   78-pin female-to-male D-sub cable assembly, 3m (9.8ft)

3720-ST: Screw Terminal panel with CJC sensor

3791-KIT78-R: 78-pin female D-sub connector kit (solder cup contacts). See *Connection information: Model 3720* (on page 9-9).

7401:   Type K thermocouple wire kit

Connection information: Model 3720

Refer to the following figure for Model 3720 D-sub connection information.

Figure 9-2: D-sub connection information for the Model 3720
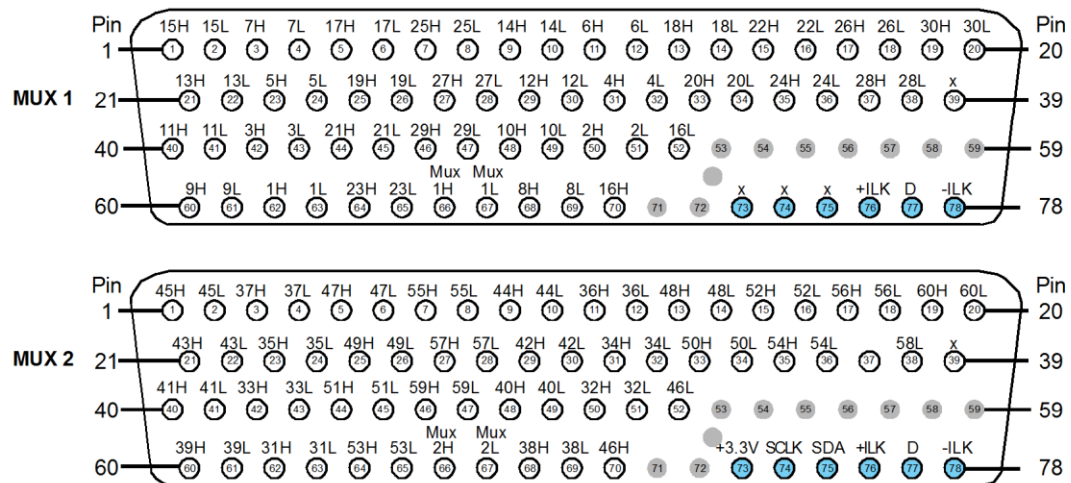
NOTE

Connector location: MUX 1   MUX 2

Schematics: Model 3720

The following figure provides a switching schematic for the Model 3720.

Figure 9-3: Schematic of the Model 3720
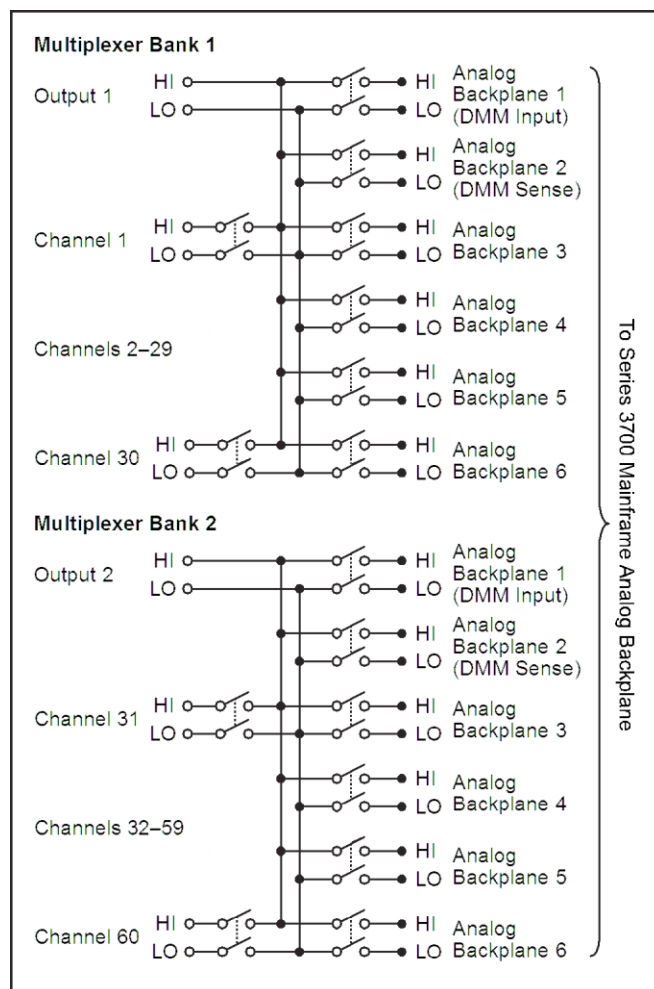
Model 3720 connection log

The following figures provides a sample of a connection log that can be used to record the wiring scheme for this module.

Figure 9-4: Sample Model 3720 connection log (1 of 2)

Channel		Color	Description
CH1	H		
	L		
CH2	H		
	L		
CH3	H		
	L		
CH4	H		
	L		
CH5	H		
	L		
CH6	H		
	L		
CH7	H		
	L		
CH8	H		
	L		
CH9	H		
	L		
CH10	H		
	L		
CH11	H		
	L		
CH12	H		
	L		
CH13	H		
	L		
CH14	H		
	L		
CH15	H		
	L		
CH16	H		
	L		
CH17	H		
	L		
CH18	H		
	L		
CH19	H		
	L		
CH20	H		
	L		
CH21	H		
	L		
CH22	H		
	L		
CH23	H		
	L		
CH24	H		
	L		
CH25	H		
	L		
CH26	H		
	L		
CH27	H		
	L		
CH28	H		
	L		
CH29	H		
	L		

Figure 9-5: Sample Model 3720 connection log

Channel (cont.)		Color	Description
CH30	H		
	L		
CH31	H		
	L		
CH32	H		
	L		
CH33	H		
	L		
CH34	H		
	L		
CH35	H		
	L		
CH36	H		
	L		
CH37	H		
	L		
CH38	H		
	L		
CH39	H		
	L		
CH40	H		
	L		
CH41	H		
	L		
CH42	H		
	L		
CH43	H		
	L		
CH44	H		
	L		
CH45	H		
	L		
CH46	H		
	L		
CH47	H		
	L		
CH48	H		
	L		
CH49	H		
	L		
CH50	H		
	L		
CH51	H		
	L		
CH52	H		
	L		
CH53	H		
	L		
CH54	H		
	L		
CH55	H		
	L		
CH56	H		
	L		
CH57	H		
	L		
CH58	H		
	L		
CH59	H		
	L		
CH60	H		
	L		

Model 3721 dual 1x20 multiplexer card

The Model 3721 provides 40 differential channels and automatic CJC with 3721-ST accessory. The Model 3721 has two independent banks of 1x20 two-pole multiplexers that are ideal for general-purpose switching, including temperature measurements.

The Model 3721 provides a number of other features. In addition to the 40 channels, two fused channels are supplied for current measurements. Also, the Model 3721 includes dedicated inputs that enable 40 channels of four-wire common side ohm measurements. For thermocouple-type measurements, automatic cold junction compensation (CJC) is supported with the Model 3721-ST (screw terminal) accessory.

The Model 3721 uses two 50-pin male D-sub connectors for signal connections. For screw terminal or automatic CJC, use the detachable Model 3721-ST accessory.

Figure 9-6: Model 3721
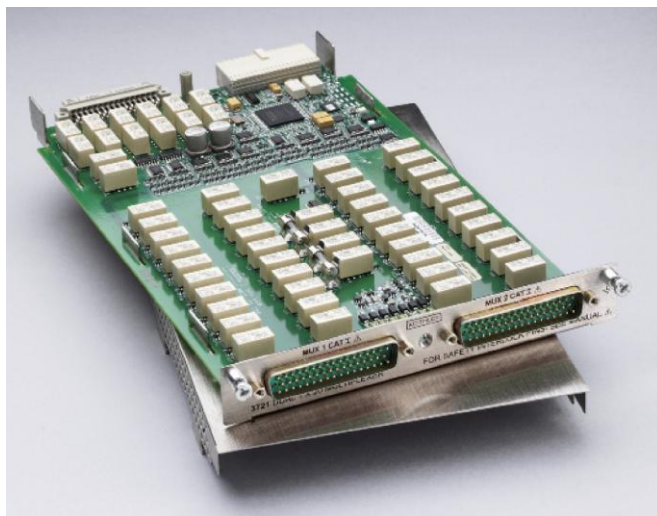
Available accessories: Model 3721

3721-MTC-1.5:   50-pin female-to-male D-sub cable assembly, 1.5m (4.9ft)

3721-MTC-3:   50-pin female-to-male D-sub cable assembly, 3m (9.8ft)

3721-ST: Screw terminal panel with CJC sensor

3790-KIT50-R: 50-pin female D-sub connector kit (solder cup contacts). See *Connection information: Model 3721.* (see "Connection information: Model 3721" on page 9-15)

7401:   Type K thermocouple wire kit

Model 3721-ST accessory board channel list

The following table shows the association between the Model 3721-ST accessory and each channel on the Model 3721.

Channel	3721-ST Terminal Board Silkscreen Label
Multiplexer # 1 Output	MUX 1 OUT
1 ... 20	1 ... 20
Multiplexer # 2 Output	MUX 2 OUT
21 ... 40	21 ... 40
Amps Channel 41	AMP1
Amps Channel 42	AMP2
DMM HI & SHI Channel n928	DMM
No Connects	NC

When viewing this table, keep in mind:

- Multiplexer #1 channels are labeled 1 through 20 and the multiplexer output is labeled MUX 1 OUT.

- Multiplexer #2 channels are labeled 21 through 40 and the multiplexer output is labeled MUX 2 OUT.

- Amps Channel 41 is labeled AMP1. This channel is accessed as "n041" where n is the slot number.

- Amps Channel 42 is labeled AMP2. This channel is accessed as "n042" where n is the slot number.

- DMM HI & SHI Channel is labeled DMM. This channel is accessed as "n928" where n is the slot number.

- No connect channels are labeled NC. Do not connect to these channels.

Connection information: Model 3721

Refer to the following figure for Model 3721 D-sub connection information.

**Figure 9-7: D-sub connection information for the Model 3721**

MUX 1

Pin																	Pin
1	1H	2L	4H	5L	7H	8L	10H	M1L	12H	13L	15H	16L	18H	19L	A1H	A2L	D	17
18		2H	3L	5H	6L	8H	9L	M1H	11L	13H	14L	16H	17L	19H	20L	A2H	ILK1H	33
34	1L	3H	4L	6H	7L	9H	10L	11H	12L	14H	15L	17H	18L	20H	A1L	D	ILK1L	50

MUX 2

Pin																	Pin
1	ILK2H	D	21H	22L	24H	25L	27H	28L	30H	M2L	32H	33L	35H	36L	38H	39L	DMM_H	17
18		T_SDA	T_VCC	22H	23L	25H	26L	28H	29L	M2H	31L	33H	34L	36H	37L	39H	40L	33
34	ILK2L	T_SCL	21L	23H	24L	26H	27L	29H	30L	31H	32L	34H	35L	37H	38L	40H	DMM_S	50

NOTE

⬤ Grey signal pins go to terminal board but not to terminal blocks.

Connector location: [MUX 1] [MUX 2]

Schematics: Model 3721

The following figure provides a switching schematic for the Model 3721 in two-pole mode.

Figure 9-8: Schematic of the Model 3721 in two-pole mode
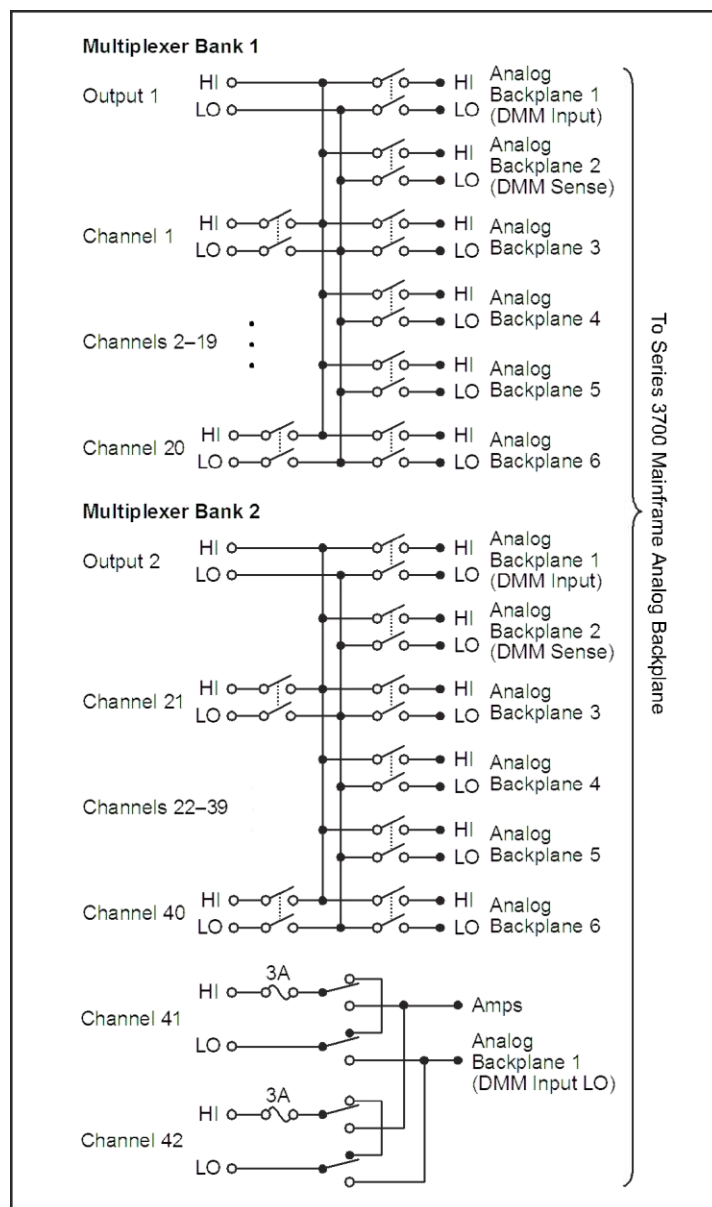
The following figure provides a switching schematic for the Model 3721 in four-wire common side ohm mode.

Figure 9-9: Schematic of the Model 3721 in four-wire common side ohm mode
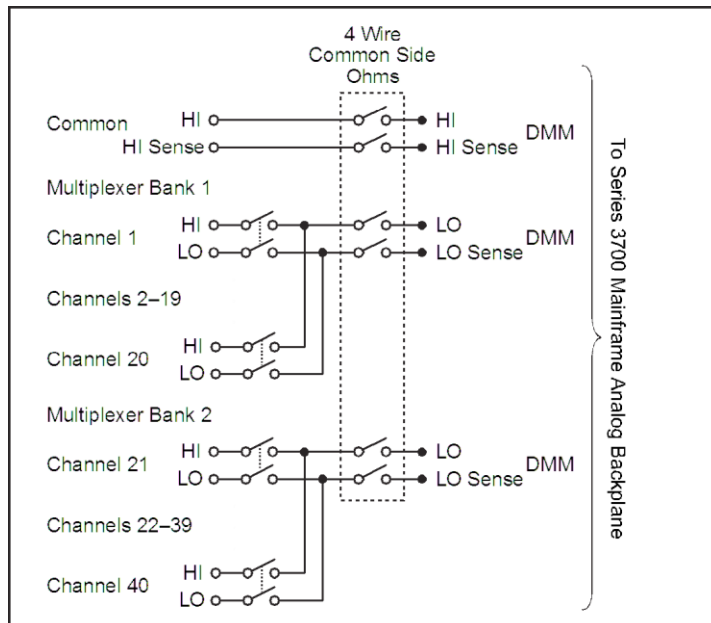
Model 3721: AMPS channels fuse replacement

Channels 41 and 42 are protected by series fuses. In the event of an overload, both channels and the DMM input are protected. The two fuses are replaceable and are located on the printed circuit board of the Model 3721 switch card. The Model 3721 must be removed from the Series 3700 and all power disconnected in order to access these fuses.

Amps channel fuse replacement procedure

WARNING	*Disconnect all external power from the equipment and the line cord before performing any maintenance on the Series 3700.*
	Make sure 3721 card is removed from the system before replacing the AMPS fuse.

CAUTION	Do not use a fuse with a higher current rating than specified or instrument damage may occur. If the Instrument repeatedly blows fuses, locate and correct the cause of trouble before replacing the fuse.

1. Remove the top shield cover:

   - Unscrew the #4-40 screw (1) as shown in the "Model 3721 shield removal" figure below.

   - Slide the top cover in a direction away from the D-sub connectors, disengaging the cover from the printed circuit board.

   - Lift the top shield cover off of the printed circuit board.

2. Replace the fuses:

   - The fuse locations for channels 41 and 42 are shown in the "Model 3721 fuse location" figure below.

   - Gently lift out the old fuse from the fuse holders. Holders are labeled FH1A-FH1B for Channel 41, and FH2A-FH2B for Channel 42. Pull the fuse away from the PCB and it should snap out of the holders.

   - Place the new fuse by gently pushing it downwards towards the PCB into the fuse holders. It should snap into the holder on each side. Make sure that the fuse body is inline with the holders before applying force. Do not use excessive force. Check that the fuse is contacting each holder.

   - Discard the old fuse.

3. Replace the top shield cover.

   - Slide the top cover in a direction toward the D-sub connectors, engaging the cover onto the printed circuit board, and securing with the #4-40 screw (1).

4. The card may now be returned to service.

Figure 9-10: Model 3721 shield removal
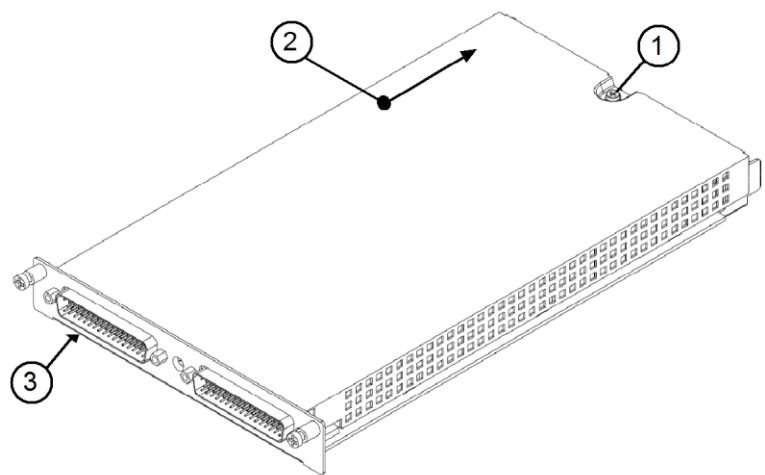
Figure 9-11: Model 3721 fuse location
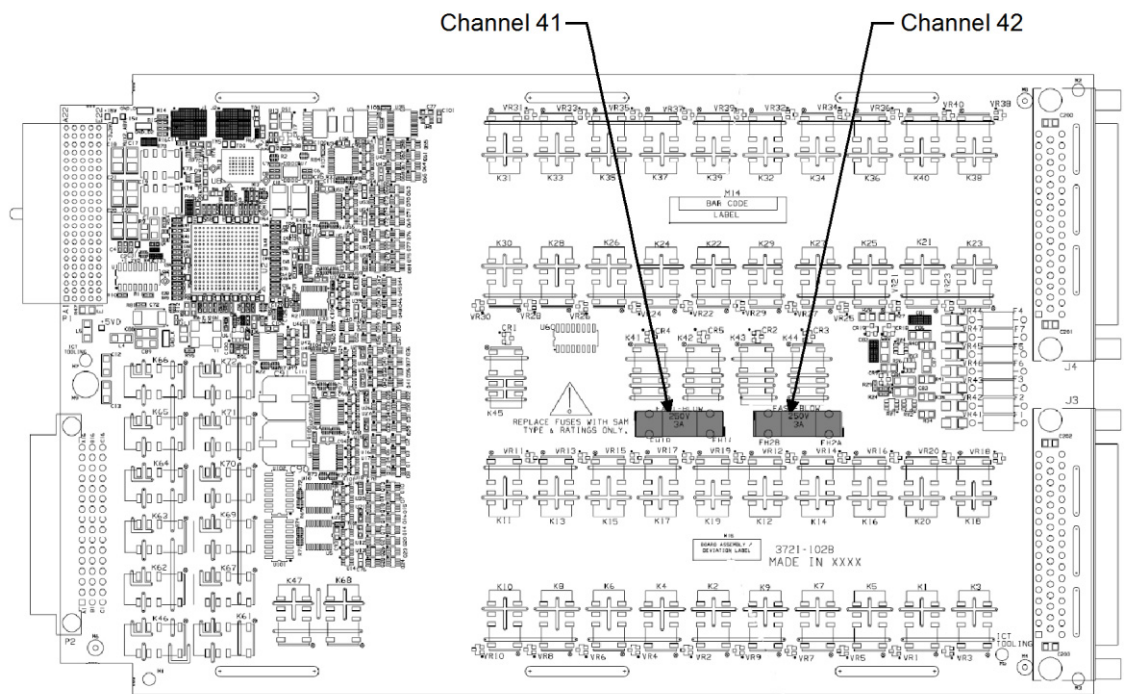
Rating	Type	Size	Keithley Instruments part number
250V, 3A	Fast blow	5 x 20mm	FU-99-1

Model 3721 connection log

The following figures provides a sample of a connection log that can be used to record the wiring scheme for this module.

Figure 9-12: Sample Model 3721 connection log (1 of 2)

Channel		Color	Description
CH1	H		
	L		
CH2	H		
	L		
CH3	H		
	L		
CH4	H		
	L		
CH5	H		
	L		
CH6	H		
	L		
CH7	H		
	L		
CH8	H		
	L		
CH9	H		
	L		
CH10	H		
	L		
CH11	H		
	L		
CH12	H		
	L		
CH13	H		
	L		
CH14	H		
	L		
CH15	H		
	L		
CH16	H		
	L		
CH17	H		
	L		
CH18	H		
	L		
CH19	H		
	L		
CH20	H		
	L		
CH21	H		
	L		
CH22	H		
	L		
CH23	H		
	L		
CH24	H		
	L		
CH25	H		
	L		
CH26	H		
	L		
CH27	H		
	L		
CH28	H		
	L		
CH29	H		
	L		

Figure 9-13: Sample Model 3721 connection log (2 of 2)

Channel (cont.)		Color	Description
CH30	H		
	L		
CH31	H		
	L		
CH32	H		
	L		
CH33	H		
	L		
CH34	H		
	L		
CH35	H		
	L		
CH36	H		
	L		
CH37	H		
	L		
CH38	H		
	L		
CH39	H		
	L		
CH40	H		
	L		
AMPS41	H		
	L		
AMPS42	H		
	L		

Model 3722 dual 1x48 high density multiplexer card

The Model 3722 has two independent banks of 1x48 two-pole multiplexers, which is ideal for applications that require a high channel count. The two banks can automatically be connected to the Series 3700 mainframe backplane and optional DMM through the analog backplane connection relays. This connection allows the mainframe to reconfigure the card as a single 1×96 two-pole multiplexer, or to enable card-to-card expansion for even larger configurations. Another feature of this card is the latching electromechanical relays that can accommodate 300V, 1A switched signal levels.

The Model 3722 uses two 104-pin D-sub connectors for signal connections. A solder-style connector kit (Model 3792-KIT104-R) and pre-assembled cables (Models 3722-MTC-1.5 and 3722-MTC-3) are available for card connections.

Figure 9-14: Model 3722
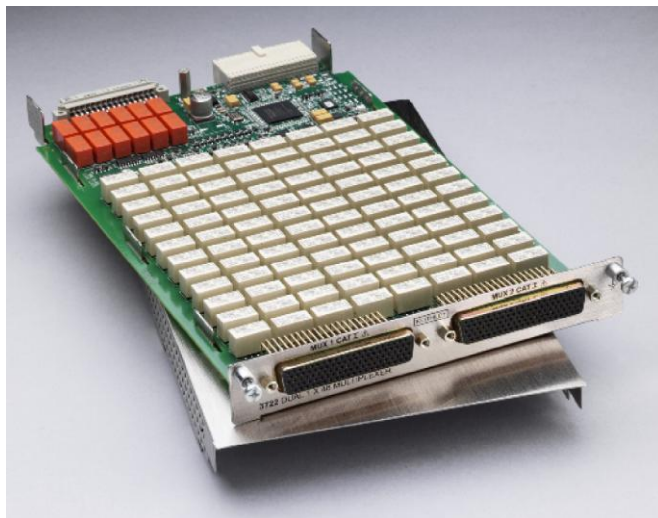
Available accessories: Model 3722

3722-MTC-1.5:   104-pin, male-to-female D-sub cable assembly, 1.5m (4.9ft)

3722-MTC-3:   104-pin, male-to-female D-sub cable assembly, 3m (9.8ft)

3792-KIT104-R: 104-pin, male, D-sub connector kit (solder-cup contacts). See *Connection information: Model 3722* (on page 9-23).

Connection information: Model 3722

Refer to the following figure for Model 3722 D-sub connection information.

Figure 9-15: D-sub connection information the Model 3722
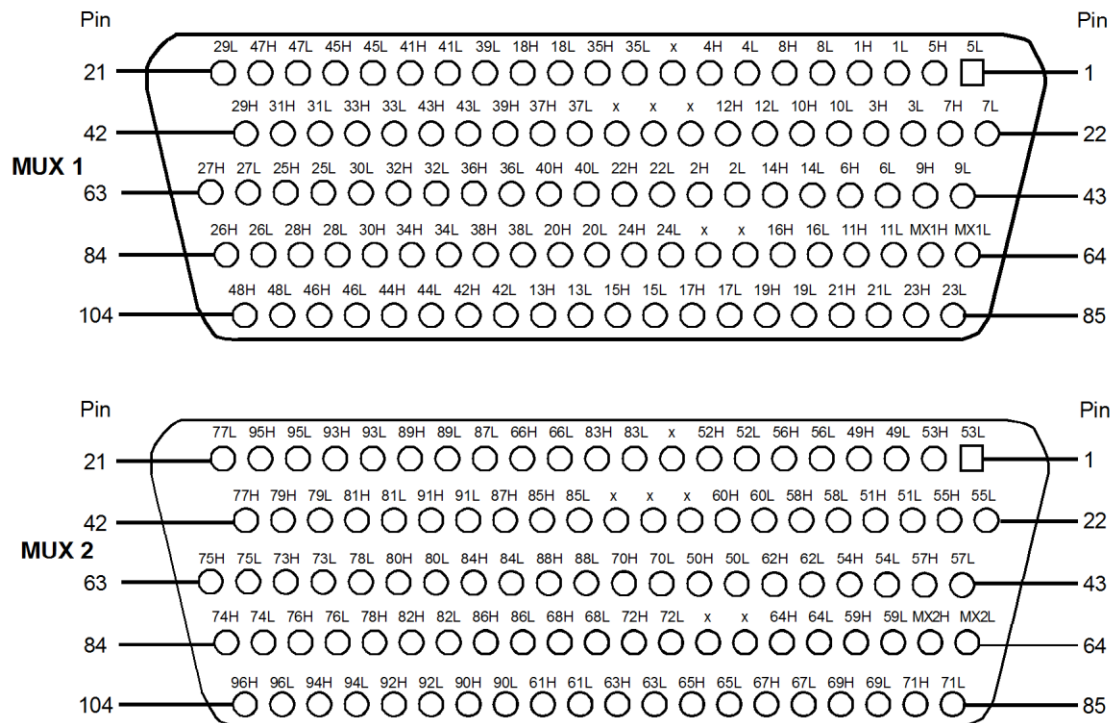
Schematics: Model 3722

The following figure provides a switching schematic for the Model 3722.

Figure 9-16: Schematic for the Model 3722
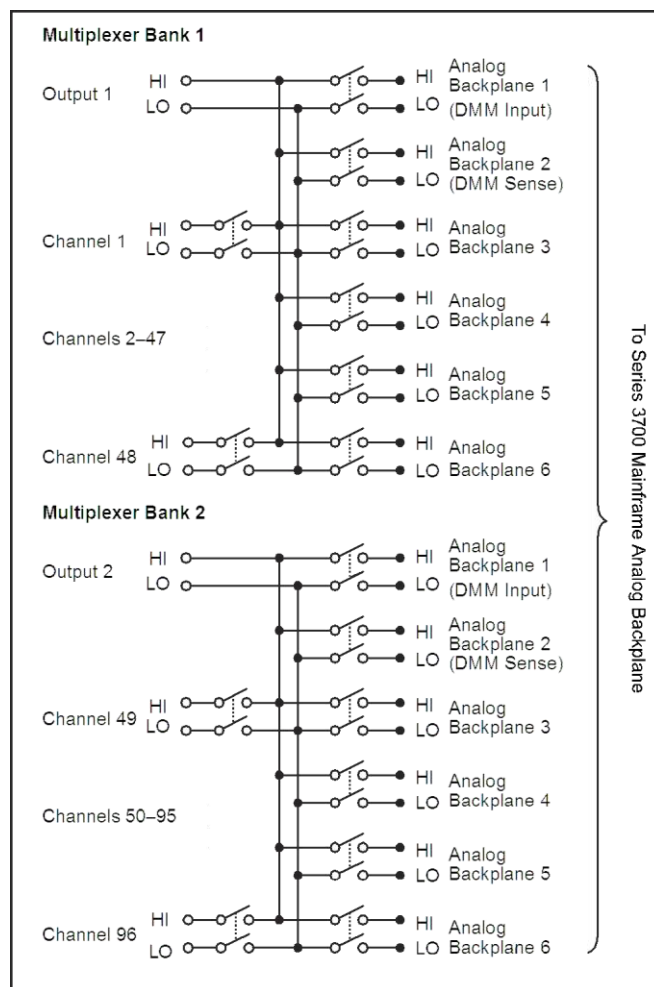
Model 3722 connection log

The following figures provides a sample of a connection log that can be used to record the wiring scheme for this module.

Figure 9-17: Sample Model 3722 connection log (1 of 3)

Channel		Color	Description
CH1	H		
	L		
CH2	H		
	L		
CH3	H		
	L		
CH4	H		
	L		
CH5	H		
	L		
CH6	H		
	L		
CH7	H		
	L		
CH8	H		
	L		
CH9	H		
	L		
CH10	H		
	L		
CH11	H		
	L		
CH12	H		
	L		
CH13	H		
	L		
CH14	H		
	L		
CH15	H		
	L		
CH16	H		
	L		
CH17	H		
	L		
CH18	H		
	L		
CH19	H		
	L		
CH20	H		
	L		
CH21	H		
	L		
CH22	H		
	L		
CH23	H		
	L		
CH24	H		
	L		
CH25	H		
	L		
CH26	H		
	L		
CH27	H		
	L		
CH28	H		
	L		
CH29	H		
	L		

Figure 9-18: Sample Model 3722 connection log (2 of 3)

Channel (cont.)		Color	Description
CH30	H		
	L		
CH31	H		
	L		
CH32	H		
	L		
CH33	H		
	L		
CH34	H		
	L		
CH35	H		
	L		
CH36	H		
	L		
CH37	H		
	L		
CH38	H		
	L		
CH39	H		
	L		
CH40	H		
	L		
CH41	H		
	L		
CH42	H		
	L		
CH43	H		
	L		
CH44	H		
	L		
CH45	H		
	L		
CH46	H		
	L		
CH47	H		
	L		
CH48	H		
	L		
CH49	H		
	L		
CH50	H		
	L		
CH51	H		
	L		
CH52	H		
	L		
CH53	H		
	L		
CH54	H		
	L		
CH55	H		
	L		
CH56	H		
	L		
CH57	H		
	L		
CH58	H		
	L		
CH59	H		
	L		
CH60	H		
	L		
CH61	H		
	L		
CH62	H		
	L		
CH63	H		
	L		

Figure 9-19: Sample Model 3722 connection log (3 of 3)

Channel (cont.)		Color	Description
CH64	H		
	L		
CH65	H		
	L		
CH66	H		
	L		
CH67	H		
	L		
CH68	H		
	L		
CH69	H		
	L		
CH70	H		
	L		
CH71	H		
	L		
CH72	H		
	L		
CH73	H		
	L		
CH74	H		
	L		
CH75	H		
	L		
CH76	H		
	L		
CH77	H		
	L		
CH78	H		
	L		
CH79	H		
	L		
CH80	H		
	L		
CH81	H		
	L		
CH82	H		
	L		
CH83	H		
	L		
CH84	H		
	L		
CH85	H		
	L		
CH86	H		
	L		
CH87	H		
	L		
CH88	H		
	L		
CH89	H		
	L		
CH90	H		
	L		
CH91	H		
	L		
CH92	H		
	L		
CH93	H		
	L		
CH94	H		
	L		
CH95	H		
	L		
CH96	H		
	L		

Model 3723 dual 1×30 high-speed multiplexer card

The Model 3723 has two independent banks of high-speed 1×30 two-pole multiplexers that are ideal for high-speed scanning applications. The two banks can automatically be connected to the Series 3700 mainframe backplane and optional DMM through the analog backplane connection relays. This connection allows the mainframe to reconfigure the Model 3723 as a single 1×60 two-pole multiplexer or as a single 1×30 single-pole multiplexer. It also enables card-to-card expansion for even larger configurations.

By using high-speed reed relays with actuation times of less than 0.5ms, this card can meet the requirements of demanding throughput applications. Another feature of the Model 3723 is its single-ended, one-pole mode, which supports up to 120 channels of single-wire measurements. The Model 3723 uses two 78-pin D-sub connectors for signal connections. For screw terminal connections, use the Model 3723-ST for two and four-pole configurations or the Model 37230-ST-1 for single-wire applications.

Figure 9-20: Model 3723
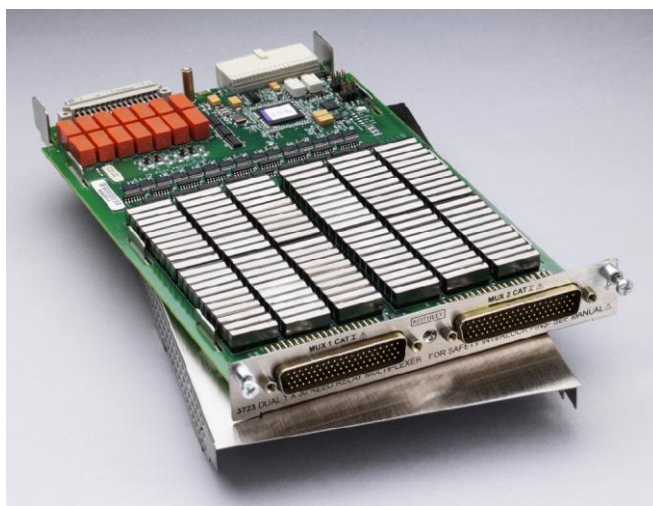
Available accessories: Model 3723

3720-MTC-1.5:	78-pin, female-to-male, D-sub cable assembly, 1.5m (4.9ft)
3720-MTC-3:	78-pin, female-to-male, D-sub cable assembly, 3m (9.8ft)
3723-ST:	Screw terminal panel
3723-ST-1:	Screw terminal panel (single pole)
3791-KIT78-R:	78-pin, female, D-sub connector kit (solder cup contacts). See *Connection information: Model 3723* (on page 9-29).

Connection information: Model 3723

Refer to the following figure for Model 3723 D-sub connection information.

Figure 9-21: D-sub connection information for the Model 3723
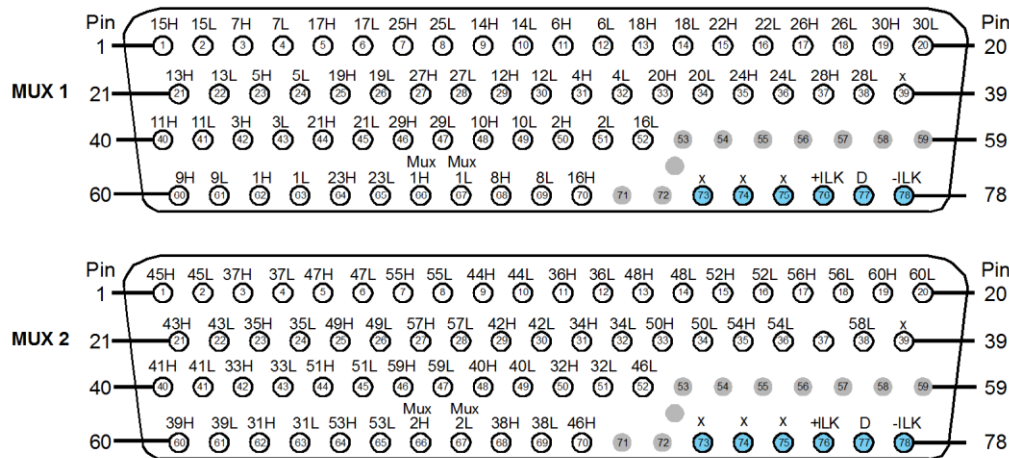
Schematics: Model 3723

The following figure provides a switching schematic for the Model 3723 in two-pole mode.

Figure 9-22: Schematic for the Model 3723 in two-pole mode
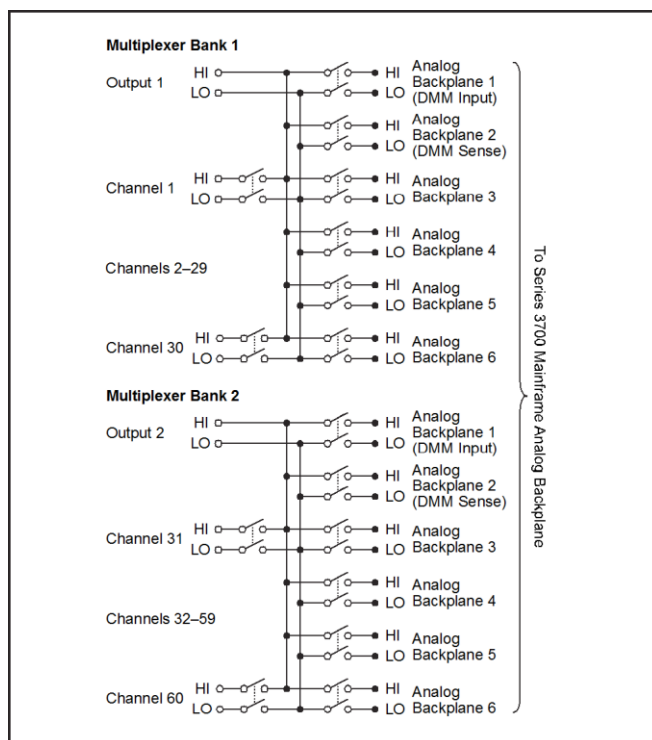
The following figure provides a switching schematic for the Model 3723 in single-pole mode.

Figure 9-23: Schematic: Model 3723 in one-pole mode
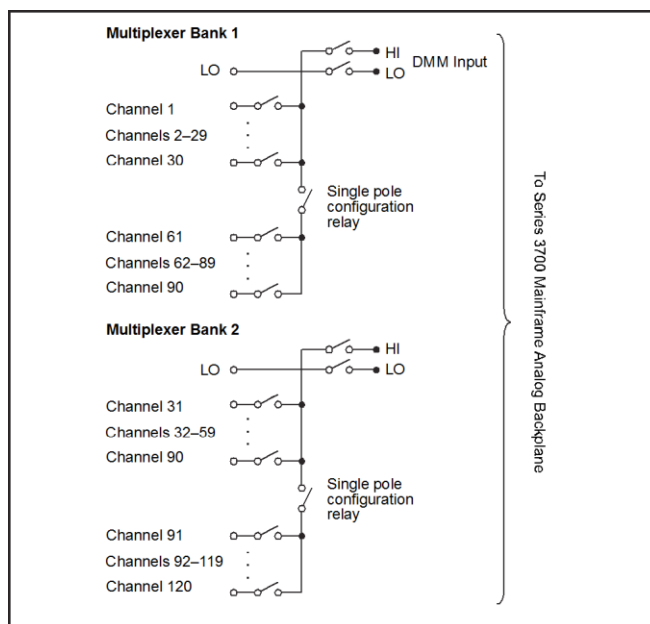
Model 3723 connection log (60 channel)

The following figures provides a sample of a connection log that can be used to record the wiring scheme for this module.

Figure 9-24: Sample Model 3723 connection log (60 channel)(1 of 2)

Channel		Color	Description
CH1	H		
	L		
CH2	H		
	L		
CH3	H		
	L		
CH4	H		
	L		
CH5	H		
	L		
CH6	H		
	L		
CH7	H		
	L		
CH8	H		
	L		
CH9	H		
	L		
CH10	H		
	L		
CH11	H		
	L		
CH12	H		
	L		
CH13	H		
	L		
CH14	H		
	L		
CH15	H		
	L		
CH16	H		
	L		
CH17	H		
	L		
CH18	H		
	L		
CH19	H		
	L		
CH20	H		
	L		
CH21	H		
	L		
CH22	H		
	L		
CH23	H		
	L		
CH24	H		
	L		
CH25	H		
	L		
CH26	H		
	L		
CH27	H		
	L		
CH28	H		
	L		
CH29	H		
	L		

Figure 9-25: Sample Model 3723 connection log (60 channel)(2 of 2)

Channel (cont.)		Color	Description
CH30	H		
	L		
CH31	H		
	L		
CH32	H		
	L		
CH33	H		
	L		
CH34	H		
	L		
CH35	H		
	L		
CH36	H		
	L		
CH37	H		
	L		
CH38	H		
	L		
CH39	H		
	L		
CH40	H		
	L		
CH41	H		
	L		
CH42	H		
	L		
CH43	H		
	L		
CH44	H		
	L		
CH45	H		
	L		
CH46	H		
	L		
CH47	H		
	L		
CH48	H		
	L		
CH49	H		
	L		
CH50	H		
	L		
CH51	H		
	L		
CH52	H		
	L		
CH53	H		
	L		
CH54	H		
	L		
CH55	H		
	L		
CH56	H		
	L		
CH57	H		
	L		
CH58	H		
	L		
CH59	H		
	L		
CH60	H		
	L		

Model 3723 connection log (120 channel)

The following figures provides a sample of a connection log that can be used to record the wiring scheme for this module.

Figure 9-26: Sample Model 3723 connection log (120 channel)(1 of 4)

Channel		Color	Description
CH1	H		
	L		
CH2	H		
	L		
CH3	H		
	L		
CH4	H		
	L		
CH5	H		
	L		
CH6	H		
	L		
CH7	H		
	L		
CH8	H		
	L		
CH9	H		
	L		
CH10	H		
	L		
CH11	H		
	L		
CH12	H		
	L		
CH13	H		
	L		
CH14	H		
	L		
CH15	H		
	L		
CH16	H		
	L		
CH17	H		
	L		
CH18	H		
	L		
CH19	H		
	L		
CH20	H		
	L		
CH21	H		
	L		
CH22	H		
	L		
CH23	H		
	L		
CH24	H		
	L		
CH25	H		
	L		
CH26	H		
	L		
CH27	H		
	L		
CH28	H		
	L		
CH29	H		
	L		

Figure 9-27: Sample Model 3723 connection log (120 channel)(2 of 4)

Channel (cont.)		Color	Description
CH30	H		
	L		
CH31	H		
	L		
CH32	H		
	L		
CH33	H		
	L		
CH34	H		
	L		
CH35	H		
	L		
CH36	H		
	L		
CH37	H		
	L		
CH38	H		
	L		
CH39	H		
	L		
CH40	H		
	L		
CH41	H		
	L		
CH42	H		
	L		
CH43	H		
	L		
CH44	H		
	L		
CH45	H		
	L		
CH46	H		
	L		
CH47	H		
	L		
CH48	H		
	L		
CH49	H		
	L		
CH50	H		
	L		
CH51	H		
	L		
CH52	H		
	L		
CH53	H		
	L		
CH54	H		
	L		
CH55	H		
	L		
CH56	H		
	L		
CH57	H		
	L		
CH58	H		
	L		
CH59	H		
	L		
CH60	H		
	L		

Figure 9-28: Sample Model 3723 connection log (120 channel)(3 of 4)

Channel (cont.)		Color	Description
CH61	H		
	L		
CH62	H		
	L		
CH63	H		
	L		
CH64	H		
	L		
CH65	H		
	L		
CH66	H		
	L		
CH67	H		
	L		
CH68	H		
	L		
CH69	H		
	L		
CH70	H		
	L		
CH71	H		
	L		
CH72	H		
	L		
CH73	H		
	L		
CH74	H		
	L		
CH75	H		
	L		
CH76	H		
	L		
CH77	H		
	L		
CH78	H		
	L		
CH79	H		
	L		
CH80	H		
	L		
CH81	H		
	L		
CH82	H		
	L		
CH83	H		
	L		
CH84	H		
	L		
CH85	H		
	L		
CH86	H		
	L		
CH87	H		
	L		
CH88	H		
	L		
CH89	H		
	L		
CH90	H		
	L		

Figure 9-29: Sample Model 3723 connection log (120 channel)(4 of 4)

Channel (cont.)		Color	Description
CH91	H		
	L		
CH92	H		
	L		
CH93	H		
	L		
CH94	H		
	L		
CH95	H		
	L		
CH96	H		
	L		
CH97	H		
	L		
CH98	H		
	L		
CH99	H		
	L		
CH100	H		
	L		
CH101	H		
	L		
CH102	H		
	L		
CH103	H		
	L		
CH104	H		
	L		
CH105	H		
	L		
CH106	H		
	L		
CH107	H		
	L		
CH108	H		
	L		
CH109	H		
	L		
CH110	H		
	L		
CH111	H		
	L		
CH112	H		
	L		
CH113	H		
	L		
CH114	H		
	L		
CH115	H		
	L		
CH116	H		
	L		
CH117	H		
	L		
CH118	H		
	L		
CH119	H		
	L		
CH120	H		
	L		

Model 3730 6×16 high-density matrix card

The Model 3730 is a two-pole, 6 row by 16 column matrix card. It can connect up to six differential instrument channels to any combination of 16 DUTs (devices under test). Any row can be connected to the Series 3700 mainframe backplane by using the analog backplane connection relays. This allows for easy matrix column expansion. A matrix of up to 6 rows by 96 columns can be supported within a single Model 3706 mainframe (with six Model 3730 cards).

The Model 3730 uses two 50-pin male D-sub connectors for signal connections. For screw terminal connections, use the detachable Model 3730-ST accessory.

Figure 9-30: Model 3730
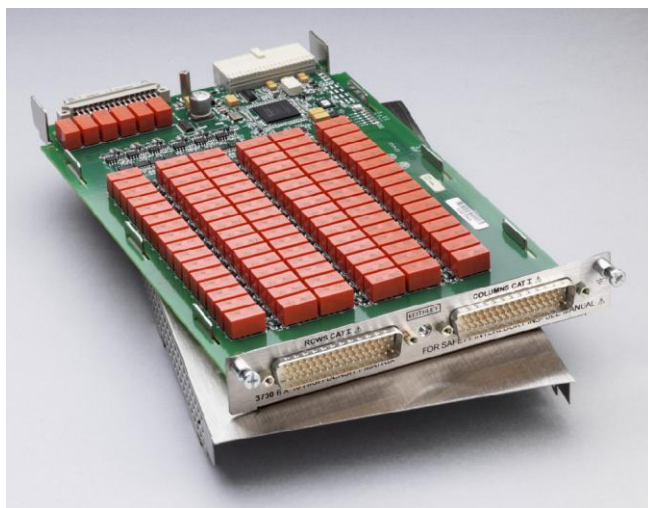
Available accessories: Model 3730

3721-MTC-1.5:   50-pin, female-to-male, D-sub cable assembly, 1.5m (4.9ft)

3721-MTC-3:   50-pin, female-to-male, D-sub cable assembly, 3m (9.8ft)

3730-ST: Screw terminal panel

3790-KIT50-R: 50-pin, female, D-sub connector kit (solder cup contacts). See *Connection information: Model 3730* (on page 9-39).

Connection information: Model 3730

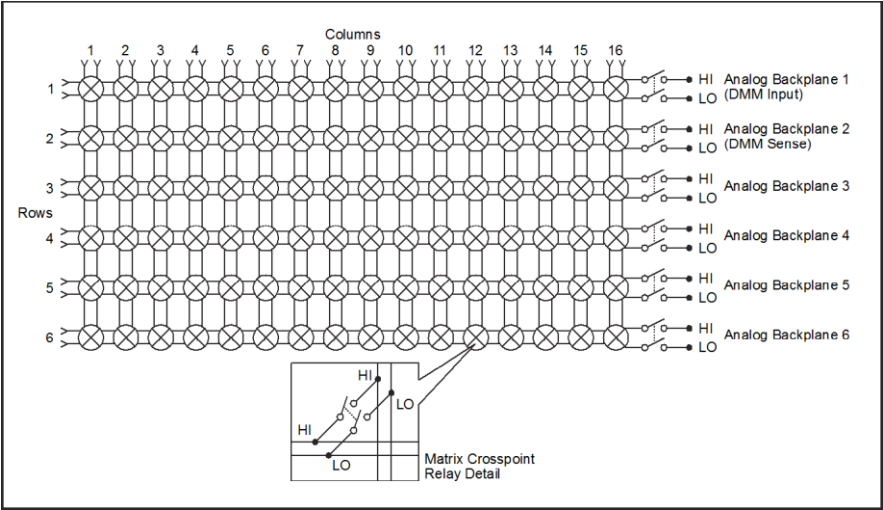Refer to the following figure for Model 3730 D-sub connection information.

Figure 9-31: D-sub connection information for the Model 3730
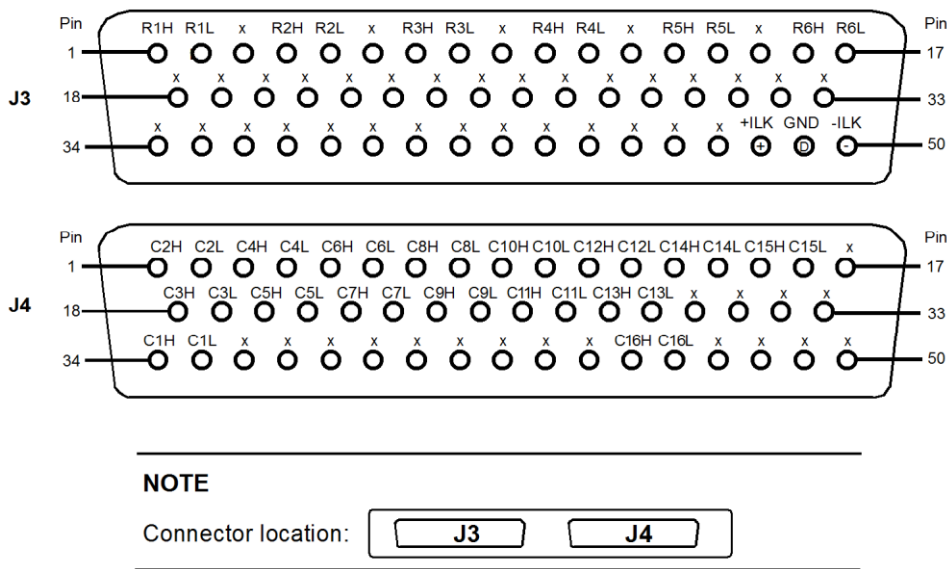
Schematics: Model 3730

The following figure provides a switching schematic for the Model 3730.

Figure 9-32: Schematic of the Model 3730

Model 3730 connection log

The following figures provides a sample of a connection log that can be used to record the wiring scheme for this module.

Figure 9-33: Sample Model 3730 connection log (1 of 3)

Channel		Color	Description
CH101	H		
	L		
CH102	H		
	L		
CH103	H		
	L		
CH104	H		
	L		
CH105	H		
	L		
CH106	H		
	L		
CH107	H		
	L		
CH108	H		
	L		
CH109	H		
	L		
CH110	H		
	L		
CH111	H		
	L		
CH112	H		
	L		
CH113	H		
	L		
CH114	H		
	L		
CH115	H		
	L		
CH116	H		
	L		
CH201	H		
	L		
CH202	H		
	L		
CH203	H		
	L		
CH204	H		
	L		
CH205	H		
	L		
CH206	H		
	L		
CH207	H		
	L		
CH208	H		
	L		
CH209	H		
	L		
CH210	H		
	L		
CH211	H		
	L		
CH212	H		
	L		
CH213	H		
	L		
CH214	H		
	L		
CH215	H		
	L		
CH216	H		
	L		

Figure 9-34: Sample Model 3730 connection log (2 of 3)

CH301	H		
	L		
CH302	H		
	L		
CH303	H		
	L		
CH304	H		
	L		
CH305	H		
	L		
CH306	H		
	L		
CH307	H		
	L		
CH308	H		
	L		
CH309	H		
	L		
CH310	H		
	L		
CH311	H		
	L		
CH312	H		
	L		
CH313	H		
	L		
CH314	H		
	L		
CH315	H		
	L		
CH316	H		
	L		
CH401	H		
	L		
CH402	H		
	L		
CH403	H		
	L		
CH404	H		
	L		
CH405	H		
	L		
CH406	H		
	L		
CH407	H		
	L		
CH408	H		
	L		
CH409	H		
	L		
CH410	H		
	L		
CH411	H		
	L		
CH412	H		
	L		
CH413	H		
	L		
CH414	H		
	L		
CH415	H		
	L		
CH416	H		
	L		
CH501	H		
	L		

Figure 9-35: Sample Model 3730 connection log (3 of 3)

CH502	H		
	L		
CH503	H		
	L		
CH504	H		
	L		
CH505	H		
	L		
CH506	H		
	L		
CH507	H		
	L		
CH508	H		
	L		
CH509	H		
	L		
CH510	H		
	L		
CH511	H		
	L		
CH512	H		
	L		
CH513	H		
	L		
CH514	H		
	L		
CH515	H		
	L		
CH516	H		
	L		
CH601	H		
	L		
CH602	H		
	L		
CH603	H		
	L		
CH604	H		
	L		
CH605	H		
	L		
CH606	H		
	L		
CH607	H		
	L		
CH608	H		
	L		
CH609	H		
	L		
CH610	H		
	L		
CH611	H		
	L		
CH612	H		
	L		
CH613	H		
	L		
CH614	H		
	L		
CH615	H		
	L		
CH616	H		
	L		

Model 3740 32-channel isolated switch card

The Model 3740 offers 28 general-purpose form C channels that are ideal for routing power or other control devices. For higher power applications of up to 7A, four additional high-current form A channels are provided.

If any general-purpose signal requires routing to the Series 3700 mainframe backplane, terminal blocks that can be enabled through jumpers are located on the card. Custom configurations can be created with the user-accessible terminal blocks. For additional protection, an onboard temperature sensor will notify the mainframe when the card's operating temperature exceeds 70°C, compromising system specifications.

The Model 3740 uses two 50-pin male D-sub connectors for signal connections. For screw terminal connections, use the detachable Model 3740-ST accessory.

Figure 9-36: Model 3740
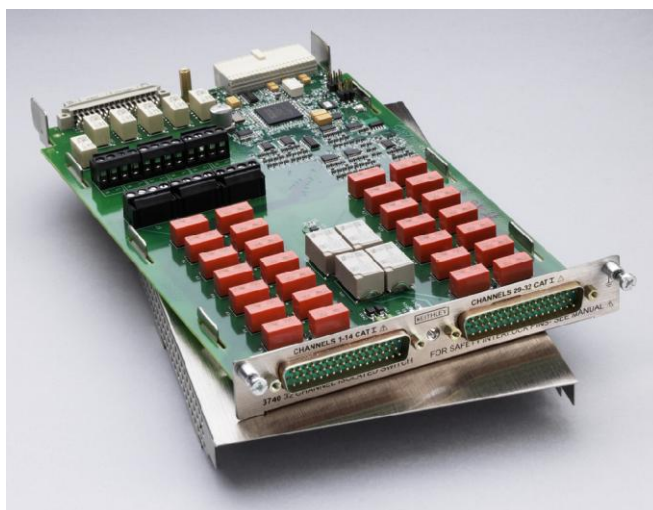
Available accessories: Model 3740

3721-MTC-1.5:   50-pin, female-to-male, D-sub cable assembly, 1.5m (4.9ft)

3721-MTC-3:   50-pin, female-to-male, D-sub cable assembly, 3m (9.8ft)

3740-ST: Screw terminal panel

3790-KIT50-R: 50-pin, female, D-sub connector kit (solder cup contacts). See *Connection information: Model 3740* (on page 9-44).

Connection information: Model 3740

Refer to the following figure for Model 3740 D-sub connection information.

Figure 9-37: D-sub connection information for the Model 3740
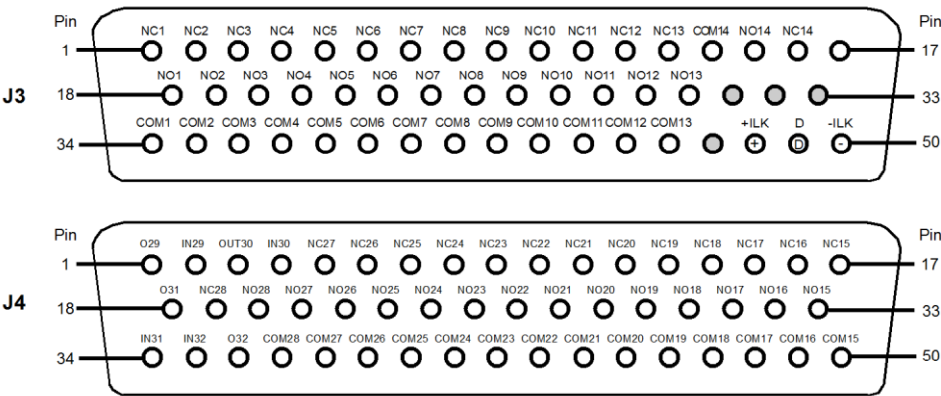
NOTE

Connector location: J3   J4

Schematics: Model 3740

The following figure provides a switching schematic for the Model 3740.

Figure 9-38: Schematic for the Model 3740
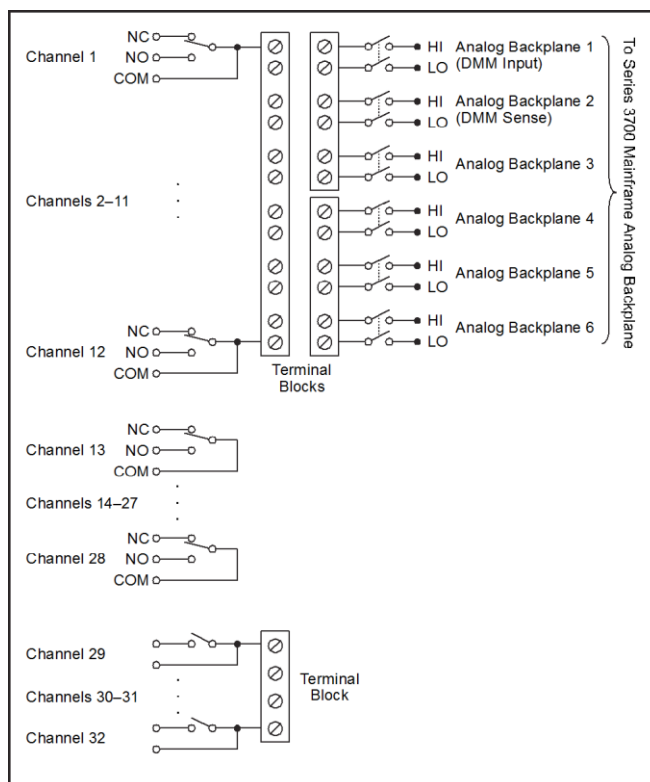
Model 3740 Connection log

The following figure provides a sample of a connection log that can be used to record the wiring scheme for this module.

Figure 9-39: Sample Model 3740 connection log

Channel		Color	Description
CH1	H		
	L		
CH2	H		
	L		
CH3	H		
	L		
CH4	H		
	L		
CH5	H		
	L		
CH6	H		
	L		
CH7	H		
	L		
CH8	H		
	L		
CH9	H		
	L		
CH10	H		
	L		
CH11	H		
	L		
CH12	H		
	L		
CH13	H		
	L		
CH14	H		
	L		
CH15	H		
	L		
CH16	H		
	L		
CH17	H		
	L		
CH18	H		
	L		
CH19	H		
	L		
CH20	H		
	L		
CH21	H		
	L		
CH22	H		
	L		
CH23	H		
	L		
CH24	H		
	L		
CH25	H		
	L		
CH26	H		
	L		
CH27	H		
	L		
CH28	H		
	L		
CH29	H		
	L		
CH30	H		
	L		
CH31	H		
	L		
CH32	H		
	L		

Specifications

In this section:

3706 Multimeter / Data Acquisition System

DC SPECIFICATIONS

CONDITIONS: MED (1 PLC) or SLOW (5 PLC).
For <1PLC, add appropriate "ppm of range" adder from "RMS Noise" table.
Includes rear panel Analog Backplane connector and transducer conversion. Refer to DC Notes for additional card uncertainties.

Accuracy: +/- (ppm of reading + ppm of range)
(ppm = parts per million) (e.g., 10ppm = 0.001%)

Function	Range [1]	Resolution	Test Current or Burden Voltage	Input Resistance or Open Ckt. Voltage [2]	24 Hour [3] 23°C ± 1°	90 Day 23°C ± 5°	1 Year 23°C ± 5°	Temperature Coefficient 0° -18°C & 28° - 50°C
Voltage [4]	100.00000 mV [19]	0.01µV		>10G Ω or 10M Ω ± 1%	10 + 9	25 + 9	30 + 9	(1 + 5)/ °C
	1.0000000 V [19]	0.1µV		>10G Ω or 10M Ω ± 1%	7 + 2	25 + 2	30 + 2	(1 + 1)/ °C
	10.000000 V	1µV		>10G Ω or 10M Ω ± 1%	7 + 2	20 + 2	25 + 2	(1 + 1)/ °C
	100.00000 V	10µV		10M Ω ± 1%	15 + 6	35 + 6	40 + 6	(5 + 1)/ °C
	300.00000 V	100µV		10M Ω ± 1%	20 + 6	35 + 6	40 + 6	(5 + 1)/ °C
Resistance [5,6,7]	1.0000000 Ω	0.1µΩ	10mA	8.2V	15 + 80	40 + 80	60 + 80	(8 + 1)/ °C
	10.000000 Ω	1µΩ	10mA	8.2V	15 + 9	40 + 9	60 + 9	(8 + 1)/ °C
	100.00000 Ω	10µΩ	1mA	13.9V	15 + 9	40 + 9	60 + 9	(8 + 1)/ °C
	1.0000000 kΩ	100µΩ	1mA	13.9V	20 + 4	45 + 4	65 + 4	(8 + 1)/ °C
	10.000000 kΩ	1m Ω	100µA	9.1V	15 + 4	40 + 4	60 + 4	(8 + 1)/ °C
	100.00000 kΩ [4]	10m Ω	10µA	14.7V	20 + 4	45 + 4	65 + 4	(8 + 1)/ °C
	1.0000000 MΩ [4]	100m Ω	10µA	14.7V	25 + 4	50 + 4	70 + 4	(8 + 1)/ °C
	10.000000 MΩ	1 Ω	0.64µA // 10MΩ	6.4V	150+ 6	200 +10	400 + 10	(70 + 1)/ °C
	100.00000 MΩ	10 Ω	0.64µA // 10MΩ	6.4V	800+ 30	2000 +30	2000 + 30	(385 + 1)/ °C
Dry Circuit Resistance [6,8]	1.0000000 Ω	1µΩ	10mA	27mV	25 + 80	50 + 80	70 + 80	(8 + 1)/ °C
	10.000000 Ω	10µΩ	1mA	20mV	25 + 80	50 + 80	70 + 80	(8 + 1)/ °C
	100.00000 Ω	100µΩ	100µA	20mV	25 + 80	90 + 80	140 + 80	(8 + 1)/ °C
	1.0000000 kΩ	1mΩ	10µA	20mV	25 + 80	180 + 80	400 + 80	(8 + 1)/ °C
	2.0000000 kΩ	10m Ω	5µA	20mV	25 + 80	320 + 80	800 + 80	(8 + 1)/ °C
Continuity (2W)	1.000 kΩ	100mΩ	1mA	13.9V	40 + 100	100 + 100	100 + 100	(8 + 1)/ °C
Current [9]	10.000000 µA	1ρA	<61mV		40 + 30	300 + 30	500 + 30	(35 +5)/ °C
	100.00000 µA	10ρA	<105mV		50 + 9	300 + 9	500 + 9	(50 +5)/ °C
	1.0000000 mA	100ρA	<130mV		50 + 9	300 + 9	500 + 9	(50 +5)/ °C
	10.000000 mA	1ηA	<150mV		50 + 9	300 + 9	500 + 9	(50 +5)/ °C
	100.00000 mA	10ηA	<0.4V		50 + 9	300 + 9	500 + 9	(50 +5)/ °C
	1.0000000 A	100ηA	<0.6V		200 + 10	500 + 10	800 + 10	(50 +5)/ °C
	3.0000000 A	1µA	<1.8V		1000 + 15	1200 + 15	1200 + 15	(50 +5)/ °C

Temperature

(Displayed in °C, °F, or K. Exclusive of probes errors.)
Thermocouples (Accuracy based on ITS-90.)

Type	Range	Resolution	90 Day /1 Year 23°C ± 5° Relative to Simulated Reference Junction	Using 3720 or 3721 Cards	Range	Using 3720 or 3721 Cards	Temperature Coefficient 0° -18°C & 28° - 50°C
J	-150 to +760 °C	0.001°C	0.2°C	1.0°C	-200 to -150 °C	1.5°C	0.03°C/°C
K	-150 to +1372°C	0.001°C	0.2°C	1.0°C	-200 to -150°C	1.5°C	0.03°C/°C
N	-100 to +1300 °C	0.001°C	0.2°C	1.0°C	-200 to -100 °C	1.5°C	0.03°C/°C
T	-100 to +400°C	0.001°C	0.2°C	1.0°C	-200 to -100°C	1.5°C	0.03°C/°C
E	-150 to +1000°C	0.001°C	0.2°C	1.0°C	-200 to -100°C	1.5°C	0.03°C/°C
R	+400 to +1768°C	0.1°C	0.6°C	1.8°C	0 to +400°C	2.3°C	0.03°C/°C
S	+400 to +1768°C	0.1°C	0.6°C	1.8°C	0 to +400°C	2.3°C	0.03°C/°C
B	+1100 to +1820°C	0.1°C	0.6°C	1.8°C	+350 to +1100°C	2.8°C	0.03°C/°C

4-Wire RTD or 3-Wire RTD: (100Ω platinum [PT100], D100, F100, PT385, PT3916, or user 0Ω to 10kΩ.   Selectable Offset compensation On or Off).
For 3-Wire RTD, dmm.connect=dmm.CONNECT_FOUR_WIRE, ≤ 0.1Ω lead resistance mis-matching in Input HI and LO. Add 0.25°C/ 0.1Ω of lead resistance mis-match.

	Range	Resolution					Temperature Coefficient
4-Wire RTD	-200 to +630°C	0.01°C	0.06°C				0.003°C/°C
3-Wire RTD	-200 to +630°C	0.01°C	0.75°C				0.003°C/°C

Thermistor: (2.2kΩ, 5k Ω, and 10kΩ)

	Range	Resolution					
	-80 to +150°C	0.01°C	0.08°C				0.002°C/°C

DC Speeds vs. RMS Noise [10, 11] Single Channel, 60Hz (50Hz) Operation				RMS Noise [16] PPM of Range — RMS Noise calculator — Add 2.5 x "RMS Noise" to "ppm of range" (e.g. 10V @ 0.006plc) "ppm of range" = 2.5 x 7.0ppm + 2ppm					Measurements into Buffer [13] (Rdg/s)		Measurement to PC [13] (ms / Rdg) AzeroOff		
Function	NPLC	Aperture (ms)	Digits	100mV	1V	10V	100V	300V	Azero On	Azero Off	Enet	GPIB	USB
DCV	5 [14]	83.3 (100)	7-½	1.0	0.07	0.05	0.7	0.2	9.5 (8)	12 (10)	86.3 (104)	86.1 (102.8)	86.3 (103.1)
	1 [14]	16.7 (20)	7-½	0.9	0.12	0.1	0.8	0.35	42 (33)	59.8 (49.5)	19.4 (22.7)	19.5 (22.8)	19.9 (23.2)
	0.2 [12, 14]	3.33 (4.0)	6-½	2.5	0.32	0.3	2.5	1.0	50 (40)	60 (50)	19.4 (22.7)	19.5 (22.8)	19.9 (23.2)
	0.2 [14]	3.33 (4.0)	6-½	3.5	6.0	0.7	3.5	1.5	120 (100)	295 (235)	7.6 (8.3)	6.2 (6.8)	6.4 (7.0)
	0.06 [15]	1.0 (1.2)	5-½	12	10	1.5	4.0	3.5	205 (165)	935 (750)	1.40 (1.80)	1.50 (1.80)	1.60 (2.30)
	0.006 [15]	0.100 (0.120)	4-½	55	15	7.0	70	35	218 (215)	6,200 (5,500)	0.55 (0.57)	0.65 (0.67)	0.75 (0.77)
	0.0005 [15]	0.0083 (0.001)	3-½	325	95	95	900	410	270 (270)	14,600 (14,250)	0.50 (0.5)	0.60 (0.60)	0.70 (0.70)
				10-100Ω	1KΩ	10KΩ							
2WΩ (≤10kΩ)	5 [14]	83.3 (100)	7-½	2.0	0.5	0.4	—	—	9.5 (8)	12 (10)	87.0 (105)	86.1 (103)	86.5 (104)
	1 [14]	16.7 (20)	7-½	3.5	0.8	0.6	—	—	42 (33)	59.8 (49.5)	21.0 (24.3)	19.5 (22.8)	19.9 (23.2)
	0.2 [12, 14]	3.33 (4.0)	6-½	6.5	1.7	1.5	—	—	50 (40)	60 (50)	21.0 (24.3)	19.5 (22.8)	19.9 (23.2)
	0.2 [14]	3.33 (4.0)	6-½	8.0	4.5	5.5	—	—	120 (100)	295 (235)	7.6 (8.3)	6.2 (6.8)	6.4 (7.0)
	0.06 [15]	1.0 (1.2)	5-½	15	6	6.5	—	—	205 (165)	935 (750)	1.40 (1.80)	1.50 (1.80)	1.60 (2.30)
	0.006 [15]	0.100 (0.120)	4-½	60	15	15	—	—	218 (215)	6,200 (5,500)	0.55 (0.57)	0.65 (0.67)	0.75 (0.77)
	0.0005 [15]	0.0083 (0.001)	3-½	190	190	190	—	—	270 (270)	14,100 (13,700)	0.50 (0.5)	0.60 (0.60)	0.70 (0.70)
				10μA	100μA	1mA-1A	3A						
DCI	5 [14]	83.3 (100)	7-½	3.5	1.3	1.2	0.4	—	9.5 (8)	12 (10)	88 (103)	86.1 (102.8)	86.3 (103.1)
	1 [14]	16.7 (20)	6-½	3.5	0.9	1.4	0.9	—	42 (33)	59.8 (49.5)	21.0 (22.7)	19.5 (22.8)	19.8 (23.1)
	0.2 [12, 14]	3.33 (4.0)	5-½	300	10	10	4.0	—	50 (40)	60 (50)	19.4 (22.7)	19.5 (22.8)	19.8 (23.1)
	0.2 [14]	3.33 (4.0)	4-½	300	35	20	4.0	—	120 (100)	295 (235)	7.6 (8.3)	6.2 (6.8)	6.4 (7.0)
	0.06 [15]	1.0 (1.2)	4-½	350	35	20	4.0	—	205 (165)	935 (750)	1.40 (1.80)	1.50 (1.80)	1.60 (2.30)
	0.006 [15]	0.100 (0.120)	4-½	400	45	25	110	—	218 (215)	6,200 (5,500)	0.55 (0.57)	0.65 (0.67)	0.75 (0.77)
	0.0005 [15]	0.0083 (0.001)	3-½	2500	450	250	375	—	270 (270)	14,100 (13,700)	0.50 (0.5)	0.60 (0.60)	0.70 (0.70)
				1Ω	10-100Ω	1KΩ	10KΩ						
4WΩ	5 [14]	83.3 (100)	7-½	3.5	3.0	0.5	0.5		5 (4)	5.9 (4.7)	173 (206)	173 (206)	173 (206)
	1 [14]	16.7 (20)	7-½	5.0	0.5	0.5	0.7		23.5 (18.5)	29 (23)	39 (46)	39 (46)	39 (46)
	0.2 [12, 14]	3.33 (4.0)	5-½	10	30	10	50		26.5 (21)	30 (24)	39 (46)	39 (46)	39 (46)
	0.2 [14]	3.33 (4.0)	5-½	300	50	10	63		80 (60)	120 (95)	12.3 (14.5)	11.3 (13.3)	11.7 (13.7)
	0.06 [15]	1.0 (1.2)	4-½	500	50	15	70		140 (110)	285 (225)	6.2 (7.2)	6.3 (7.3)	6.5 (7.6)
	0.006 [15]	0.100 (0.120)	4-½	750	75	30	100		200 (195)	580 (565)	4.2 (4.4)	4.3 (4.5)	4.6 (4.8)
	0.0005 [15]	0.0083 (0.001)	3-½	3500	450	250	250		210 (205)	650 (645)	4.2 (4.4)	4.3 (4.5)	4.6 (4.8)
				1Ω	10-100Ω	1KΩ	10KΩ						
4WΩ OCOMP	5 [14]	83.3 (100)	7-½	4.0	3.0	0.5	0.5	—	2.5 (2.0)	2.9 (2.3)	343 (427)	341 (425)	342 (426)
	1 [14]	16.7 (20)	7-½	11	1.5	0.7	1.5	—	12.7(10)	14 (11.2)	77 (95)	74 (92)	75 (93)
	0.2 [12, 14]	3.33 (4.0)	6-½	30	3.5	2.1	3.5	—	14 (11.2)	15 (12)	70 (86.5)	70 (86.5)	70 (86.5)
	0.2 [14]	3.33 (4.0)	5-½	500	50	13	30	—	46.5 (37)	56 (44)	22.7 (25)	20.5 (23)	21.1 (24)
	0.0005 [15]	0.0083 (0.001)	3-½	4500	650	400	400	—	129 (125)	215 (210)	6.7 (6.7)	6.8 (6.8)	7 (7)
				1-10Ω	100Ω	1KΩ	2KΩ						
Dry-CktΩ OCOMP	5 [14]	83.3 (100)	6-½	8.0	10	10	8.0	—	2.5 (2.0)	2.9 (2.3)	347 (430)	345 (428)	346 (429)
	1 [14]	16.7 (20)	5-½	17	22	25	28	—	12 (9.5)	13 (10)	80 (99)	77 (95)	78 (97)
	0.2 [12, 14]	3.33 (4.0)	4-½	50	50	50	50	—	14 (11.2)	15 (12)	70 (86.5)	70 (86.5)	70 (86.5)
	0.2 [14]	3.33 (4.0)	3-½	500	1000	1000	1500	—	35 (30)	45 (36)	27 (33)	25 (31)	26 (32)
	0.0005 [15]	0.0083 (0.001)	2-½	8500	8500	8500	8500	—	84 (84)	115 (110)	10.7 (10.7)	10.7 (10.7)	11 (11)

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System Performance [13, 14]

4-1/2 Digit Mode, azero off and nPLC=0.0005

Function	Function Change (msec)	Range Change (msec)	Auto-range (msec)
DCV or 2WΩ (<10KΩ)	10	10	10
4WΩ (<10k)	20	20	20
DCI	10	10	10
Frequency or Period	22	10	—
ACV or ACI[17]	85	85	300

Buffer Transfer Speed	Enet	GPIB	USB
Average for 1000 readings	2450/s	2000/s	1800/s
Average for 1000 readings with timestamp	2300/s	1800/s	1600/s

			Single Command Excecution time (ms)		
Card	Command		Enet	GPIB	USB
3720, 3721, 3722, 3730	channel.close (ch_list) or channel.open (ch_list)		5.7	5.8	6.1
3723[18]	channel.close (ch_list) or channel.open (ch_list)		2.3	2.4	2.7
3740	channel.close (ch_list 1-28) or channel.open (ch_list 1-28)		10.7	10.8	11.1
	channel.close (ch_list 29-32) or channel.open (ch_list 29-32)		22.7	22.8	23.1

AC Speeds Single Channel, 60Hz (50Hz) Operation				Measurements into Buffer [13] (Rdg/s)		Measurement to PC [13] (ms / Rdg)		
Function	NPLC	Aperture (ms)	Digits	Azero On	Azero Off	Enet	GPIB	USB
ACI / ACV	SLOW	n/a	6-½	0.45 (0.45)	n/a	2150 (2150)	2150 (2150)	2150 (2150)
	MED	n/a	6-½	2.5 (2.5)	n/a	400 (400)	400 (400)	400 (400)
	1.0[14]	16.67 (20)	6-½	42 (33)	59.5 (50)	19.4 (22.7)	19.5 (22.8)	19.8 (23.1)
	0.2[14]	3.33 (4.0)	6-½	120 (100)	295 (235)	7.6 (8.3)	6.2 (6.8)	6.4 (7.0)
	0.06[15]	1.0 (1.2)	5-½	170 (165)	935 (750)	1.40 (1.80)	1.50 (1.80)	1.60 (2.30)
	0.006[15]	0.100 (0.120)	4-½	218 (215)	6,200 (5,500)	0.55 (0.57)	0.65 (0.67)	0.75 (0.77)
	0.0005[15]	0.0083 (0.001)	3-½	218 (215	14,600 (14,250)	0.50 (0.5)	0.60 (0.60)	0.70 (0.70)
Frequency / Period	n/a	SLOW, MED, FAST	n/a	2x input period + Gate time	n/a	2x input period + Gate time + 2.7ms	2x input period + Gate time + 2.8ms	2x input period + Gate time + 3.1ms

DC Measurement Characteristics

DC Volts:
A-D LINEARITY: 1.0 ppm of reading + 2.0 of range.
INPUT IMPEDANCE:
    100mV – 10V Ranges: Selectable >10GΩ// <400pF or 10MΩ ±1%.
    100V – 300Vranges: 10MΩ ±1%.
Input Bias Current: <50pA at 23°C with dmm.autozero=dmm.OFF or dmm.inputdivider=dmm.ON.
Common Mode Current: <500nA peak-to-peak for ≤1MHz.
Autozero OFF Error: For DCV ±1°C and <10minutes,
    Add ±(8ppm of reading + 5µV).
Input Protection: 300V all ranges.
Common Mode Voltage: 300V DC or 300Vrms (425V peak for AC waveforms) between any terminal and chassis.

Resistance:
MAX 4WΩ LEAD RESISTANCE: 5Ω per lead for 1Ω range, 10% of range for 10Ω → 1kΩ ranges; 1kΩ per lead for all other ranges.
For Dry Ckt.
MAX 4WΩ LEAD RESISTANCE: 0.5Ω per lead for 1Ω range; 10% of range per lead for 10Ω → 100Ω ranges; 50Ω per lead for 1kΩ → 2kΩ range.
INPUT IMPEDANCE:
    1Ω – 100Ω Ranges: 99kΩ ±1% // <1µF.
    1KΩ – 2KΩ Ranges: 10MΩ ±1% // <0.015µF.
OFFSET COMPENSATION: Selectable on 4WΩ 1Ω →10kΩ ranges.
OPEN LEAD DETECTOR: Selectable per channel. 1.5uA, ±20% sink current per DMM SHI and SLO lead. Default on.
CONTINUITY THRESOLD: Adjustable 1 to 1000Ω.
Autozero OFF Error: For 2WΩ ±1°C and <10minutes,
    Add ±(8ppm of reading + 0.5mΩ for 10Ω and 5mΩ for all other ranges).
INPUT PROTECTION: 300V all ranges.

DC Current:
Autozero OFF Error: For ±1°C and <10minutes,
    Add ±(8ppm of reading + range error). Refer to table below.

Range	3A	1A	100mA	10mA	1mA	100µA	10µA
Shunt Resistance guarantee by design	0.1Ω	0.1Ω	1Ω	10Ω	100Ω	1kΩ	6kΩ
Burden Voltage	<1.8V	<0.6V	<0.4V	<150mV	<130mV	<105mV	<61mV
Burden Voltage with 3721 card	<2.4V	<1.2V	<0.4V	<150mV	<130mV	<105mV	<61mV
Autozero OFF "of range" Error	50µA	50µA	5µA	0.5µA	50ηA	5ηA	0.85ηA

INPUT PROTECTION: 3A, 250V fuse.

Thermocouples:
CONVERSION: ITS-90.
REFERENCE JUNCTION: Internal, External, or Simulated (Fixed).
OPEN LEAD DETECTOR: Selectable per channel. Open >1.15k ±50Ω. Default on.

COMMON MODE ISOLATION: 300V DC or 300Vrms (425V peak for AC waveforms), >10GΩ and <350ρF any terminal to chassis.

DC Notes

1. 20 % overrange except 1% on 300V and 3.33% on 3A.
2. ±5% (Measured with 10MΩ input Resistance DMM, >10GΩ DMM on 10MΩ and 100MΩ ranges). Refer to table for other 2W/4W configurations. For Dry Circuit, +20%, <1mV with dmm.offsetcompensation=ON for 100Ω → 2kΩ ranges.

Range	2W	4W	4W-Kelvin	Ocomp 4W	Ocomp 4W -Kelvin
1, 10Ω	8.2V	8.2V	8.2V	12.1V	12.1V
100, 1kΩ	13.9V	14.1V	13.9V	15.0V	12.7V
10kΩ	9.1V	9.1V	9.1V	0.0V	0.0V
100k, 1MΩ	12.7V	14.7V	12.7V	—	—
10M, 100MΩ	6.4V	6.4V	6.4V	—	—

3. Relative to calibration accuracy.
4. Add the following additional uncertainty:

Card	DCV "of range"	100kΩ "of reading + of range"	1MΩ "of reading"
3720, 3721 , 3730	4.5µV	8ppm + 7pm	8ppm
3722	4.5µV	8ppm + 7ppm	8ppm
3723	6µV	8ppm + 7ppm	8ppm

5. Specifications are for 4-wire Ω, 1Ω→ 100Ω with offset compensation on. Model 3700 plug-in cards with LSYNC and offset compensation on. 2-wire Ω specifications are for dmm.connect=dmm.CONNECT_ALL.
   For 2-wire Ω, add the following to "ppm of range" uncertainty,
   700mΩ with dmm.connect=dmm.CONNECT_TWO_WIRE, 100mΩ with REL, and 1.5Ω without REL.
   1Ω range is 4-wire only.
6. Test current with dmm.offsetcompensation=OFF, (± 5%).
7. Add the following to "ppm of reading" uncertainty when using 3700 plug in cards in Operating Environment ≥50%RH.

Card	10kΩ	100kΩ	1MΩ	10MΩ	100MΩ
3720, 3721, 3730 with MTC D-Shell connector	1ppm	10 ppm	0.01%	0.1%	1%
3722, 3723 and 3720, 3721, 3730 with –ST screw terminal module	10ppm	100 ppm	0.1%	1%	10%

    3700 plug in cards Operating Environment: Specified for 0°C to 50°C, ≤70%RH at 35°C.
8. For 4-wire Ω only, offset compensation and LSYNC on. For Models 3722 and 3723, 10Ω →2kΩ ranges only.
9. Includes Analog Backplane 15-pin rear panel connector. For 3721, refer to DC Current table for additional uncertainties.
10. For L_{SYNC} On, line frequency +/-0.1 %.

	nPLC	5	1	0.2	<0.2
L_{SYNC} On	NMRR	110 dB	90dB	70dB	—
L_{SYNC} Off	NMRR	60dB, ±2dB	60dB, ±2dB	—	—

11. For 1kohm unbalance in LO lead. AC CMRR is 70dB.

nPLC	5	1	0.2[12]	≤0.2
CMRR	140 dB	140dB	120dB	80dB

12. For L_{SYNC} On.
13. Reading rates are for 60Hz (50Hz) operation using factory defaults operating conditions dmm.reset("all"), Autorange off, Limits off, dmm.autodelay=dmm.ON, dmm.opendetector=dmm.OFF, format.data.=format.SREAL, DCV=10V, 2W/4W=1KΩ, DCI=1mA, Dry-Ckt=10Ω, ACI=1mA, and ACV=1V. For Dry-Ckt 100Ω and 2KΩ, 60rdg/s max with offset compensation OFF and 29.5rdg/s max with offset compensation ON. For Temperature reading rates use DCV for T/C, 2WΩ for Thermistor, and 4WΩ for RTD. Speeds include measurements and binary data transfer out the Enet, GPIB or USB.
14. DMM configured for single reading, dmm.measurecount=1 and print(dmm.measure()).
15. DMM configured for multi-sample readings and single buffer transfer, dmm.measurecount=1000, buf=dmm.makebuffer(1000), dmm.measure(buf), and printbuffer(1, 1000, buf).
16. dmm.autozero=dmm.ON. RMS Noise using low thermal short for DCV, 2WΩ, 4WΩ, and Dry-Ckt Ω. For DCI, dmm.connect=dmm.CONNECT_NONE or 0. Includes Model 3721 card accuracies.
17. For DC, dmm.nplc=0.0005. For AC, dmm.detectorbandwidth=300, dmm.nplc=0.0005. For ACI, dmm.autodelay=dmm.ON (50ms), max rate is 50ms and ACV dmm.autodelay=dmm.ON (50ms), max rate is 50ms.
18. Speeds are within same Mux bank. Add an additional 8msec when changing banks or slots.
19. When properly zeroed using REL function.

End dc

AC

Accuracy: ± (% of reading + % of range)   23°C ± 5°

Function	Range[1]	Resolution	Calibration Cycle	3 Hz – 5Hz	5Hz – 10Hz	10Hz – 20kHz	20kHz – 50kHz	50kHz – 100kHz	100kHz – 300kHz
Voltage[2]	100.0000mV	0.1µV	90 Day (all ranges)	1.0 + 0.03	0.30 + 0.03	0.05 + 0.03	0.11 + 0.05	0.6 + 0.08	4.0 + 0.5
	1.000000V	1µV							
	10.00000V	10µV	1 Year (all ranges)	1.0 + 0.03	0.30 + 0.03	0.06 + 0.03	0.12 + 0.05	0.6 + 0.08	4.0 + 0.5
	100.0000V	100µV							
	300.0000V	1mV							
			Temp. Coeff. /°C[3]	0.010 + 0.003	0.030 + 0.003	0.005 + 0.003	0.006 + 0.005	0.01 + 0.006	0.03 + 0.01

				3 Hz – 5Hz	5 Hz – 10Hz	10Hz – 2kHz	2kHz – 5kHz	5kHz – 10kHz
Current[2]	1.000000mA[8]	1ηA		1.0 + 0.04	0.30 + 0.04	0.08 + 0.03	0.09 + 0.03	0.09 + 0.03
	10.00000mA	10ηA		1.0 + 0.04	0.30 + 0.04	0.08 + 0.03	0.09 + 0.03	0.09 + 0.03
	100.0000mA	100ηA	90 Day / 1 Year (all ranges)	1.0 + 0.04	0.30 + 0.04	0.08 + 0.03	0.09 + 0.03	0.09 + 0.03
	1.000000A	1µA		1.0 + 0.04	0.30 + 0.04	0.20 + 0.03	0. 88 + 0.04	2.0 + 0.04
	3.000000A	10µA		1.0 + 0.04	0.30 + 0.04	0.20 + 0.03	0. 88 + 0.04	2.0 + 0.04
			Temp. Coeff. /°C[3]	0.10 + 0.004	0.030 + 0.004	0.005 + 0.003	0.006 + 0.005	0.006 + 0.005

			Accuracy:	±(ppm of reading (3Hz – 500kHz)	±(ppm of reading (3Hz – 500kHz)	+ offset ppm) (333ms – 2µs)
Frequency[4] and Period	100.0000mV to 300.0000V	0.333 ppm 3.33 ppm 33.3 ppm	90 Day / 1 Year (all ranges)	80 +0.333 80 + 3.33 80 + 33.3	80 +0.333 80 + 3.33 80 + 33.3	(SLOW, 0.25s gate) (MED, 100ms gate) (FAST, 10ms gate)

Additional Uncertainty ±(% of reading)	Detectorbandwidth		
Low Frequency Uncertainty	3 (3Hz –300KHz SLOW)	30 (30Hz –300KHz MED)	300 (300Hz –300KHz FAST)
20Hz – 30Hz	0	0.3	—
30Hz – 50Hz	0	0	—
50Hz – 100Hz	0	0	4.0
100Hz – 200Hz	0	0	0.72
200Hz – 300Hz	0	0	0.18
300Hz – 500Hz	0	0	0.07
>500Hz	0	0	0

			Crest Factor[5]	Maximum Crest Factor: 5 at full-scale		
Additional Uncertainty±(% of reading)	Detectorbandwidth	1 - 2	2- 3	3- 4	4 - 5	
5Hz – 10Hz	3	0.50	1.20	1.30	1.40	
10Hz – 30Hz	3	0.20	0.30	0.60	0.90	
30Hz – 100Hz	3 or 30	0.20	0.30	0.60	0.90	
>100Hz	3 or 30	0.05	0.15	0.30	0.40	
300Hz – 500Hz	300 only	0.50	1.20	1.30	1.40	
≥500Hz	300 only	0.05	0.15	0.30	0.40	

AC MEASUREMENT CHARACTERISTICS

AC Volts

MEASUREMENT METHOD: AC-coupled, True RMS.
INPUT IMPEDANCE: 1MΩ±2% // by <150ρF.
INPUT PROTECTION: 300VDC or 300Vrms rear inputs or 37xx cards.

AC Current

MEASUREMENT METHOD: AC-coupled, True RMS.

Range	3A	1A	100mA	10mA	1mA
Shunt Resistance[7]	0.1Ω	0.1Ω	1.0Ω	10Ω	100Ω
Burden Voltage Rear panel	<1.8Vrms	<0.6Vrms	<0.4Vrms	<150mVrms	<125mVrms
Burden Voltage 3721card	<2.4Vrms	<1.0Vrms	<0.6Vrms	<200mVrms	<130mVrms

INPUT PROTECTION: 3A, 250V fuse.

FREQUENCY and PERIOD

MEASUREMENT METHOD: Reciprocal Counting technique.
GATE TIME: SLOW 0.25s, MED 100ms, and FAST 10ms (dmm.aperture=0.25, 0.1, or 0.01).

AC General

AC CMRR[6]: 70dB

VOLT HERTZ PRODUCT: ≤8 × 10⁷ Volt∗Hz (guaranteed by design), ≤2.1 × 10⁷ Volt∗Hz verified. Input frequency verified for ≤3x10⁵ Hz.

AC Notes
1. 20 % overrange except 1% on 300V and 3.33% on 3A. Default resolution is 5-½ digits; maximum useable resolution is 6-½ with 7-½ digits programmable.
2. Specification are for SLOW mode and sinewave inputs >5% of range. SLOW and MED are multi-sample A/D conversions. FAST is dmm.detectorbandwidth=300 with dmm.nplc=1.0.
3. Applies to 0°C - 18°C and 28°C - 50°C.
4. Specified for square wave inputs. Input signal must be >10% of ACV range. If input is<20mV on the 100mV range then the frequency must be >10Hz. For sinewave inputs, frequency must be >100Hz.
5. Applies to non-sinewave inputs ≥5Hz.
6. For 1kohm unbalance in LO lead.
7. Shunt resistance guaranteed by design.
8. For Model 3721, 1mA ACI, add 0.05% to "of reading" uncertainty from 250Hz → 10kHz.

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GENERAL SPECIFICATIONS

EXPANSION SLOTS: 6
POWER LINE: Universal, 100V to 240V.
LINE FREQUENCY: 50Hz and 60Hz, automatically sensed at power-up.
POWER CONSUMPTION: 28VA with DMM and display, up to 140VA with (6) 3700 cards.
OPERATING ENVIRONMENT: Specified for 0°C to 50°C, ≤80%RH at 35°C, altitude up to 2000 meters
STORAGE ENVIRONMENT: -40°C to 70°C.
REAL TIME CLOCK: Battery backed, 10-years typical life.
WARRANTY: 1-yr.
EMC: Conforms to European Union Directive 2004/108/ EC EN61326-1.
SAFETY: Conforms to European Union Directive 73/23/EEC EN61010-1.
VIBRATION: MIL-PRF-28800F Class 3, Random.
WARM-UP: 2-hours to rated accuracy.
DIMENSIONS:

	High	Wide	Deep
Rack Mounted	89mm (3.5 in.)	483mm (19 in.)	457mm (18 in.)
Bench Configuration (includes handle and feet)	104mm (4.125 in.)	483mm (19 in.)	457mm (18 in.)

SHIPPING WEIGHT: 13kg (28 lbs).
DIGITAL I/O: 25-pin female D-shell.

	I/O 1-9	I/O 10-14	Vext
I_{SINK}, max	5mA	250mA	—
Absolute V_{IN}	5.25V → -0.25V	5.25V → -0.25V	5V → 33V
V_{IH} min	2.2V	2.2V	—
V_{IL} max	0.7V	0.7V	—
V_{OL} max at Isink max	0.7V	0.7V	—
V_{OH} min, 0.4mA sour	2.7V	2.4V	—
Min V_{IN} pulse	2μs	10μs	—
Min V_O pulse	1μs	50μs	—
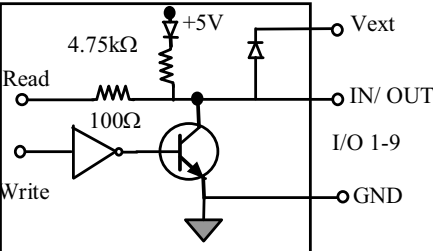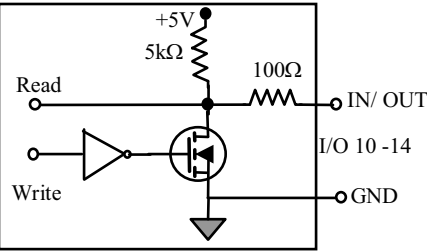
TRIGGERING AND MEMORY:

    Window Filter Sensitivity: 0.01%. 0.1%, 1%, 10%, or full-scale of range (none).
    Trigger Delay: 0 to 99 hrs (10us step size)
    External Trigger Delay: <10us.
    Memory: Up to 650,000 time-stamped readings with web page disabled. Additional memory available with external "thumb drive".
    Non-volatile Memory: Single user save setup, with up to 75 DMM configurations and ≥600 Channel Patterns (dependent on name length, DMM function and configuration, and pattern image size). Additional memory available with external "thumb drive".

MATH FUNCTIONS: Rel, dB, Limit Test, %, 1/x, and mX + b with user defined displayed.
REMOTE INTERFACE: Ethernet: RJ-45 connector, LXI Class C, 10/100BT, no auto MDIX.
          GPIB: IEEE-488.1 compliant. Supports IEEE-488.2 common commands and status model topology.
          USB device (rear panel, type B): full speed, USBTMC compliant.
          USB host (front panel, type A): USB 2.0, support for thumb drives.
LXI COMPLIANCE: LXI Class B with IEEE 1588 precision time protocol.
LXI TIMING (applies to scanning) and SPECIFICATION: Receive LAN[0-7] event delay: 600 us. Min, 800us. Typ., n/s Max.
          Alarm to trigger delay: 25 us. Min., 50us. Typ., n/s max..
          Generate LAN[0-7] event: 750 us. Min., 1000us. Typ., n/s Max.
          [minimums are probabilistic and represent a 95% confidence factor]
          Clock accuracy: 25 ppm.
          Synchronization accuracy: < 150ns. [probabilistic and represent a 95% confidence factor]
          Timestamp accuracy: 100 us.
          Timestamp resolution: 20 ns.
LANGUAGE: Embedded Test Script Processor (TSP) accessible from any host interface. Responds to individual Instrument Control Library (ICL) commands. Responds to high-speed test scripts comprised of ICL commands and Test Script Language (TSL) statements (e.g. branching, looping, math, etc.). Able to execute high-speed test scripts stored in memory without host intervention.
ACCESSORIES SUPPLIED: Product Information CD-ROM and 3m Ethernet cable.
ACCESSORIES AVAILABLE: 3700 Cards, 3700-MTC cables, 3706-BKPL (analog backplane extender), 3706-3Y/5Y-EW (extended warranty)
          C/3706-3Y (Calibration / Data / ISO 17025), Software IVI/VISA drivers for VB, VC/C++, LabView, TSP Script, Script Builder, and LabWindows/CVI.
IP CONFIGURATION: Static or DHCP.
PASSWORD PROTECTION: 11 characters
MINIMUM PC HARDWARE: Intel Pentium 3, 800MHz, 512Mbyte RAM, 210Mbyte disk space or better.
OPERATING SYSTEMS /SOFTWARE: Windows 2000 and XP compatible, supports Web browsers with Java plug-in (requires Java plug-in 1.6 or higher). Web pages served by 3706.

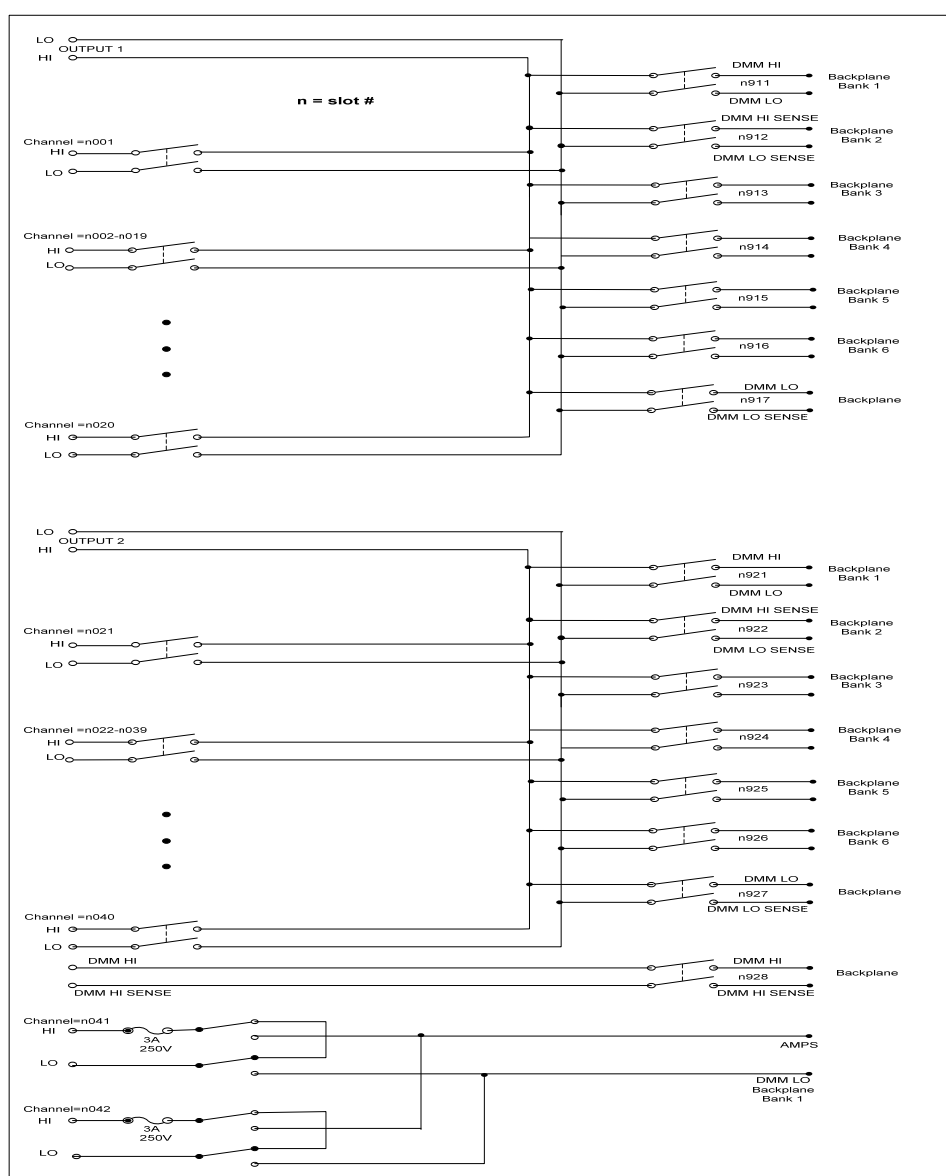Specifications are subject to change without notice.

End

Rev A 9/14/07

KEITHLEY

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
1-888-KEITHLEY
www.keithley.com

Dual 1x30 Multiplexer Specification

60 differential channels, automatic CJC w/3720-ST accessory

MULTIPLEXER CONFIGURATION: Two independent 1x 30 2-pole Multiplexers. Banks can be isolated from the backplane by relays. Card can be configured for 2 and 4 wire.

CONTACT CONFIGURATION: 2 pole form A.

CONNECTOR TYPE: Two 78 pin male D-shells.

Model 3720-ST screw terminal option:
 #22AWG typical wire size with .062 inch O.D 124 conductors maximum. 16 AWG maximum wire size with .092 inch O.D. 36 conductor per card maximum.

MAXIMUM SIGNAL LEVEL:
   Channels (1-60): 300V DC or RMS, 1A switched (2A carry), 60W, 125VA.

COMMON MODE VOLTAGE: 300V DC or RMS between any terminal and chassis.

VOLT-HERTZ LIMIT: $8{\times}10^{7}$

CONTACT LIFE: > 10^{5} operations at max signal level.
              > 10^{8} operations no load.[1]

	Dual 1x30[3]	Single 1x60 [2, 3]
Channel Resistance (end of contact life)	<1.0Ω	<1.5Ω
Contact Potential (differential)	<± 1µV	<± 3µV
Offset Current	<±250pA	<±250pA
Isolation		
Differential	10^{9}Ω,250pF	10^{9}Ω,450pF
Bank-Bank	10^{10}Ω,75pF	▬
CH –CH	10^{9}Ω,75pF	10^{9}Ω,75pF
Common mode	10^{9}Ω,200pF	10^{9}Ω,400pF

Crosstalk CH-CH
    300KHz:
    1MHz:
    20MHz:
	<-60dB
	<-50dB
	<-25dB
		<-55dB
		<-50dB
		<-20dB

Bandwidth	30MHz	10MHz

---

[1] Open detector enabled during thermocouple measurements. Minimum signal level 10mV,10uA.
[2] 3706 mainframe with all DMM backplane relays disconnected. Maximum two card backplane relays closed.
[3] Connections made using 3720-ST accessory

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
(440) 248-0400
www.keithley.com

Dual 1x30 Multiplexer Specification

60 differential channels, automatic CJC w/3720-ST accessory

GENERAL:

ACTUATION TIME: 4ms

TEMPERATURE ACCURACY USING Automatic CJC with 3720-ST accessory:
 1°C for J, K, T and E type (see mainframe specification for details)

RELAY TYPE: Latching electromechanical

RELAY DRIVE SCHEME: Matrix

INTERLOCK: Backplane relays disabled when interlock connection removed.

OPERATING ENVIRONMENT:
 Specified for 0ºC to 50ºC.
 Specified to 70% R.H. at 35º

STORAGE ENVIRONMENT: -25ºC to 65ºC

WEIGHT: 2.5lb

SAFETY: Conforms to European Union Directive 73/23/EEC, EN61010-1

EMC: Conforms to European Union Directive 2004/108/EC, EN61326-1

Typical Scanning Speeds, switch only[4]

	Ch/Sec
Sequential scanning ,single channel, immediate trigger advance	>120

Typical Scanning Speeds, with measurements into memory[5]

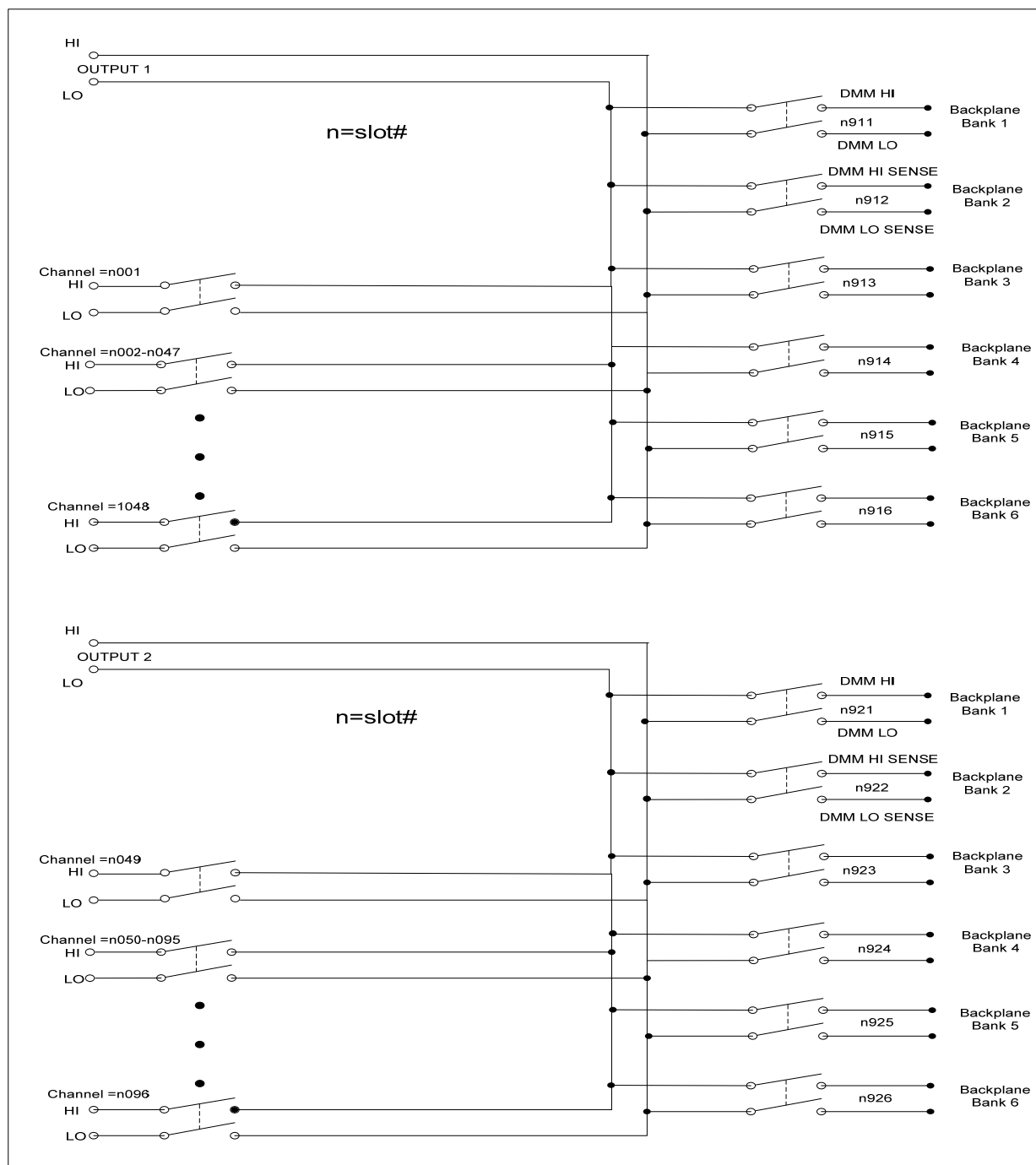|	Ch/Sec
DCV (10V range) or 2W Ohms (1KΩ range)	>110
Thermocouple	>110
3 or 4 Wire RTD	>100
4 Wire Ohms (1kΩ range)	>100
ACV (10V range)	> 110

---

[4] Scanning script local to 3706 mainframe, within same bank, and break before make switching.
[5] 3706 mainframe with autorange off, limits off, dmm.autozero=0, dmm.autodelay=0, 4½ digits (NPLC=.006), for ACV dmm.detectorbandwidth=300,for OHMs dmm.offsetcompensation=off ,dmm.opendetector=off. Scanning script local to mainframe, sequential scan within same bank (2 pole) or card (4 pole), and break before make switching.

Specifications are subject to change without notice.

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
1-888-KEITHLEY
www.keithley.com

Dual 1x30 Multiplexer Specification
60 differential channels, automatic CJC w/3720-ST accessory

ACCESSORIES AVAILABLE:

3791-KIT78-R 78 pin female D-sub connector kit (contains 2 female D-sub connectors and 156 solder-cup contacts)
3720-MTC-3 78 pin D-sub female to male cable, 3m.
3720-MTC-1.5 78 pin D-sub female to male cable, 1.5m.
3720-ST screw terminal block (Required for auto CJC thermocouple measurements)
7401 Type K Thermocouple Wire (100ft)
3791-CIT Contact insertion and extraction tool.
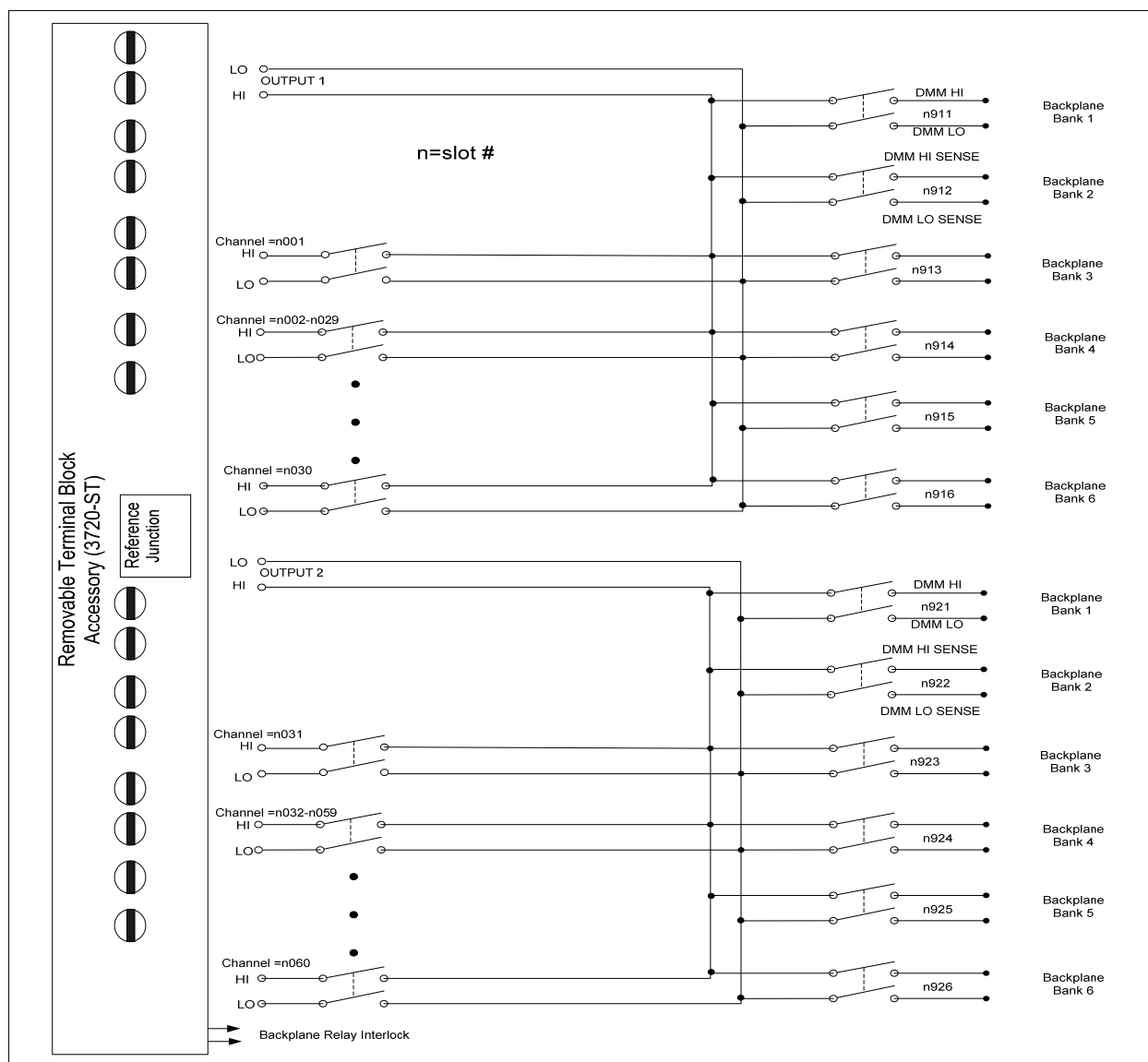
Specifications are subject to change without notice.

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
1-888-KEITHLEY
www.keithley.com

Dual 1x20 Channel Multiplexer Specifications

40 differential channels, automatic CJC w/3721-ST accessory

MULTIPLEXER CONFIGURATION: Two independent 1x 20 2-pole Multiplexers. Banks can be connected together via relay creating a single 1 x 40 Multiplexer. Banks can be isolated from the backplane by relays. Card can be configured for common side Ohm measurement via back plane relays.

Channel (41-42): Multiplex one of two 2-pole current signals into DMM

CONTACT CONFIGURATION: 2 pole form A.

CONNECTOR TYPE: Two 50 pin male D-shells. Removable screw terminal option.

MAXIMUM SIGNAL LEVEL:

 Channels (1-40): 300V DC or RMS, 2A switched (3A carry), 60W, 125VA Maximum.

 Channels (41-42): 60V DC or 30VRMS, 3A switched, 60W, 125VA Maximum. Fused 3A, 250V RMS

COMMON MODE VOLTAGE: 300V DC or RMS between any terminal and chassis. Channels (1-40)

VOLT-HERTZ LIMIT: 8×10^{7}

CONTACT LIFE: $> 10^{5}$ operations at max signal level.
 $> 10^{8}$ operations no load.[1]

	Dual 1x20 [3]	Single 1x40 [2, 3]
Channel Resistance (end of contact life)	< 1.0 Ω	< 1.5 Ω
Contact Potential (differential)	< ± 1 µV	< ± 3 µV
Offset Current	< ±250 pA	< ±250 pA
Isolation		
Differential	10^{9}Ω, 280pF	10^{9}Ω, 530pF
Bank-Bank	10^{11}Ω, 60pF	--
CH -CH	10^{9}Ω, 50pF	10^{9}Ω, 50pF
Common mode	10^{9}Ω,180pF	10^{9}Ω, 480pF
Crosstalk CH-CH 300KHz: 1MHz: 20MHz:	< -60dB < -50dB < -25dB	< -60dB < -50dB < -15dB
Bandwidth	28 MHz	9 MHz

---

[1] Open detector enabled during thermocouple measurements. Minimum signal level 10mV,10uA
[2] 3706 mainframe with all DMM backplane relays disconnected. Maximum two card backplane relays closed.
[3] Connections made using 3721-ST accessory

Specifications are subject to change without notice.

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
(440) 248-0400
www.keithely.com

Dual 1x20 Channel Multiplexer Specifications
40 differential channels, automatic CJC w/3721-ST accessory

GENERAL:

ACTUATION TIME: 4ms

TEMPERATURE ACCURACY USING Automatic CJC with 3721-ST accessory:
1ºC for J, K, T and E types (see mainframe specification for details)

RELAY TYPE: Latching electromechanical

RELAY DRIVE SCHEME: Direct

INTERLOCK: Backplane relays are disabled when interlock connection is removed.

OPERATING ENVIRONMENT:

Specified for 0ºC to 50ºC.

Specified to 70% R.H. at 35ºC

STORAGE ENVIRONMENT: -25ºC to 65ºC

WEIGHT: 2.25 lb

SAFETY: Conforms to European Union Directive 73/23/EEC, EN61010-1

EMC: Conforms to European Union Directive 2004/108/EC, EN61326-1

Typical Scanning Speeds, switch only[4]

	Ch/Sec
Sequential scanning ,single channel, immediate trigger advance	>120

Typical Scanning Speeds, with measurements into memory[5]

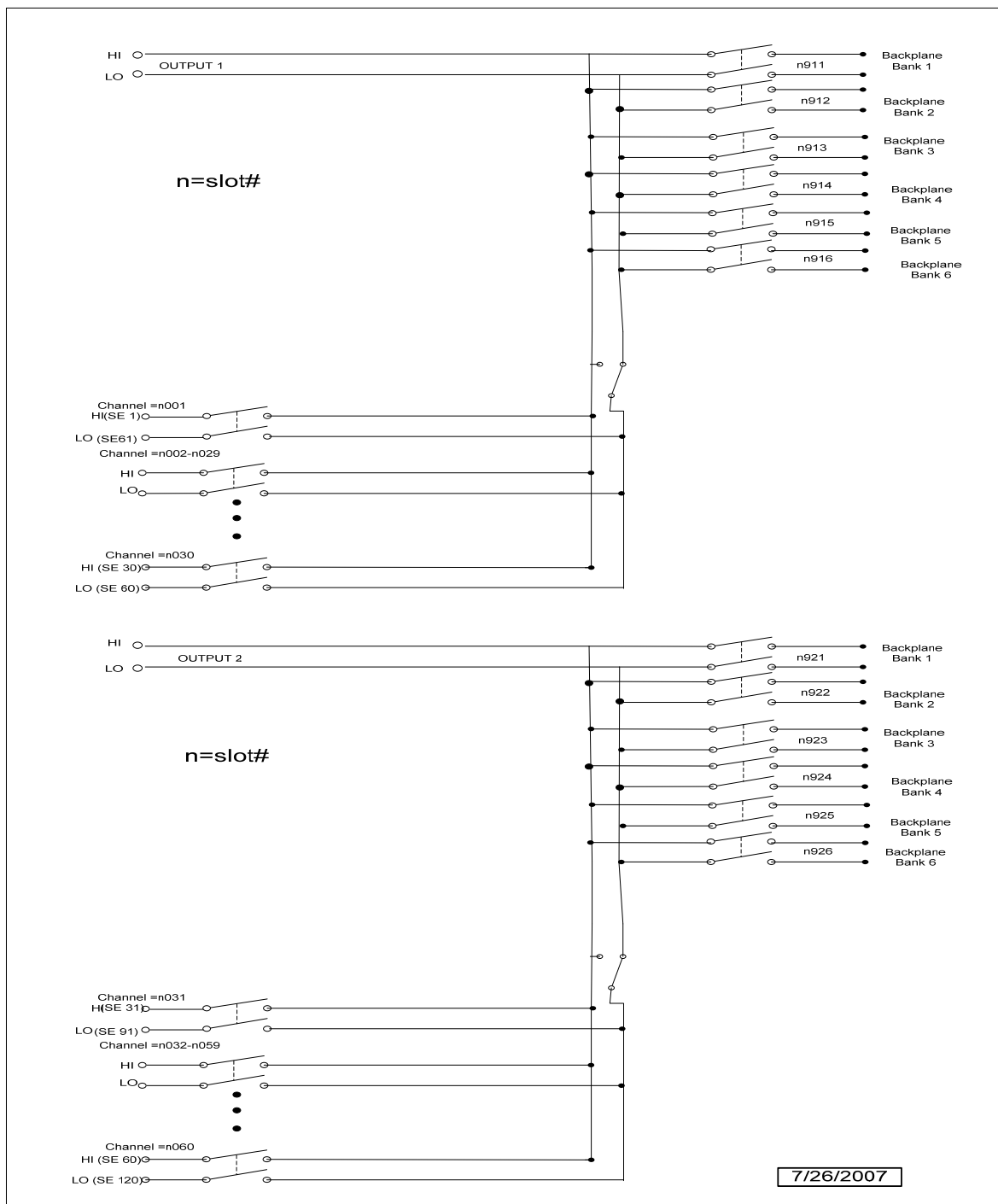|	Ch/Sec
DCV (10V range) or 2W Ohms (1KΩ range)	>110
Thermocouple	>110
3 or 4 Wire RTD	>100
4 Wire Ohms (1kΩ range)	>100
ACV (10V, 400Hz range) or ACI (1A, 400Hz range)	>110

---

[4] Scanning script local to 3706 mainframe, within same bank, and break before make switching.
[5] 3706 mainframe with autorange off, limits off, dmm.autozero=0, dmm.autodelay=0, 4½ digits (NPLC=.006), for ACV dmm.detectorbandwidth=300,for OHMs dmm.offsetcompensation=off, dmm.opendetector=off. Scanning script local to mainframe, sequential scan within same bank (2 pole) or card (4 pole), and break before make switching.

Specifications are subject to change without notice.

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
1-888-KEITHLEY
www.keithley.com

Dual 1x20 Channel Multiplexer Specifications

40 differential channels, automatic CJC w/3721-ST accessory

ACCESSORIES AVAILABLE:
3790-KIT50R 50 pin female D-sub connector kit (contains 2 female D-sub connectors and 100 solder-cup)
3721-MTC-3 50 pin D-sub female to male cable, 3m
3721-MTC-1.5 50 pin D-sub female to male cable, 1.5m
3721-ST screw terminal block (Required for auto CJC thermocouple measurements)
7401 Type K Thermocouple Wire (100ft)

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
1-888-KEITHLEY
www.keithley.com

Dual 1x48, High Density Multiplexer Specifications

96 differential channels, 300V Volts/1 Amp

MULTIPLEXER CONFIGURATION: Two independent 1x 48 2-pole Multiplexers. Banks can be connected together via relays creating a single 1 x 96 Multiplexer. Banks can be isolated from the backplane by relays. Card can be configured for 2 and 4 wire mode.

CONTACT CONFIGURATION: 2 pole form A.

CONNECTOR TYPE: Two 104 pin female D-shells.

MAXIMUM SIGNAL LEVEL: 300V DC or RMS, 1A switched (2A carry), 60W, 125VA.

COMMON MODE VOLTAGE: 300V DC or RMS between any terminal and chassis.

VOLT-HERTZ LIMIT: 8×10^7

CONTACT LIFE: $> 10^5$ operations at max signal level.

$> 10^8$ operations no load.[1]

	Dual 1x48[2]	Single 1x96
Channel Resistance (end of contact life)	<1.5 Ω	<2.5Ω
Contact Potential (differential)	<±1 µV	<± 2µV
Offset Current	<100pA	<100pA
Isolation		
Differential	$5 \times 10^9 \Omega$,200pF	$5 \times 10^9 \Omega$,400pF
Bank-Bank	$10^9 \Omega$,50pF	▬
CH –CH	$10^9 \Omega$,50pF	$10^9 \Omega$,50pF
Common mode	$10^{10} \Omega$,200pF	$10^{10} \Omega$,400pF
Crosstalk CH-CH 300KHz: 1MHz: 20MHz:	<-65dB <-55dB <-30dB	<-65dB <-55dB <-30dB
Bandwidth	25MHz	15MHz

---

[1] Minimum signal level 10mV,10uA
[2] 3706 mainframe with all DMM backplane relays disconnected. Maximum two card backplane relays closed.

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
(440) 248-0400
www.keithley.com

Dual 1x48, High Density Multiplexer Specifications

96 differential channels, 300V Volts/1 Amp

GENERAL:

ACTUATION TIME: 4ms

RELAY TYPE: Latching electromechanical

RELAY DRIVE SCHEME: Matrix

OPERATING ENVIRONMENT:

Specified for 0ºC to 50ºC.

Specified to 70% R.H. at 35ºC

STORAGE ENVIRONMENT: -25ºC to 65ºC

WEIGHT: 2.5lb

SAFETY: Conforms to European Union Directive 73/23/EEC,EN61010-1

EMC: Conforms to European Union Directive 2004/108/EC,EN61326-1

Typical Scanning Speeds, switch only[3]

	Ch/Sec
Sequential scanning ,single channel, immediate trigger advance	>120

Typical Scanning Speeds, with measurements into memory[4]

	Ch/Sec
DCV (10V range) or 2W Ohms (1KΩ range)	>110
3 or 4 Wire RTD	>100
4 Wire Ohms (1kΩ range)	>100
ACV (10V, 400Hz range)	>110

ACCESSORIES AVAILABLE:
3791-KIT104-R   104 pin male D-sub connector kit (Contains 2 male D-sub connector with housings and 208 solder-cup contacts)
3722-MTC-1.5 104 pin D-sub male to male cable, 1.5m.
3722-MTC-3 104 pin D-sub male to male cable, 3m.
3791-CIT Contact insertion and extraction tool.

---

[3] Scanning script local to mainframe, within same bank, break before make.
[4] 3706 mainframe with autorange off, limits off, DMM.autodelay=0, dmm.autozero=0, 4 ½ digits (NPLC=.006), for ACV dmm.detectorbandwidth=300,for OHMs dmm.offsetcompensation=off, dmm.opendetector=off. Scanning script local to mainframe, sequential scan within same bank (2 pole) or card (4 pole), and break before make switching.

Specifications are subject to change without notice.

KEITHLEY

Model 3722

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
1-888-KEITHLEY
www.keithley.com

Dual 1x48, High Density Multiplexer Specifications

96 differential channels, 300V Volts/1 Amp

KEITHLEY

Model 3723

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
1-888-KEITHLEY
www.keithley.com

Dual 1x30, High Speed Multiplexer Specifications
60 differential channels, long life reed relays

MULTIPLEXER CONFIGURATION: Two independent 1x 30 2-pole Multiplexers. Banks can be connected together via relay creating a single 1 x 60 Multiplexer. Banks can be isolated from the backplane by relays. Card can be configured for 1,2 and 4 wire.

CONTACT CONFIGURATION: 2 pole form A.

CONNECTOR TYPE: Two 78 pin male D-shells.

Model 3723-ST screw terminal option:

 #22AWG typical wire size with .062 inch O.D 124 conductors maximum. 16 AWG maximum wire size with .092 inch O.D. 36 conductor per card maximum.

MAXIMUM SIGNAL LEVEL: 200V DC or RMS, 1A switched (1.25A carry), 15W.

COMMON MODE VOLTAGE: 300V DC or RMS between any terminal and chassis.

VOLT-HERTZ LIMIT : $8x10^7$

CONTACT LIFE: REED > $1x10^9$ operations, No Load

$1x10^7$ operation @100V, 10mA

EMR > $1x10^8$ operations @5V,10mA

$1x10^5$ operations @ max signal level

	Dual 1x30[1]	Single 1x60[1, 2]
Channel Resistance (end of contact life)	<1.5Ω	<2.0Ω
Contact Potential (differential) (single ended)	<±6µV <±12µV	<±6µV <±12µV
Offset Current	<250pA	<250pA
Isolation		
Differential	10^{10}Ω,260pF	10^{10}Ω,500pF
Bank-Bank	10^{10}Ω,75pF	▬
CH –CH	10^{10}Ω,75pF	10^{10}Ω,75pF
Common mode	10^{10}Ω,280pF	10^9Ω,625pF
Crosstalk CH-CH 300KHz: 1MHz: 20MHz:	<-55dB <-50dB <-20dB	<-55dB <-45dB <-20dB
Bandwidth	20MHz	10MHz

---

[1] Connections made using 3723-ST
[2] 3706 mainframe with all DMM backplane relays disconnected. Maximum two card backplane relays closed.

Specifications are subject to change without notice.

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
1-888-KEITHLEY
www.keithley.com

Dual 1x30, High Speed Multiplexer Specification

60 differential channels, long life reed relays

GENERAL:

ACTUATION TIME: <.5ms

RELAY TYPE: Dry reed

RELAY DRIVE SCHEME: Direct

INTERLOCK: Backplane relays disabled when interlock connection removed.

RELAY DRIVE CURRENT: 10mA

OPERATING ENVIRONMENT:

Specified for 0ºC to 50ºC.

Specified to 70% R.H. at 35º

STORAGE ENVIRONMENT: -25ºC to 65ºC

WEIGHT: 3.0lb

SAFETY: Conforms to European Union Directive 73/23/EEC,EN61010-1

EMC: Conforms to European Union Directive 2004/108/EC,EN61326-1

Typical Scanning Speeds,switch only[3]

	Ch/Sec
Sequential scanning ,single channel,Immediate Trigger Advance	> 1000

Typical Scanning Speeds,with measurements into memory[4]

	Ch/Sec
DCV (10V range) or 2W Ohms (1KΩ range)	>800
3 or 4 Wire RTD	>450
4 Wire Ohms1KΩ range)	>450
ACV (10V,400Hz range)	>800

ACCESSORIES AVAILABLE:
3791-KIT78-R 78 pin female D-sub connector kit (Contains 2 female D-sub connectors and 156 solder cups)
3720-MTC-3 78 pin D-sub female to male cable,3m.
3720-MTC-1.5 78 pin D-sub female to male cable,1.5m.
3723-ST screw terminal block
3723-ST-1 screw terminal block for Single-Pole applications.
3791-CIT Contact insertion and extraction tool.

---

[3] Scanning script local to mainframe, within same bank, break before make.
[4] 3706 mainframe with autorange off, limits off, dmm.autodelay=0, dmm.autozero=0, 4½ digits (NPLC=.006), for ACV dmm.detectorbandwidth=300,for OHMs dmm.offsetcompensation=off, dmm.opendetector=off . Scanning script local to mainframe, sequential scan within same bank (2 pole) or card (4 pole), and break before make switching.

Specifications are subject to change without notice.

KEITHLEY

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
1-888-KEITHLEY
www.keithley.com

Model 3723

Dual 1x30, High Speed Multiplexer Specifications
60 differential channels, long life reed relays

7/26/2007

6x16 Matrix Specifications

96 two-pole crosspoints with column expansion relays

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
1-888-KEITHLEY
www.keithley.com

MATRIX CONFIGURATION: 6 row by 16 column matrix. Columns can be expanded using the backplane or isolated by relays.

CONTACT CONFIGURATION: 2 pole form A.

CONNECTOR TYPE: Two 50 pin male D-shells.

MODEL 3730-ST SCREW TERMINAL OPTION:

#22 AWG typical wire size with .062 inch O.D. 88 conductors maximum. #16 AWG maximum wire size with .092inch O.D. 44 conductors per card maximum.

MAXIMUM SIGNAL LEVEL: 300V DC or RMS, 1A switched (2A carry), 60W, 125VA.

COMMON MODE VOLTAGE: 300V DC or RMS between any terminal and chassis.

VOLT-HERTZ LIMIT: 8×10^7

CONTACT LIFE: $> 10^5$ operations at max signal level.

$>10^8$ operations no load.[1]

	6x16 [2, 3]
Channel Resistance (end of contact life)	<1.0Ω
Contact Potential (differential)	<± 2µV
Offset Current	<±100pA
Isolation	
Differential	10^{10}Ω,250pF
CH –CH	10^{10}Ω,75pF
Common mode	10^{10}Ω,150pF
Crosstalk CH-CH	
300KHz:	<-65dB
1MHz:	<-55dB
20MHz:	<-30dB
Bandwidth	27MHz

---

[1] Minimum signal level 10mV, 10uA
[2] Connections made using 3730-ST
[3] 3706 mainframe with all DMM backplane relays disconnected.

Specifications are subject to change without notice.

6x16 Matrix Specifications
96 two-pole crosspoints with column expansion relays

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
(440) 248-0400
www.keithley.com

GENERAL:

ACTUATION TIME: 4ms

RELAY TYPE: Latching electromechanical

RELAY DRIVE SCHEME: Hybrid Matrix

INTERLOCK: Backplane relays disabled when terminal assemble removed.

OPERATING ENVIRONMENT:

Specified for 0ºC to 50ºC.

Specified to 70% R.H. at 35ºC.

STORAGE ENVIRONMENT: -25ºC to 65ºC

WEIGHT: 2.5lbs

SAFETY: Conforms to European Union Directive 73/23/EEC, EN61010-1

EMC: Conforms to European Union Directive 2004/108/EC, EN61326-1

ACCESSORIES AVAILABLE:

3790-KIT-R 50 pin female D-sub connector kit (Contains 2 female D-sub connectors and 100 solder-cup contacts)

3721-MTC-1.5 50 pin D-sub female to male cable, 1.5m.

3721-MTC-3 50 pin D-sub female to male cable, 3m.

3730-ST screw terminal block

Specifications are subject to change without notice.

KEITHLEY

6x16 Matrix Specifications
96 two-pole crosspoints with column expansion relays
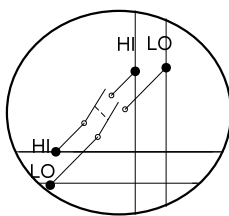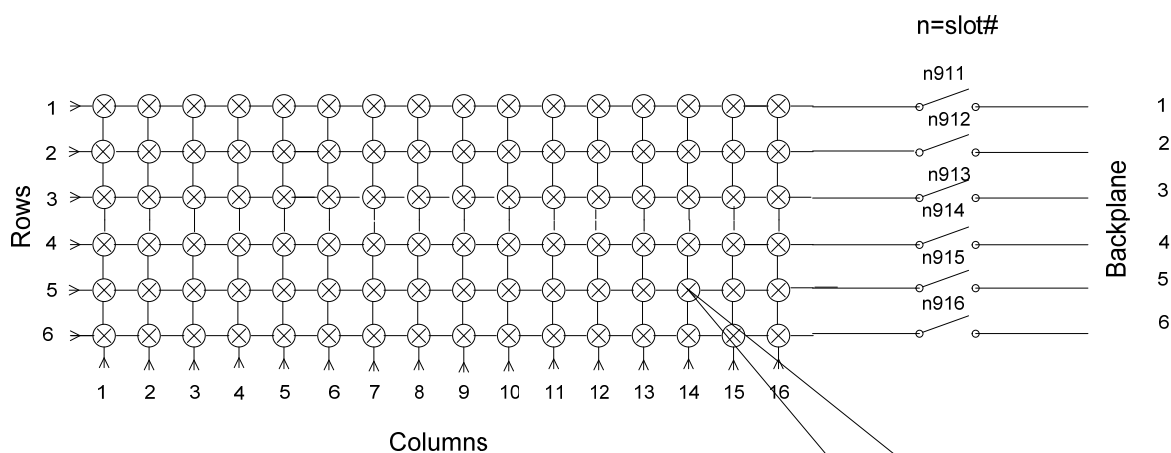
Cross point relay detail
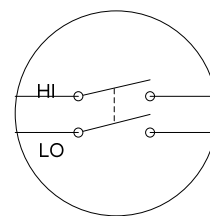
Bank relay detail

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
1-888-KEITHLEY
www.keithley.com

32 Channel Isolated Switch Card Specifications

28 Form C relays and 4 high power Form A relays

RELAY SWITCH CONFIGURATION: 32 general purpose independent channels. 28 channels of FORM C switching at 2A and 4 channels of FORM A switching at 7A. Relays can be connected to each other and backplane via removable terminal blocks.

CONTACT CONFIGURATION:

GENERAL PURPOSE: 1 pole FORM C.

HIGH CURRENT: 1 pole FORM A

CONNECTOR TYPE: Two 50 pin male D-shells.

MODEL 3740-ST SCREW TERMINAL OPTION:

#22 AWG typical wire size with .062 inch O.D. 84 conductors maximum. #16 AWG maximum wire size with .092inch O.D. 44 conductors per card maximum.

MAXIMUM SIGNAL LEVEL:

FORM C: 300V DC or RMS, 2A switched (3A carry), 60W, 125VA.

FORM A: 250VAC 7A, 30VDC 7A, 210W

COMMON MODE VOLTAGE: 300V DC or RMS between any terminal and chassis.

VOLT-HERTZ LIMIT: 8×10^7.

CONTACT LIFE:

FORM C > 10^5 operations at max signal level.

FORM C >10^8 operations no load.[1]

FORM A > 10^5 operations at max signal level.

FORM A > 5×10^7 operations no load [1]

CHANNEL RESISTANCE :< .5 Ω at end of contact life

CONTACT POTENTIAL: ≤ ±3μV typical per contact

ISOLATION:

CHANNEL TO CHANNEL: >10^9Ω, <200pF

COMMON MODE: >10^{10}Ω, <150pF

CROSSTALK CH-CH (50Ω load- 50Ω source):
100KHz : <-50dB
1MHz: <-35dB
10 MHz: <-15dB

BANDWIDTH: 30MHz

---

[1] Minimum signal level 10mV,10uA

Specifications are subject to change without notice.

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
(440) 248-0400
www.keithley.com

32 Channel Isolated Switch Card Specifications

28 Form C relays and 4 high power Form A relays

GENERAL:

OVER-TEMPERATURE: Temperature sensor indicates over temperature.

ACTUATION TIME: Form C 4ms, Form A 10mS

RELAY TYPE: Form C Latching electromechanical, Form A nonlatching electromechanical.

RELAY DRIVE SCHEME: Direct

INTERLOCK: Backplane relays disabled when interlock connection removed.

OPERATING ENVIRONMENT:

Specified for 0ºC to 50ºC.

Specified to 70% R.H. at 35º

STORAGE ENVIRONMENT: -25ºC to 65ºC

WEIGHT: 2.5LBS

SAFETY: Conforms to European Union Directive 73/23/EEC, EN61010-1

EMC: Conforms to European Union Directive 2004/108/EC, EN61326-1

ACCESSORIES AVAILABLE:

3790-KIT50-R pin female D-sub connector kit (contains 2 female D-sub Connectors and 100 solder cup contacts)

3721-MTC-3 50 pin D-sub female to male cable, 3m

3721-MTC-1.5 50 pin D-sub female to male cable, 1.5m

3740-ST screw terminal block

Specifications are subject to change without notice.

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
1-888-KEITHLEY
www.keithley.com

32 Channel Isolated Switch Card Specifications
28 Form C relays and 4 high power Form A relays

Index

KEITHLEY

Service Form

Model No._____ **Serial No.**_____ **Date**_____

Name and Telephone No._____

Company_____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

❏ Intermittent   ❏ Analog output follows display   ❏ Particular range or function bad; specify

❏ IEEE failure   ❏ Obvious problem on power-up   ❏ Batteries and fuses are OK
❏ Front panel operational   ❏ All ranges or functions are bad   ❏ Checked all cables

Display or output (check one)

❏ Drifts   ❏ Unable to zero
❏ Unstable   ❏ Will not read applied input
❏ Overload

❏ Calibration only   ❏ Certificate of calibration required
❏ Data required
(attach any additional sheets as necessary)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

_____

What power line voltage is used? _____   Ambient temperature?°F _____

Relative humidity? _____   Other? _____

Any additional information. (If special modifications have been made by the user, please describe.)

_____

Be sure to include your name and phone number on this service form.

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KEITHLEY

A G R E A T E R M E A S U R E O F C O N F I D E N C E

Keithley Instruments, Inc.

Corporate Headquarters • 28775 Aurora Road • Cleveland, Ohio 44139 • 440-248-0400 • Fax: 440-248-6168 • 1-888-KEITHLEY • www.keithley.com