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Series 3700 System Switch/Multimeter

User's Manual

3700S-900-01 Rev. C / July 2008

KEITHLEY

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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.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE. THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES.

NEITHER KEITHLEY INSTRUMENTS, INC. NOR ANY OF ITS EMPLOYEES SHALL BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OF ITS INSTRUMENTS AND SOFTWARE, EVEN IF KEITHLEY INSTRUMENTS, INC. HAS BEEN ADVISED IN ADVANCE OF THE POSSIBILITY OF SUCH DAMAGES. SUCH EXCLUDED DAMAGES SHALL INCLUDE, BUT ARE NOT LIMITED TO: COST OF REMOVAL AND INSTALLATION, LOSSES SUSTAINED AS THE RESULT OF INJURY TO ANY PERSON, OR DAMAGE TO PROPERTY.

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Safety Precautions

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 documentation.

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 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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Section 1

Introduction

In this section:

Contact information

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* (http://www.keithley.com).

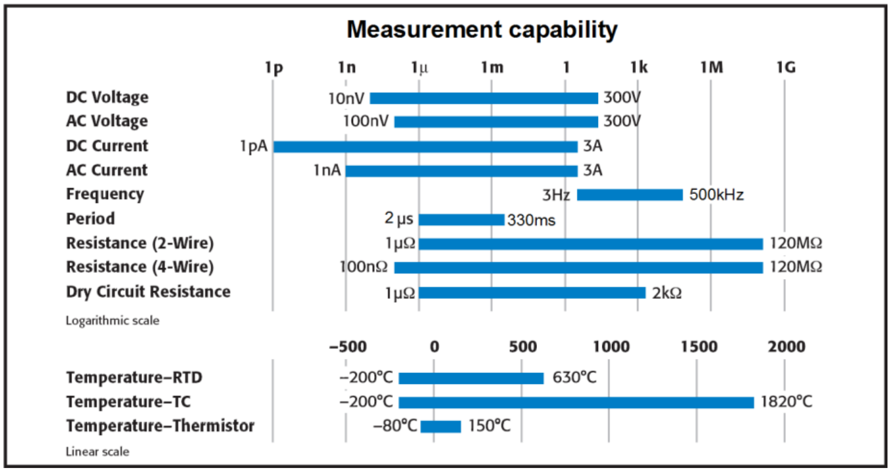
Overview

The Keithley Instruments Series 3700 System Switch/Multimeter features 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 operations, including:

- TSP programming fundamentals and advanced features
- Range, digits, rate, bandwidth, and filter
- Relative, math, and dB
- Buffer
- Scanning
- Files
- TSP-Net™
- LXI Class B Synchronization
- Status model
- Verification
- Calibration
- Maintenance
- Error codes

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 disconnect 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.

Section 2

Using the Front Panel

In this section:

Front panel introduction

This section describes the Keithley Instruments Series 3700 System Switch/Multimeter front panels.

The menu options under the CHAN key and CONFIG CHAN menus vary, depending on the channel type of the selected channel. When selecting a range of channels, all channel types might need to match for some operations like read and write of a Digital I/O channel or opening and closing of Switch channels. Some operations, like `reset()`, work with a range of mix channel types.

NOTE Not all models will have a digital multimeter (DMM) installed. All DMM-related documentation is not applicable to those models.

If your model does not have a front panel, see the following sections to make the appropriate changes.

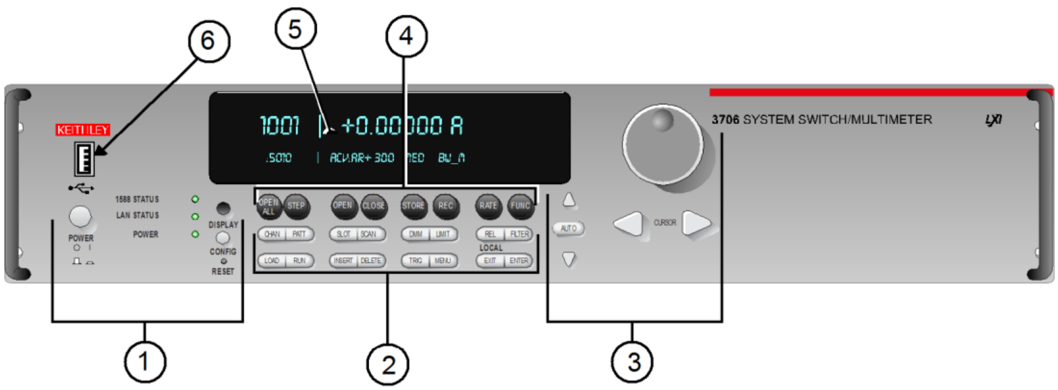
- GPIB address with `gpib.address` command.
- LAN configuration using LAN functions and attributes.

Use the menu system to scan channels, with the following limitations:

- You can add digital I/O and totalizer channels to a front panel scan list for reading by using the INSERT key (ICL equivalent of `scan.add()`).
- You cannot add digital I/O and totalizer channels to a front panel scan list for writing (ICL equivalent of `scan.addwrite()`).
- You cannot add DAC channels to a front panel scan list for writing or reading.
- Pressing the INSERT key with a DAC channel selected generates an error message.

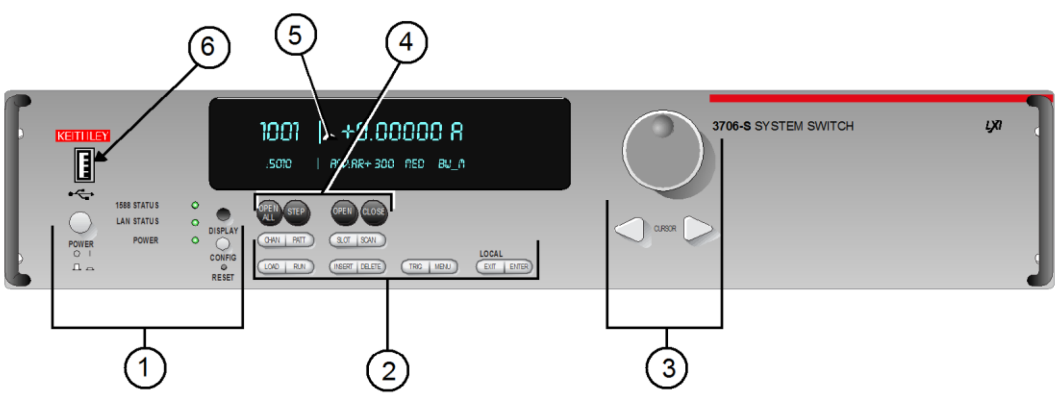
NOTE	Only widths of one are supported by the front panel when reading or writing to a Digital I/O channel.

Figure 2-1: Model 3706 System Switch/Multimeter



Item	Description
1	*Special keys and power switch* (on page 2-10)
2	*Operation keys* (on page 2-16)
3	*Range keys, cursor keys, and navigation wheel* (on page 2-31)
4	*Action keys* (on page 2-32)
5	*Display* (on page 2-4)
6	*USB connector* (see "USB connectors" on page 3-5)

Figure 2-2: Model 3706-S System Switch (no DMM)



NOTE 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

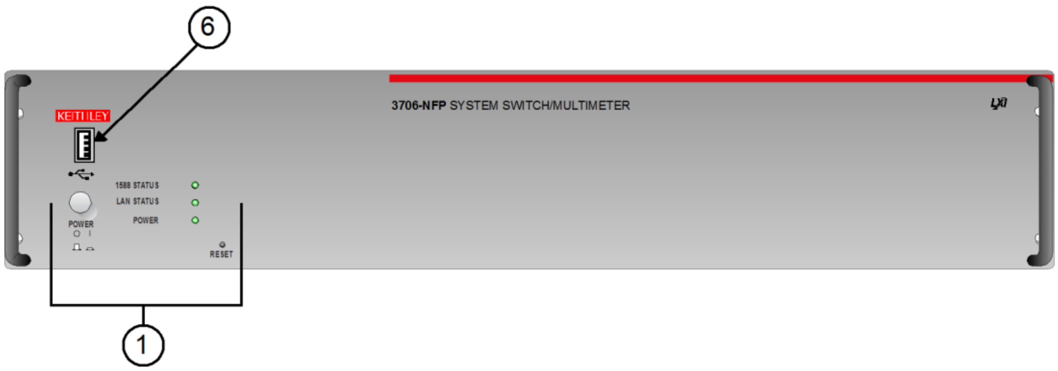


Figure 2-4: Model 3706-SNFP System Switch (no DMM)

Display

The Series 3700 display provides visual information on the present active channel, including the channel selected (or range or pattern), channel state, last DMM measurement reading (where applicable), DMM settings (where applicable), and error indications. The display and the navigation wheel provide a way to change the active channel or channel ranges, as well as access, view, and edit the various menus and menu items.

The Series 3700 has three LEDs on the front panel; these LEDs represent 1588 status, LAN status, and power.

- When you turn on the unit, the power LED is illuminated.
- When the instrument is connected through the Ethernet with no errors, the LAN status LED is illuminated. However, the LAN status LED is off when the instrument is not connected through the Ethernet or there is a connection problem.
- When you press the identify option (ID button) on the home web page for the Series 3700, the LAN status LED blinks.
- The 1588 status LED indicates 1588 operation. When this LED is off, the 1588 feature is disabled or improperly configured.
- The LED blinks at a one-second rate when the instrument is the 1588 master. If the instrument is a slave, the LED will not blink.

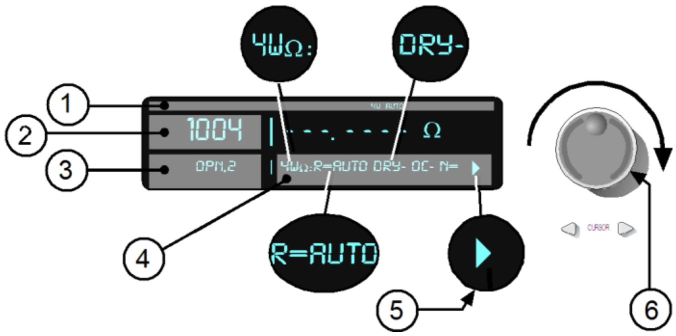
See the following figure (labeled "Active channel display example") for an active channel example. The 4WΩ and AUTO range annunciators are lit (1). Also, the active channel is 1004 (Slot 1, Channel 004) (2). The present state of the channel is open and it has two poles (3). The present state of the attributes 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. View them by turning the navigation wheel (6) to scroll through the attribute list.

NOTE	Access attribute and menu lists that are larger than the display by turning the navigation wheel (6). Displayed arrows (5) indicate additional attributes or menu items (as applicable) that are available by turning the navigation wheel (6) in the direction the arrow points. If an arrow (5) is not displayed, there are no additional menu choices in that direction. Switch-only systems have none of these features.

Figure 2-5: Active channel display example



The top line of the display (1) contains the following annunciators:

Annunciator	Description
* (asterisk)	Readings are being stored in the selected reading buffer. This is OFF when no buffer is selected or the selected buffer is full.
4W	Displays 4-wire resistance or RTD temperature reading.
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 interface control mode (all interfaces, LAN, GPIB, or USB).
SRQ	Service request over GPIB.
TALK	Instrument addressed to talk over GPIB bus.
TRIG	ON when the front panel has requested a reading from the DMM. OFF when the reading is finished.

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

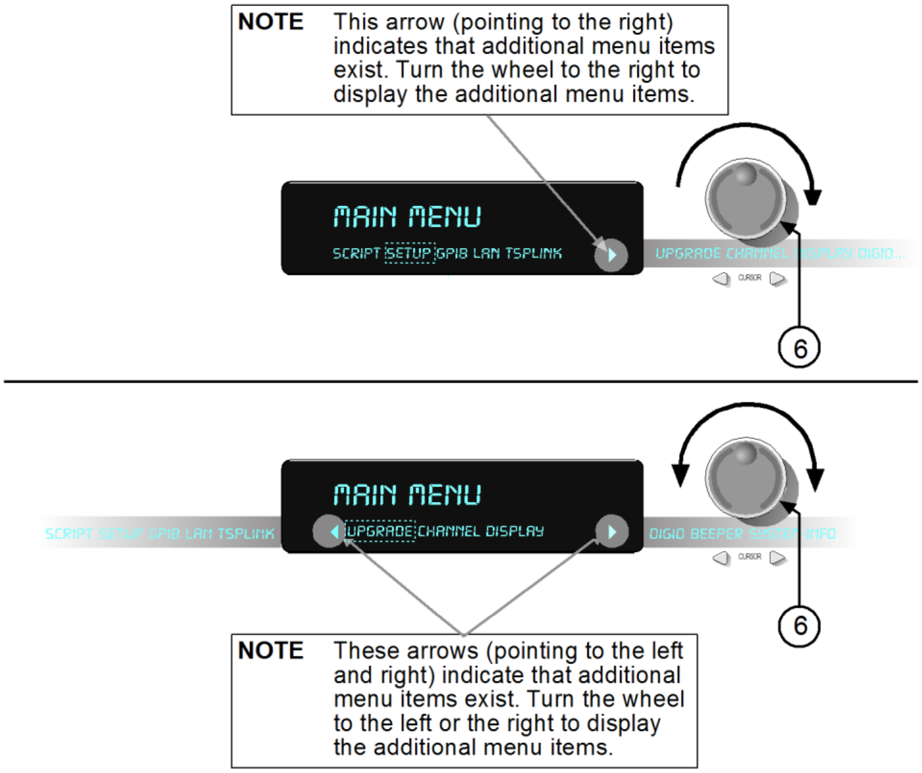
Front panel DMM attribute	Symbol	Values
range	R=	AUTO or n, where n equals the range
nplc	N=	n, where n equals the NPLC
auto delay	AD	+ for ON, 1 for ONCE, or 0 for OFF

Front panel DMM attribute	Symbol	Values
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
4-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 navigation 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 the figure's second display, both right and left arrows are active, indicating that there are additional items in both directions. To select the highlighted (flashing) menu item, press the navigation wheel or press the **ENTER** key.

Figure 2-6: MAIN MENU display



Channel type indication

When selecting channels, the following information is displayed, which indicates the channel type on the front panel.

- For switch channels, the name of the assigned DMM configuration (for example, “nofunction”, “dcvolts”, “my4wire”, and so on) is displayed and below it, the channel state (for example, OPN or CLS, along with 2 or 4 for pole setting) is displayed.
- For digital I/O channels, DIGITAL IO appears and below the channel number is DIG IN or DIG OUT to indicate the channel mode.
- For totalizer channels, TOTALIZER appears and below the channel number is Fall Ed or Rise Ed to indicate mode edge.
- For DAC channels, DAC OUTPUT appears and below the channel number is pv1, off, and so on to indicate protection, function, and output enable.

Using the front panel with non-switch channels

To read a value from the main front panel screen, select the channel and press TRIG. To see a digital I/O channel in hex format (instead of normal binary) use CONFIG+TRIG.

A star symbol (*) or exclamation point symbol (!) may appear after the reading. The meaning of the symbol depends on channel type.

- A star symbol (*) appears after the reading to indicate that the reading matches the MATCH setting for digital I/O and totalizer channels.
- An exclamation point symbol (!) appears after the reading to indicate an overload state condition on that channel for digital I/O and DAC channels.
- An exclamation point symbol (!) appears after the reading to indicate an overflow state condition on a totalizer channel.
- If the power state is OFF for totalizer or DAC channels, the display shows “DISABLED” instead of any readings.

The following table lists the front panel channel attributes that indicate the various channel mode settings (ICL equivalent `channel.setmode()`), channel output enable (ICL equivalent `channel.setoutputenable()`), and channel label (ICL equivalent `channel.setlabel()`). Some of the attributes have alternate symbols, depending on the operation performing on front panel and whether it is being used with the 6 or 12 character label symbol.

- For digital I/O and totalizer channels, the label symbol is listed first, followed by a comma and then mode symbols. If the label is the factory default setting, then only the mode is listed.
- For DAC channels, the label symbol is listed first, followed by a comma and then mode symbols, followed by another comma and the output enable symbol. If the label is the factory default setting, then only the mode and output enable symbols are listed.

Front Panel Channel Setting	Symbol	Definition	Symbol meaning
Channel label	XXXXXX	First 6 characters of label	Used with single letter symbols
	XXXXXXXXXX XX	First 12 characters of label	Used with the non-single letter symbols
Digital I/O mode settings	DIG IN	Digital input mode	Used with 12-character label or no label
	DIG OUT	Digital output mode	Used with 12-character label or no label
	DIG pOUT	Digital output protected mode	Used with 12 character label or no label

Front Panel Channel Setting	**Symbol**	**Definition**	**Symbol meaning**
	I (uppercase "i")	Digital input mode	Used with 6-character label
	O	Digital output mode	Used with 6-character label
	P	Digital output protected mode	Used with 6-character label
Totalizer mode settings	Rise Ed	Totalizer rising edge mode	Used with 12-character label or no label
	Fall Ed	Totalizer falling edge mode	Used with 12-character label or no label
	Rise-TTL	Totalizer rising edge TTL level mode	Used with 12-character label or no label
	Fall-TTL	Totalizer falling edge TTL level mode	Used with 12-character label or no label
	Rise-RST	Totalizer rising edge read reset mode	Used with 12-character label or no label
	Fall-RST	Totalizer falling edge read reset mode	Used with 12-character label or no label
	RiseTRST	Totalizer rising edge TTL read reset mode	Used with 12-character label or no label
	FallTRST	Totalizer falling edge TTL read reset mode	Used with 12-character label or no label
	R	Totalizer rising edge mode	Used with 6-character label
	F	Totalizer falling edge mode	Used with 6-character label
DAC mode settings	V	Voltage function mode	Used with 6-character label
	I (uppercase "i")	Current function either 1 or 2 mode	Used with 6-character label
	V1	Voltage function 1 mode	Used with 12-character label or no label
	I1	Current function 1 mode	Used with 12-character label or no label
	I2	Current function 2 mode	Used with 12-character label or no label
	pV1	Protected voltage function 1 mode	Used with 12-character label or no label
	pI1	Protected current function 1 mode	Used with 12-character label or no label

Front Panel Channel Setting	Symbol	Definition	Symbol meaning
	pI2	Protected current function 2 mode	Used with 12-character label or no label
DAC output enable settings	Off	Output enable is disabled	Used with 6 or 12 character label
	On	Output enable is enabled	Used with 6 or 12 character label

Special keys and power switch

CONFIG key

Press the **CONFIG** key to access an attribute menu that enables you to configure channels, channel patterns, DMM functions or settings, reading buffers, scans, and other operations. Refer to the following for more information:

- *CHAN key configuration* (see "CONFIG CHAN key - SWITCH channel type" on page 2-10)
- *PATT key configuration* (on page 2-29)
- *SCAN key configuration* (on page 2-30)
- *DMM key configuration* (on page 2-20)
- *LIMIT key configuration* (on page 2-26)
- *REL key configuration* (on page 2-29)
- *FILTER key configuration* (on page 2-24)

CONFIG CHAN key

CONFIG CHAN key - SWITCH channel type

Press the **CONFIG** key and then the **CHAN** key to open the CHANNEL ATTRibute menu. If you press the **CHAN** key when a pattern is selected, the unit goes into channel selection mode.

When changing attribute settings for a range of channels, the menu option for the first channel specified in the range is highlighted. For example, selecting Channels 3 to 5 on Slot 3 on the front panel (3003:3005) as a range shows the current attribute setting for 3003 when an attribute menu is displayed. When the attribute setting is selected for a range, the entire range of channels is updated to that value. To view or set an individual attribute setting for only one channel, be sure to select a single channel range. For example, 3003:3003 would only affect Channel 3 on Slot 3, which is displayed as 3003 with the channel state and poles setting below it.

The CHAN ATTR menu contains:

- **LABEL:** Sets the label associated with the specified channel. From the front panel, the label can be up to 12 characters. Remotely, the label may be up to 20 characters. This option will not be displayed if multiple channels are selected. Related ICL command: channel.setlabel().
- **BACKPLANE:** Opens the BACKPLANE menu. Use this menu to add or remove backplane channels from the specified channels. Related ICL command: channel.setbackplane().
- **FORBID:** Allows or prevents the closing of the specified channels. Related ICL commands: channel.setforbidden() and channel.clearforbidden().
- **POLE:** Sets the number of poles for the specified channels. Related ICL command: channel.setpole().
- **DELAY:** Sets additional delay time for the specified channels. Related ICL command: channel.setdelay().
- **COUNT:** Displays closure cycles for the specified channel. This option is not displayed if multiple channels are selected. Related ICL command: channel.getcount().
- **DMM_CONFIG:** Sets the DMM configuration associated with the specified channels. Related ICL command: dmm.setconfig().

CONFIG CHAN key - DIGIO channel type

Press the **CONFIG CHAN** key to open the DIGIO ATTR menu. The DIGIO ATTR menu is not available when a range of channels is selected. If a range is selected, pressing CONFIG CHAN displays the following:

- DIGIO ATTR MENU
- <No Edit by Range, Use EXIT>

Therefore, to see the following options, select a single DIGIO channel.

LABEL

Enter up to 12 characters for the label for a channel. Related ICL command: channel.setlabel().

DELAY

Enter the value for the delay in 1ms steps from 0 to 60 seconds for a channel. Related ICL command: channel.setdelay().

MODE

Sets the mode attribute on a channel. Select one of the following options:

- INPUT
- OUTPUT
- OUTPUT_PROTECTED

Related ICL command: channel.setmode().

MATCH

Sets the match value on a channel. Enter the value as 8-bit binary. Related ICL command: channel.setmatch().

MATCH_TYPE

Sets the match type on a channel. Select one of the following options:

- EXACT
- ANY
- NOT_EXACT
- NONE

Related ICL command: channel.setmatchtype().

STATE

Queries for the state of a channel and displays the value in the top line, labeled by `STATE=`. Related ICL command: channel.getstate().

CONFIG CHAN key - TOTALIZER channel type

Press the **CONFIG CHAN** key to open the TOTAL ATTR menu. The TOTAL ATTR menu is not available when a range of channels is selected. If a range is selected, pressing CONFIG CHAN displays the following:

- TOTAL ATTR MENU
- <No Edit by Range, Use EXIT>

Therefore, to see the following options, select a single Totalizer channel.

LABEL

Enter up to 12 characters for the label for a channel. Related ICL command: channel.setlabel().

MODE

Sets the mode attribute on a channel. Select one of the following options:

- EDGE. Indicates the edge for the Totalizer channel to increment its count. Select from one of the following options:
  - FALLING
  - RISING
- THRESHOLD. Indicates the threshold range. Select from one of the following options:
  - TTL
  - NON_TTL
- RESET. Indicates if the count value gets reset after being read. Select from one of the following options:
  - ON
  - OFF

Related ICL command: channel.setmode().

MATCH

Sets the match value on a channel. Enter the value between 0 and 65535. Related ICL command: channel.setmatch().

MATCH_TYPE

Sets the match type on a channel. Select one of the following options:

- EXACT
- ANY
- NOT_EXACT
- NONE

Related ICL command: channel.setmatchtype().

STATE

Queries for the state of a channel and displays the value in the top line, labeled by `STATE=`. Related ICL command: channel.getstate().

POWER

Sets the power state attribute on a channel. Select one of the following options:

- ENABLE
- DISABLE

Related ICL command: channel.setpowerstate()

CONFIG CHAN key - DAC channel type

Press the **CONFIG CHAN** key to open the DAC ATTR menu. The DAC ATTR menu is not available when a range of channels is selected. If a range is selected, pressing CONFIG CHAN displays the following:

- DAC ATTR MENU
- <No Edit by Range, Use EXIT>

Therefore, to see the following options, select a single DAC channel.

NOTE If the DAC channel has power set to DISABLE, then the menu choices change to only show the option to change the power setting, until the power is set to ENABLE.

LABEL

Enter up to 12 characters for the label for a channel. Related ICL command: channel.setlabel().

DELAY

Enter the value for the delay in 1ms steps from 0 to 60 seconds for a channel. Related ICL command: channel.setdelay().

MODE

Sets the mode attribute on a channel. Select one of the following options:

- FUNCTION. Sets the desired function for a channel. Select one of the following options:
  - VOLTAGE
  - CURRENT_1
  - CURRENT_2
- PROTECT. Indicates if the protection mode for a channel is enabled. Select one of the following options:
  - AUTO
  - OFF

Related ICL command: channel.setmode().

OUTPUT

Sets the output enable attribute on a channel. Select one of the following options:

- ENABLE
- DISABLE

Related ICL command: channel.setoutputenable()

STATE

Queries for the state of a channel and displays the value in the top line, labeled by `STATE=`. Related ICL command: channel.getstate().

POWER

Sets the power state attribute on a channel. Select one of the following options:

- ENABLE
- DISABLE

Related ICL command: channel.setpowerstate()

DISPLAY key

Press this key to toggle between the main and user display modes.

POWER switch

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

RESET switch

Use the **RESET** switch to restore the Series 3700 factory default LAN settings. Refer to the LAN functions and attributes (`lan.config.x`, where `x` represents the specific command) for factory default information.

Operation keys

CHAN key

Different menus are displayed for switch channel types or non-switch channel types when the CHAN key is pressed.

CHAN key - switch channel type

Press the **CHAN** key to open the CHANNEL ACTION menu.

The CHANNEL ACTION menu contains the following 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 channels so that 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().
- **RESET:** This menu item resets specified channels to factory default settings. Resetting a channel deletes any channel patterns that contain that channel. Related ICL command: channel.reset().

CHAN key - DIGIO channel type

Press the **CHAN** key to open the DIGIO ACTION menu. Unless noted, the menu option supports a range of selected channels.

READ

Displays a value from a channel as 8-bit binary. This menu option does not appear if a range of channels is selected. Related ICL command: channel.read().

NOTE	Only widths of one are supported by the front panel when reading or writing to a Digital I/O channel.

WRITE

Writes a value to a channel. Enter the value as 8-bit binary. Related ICL command: channel.write().

NOTE	Only widths of one are supported by the front panel when reading or writing to a Digital I/O channel.

RESET_STATE

Resets the channel state. Related ICL command: channel.resetstatelatch().

RESET

Restores the factory default settings of selected channels or all channels. Related ICL command: channel.reset().

CHAN key - TOTALIZER channel type

Press the **CHAN** key to open the TOTAL ACTION menu. Unless noted, the menu option supports a range of selected channels.

READ

Displays a value from a channel as a number between 0 and 65535. This menu option does not appear if a range of channels is selected. Related ICL command: channel.read().

WRITE

Writes a value to a channel. Enter the value between 0 and 65535. Related ICL command: channel.write().

RESET_STATE

Resets the channel state. Related ICL command: channel.resetstatelatch().

RESET

Restores the factory default settings of selected channels or all channels. Related ICL command: channel.reset().

CHAN key - DAC channel type

Press the **CHAN** key to open the DAC ACTION menu. Unless noted, the menu option supports a range of selected channels.

NOTE If the DAC channel has power set to DISABLE, then the menu choices change to only show the option to change the power setting, until the power is set to ENABLE.

READ

Displays a value from a channel. This menu option does not appear if a range of channels is selected.

A number is displayed that is dependent on the channel's selected mode function, as well as the card model of the selected channel. For example, a number from one of the following ranges is displayed for a DAC channel on the 3750, based on the channel's selected mode function:

- -12 to +12 for MODE-FUNCTION as VOLTAGE_1
- 0 to 20 mA for MODE-FUNCTION as CURRENT_1
- 4 to 20 mA for MODE-FUNCTION as CURRENT_2

Related ICL command: channel.read().

WRITE

Writes a value from a channel. This menu option does not appear if a range of channels is selected.

A number is displayed that is dependent on the channel's selected mode function, as well as the card model of the selected channel. For example, a number from one of the following ranges is displayed for a DAC channel on the 3750, based on the channel's selected mode function:

- -12 to +12 for MODE-FUNCTION as VOLTAGE_1
- 0 to 20 mA in 1 uA steps for MODE-FUNCTION as CURRENT_1
- 4 to 20 mA in 1 uA steps for MODE-FUNCTION as CURRENT_2

Related ICL command: channel.write()

RESET_STATE

Resets the channel state. Related ICL command: channel.resetstatelatch().

RESET

Restores the factory default settings of selected channels or all channels. Related ICL command: channel.reset().

DELETE key

Press the **DELETE** key to delete the first occurrence of the selected channel(s) or channel pattern (including function) from the scan list. If a selected item is not contained in the scan list, no error is reported.

To remove all occurrences of a channel from the list, keep pressing the **DELETE** key.

To view the current scan list after deleting items:

1. Press the **SCAN** key when on the main display.
2. Select the **LIST** option and press the **ENTER** key.
3. Use the navigation wheel or **CURSOR** keys to scroll through the list.

DMM key

Press the DMM key to open the DMM ACTION menu.

The DMM ACTION menu contains the following items:

- **MEASURE:** Takes measurements on the digital multimeter (DMM) without using the trigger model. Related ICL command: dmm.measure().
- **COUNT:** Indicates the number of measurements to take when a measurement is requested. Related ICL command: dmm.measurecount.
- **LOAD:** Recalls a user or factory DMM configuration. Use the navigation wheel to scroll through available configurations. Related ICL command: dmm.configure.recall().
- **SAVE:** 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:** Opens the specified channel and/or channel pattern. Related ICL command: dmm.open().
- **CLOSE:** Closes the specified channel or channel pattern in preparation for a DMM measurement. Related ICL command: dmm.close().
- **RESETFUNC:** Returns the DMM aspects of the system for only the active function to factory default settings. Related ICL command: dmm.reset().
- **RESETALL:** Returns all DMM functions of the instrument to the factory default settings. Related ICL command: dmm.reset().

DMM key configuration

Press the **CONFIG** key and then the **DMM** key to open 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 for additional attribute information in 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.

DETECTBW

Configures the detector bandwidth setting for the selected DMM function. For more information, see Bandwidth. Related ICL command: dmm.detectorbandwidth.

DIGITS

Configures the display digits setting for the selected DMM function. For more information, see Digits ICL programming. 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 2-24).

FUNC

Displays a menu that allows you to scroll through the available DMM functions. Use the navigation wheel or **CURSOR** keys to scroll the menu options and press **ENTER** as soon as the desired function is highlighted. Related ICL command: dmm.func.

INPUTDIV

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

LIMIT

Opens the LIMIT menu for the selected DMM function. See *LIMIT key configuration* (on page 2-26).

LINESYNC

Enables or disables line sync during measurements.

Related ICL command: dmm.linesync.

MATH

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

- **ENABLE:** Enables or disables 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.

For more information, see:

- mX+b
- Reciprocal (1/X)
- 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 4-wire ohms open detector that is being used. Related ICL command: dmm.opendetector.

RANGE

Configures the range of DMM for the selected function for one channel type. For more information, see Range. Related ICL command: dmm.range.

REL

Opens the REL menu for the selected DMM function. See *REL key configuration* (on page 2-29).

THERMO

Selecting the **THERMO** menu item opens the THERMO menu. Items contained in this menu are:

- **REFJUNCT:** 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.
- **THERMOCOUPLE:** 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.

ENTER key

Press the **ENTER** key to accept the current selection or bring up the next menu options.

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

EXIT key

Press the **EXIT** key to:

- Cancel the selection and to return to the previous menu display.
- Exit remote operation.
- Abort a scan that is running.
- Abort a script that is executing.

FILTER key

Press the **FILTER** key to enable and disable the filter for selected function. When the filter is enabled, the FILT annunciator will light. See Filter for more information.

FILTER key configuration

Press the **CONFIG** key and then the **FILTER** key to open the FILTER menu.

The FILTER menu contains the following menu items:

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

FUNCtion key

Each press of the **FUNC** key immediately configures the DMM for the next function in the list:

- **dcvolts**: DC voltage
- **acvolts**: AC voltage
- **dccurrent**: DC current
- **accurrent**: AC current
- **twowireohms**: 2-wire ohm (resistance)
- **fourwireohms**: 4-wire ohm (resistance)
- **commonsideohms**: Common-side ohm (resistance)
- **frequency**: Frequency
- **period**: Period
- **continuity**: Continuity
- **temperature**: Temperature

For example, if the DMM function is configured for dcvolts, pressing the **FUNC** key four times will configure the DMM for acvolts, then for dccurrent, then for accurrent, and then finally for twowireohms, which ends up as the active function on the DMM. If you do not want the DMM to be momentarily configured for the other functions while getting to desired one then, press the **CONFIG** key followed by the **FUNC** key. Next, scroll to the desired function and press the **ENTER** key when the desired function is highlighted (blinking). Related ICL command: dmm.func.

FUNC key configuration

Press the **CONFIG** key and then the **FUNC** key to display a menu that allows you to scroll through the available DMM functions. Turn the navigation wheel or press the **CURSOR** keys to scroll through available functions. Press the navigation wheel or the **ENTER** key to make the displayed function active when it is highlighted and blinking. While in the configuration mode of the **FUNC** key, the function takes effect for the highlighted function only when the **ENTER** key is pressed (the function does not change while scrolling).

INSERT key

Press the **INSERT** key to append the present channels to the scan list.

LIMIT key

Press the **LIMIT** key to 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 LIMIT 2 menu.

These menus contain the following items:

- **ENABLE:** Enables or disables limit testing. Related ICL command: dmm.limit[Y].enable.
- **CLEAR:** Clears the test results of the limit. Related ICL command: dmm.limit[Y].clear().
- **AUTOCLEAR:** Indicates if the limit should be cleared automatically or not. Related ICL command: dmm.limit[Y].autoclear.
- **LOWVAL:** Sets the low limit value. Related ICL command: dmm.limit[Y].low.value.
- **LOWFAIL:** Queries for the low test results of the limit. Related ICL command: dmm.limit[Y].low.fail.
- **HIGHVAL:** Sets the high limit value. Related ICL command: dmm.limit[Y].high.value.
- **HIGHFAIL:** Queries for the high test results of limit. Related ICL command: dmm.limit[Y].high.fail.

LOAD key

Press the **LOAD** key to load scripts along with the Lua chunks added with display.loadmenu.add() for execution. The LOAD TEST menu is displayed.

The LOAD TEST menu contains the following items:

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

MENU key

Press the **MENU** key to open the MAIN menu.

The MAIN menu contains the following 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:** Upgrades the firmware on the unit and installed cards (see *Upgrade procedure using USB flash drive* (on page 7-1)). This menu includes three options (YES, NO, and PREVIOUS).
- **CHANNEL:** 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 commands: channel.connectrule and channel.connectsequential.
- **DISPLAY:** Opens the DISPLAY menu. Select the **TEST** item to open 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:** Enables or disables the beeper, along with selection KEYCLICK option.
- **SYSTEM-INFO:** Opens the SYSTEM INFORMATION menu that can query FIRMWARE, SERIAL#, and CAL information.

PATT key

Press the **PATT** key to open the PATTERN ACTION menu.

- If you press the **PATT** key, but no patterns have been created or if the unit is powered up with the factory default settings, the only option that is displayed is CREATE.
- If you press the **PATT** key after creating channel patterns, the name of an existing pattern blinks, and you are in pattern selection mode. Use the **CURSOR** keys or navigation wheel to scroll through the available patterns, and press **ENTER** to select the one you want to use. The selected pattern is used with the **OPEN** and **CLOSE** action keys, among others.

The PATTERN ACTION menu contains the following items:

- **OPEN:** Opens the specified channel pattern for switching aspects. Related ICL command: channel.open().
- **CLOSE:** Closes the specified channel pattern. These closures are appended to the already closed channels. Related ICL command: channel.close().
- **EXCLOSE:** Closes the specified channel pattern so that the channels associated with the pattern are exclusively closed. Related ICL command: channel.exclusiveclose().
- **EXSLOTCLOSE:** Exclusively closes specified channels in the channel pattern image for the specified slots. Related ICL command: channel.exclusiveslotclose().
- **CREATE:** Creates a channel pattern from a snapshot and associates it with the specified name. From the front panel, only the first 12 characters of the name are visible. If no patterns exist in the system when the **PATT** key is pressed, CREATE is the only menu item that is displayed. Related ICL command: channel.pattern.snapshot().
- **VIEW:** Shows the channels associated with the pattern. Related ICL command: channel.pattern.getimage().
- **DELETE:** Deletes a channel pattern. Related ICL command: channel.pattern.delete().
- **RESET:** Resets the channels representing the image of the selected channel pattern to the factory default settings. Also, the pattern is deleted because resetting a channel causes any patterns that contain a channel being reset to be deleted. Related ICL command: channel.reset().

NOTE	CREATE is the only item that is displayed unless a pattern has been selected.

PATT key configuration

Press the **CONFIG** key and then the **PATT** key to open the PATTERN ATTRibute menu.

The PATTERN ATTRibute menu contains the following item:

- **DMM_CONFIG**: Sets the DMM configuration associated with the specified channel pattern. Use the navigation wheel to scroll through the available DMM configurations. Related ICL command: dmm.setconfig().

REL key

Press the **REL** key to enable and disable relative for the selected function. When enabled, the REL annunciator is lit. See Relative.

REL key configuration

Press the **CONFIG** key and then the **REL** key to open the RELATIVE OFFSET menu.

The RELATIVE OFFSET menu contains the following menu items:

- **ACQUIRE:** Acquires an internal measurement to store as the REL level value. Related ICL command: dmm.rel.acquire().
- **ENABLE:** Enables or disables relative measurement control for the DMM. Related ICL command: dmm.rel.enable.
- **LEVEL:** Sets a specific offset value to use for relative measurements for the DMM. Related ICL command: dmm.rel.level.

RUN key

Press the **RUN** key to run the last selected script or load menu item.

SCAN key

If the scan list is present, press the **SCAN** key to open the SCAN ACTION menu.

The SCAN ACTION menu contains the following items:

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

- **BACKGROUND:** Runs the scan. Related ICL command: scan.background().
- **CREATE:** Displays following message: Use <INSERT> key.
- **LIST:** Displays the scan list (turn the navigation wheel to scroll). Related ICL command: scan.list().
- **CLEAR:** Clears the scan list. Related ICL command (when sent with an empty string): scan.create().
- **RESET:** Resets the scan settings to factory default values. Related ICL command: scan.reset().

SCAN key configuration

Press the **CONFIG** key and then the **SCAN** key to open the SCAN ATTR menu.

The SCAN ATTR menu contains the following items:

- **ADD:** Instructs how to add an additional list of channels and/or channel patterns to scan. When you select **ADD** from the SCAN ATTR menu, "Use <INSERT> key" is displayed for a few seconds before going back to the SCAN ATTR menu options. To add items to an existing scan list, press **INSERT**.

  NOTE Press the **INSERT** key when you are not in the SCAN ATTR menu on the MAIN display.

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

- **MODE:** Sets the `scan.mode` value to one of the following:
  - OPEN_ALL, which is equivalent to scan.MODE_OPEN_ALL or 0 (default setting)
  - OPEN_SELECT, which is equivalent to scan.MODE_OPEN_SELECTIVE or 1
  - FIXED_ABR, which is equivalent to scan.MODE_FIXED_ABR or 2

  Related ICL command: scan.mode()
- **MEAS_CNT:** Sets the measure count value. Related ICL command: scan.measurecount
- **SCAN_CNT:** Sets the scan count value. Related ICL command: scan.scancount

SLOT key

Press the **SLOT** key to display information about the installed card(s) and the main system. The information that is displayed includes firmware revisions, model names, and model numbers. After pressing this key, scroll through all available instruments, including the internal DMM (if installed), using the **CURSOR** keys, navigation wheel, or multiple presses of the **SLOT** key.

TRIG key

Press the **TRIG** key to trigger a measurement equivalent to the dmm.measure() command. If the **TRIG** key is held for more than two seconds, the unit will go into continuous trigger mode and take measurements every .25 seconds (if possible, as defined by DMM attributes). Press **TRIG** or **EXIT** to stop continuous trigger mode.

The **TRIG** key can also be tied to the system trigger model and event system (see Trigger model).

Range keys, cursor keys, and navigation wheel

AUTO key

Press the **AUTO** key to enable or disable autorange for the selected function. The AUTO annunciator lights when enabled.

CURSOR keys

Press the ≺ **CURSOR** ➢ keys in a menu to control the cursor position when making selections or changing values.

Navigation wheel

Turn the navigation wheel to scroll to the desired menu option or to change the value of the selected numeric parameter. Pressing the navigation wheel has the same functionality as pressing the **ENTER** key. See *ENTER key* (on page 2-23) for more information.

When changing a multiple character value, such as an IP address or channel pattern name, press the navigation wheel to enter edit mode, rotate the navigation 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 navigation wheel to change their value as needed. Press the **ENTER** key when finished changing all the characters.

RANGE keys

Press the **RANGE** keys ⮝⮟ to select the next higher or lower measurement range on the measurement display for the selected function.

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. You can also use these keys when entering a range value from the front panel. For details, see Auto ranging over the front panel.

If you select a range of channels, that range must stop when the channel type changes. Therefore, you can never select a range of channels which includes different channel types.

For more information, see Range.

Action keys

CLOSE key

Press the **CLOSE** key to close specified channels or channel patterns.

OPEN ALL key

Press the **OPEN ALL** key to open all closed channels.

OPEN key

Press the **OPEN** key to open selected channels or channel patterns.

RATE key

Press the **RATE** key to set the measurement speed (fast, medium, or slow) for the active or selected function. For more information, see Rate.

RECall key

Press the **RECall** key to display stored readings and buffer statistics for selected reading buffer. Use the ≺ **CURSOR** ➢ keys or turn the navigation wheel to navigate through the buffer. For more information, see Recalling readings.

STEP key

Press the **STEP** key to step through the defined scan list, where each press results in one scan step.

NOTE	You cannot use an external trigger event, like digital I/O, for the channel stimulus setting of the trigger model when using the STEP key. For more information, see Scanning and Trigger model.

STORE key

Press the **STORE** key to open the RD BUFF ACTION menu or <selected buffer name> menu. For more information, see Buffer: Data Storage and Retrieval.

The **RD BUFF ACTION** menu contains the following items:

- **CREATE:** Allows creation of a reading buffer. When a new buffer is created, you can enter the name and set the number of readings to store. The new buffer is created with append mode ON and is automatically selected for front panel use (store readings, clear, delete, save, and so on). Related Instrument Control Library (ICL) command: dmm.makebuffer().
- **SELECT:** Allows you to select a previously created reading buffer, which you can use to store readings taken on the front panel.
- **CLEAR:** Removes readings from a selected buffer.
- **SAVE:** Allows you to save a selected reading buffer to a USB flash drive (the flash drive must be installed and have enough available memory).
- **DELETE:** Lets you delete a selected reading buffer from the system. All data associated with the deleted buffer will be lost. This is equivalent to setting the reading buffer variable name to `nil` over the bus.

STORE key configuration

With a buffer selected, press the **CONFIG** key and then the **STORE** key to open the RD BUFFER ATTR menu.

This menu contains the following menu items:

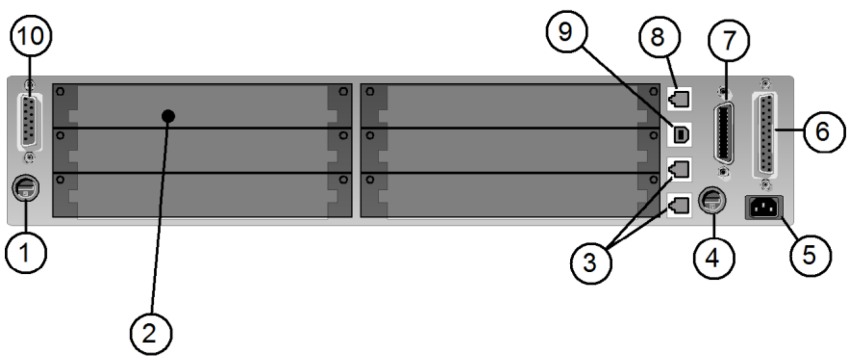
- **CAPACITY:** Displays the maximum number of readings that can be stored.
- **COUNT:** Displays the actual number of readings that have been stored.
- **APPEND:** Indicates the append mode setting of the reading buffer. For buffers created on the front panel or web, this defaults to ON or enabled. For buffers created over the bus, the default is OFF or disabled.

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-LinkTM 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 3-5)
10	*Analog backplane connector* (on page 3-6)

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 2-31).

TSP-LinkTM 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.

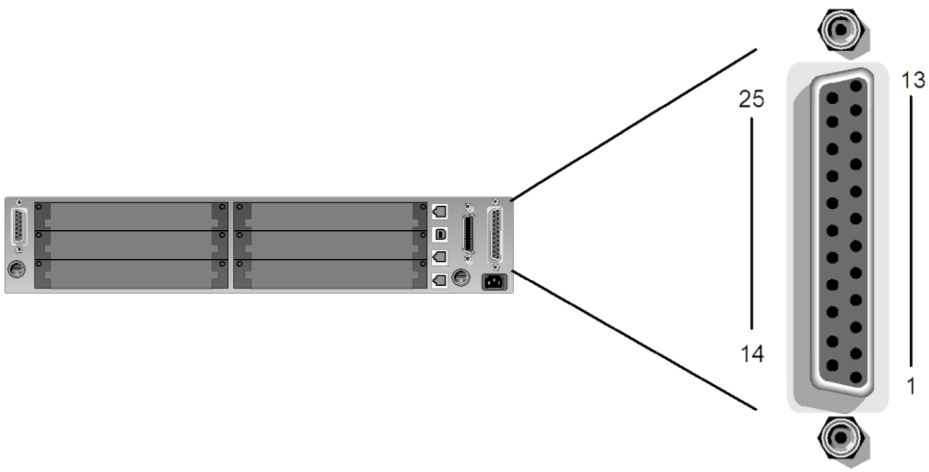
Power connector

Using the supplied line cord, connect to a grounded AC power outlet. See *Line power connection* (on page 3-14) 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



Pin	Description
1 ... 9	Digital I/O #1 ... Digital I/O #9
10 ... 14	Digital I/O #10 (High Current Pins see Note) ... 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).

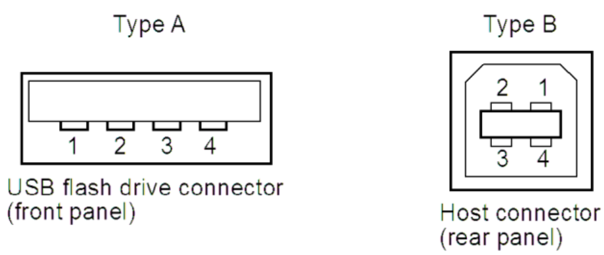
To connect the Series 3700 to an Ethernet system hub or receptacle, use a standard Ethernet cable (RJ-45, male/male).

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

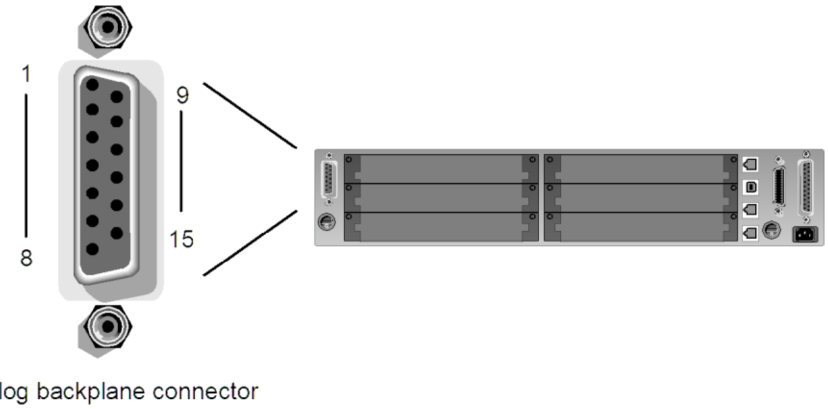


Pin number	Function
1	VBUS (5 volts)
2	D-
3	D+
4	Ground

Analog backplane connector

Refer to the following figure for analog backplane connector information. See *Connections* (on page 3-10) before making any connections.

Figure 3-4: Analog backplane connector



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

Description	Pin
Analog backplane 3-HI	5
Analog backplane 3-LO	6
Analog backplane 4-HI	7
Analog backplane 4-LO	8
Analog backplane 5-HI	12
Analog backplane 5-LO	13
Analog backplane 6-HI	14
Analog backplane 6-LO	15

Description	Pin
DMM-SLO	4
DMM-SHI	3
DMM-LO	2, 9
DMM-HI	1
AMP-LO	2, 9
AMP	10, 11

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.

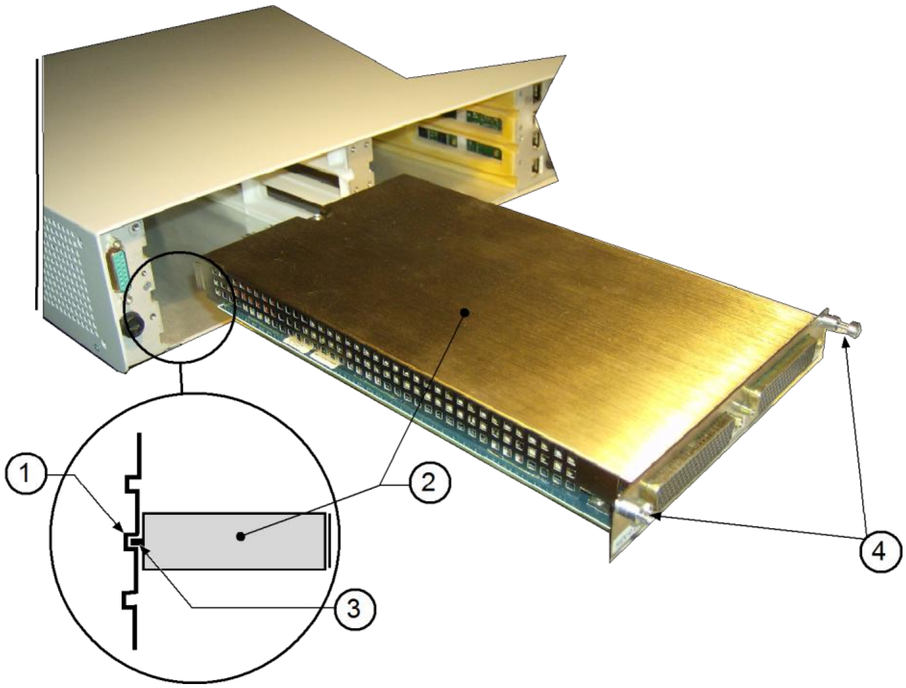
Module installation

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 2-31) 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 4-digit channel number includes the slot number 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, you must specify the slot location and channel number of the switching module 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 *MUX (multiplexer) channel notation* (on page 4-2)
- The row and column of *matrix card notation* (on page 4-3)
- The modules' backplane relay notation

Bus operation

The Series 3700 supports bus operation over USB, Ethernet, and GPIB. Set the GPIB settings 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 navigation 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 you 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 using 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 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 is displayed.

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 navigation 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
```

Section 4

Close-open overview

In this section:

Overview

NOTE This section provides basic close/open information for switching module channels. To install the switching module, refer to instructions in *Rear Panel* (on page 3-1). Operating characteristics unique to a specific Series 3700 switching module are provided in *Series 3700 Module Schematics and Connections* (on page 9-1), where you can also find information to make connections to the switching module.

The switching channels of a Series 3700 have specific settings for switch-only operations and specific settings for switch with DMM operations. The Series 3700 accesses different settings based upon the close or open operation you specify. You can perform such operations on switching module channels, analog backplane relays, and channel patterns.

Channel designations

You designate channels to perform close and open operations, create scans, and create channel patterns. You can reference individual channels or a range of channels when performing these operations using the front panel interface or using the remote command interface.

Channel and backplane notation

There are three different notations used to control relays: *Backplane relay notation* (on page 4-2), *MUX (multiplexer) channel notation* (on page 4-2), and *Matrix card notation* (on page 4-3).

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:

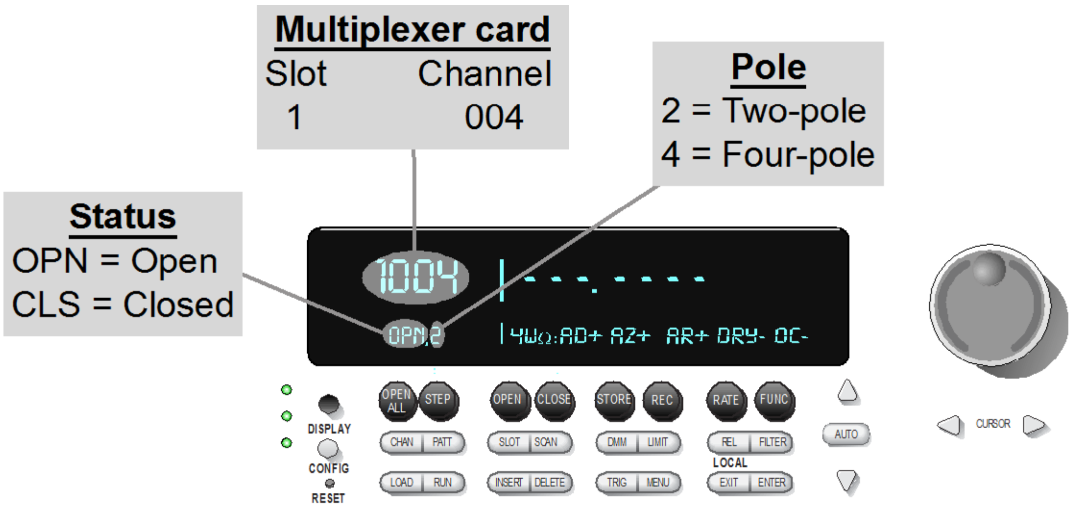
S: Slot number

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

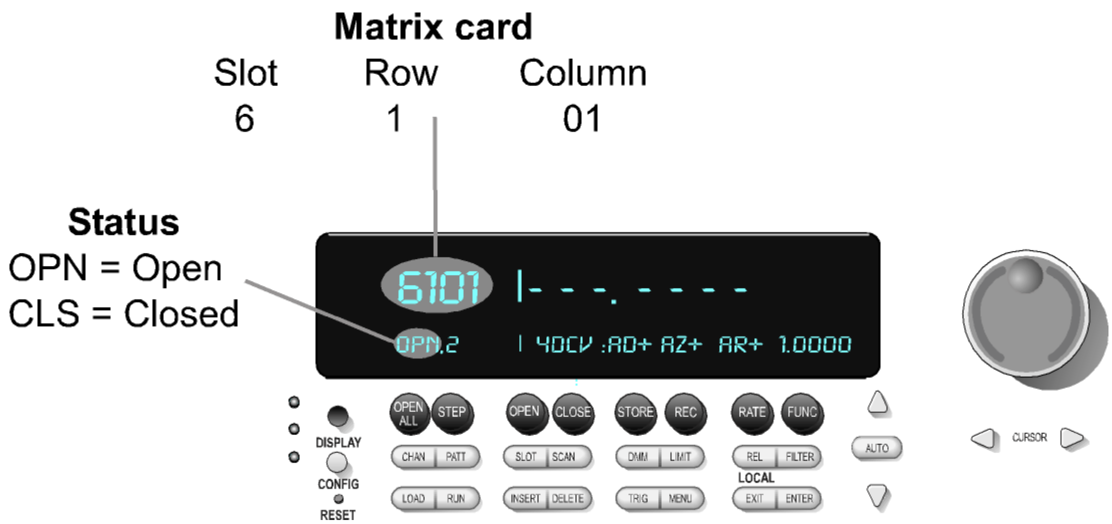
R: Row number

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



Selecting a range of channels on the front panel

You can perform operations on a single channel or range of channels. Specify a channel range by selecting a starting channel number and ending channel number. When you request an operation be performed on a range of channels, the Series 3700 performs the same operation on all channels within the channel range.

To select a channel range on the front panel (as an example a range of Channels 1003 through 1005):

NOTE A single channel is selected when the starting and ending channel for a range match.

You cannot explicitly select an analog backplane relay on the front panel interface. You can only associate a backplane relay with a switching module channel. Refer to *Channel attributes* (on page 4-7) for further details.

---

1. To change the present slot, press the navigation wheel, and the first digit of the four-digit channel number flashes, indicating edit mode. Turn the navigation wheel to change the number to select any slot that has a switching module or pseudocard installed. For example, change the digit to a 1.
2. Press the navigation 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 flash, indicating edit mode. Turn the navigation wheel to change the starting channel number (any channel available for the selected slot's module can be selected). For example, change the digits to 003.
3. Press the navigation 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 flash, indicating edit mode. Turn the navigation wheel to change the ending channel number (any channel available for the selected slot's module can be selected). For example, change the digits to 005.
4. Press the navigation wheel a fourth time to accept the channel selection.
5. Press the navigation wheel a fifth time to return to the main display after selecting the desired user configuration for the channel range.
6. Press the **CONFIG** key followed by **CHAN** key to change other channel attributes for the range. Likewise, press the **CHAN** key without the **CONFIG** key to bring up the **CHANNEL ACTION MENU** for use with the selected channel range.

Channel list parameter <ch_list>

The channel list parameter `<ch_list>` is a string-type parameter that is used when controlling the relays of the Series 3700 using the remote command interface. You can specify a list of individual channels or a range of channels.

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* (on page 4-18).
- 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-delimited.
- Use a colon to specify a range of channels.

Examples:

- To perform an open or close operation on Channels 1 and 3 of Slot 1, use ('1001, 1003') for the `<ch_list>`.
- To perform an open or close operation on all channels within the range of Channels 1 through 5 of Slot, use ('1001:1003') for the `<ch_list>`.

<ch_list> queries

For queries that return a channel list parameter, a channel configured for 4-pole operations will indicate the paired channel in parentheses. For example, if Channel 3003 on a 60-channel card is configured for 4-pole, then its paired channel is 3033. Notice the response to the query in the code example below:

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

Channel attributes

NOTE	Analog backplane relays and channel patterns do not support all the attributes of switching module channels. Refer to *Channel patterns* (on page 4-18) for a discussion of channel pattern attributes.

Each switching module 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 can be used to refer to that channel. You cannot apply a label to a range of channels.

NOTE	The label for a channel cannot match the name of an existing channel pattern. For more information on channel patterns, refer to Channel patterns.

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 switch-only operation on a single channel or range of channels. This attribute is not applicable to channel patterns. Refer to Channel patterns.

pole setting: pole setting for multiplexer (MUX) channels indicates if the paired MUX channel should be included when performing a close or open operation on channel.

In a switching module that has 60 channels, the Series 3700 automatically pairs Channels 1 through 30 with Channels 31 through 60 (respectively) when the pole setting for a channel is set to 4-pole. Once you configure the pole setting of a switching channel for 4-pole, the associated paired channel becomes unavailable for switching operation. For example, assume 3003 is set to 4-pole and its paired channel is 3033. Now, you cannot set attributes or perform close/open operations on 3033. A paired channel settings conflict error generates if you specify Channel 3033 for a close/open operation.

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

forbidden setting: indicates if the channel is forbidden to close. An analog backplane relay can be marked as forbidden to close.

NOTE	Analog backplane relays only support the forbidden setting attribute.

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. Refer to *Relay closure count* (on page 4-22) for information on querying this attribute.

DMM configuration: indicates the DMM function associated with a MUX channel along with that function's pertinent attributes. For switch with DMM operations on a single channel or range of channels, the Series 3700 verifies that the channel supports the function associated with the DMM configuration will take place.

The pole setting and DMM configuration of channel can 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 prevailing attribute depends on the operation you want to perform. The DMM configuration predominates in switch with DMM operations (`dmm.close` or `dmm.open`); the pole setting predominates for switch-only operations (`channel.close`, `channel.open`, `channel.exclusiveclose` and `channel.exclusiveslotclose`).

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)
- are allocated 32KB of memory within the Series 3700 mainframe for storage of all DMM configurations.

The number of DMM configurations you can store varies with the number of characters of the name of the DMM configuration as well as the number of attributes associated with a particular function. If each DMM configuration name is six characters long, then you can store 78 temperature configurations (temperature has 41 unique DMM associated attribute settings). However, if the the function is set to DC volts, and each name is six characters long, then you can store 99 DMM configurations (DC volts only has 31 unique DMM associated attribute settings).

NOTE	Use the DMM configuration query command to determine how many attributes are associated with a function (see `dmm.configure.query`).

To see how much of the DMM configuration memory is available or used, see the `memory.available` or `memory.used` ICL commands. Refer to Instrument Control Library in the Series 3700 Reference manual for more details on these commands.

Refer to *Basic Digital Multimeter (DMM) Operation* (on page 5-1) for more details on DMM functions, attributes, and configurations.

Setting and querying channel attributes

You can view and edit channel attributes on the front panel using the channel attributes menu. To access the channel attributes menu, press the **CONFIG** key and then press the **CHAN** key. Use the navigation wheel and **CURSOR** keys to change attribute values. Use the **ENTER** and **EXIT** keys to apply or cancel settings.

With the exception of the DMM configuration attribute, you can view and edit channel attributes using the remote command interface using the commands residing in the channel logical instrument. For example, to set the label attribute of a channel, use the `channel.setlabel` command; to retrieve the label attribute of a channel, use the `channel.getlabel` query.

To set the DMM configuration attribute for a channel or group of channels, use the `dmm.setconfig` command and specify the desired channels in the `<ch_list>` parameter. To retrieve the DMM configuration attribute for a channel or group of channels, use the `dmm.getconfig` query.

For specific instructions on retrieving the relay closure count attribute, refer to *Relay closure count* (on page 4-22).

Closing and opening channels

Switching channels have specific settings for switch-only operations and specific settings for switch with DMM operations. For switch-only operation, there are three close methods and one open method. For switch with DMM operation, there is one close and one open method.

The Series 3700 verifies the operation being requested for a channel is supported by the specified channel and that the channel exists in the system.

NOTE You can also scan, that is, perform a user-specified sequence of close/open operations on multiple channels, for switch only applications or the switch with DMM applications. Refer to Scanning in the Series 3700 Reference Manual for information on scan operations.

Close/open channel operations and commands

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 specifies the completion of either a switch-only operation or a switch with DMM operation.

Available close/open switch only operations:

- Channel close
- Channel exclusive close
- Channel exclusive slot close
- Channel open

Corresponding remote commands for switch only operations:

ICL command	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()	It will open the channels and possibly analog backplane relays that would get closed with channel.close().

Available close and open switch with DMM operations:

- Dmm close
- Dmm open

NOTE An error occurs if you attempt to perform a switch with DMM operation on an item that does not have an associated DMM configuration.

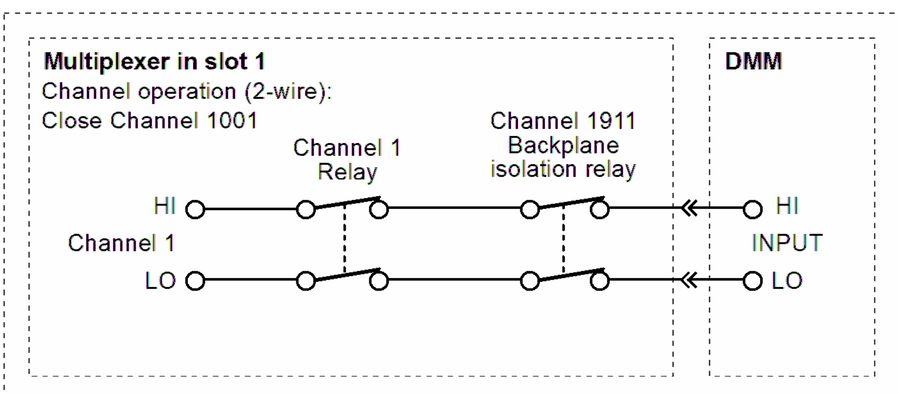
Corresponding remote commands for switch with DMM operations:

ICL command	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. It closes any needed backplane relays and paired channels. It opens channels and backplane relays that will interfere with measuring on the specified item.
dmm.open()	It opens the items that would get closed with a dmm.close().

When you perform a switch with DMM operation, the Series 3700 also closes the appropriate analog backplane relays to connect to the DMM Input and/or DMM Sense terminals. For 2-wire or two-pole DMM operations, the Series 3700 closes only the analog backplane relay to connect to the DMM Input terminal. For 4-wire or four-pole DMM operations, the Series 3700 closes the analog backplane relays to connect to the DMM Input and DMM Sense terminals.

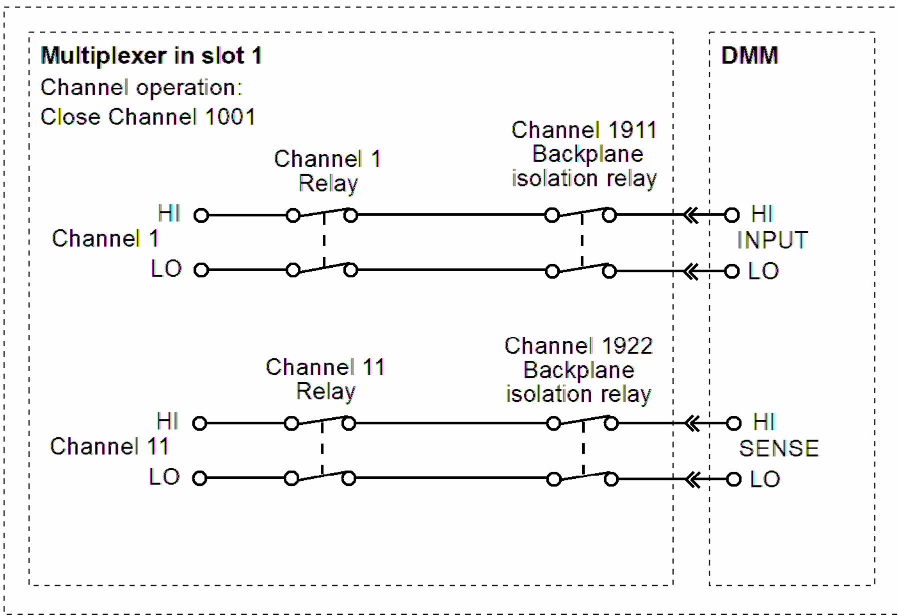
The following figure shows an example of how the channel is connected to the DMM Input of the Series 3700 for a 2-wire DMM operation. Assume a switching module with 20 channels is installed in Slot 1 of the mainframe and a 2-wire DMM operation, such as DC Volts, is selected. When you perform a DMM close operation on Channel 1001, the Series 3700 closes Channel 1001 and Channel 1911 (the backplane isolation relay) to connect the channel to the DMM Input terminal.

Figure 4-3: Two-wire function



The following figure shows an example of how the channel and its paired channel are connected to the DMM Input and Sense terminals of the Series 3700 for a 4-wire DMM operation. Assume a switching module with 20 channels is installed in Slot 1 of the mainframe, and a 4-wire function, such as Ω4, is selected. When you perform a DMM close operation on Channel 1001, the Series 3700 closes Channel 1001 and Channel 1911 (backplane isolation relay) to connect the channel to DMM Input. The Series 3700 also closes Channel 1011 (the paired channel) and Channel 1922 (the sense backplane isolation relay) to connect the paired channel to DMM Sense.

Figure 4-4: Four-wire function



NOTE Refer to the Instrument Control Library (ICL) in the Series 3700 Reference Manual for more detail on each ICL command.

Front panel close and open keys

You can use the front panel **CLOSE** and **OPEN** keys to perform either switch only operations or switch with DMM operations on the selected channel(s). The operations of the keys depend on the DMM configuration attribute setting of the selected channel. Refer to *Channel Attributes* (on page 4-7) for more information on the DMM Configuration attribute.

When the DMM configuration is set to "nofunction", the **CLOSE** and **OPEN** keys function as switch only operations in the same manner as `channel.close` and `channel.open` commands. When the DMM configuration is associated with a particular function (for example, DC Volts), the CLOSE and OPEN keys function as switch with DMM operations, that is, in the same manner as `dmm.close` and `dmm.open` commands.

To access the other switch only operations (exclusive close and exclusive slot close), use the CHAN key to choose and initiate the desired operation after selecting a channel or range of channels.

Examples of switch-only and switch with DMM operations

Switching channels have specific settings for switching and specific settings for switching with DMM operations. The operation you employ for closing or opening channels determines which attributes for a channel are accessed for that operation. 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 In this example, 3031 and 3032 are paired channels because channels 3001 and 3002 are configured with a DMM setting of "fourwireohms", which is a four-pole function. Two poles are supplied from channels 3001 or 3002, and two poles from the associated paired channel.

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 (because 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 because 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

Viewing close/open status of a channel

To determine whether a channel or backplane relay is closed or open, you can view its status using the front panel interface, remote command query, or internal web page.

Viewing status from the front panel

You can only view the status of a specific channel on the front panel. The selected channel appears in the right field on the display. Its status appears directly under the channel number.

NOTE For a four-pole operation the paired channel is not displayed on the front panel of the Series 3700.

You can view examples on the front panel display of channel status information in *MUX (multiplexer) channel notation* (on page 4-2) and *Matrix card notation* (on page 4-3).

Viewing status from the remote command interface

To view a list of closed channels in a specific channel range, in a specific slot, or across all slots use the `channel.getclose()` command.

To view the closed/open status of a specific channel range, in a specific slot, or across all slots, use the `channel.getstate()` command.

Viewing status from the internal web page

The Cards page(s) on the internal web page diagram the relay configuration of the switching module and display a visual representation of present channel status. To access the internal web page, refer to the Series 3700 Quick Start Guide for instructions.

Connection methods for close operations

Switch only operations using exclusive channel closures or exclusive slot channel closures and switch with DMM operations using dmm closures can open and close switch channels in a single command. You can dictate the order of opening and closing relays using the channel connection rule.

When specifying a list of channels to close, the number of relays that can close simultaneously is limited by the power drive of a specific switching module. If the switching module does not permit simultaneous channel closure, action settling times may vary at each execution of the channel closure command. You can obtain determining timing by enabling sequential channel closures, a system level attribute.

Channel connection rule: Break-Before-Make, Make-Before-Break

The channel connect rule is a system-level attribute that determines the order of opening and closing channels when performing close operations that open and close multiple relays. This attribute is applicable for electromechanical, reed, and solid state relay switching modules. The same attribute setting is associated with all applicable channels in the system.

You can set the channel connect rule to Break-Before-Make (BBM), Make-Before-Break (MBB), or Off. The default setting is BBM. You can minimize the settling time for the close operation by setting connect sequential “Off”, which permits the instrument to initiate close and open operations simultaneously.

NOTE You cannot guarantee the sequence of open and closure operations with the channel connect rule set to “Off.” It is highly recommended that you implement cold switching when the channel connect rule is set to “Off”.

To set the channel connect rule through the front panel interface:

1. Press the **MENU** key.
2. Use the navigation wheel to scroll to the CHANNEL menu item.
3. Press the **ENTER** key (or the navigation wheel) to display the CONNECT MENU.
4. From this menu, select the RULE menu item: Use this menu item to set the rule to BBM, MBB, or OFF.
5. Use the **ENTER** key to apply the selection.
6. Use the **EXIT** key to leave the menu.

To set the channel connect rule through the remote command interface, use the `channel.connectrule` command. Refer to the Instrument Control Library (ICL) in the Reference Manual for details on the `channel.connectrule` command.

Using sequential connecting to achieve deterministic settling times

Relays of a specific switching module have a specified settling time, which is also referred to as actuation time. You incur these settling times at each close or open operation for both switch-only and switch with DMM operations. When specifying multiple channels for a single close or open operation, the total settling time depends on the relay drive scheme for the switching module -- how each switching module budgets power to change the state of its relays.

The Series 3700 supports the following relay drive schemes:

- Direct Drive: You can simultaneously update the state of all relays on a switching module with a single close or open operation. The total settling time for a close or open operation is the settling time for a single relay.
- Matrix Drive: Executing a close or open operation on a list of channels can result in multiple actions to update the state of all specified relays. Settling time is not deterministic.
- Hybrid Matrix Drive: For a single close or open operation, the state of all relays can be updated in no more than two steps. The total settling time for a close or open operation does not exceed twice the settling time for a single relay.

For applications that require deterministic settling time for every close or open operation, you can enable sequential connecting. Sequential connecting forces the instrument to close all channels specified in the close or open operation in a sequential manner. The total settling time will be a sum of the settling time for each relay of the specified channel list.

By default, sequential connecting is off and the Series 3700 performs the close or open operation as quickly as possible.

To enable sequential connecting through the front panel interface:

1. Press the **MENU** key.
2. Use the navigation wheel to scroll to the CHANNEL menu item.
3. Press the **ENTER** key (or the navigation wheel) to display the CONNECT MENU.
4. From this menu, select the SEQUENTIAL menu item: Use this menu item to to turn ON sequential connecting.
5. Use the **ENTER** key to apply the selection.
6. Use the **EXIT** key to leave the menu.

To enable using the remote command interface use the `channel.connectsequential` command. Refer to Instrument Control Library (ICL) in the Reference Manual for details on the `channel.connectsequential` command.

Channel patterns

You can use channel patterns as a convenient way to refer to an image of switching channels and backplane relays with a single alphanumeric name. Close or open operations on a channel pattern only control the channels and analog backplane relays included in the channel pattern image. There is no speed advantage in performing close/open operations on channel patterns versus the same operations on individual channels or a list of channels.

Creating channel patterns

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 any DMM configuration associated with the pattern is valid, based on the switch path connections that the image makes.

NOTE The first character of a channel pattern name must be alphabetical (uppercase or lowercase letter). Pattern names are case sensitive. Channel labels and channel patterns cannot have the same names.

To create a channel pattern from the front panel:

1. Use the **CLOSE** and/or **CHAN** key to close the channels you want to include in the channel pattern.
2. Press the **PATT** key.
3. From this menu, select the **CREATE** menu item.
4. From this menu, select the **SNAPSHOT** menu item.
5. At the prompt, enter a pattern name using the navigation wheel and **CURSOR** keys.
6. Use the **ENTER** key to apply the selection.
7. Use the **EXIT** key to leave the menu.

To create a channel pattern using the remote command interface, use the `channel.pattern.setimage` or the `channel.pattern.snapshot` command. Refer to Instrument Control Library in the Series 3700 Reference Manual for more details.

NOTE Channel patterns inherit the delay times of the individual channels that comprise the pattern. For information on the sequence of close operations on multiple channels, refer to *Connection methods for close operations* (on page 4-15).

NOTE Marking a channel as 'forbidden to close' deletes any existing channel patterns containing that channel.

Channel pattern storage

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.
- are allocated 32KB of memory within the Series 3700 mainframe for all channel pattern storage.

The number of channel patterns you can store varies with the number of characters of the channel pattern name, the number of characters used in listing the switching channels, and the number of characters in the name of the DMM configuration. 32KB of memory is equivalent to 32,000 characters. If each channel pattern name is five characters long, and each pattern is comprised of five channels, and the channel list is comma delimited (for example, "2003,4003,2005,4005,2915"), then you can store 642 channel patterns. You can store additional channel patterns by decreasing the number of characters in each channel pattern name or the number of channels in the channel pattern image. Conversely, you store fewer than 642 channel patterns by increasing the number of characters in the channel pattern name or number of channels in the channel pattern image.

To see how much of the channel pattern memory is available or used, see the `memory.available` or `memory.used` ICL commands. Refer to Instrument Contol Library (ICL) in the Series 3700 Reference Manual for more details on these commands.

Assigning channel pattern attributes

A channel pattern has only two attributes: the channel pattern name and a DMM configuration. An error occurs if you attempt to assign or query any channel attributes other than DMM configuration for a channel pattern.

You associate a name with a channel pattern when you create the pattern.

To assign a DMM configuration to a channel pattern using the front panel interface use the PATTERN ATTRibutes menu. You must create the channel pattern before you can access the PATTERN ATTRibutes menu. To access this menu after creating a channel pattern, press the **CONFIG** key followed by the **PATT** key.

To assign a DMM configuration to a channel pattern using the remote command interface, use the `dmm.setconfig` command and specify the channel pattern name for the <ch_list> parameter. To retrieve the DMM configuration attribute for a channel pattern, use the `dmm.getconfig` query and specify the channel pattern name for the `<ch_list>` parameter.

Pole settings and channel patterns

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

Set the pole setting of switching module channels prior to creating a channel pattern image. If you change the pole setting for a channel, the Series 3700 will delete any patterns that contain that channel. 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 exists in system. However, the pattern called 'myimage2' still exists.

While creating channel pattern images, the paired channel is automatically accounted for based on pole setting. Therefore, you do not need to manually specify the paired channel in the channel pattern image. 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 parentheses in `<ch_list>` queries.

Performing close and open operations on channel patterns

You can perform the same close and open operations on channel patterns as you can for individual channels.

To perform a close/open operation on a channel pattern using the front panel interface, first press the **PATT** key to select the desired pattern. Use the **CLOSE** or **OPEN** key to perform a channel close or DMM close operation. Use the **PATT** key to perform a channel exclusive close or channel exclusive slot close operation.

To perform a particular operation on a channel pattern, use the appropriate open or close command with the channel pattern name for the `<ch_list>` parameter. Refer to *Close/open channel operations and commands* (on page 4-10) for more details.

When you request a close or open operation, the Series 3700 verifies that the channels exist for a pattern, but does not verify that the switch path connection is correct. You must ensure the requested operation is safe for a channel pattern and that a good measurement will result if performing switch with DMM operations.

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.***

Relay closure count

The Series 3700 keeps an internal count of the number of times each switching module relay has been closed. The total number of relay closures is stored in nonvolatile memory on the switching module. Use this count to determine when any relays require replacement (see the specific module's contact life specifications).

Relay closures are counted only when a relay transitions 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 view the close counts for channels 1 to 5 on Slot 2 using the remote command interface, 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 view the close counts for channel 5 on the card in Slot 1 using the front panel keys:

1. Select channel 1005 using the navigation wheel.
2. Press the **CONFIG** key.
3. Press the **CHAN** key.
4. Use the navigation wheel to scroll to the "COUNT" menu item.
5. Press the **ENTER** key (or the navigation wheel) to display the close counts for Channel 1005.
6. Use the **EXIT** key to leave the menu.

NOTE	You can query the backplane relay closure count only using the remote command interface, but not on the front panel.

Identifying installed modules

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
```

Section 5

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 warmup 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.

The dmm.autozero=dmm.AUTOZERO_ONCE or 2 has significant delay for dmm.nplc settings <0.2plc. Refer to the table below for delay time at selected NPLC.

```
timer.reset()
dmm.autozero=2
time=timer.measure.t()
print(time)
```

NPLC	Delay time (s)
0.0005	2.75
0.199	5.45

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

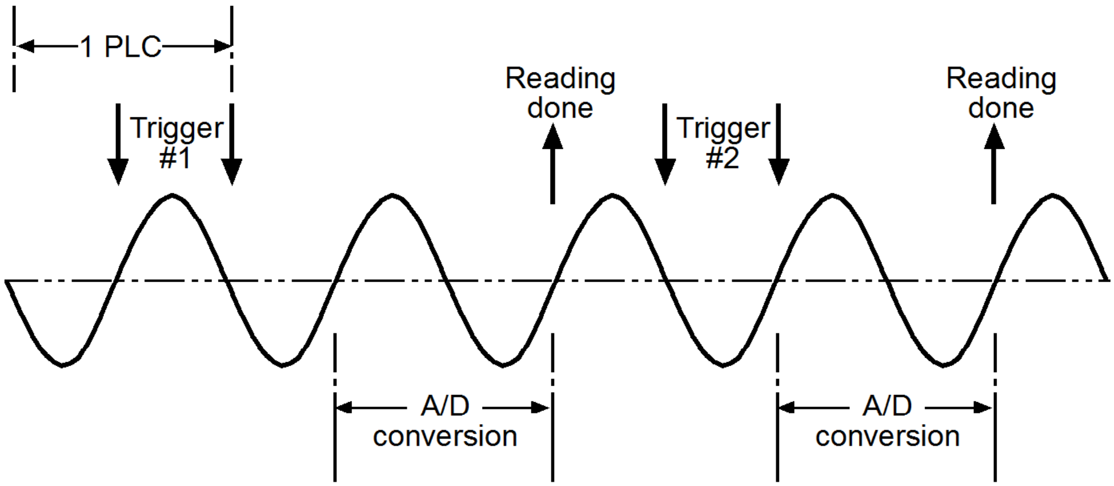
Synchronizing A/D conversions with the frequency of the power line increases common mode and normal mode noise rejection. When line cycle synchronization is enabled, the measurement is initiated at the first positive-going zero crossing of the power line cycle after the trigger.

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 any DC function and any NPLC measurement, increasing NMRR and CMRR.

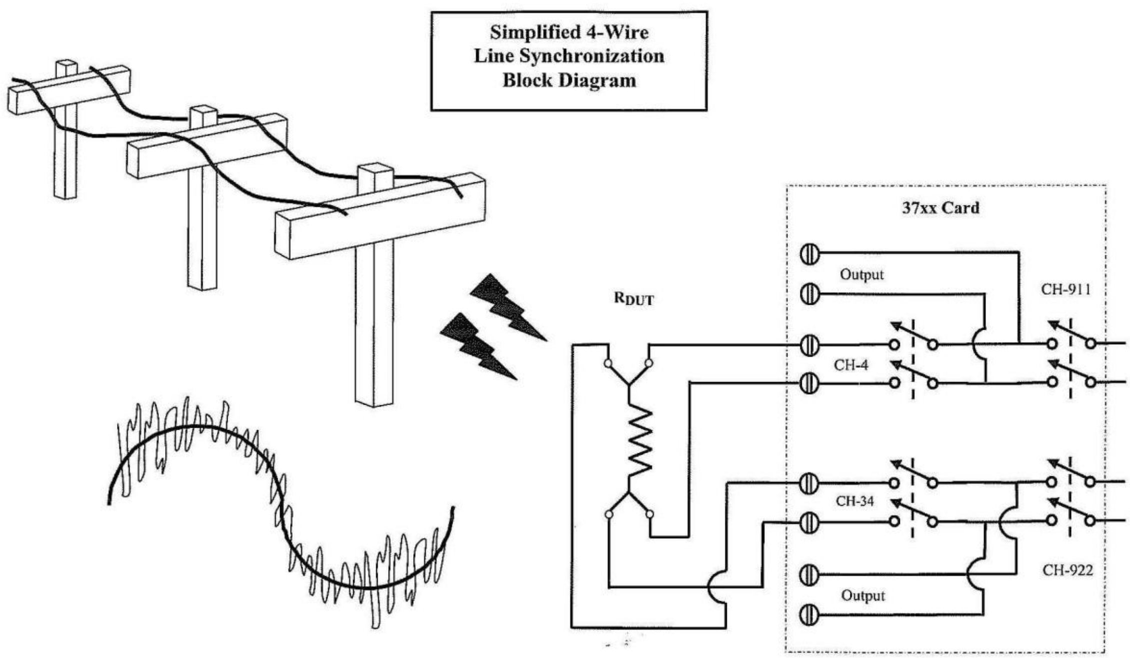
See dmm.linesync in the Reference Manual for remote programming information.

Figure 5-1: Line cycle synchronization



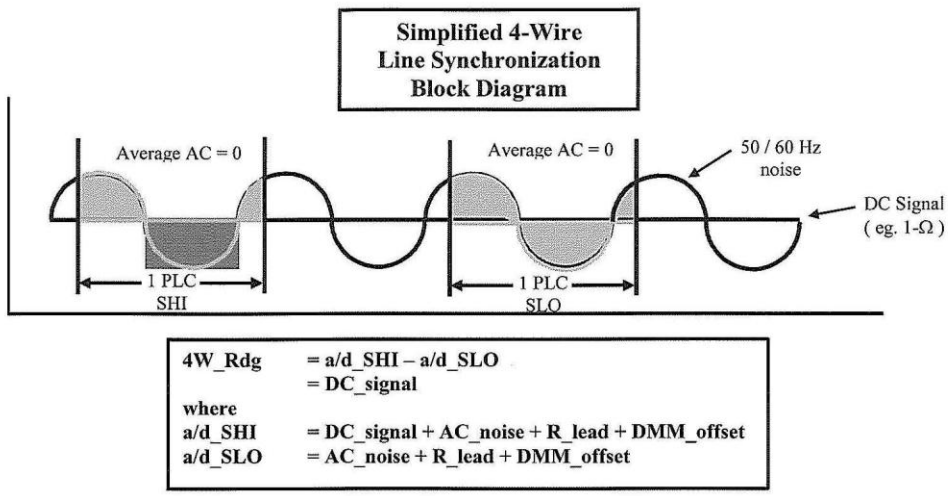
4-Wire Ohms are sensitive to 50 / 60Hz power line noise, due to cabling and Model 3700 switch card loop area.

Figure 5-2: 4-Wire Line Synchronization Block Diagram



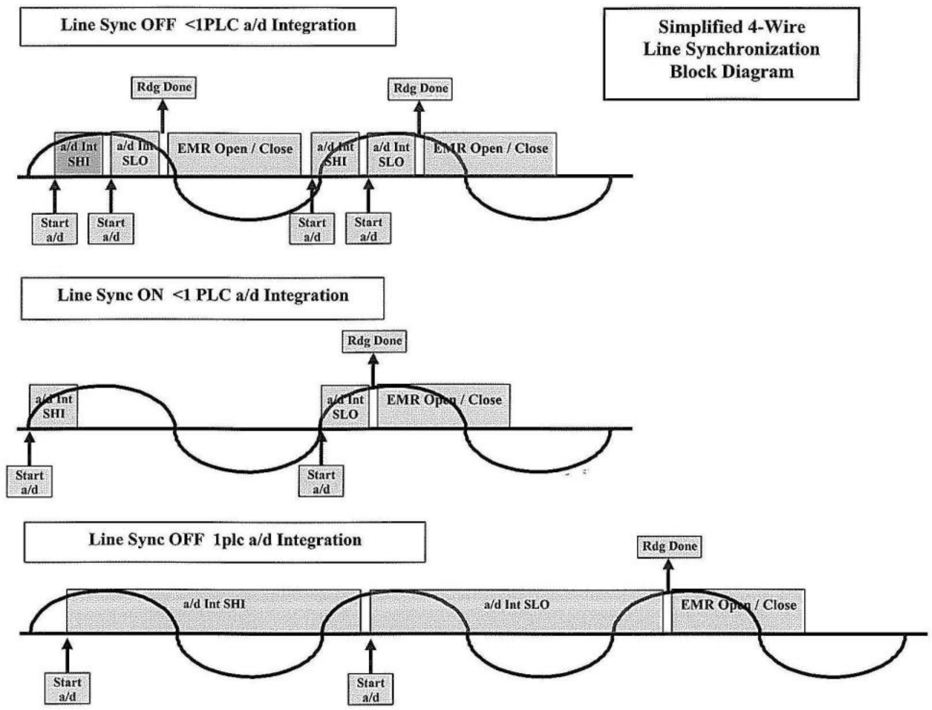
Traditional DMM 4-wire measurements are made in two phases, SHI and SLO. If the dmm.nplc=1 or a multiple of the power line, theoretically, the average AC noise is 0. Refer to the 4W-Rdg calculation (http://www.maxim-ic.com/appnotes.cfm/appnote_number/1041/).

Figure 5-3: 1plc Line Sychronization Block Diagram



For Line Synchronization off and <1plc, reading rate increases, but measurement uncertainty and noise increases due to the Average AC noise during the SHI phase not cancelling with the SLO phase. With Line Synchronization ON, the SHI and SLO measurement phases are triggered at the rising edge of the power line zero crossing. This improves reading uncertainty and noise by >30x while minimal reading rate reduction.

Figure 5-4: Line Sync Off and On <1plc



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 <-0.4mV. With a short circuit (and the input divider on or off), the short circuit to read < ±0.9μV.

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.*** ***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 5-5: DCV connection

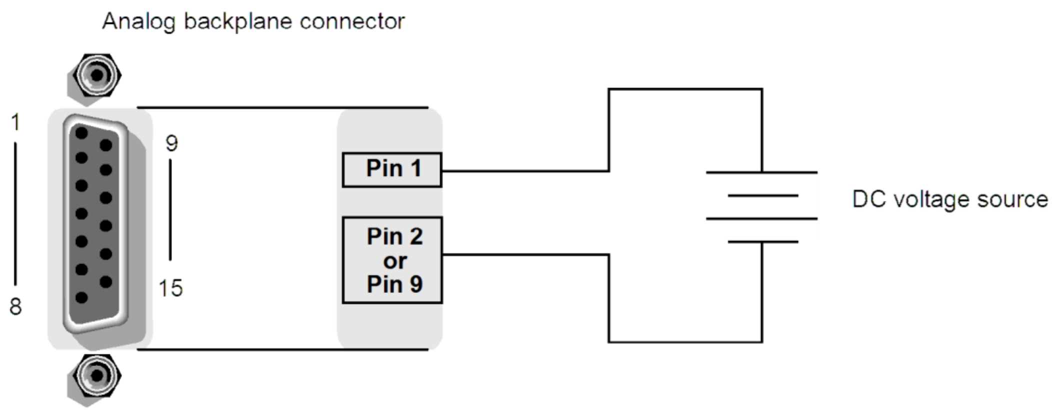
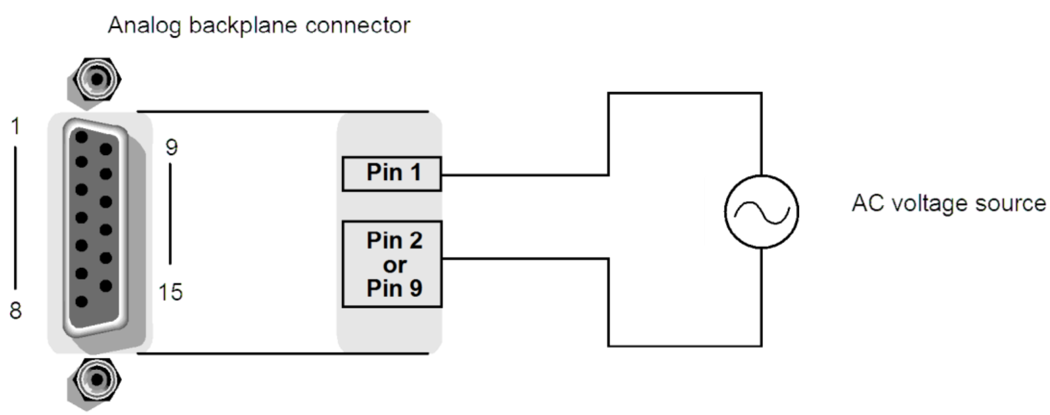


Figure 5-6: ACV connection

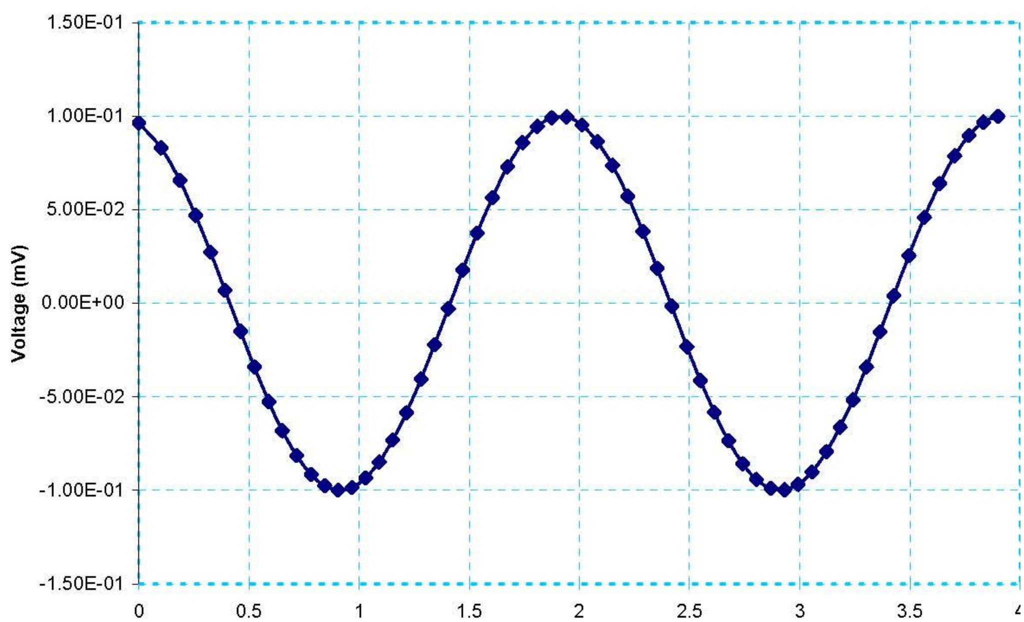


Fast DCV measurements

The following example script samples a 500Hz 70.7mV sine wave into the 100mVDC range at 0.0005plc with autozero and autodelay disabled. You can cut and paste the output data from the script into an editor like WordPad, where you can save it as a .csv (comma separated variable) file (using File > Save As, and typing .csv as the extension). You can open .csv files in Microsoft Excel or other spreadsheet application.

```
loadscript test_dcv_time
dmm.func="dcvolts"
dmm.range=100e-3
dmm.linesync=0
dmm.nplc=0.0005
dmm.autodelay=0
dmm.autozero=0
dmm.measurecount=1
print (dmm.measure())
print ("wait nplc delay")
buf=dmm.makebuffer(30)
buf.clear()
buf.appendmode=1
dmm.measurecount=30
dmm.measure(buf)
for x=1,buf.n do printbuffer(x,x,buf,
   buf.relativetimestamps) end
endscript
```

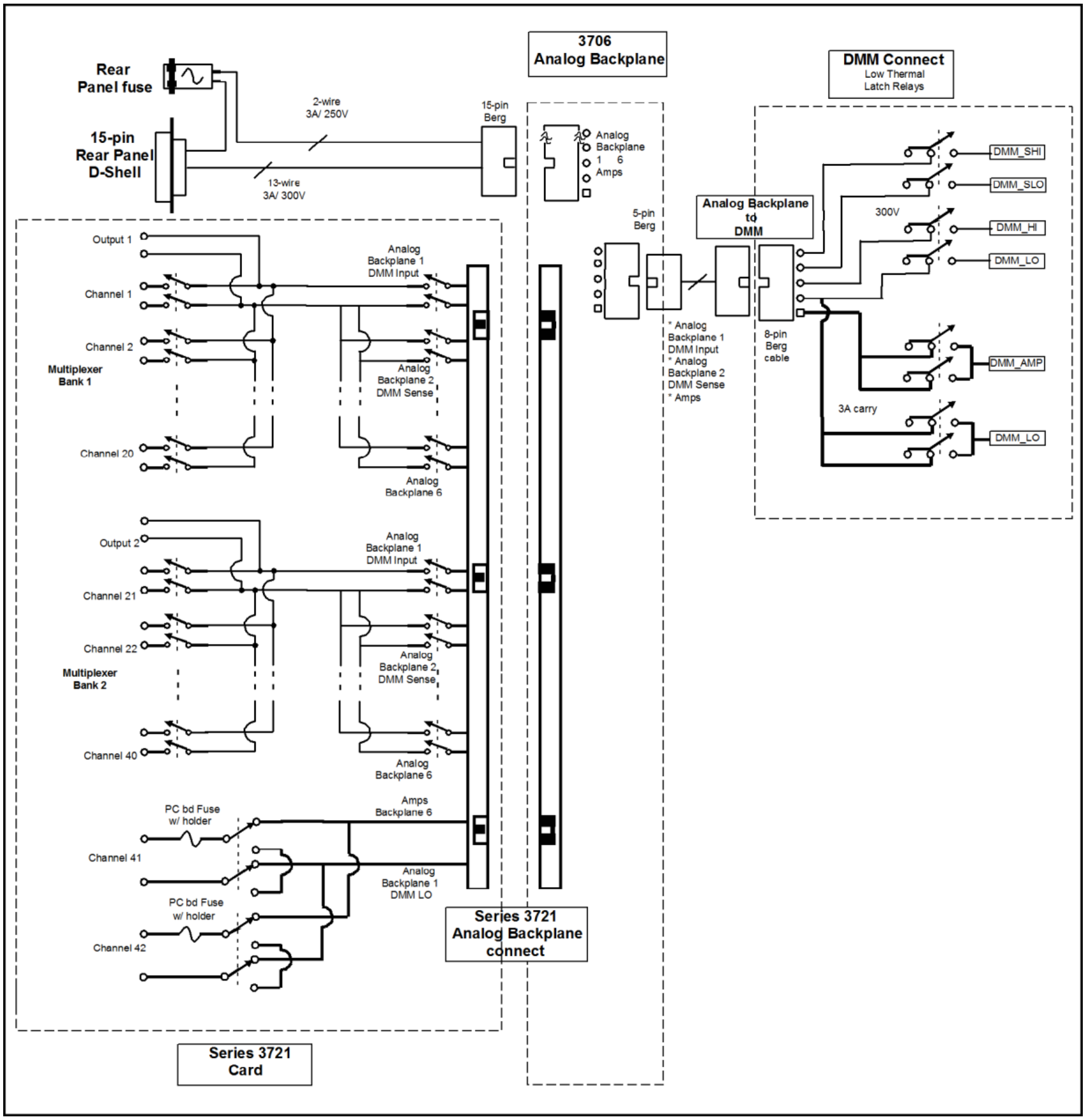
Figure 5-7: 3706 ACV Input on DCV at 0.0005plc



Schematic

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

Figure 5-8: 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 8×10^7VHz product.

Perform the following steps to change a DMM function, range, NPLC, autozero settings, filter settings, and so on. Unique features for a particular DMM function are covered under that DMM section. For example, `dmm.offsetcompensation` is discussed under 4-wire ohms and RTD temperature measurement sections.

1. Press the **OPENALL** key to open all switching channels.
2. Select the voltage measurement function by pressing the **CONFIG** key, and then pressing the **DMM** key. FUNC flashes on, then off. Press the **ENTER** key or wheel. **Function?** is displayed on the first line of the VFD display and the second line displays available functions. Use the left or right arrow keys or the knob to select DCV or other functions.
3. Use the **RANGE** ⮝ and ⮟ keys to:
    - Select a measurement range
    - Adjust Autorange, Range, NPLC, Autodelay, Autozero, Filter, Limit, Linesync, Math, REL, Aperture, and Digits after selecting the desired function under the Config DMM menu
    - Press the **AUTO** key to select autoranging (AUTO annunciator turns on)
4. Apply the voltage(s) to be measured.
5. If using a 3700 switch card, perform the following steps to assign a range of channels and assign the channel a DMM configuration, such as DCV, ACV, or user defined "my_dmm_cong1":
    a. Using the navigation wheel:
        - Press once to select 3700 card slot number and adjust 1-6.
        - Press a second time to select the start channel number.

- Press a third time to select the end channel.
- Press a fourth time to allow DMM configuration assignment to the channel or range of channels.

NOTE The ICL command `reset()` erases any channel assignments but maintains the user-defined configurations such as "my_dcv_conf1". Refer to the reset() command in the ICL reference manual for additional details. Also, the default setting is `nofunction` for all channel assignments.

a. Press the **CLOSE** key.

6. Press the **TRIG** key and observe the display. 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, because 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 5-9: ACV measurements: sine waves

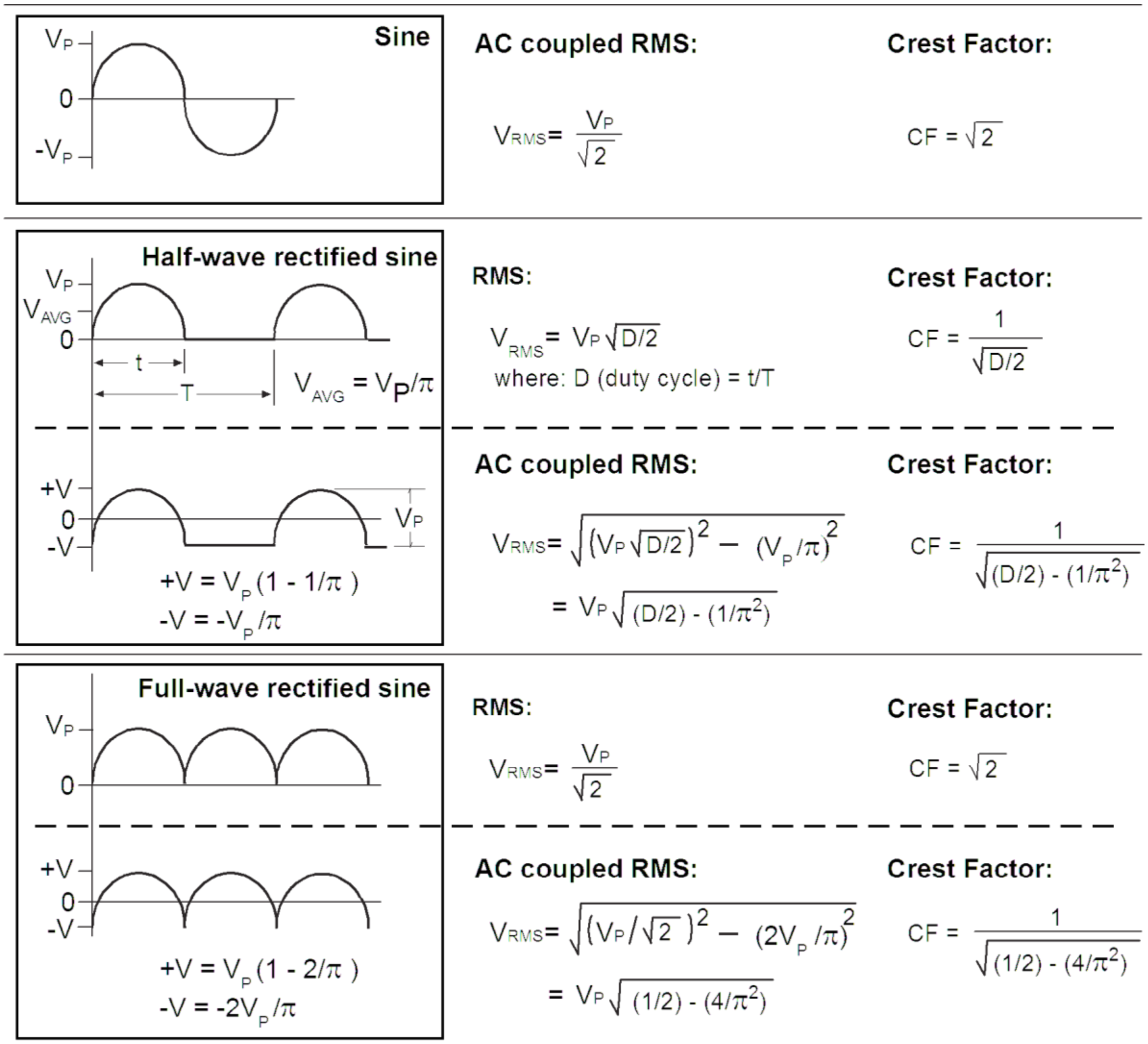
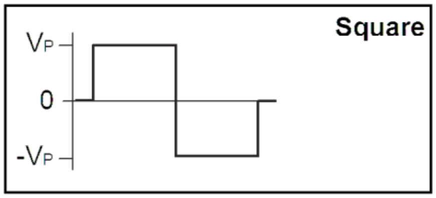
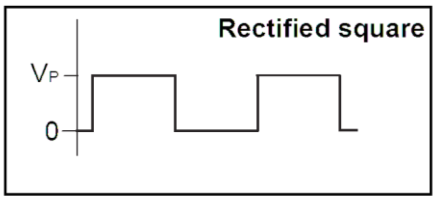


Figure 5-10: ACV measurements: square, pulse, and sawtooth waves



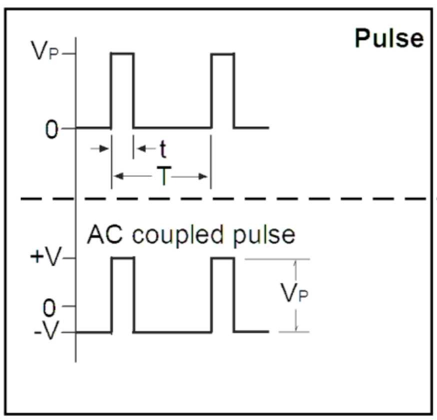
AC coupled RMS: $V_{RMS} = V_P$

Crest Factor: CF = 1



AC coupled RMS: $V_{RMS} = \frac{V_P}{2}$

Crest Factor: CF = 2



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 peak:

$+V = V_P(1 - D)$

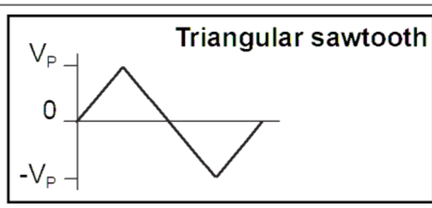
$-V = -V_PD$

when: $0 < D \leq 0.5$

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

when: $0.5 < D \leq 1$

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



RMS: $V_{RMS} = 0.557V_P$

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.

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	Detector Bandwidth	Range and delays							
		Range	100mV	1V	10V	100V	300V		
DCV		Autodelay	1ms	1ms	1ms	5ms	5ms		
		Auto Range	1ms	1ms	1ms	5ms	5ms		
		Range	100mV	1V	10V	100V	300V		
	3 or 30	Autodelay	200ms	200ms	200ms	200ms	1s		
ACV		Auto Range	200ms	200ms	200ms	200ms	1s		
	300	Autodelay	50ms	50ms	50ms	50ms	250ms		
		Auto Range	50ms	50ms	50ms	50ms	250ms		
Freq and		Range	100mV	1V	10V	100V	300V		
Period		Autodelay	100ms	100ms	100ms	100ms	100ms		
		Auto Range	100ms	100ms	100ms	100ms	100ms		
		Range	10uA	100uA	1mA	10mA	100mA	1A	3A
DCI		Autodelay	13ms	2ms	2ms	2ms	2ms	2ms	2ms
		Auto Range	13ms	2ms	2ms	2ms	2ms	2ms	2ms
		Range			1mA	10mA	100mA	1A	3A
	3 or 30	Autodelay			200ms	200ms	200ms	200ms	300ms
ACI		Auto Range			200ms	200ms	200ms	200ms	300ms
	300	Autodelay			50ms	50ms	50ms	50ms	75ms
		Auto Range			50ms	50ms	50ms	50ms	75ms

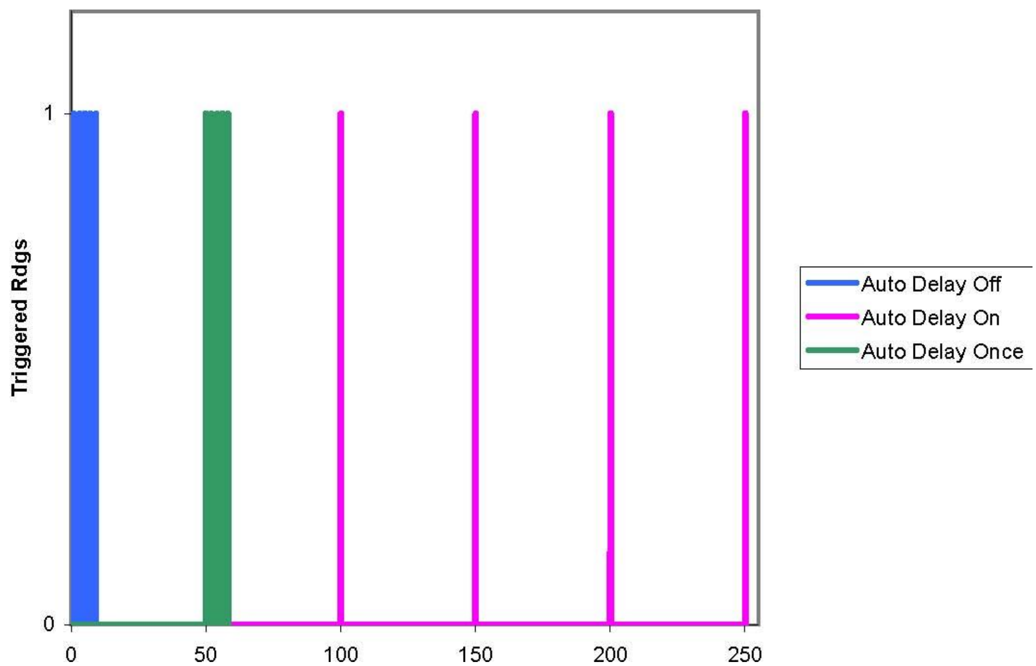
Function	**Detector Bandwidth**	**Range and delays**							
		Range	1 - 100Ω	1kΩ	10kΩ	100kΩ	1MΩ	10MΩ	100MΩ
2Ω and 4Ω		Autodelay	3ms	3ms	13ms	25ms	100ms	250ms	375ms
		Auto Range	2.5ms	2.5ms	12.5ms	25ms	100ms	250ms	375ms
		Range	1 - 10Ω	100 - 2kΩ					
Dry-Ckt-Ω		Autodelay	3ms	13ms					
		Auto Range	2.5ms	12.5ms					
		Range		1kΩ					
Continuity		Autodelay		3ms					
		Auto Range		2.5ms					
	RTDs	PT100, D100, F100, PT385, and PT3916				Use 1kΩ.			
Temp		User		Use 1k and 10kΩ, dependent on Alpha, Beta, Delta, and Ro.					
	T/C			Autodelay and Auto Range 1ms.					
	Thermistor	2252Ω and 5kΩ		Use 100 - 10MΩ, dependent on temperature.					
		10kΩ		Use 1k - 10MΩ, dependent on temperature.					

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 scan list where multiple measurements are required per channel. If `dmm.measurecount` is >1, the front panel **TRIG** key will perform the measurecount number at 250msec intervals. Press **EXIT** or send dmm.measurecount=1 to halt triggering.

For example, for ACV 1V range with a dmm.measurecount=5, the following graph illustrates the time to complete the 5 readings with autodelay Off, Once, and ON using ICL commands.

Figure 5-11: Autodelay Off, Once, and On timeline



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.

The following example illustrates how to optimize ACV. The block diagram shows a two-channel scan measuring 1Vrms on the first channel and approximately 100mV on the second channel. Due to the internal DMM circuitry, the RMS converter must settle 50ms before the start of the first reading on each channel. For each channel, 25 readings are taken at a 1msec interval. With Autodelay off, the measurement uncertainty follows the 50msec settling time of the RMS converter. With Autodelay Once, the first reading is delayed 50msec, allowing the RMS converter to settle, then 25 readings are taken at a 1msec internal, resulting in <0.01% uncertainty.

Figure 5-12: Simplified ACV Detector Bandwidth 300 (FAST) Scan Block Diagram

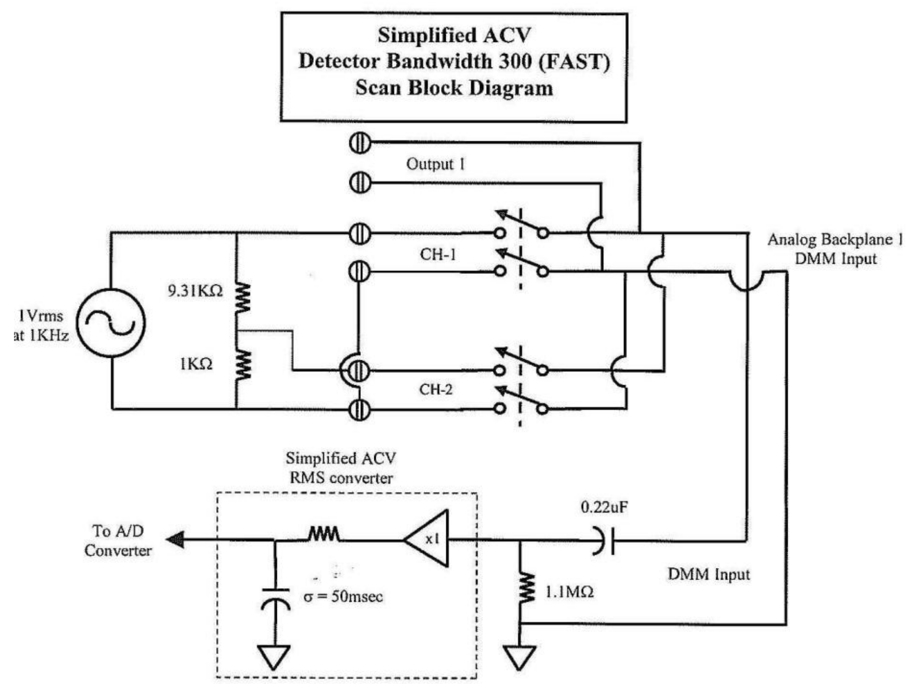
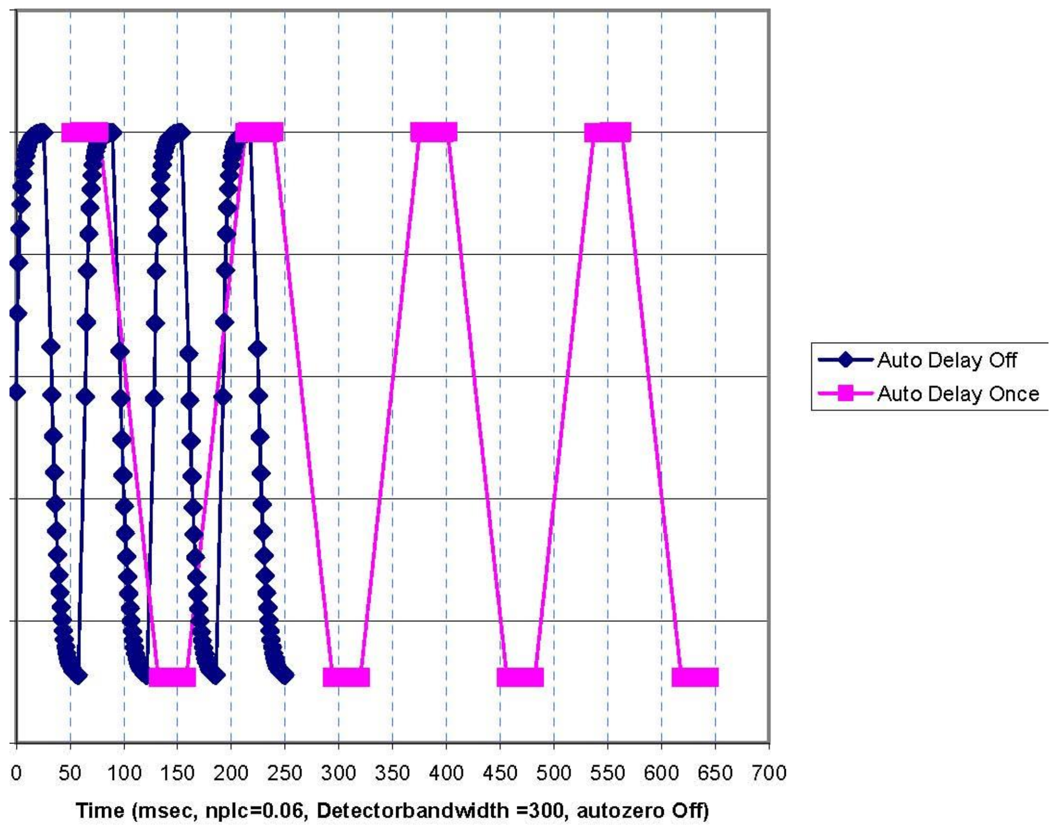


Figure 5-13: Two Channel Scan alternating from 1Vac to 100mVac, 1KHz, with a Measurecount of 25



ACV Autodelay Once script example

```
-- Script Name.
loadscript test_acv_autodelay

-- Resets the 3706 to factory defaults.
reset()

-- Break-before-make off. Fastest closure method.
channel.connectrule=channel.OFF
dmm.func="acvolts"
dmm.range=1

-- Default bandwidth setting.
dmm.detectorbandwidth=300

-- When bandwidth set to 300, NPLC can be programmed from
   0.0005plc to 12plc (60Hz, 15plc(50Hz)
dmm.nplc=0.06
dmm.autozero=0

-- 0 or dmm.OFF
dmm.autodelay=dmm.OFF

-- 1 or dmm.ON
dmm.autodelay=dmm.ON

-- 2 or dmm.AUTODELAY_ONCE.
dmm.autodelay=dmm.AUTODELAY_ONCE

-- Applies a single 50msec trigger delay to DMM after
   channel closure.

-- DMM takes a 25 readings on the same channel.
scan.measurecount=25

-- DMM settlings defined as "my-1Vac".
dmm.configure.set("my-1Vac")
dmm.setconfig("4004, 4024", "my-1Vac")

-- Channels 4 and 24 defined as "my-1Vac".

-- Buffer size set to 200 readings.
buf=dmm.makebuffer(200)
buf.clear()
buf.appendmode=1

-- Scan list created with Channels 4 and 24. Backplane
   Channels 4911 and 4921 are automatically paired.
scan.create("4004, 4024")

-- Scan loops 4 times.
scan.scancount=4

-- Starts scan.
scan.execute(buf)
for x=1,buf.n do printbuffer(x,x,buf,
   buf.relativetimestamps) end

-- Prints the reading and relative time from start of scan
```

```
-- buf.timestamp includes date and real time.
-- Note that x,x prints reading and time vertically for
   easy copy / paste to Excel
endscript
```

This table illustrates how to optimize ACV or ACI for input signal frequency, reading rate, autodelay, and measure count.

Setting	Detector bandwidth	Freq band	Aperture time	Fixed no. samples per reading	Auto zero	Autodelay (ms)		Measure count	Total measure-count time (s)	Average Reading(s)
SLOW	3	3Hz-300KHz	1ms, fixed	2000	N/a	200	Off	10	21.41167	0.467
							Once		21.61796	0.463
							On		23.41259	0.427
MED	30	30Hz-300KHz	1ms, fixed	200	N/a	200	Off	20	6.00595	3.33
							Once		6.22548	3.213
							On		10.0174	1.997
FAST	300	300Hz-300KHz	8.33us (10us) min	1	Off	50	Off	100	0.00765	13,070
							Once		0.15072	663.5
							On		5.08854	19.65
FAST	300◄	300Hz-300KHz	16.67ms (20ms)	1	On◄	50	Off	100	2.35427	42.48
							Once◄		2.50335	39.95
							On		7.08160	14.12

Default setting ◄, (50 Hz power line frequency)

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}):

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

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

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

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 5-13).

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 5-11) 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 9-24).

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 1MΩ. 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 10MΩ and 100MΩ ranges, the ratiometric method is used to measure resistance.

Basic resistance measurements

The Series 3700 can make resistance measurements from 0.1µΩ to 120MΩ. For resistances >1kΩ, the 2-wire (Ω2) method is typically used for measurements. For resistances ≤1kΩ, the 4-wire (Ω4) measurement method should be used to cancel the effect of test lead (and channel path) resistances.

When measuring resistance >10K-ohms, cable and 3700 card capacitance, along with dielectric absorption, can cause additional uncertainties, such as low readings. The low readings are caused by insufficient settling time after the closure of a Model 3700 switch card channel. Auto delays have been optimized to allow proper settling after the close of a channel. Refer to the Auto Delay table for additional details. If the application requires an additional settling delay, use the following ICL commands to the channel or slot of interest:

`channel.setdelay("4004", 0.050)` adds 50msec of delay after closing channel 4 in slot 4.

`dmm.setdelay("slot4", 0.050)` adds 50msec of delay to all channel in slot 4.

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, 1kΩ, and 10kΩ ranges for the Ω4 function.

Optimizing low ohm measurement and speed

When measuring resistance 100-ohms or less, cable, connectors, and Model 3700 switch cards can have thermal offsets, which can result in additional reading uncertainties. Auto delays for <=100-ohms have been optimized for throughput and settling, resulting in the best measurement. If the above conditions cause additional uncertainty, adding a delay of 10msec can improve accuracies. Refer to the Auto Delay table for additional details. If the application requires additional settling delay, use the following ICL commands to the channel or slot of interest:

`channel.setdelay("4004", 0.010)` adds 10msec of delay after closing channel 4 in slot 4.

`dmm.setdelay("slot4", 0.010)` adds 10msec of delay to all channels in slot 4.

Amps measurement procedure

1. Press the **OPENALL** key to open all switching channels. Refer to the DCV section on how to select a DMM function, range, filter setting, and more.

NOTE The Model 3721 switch card is the only card that supports DCI or ACI functions. You can only assign DCI or ACI to channels 41 and 42. If DCI or ACI is assigned to Channel 1-40, error 1116 "function mismatch in configuration" is displayed. Also, if DCV, ACV, 2W, 4W, Continuity, Temp, Freq, or Period are assigned to Channel 41 or 42, error 1114 "function mismatch in configuration" is displayed.

2. Apply the current(s) to be measured. Refer to DCV section on channel closer, assignments, and triggering.
3. To measure other switching channels, repeat steps 5 and 6.
4. When finished, press the **OPENALL** key to open all channels.

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

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

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, 1kΩ, and 10kΩ ranges (maximum of 2.4kΩ) for the Ω4 function. When Dry Circuit is enabled, Offset Compensation is defaulted On.

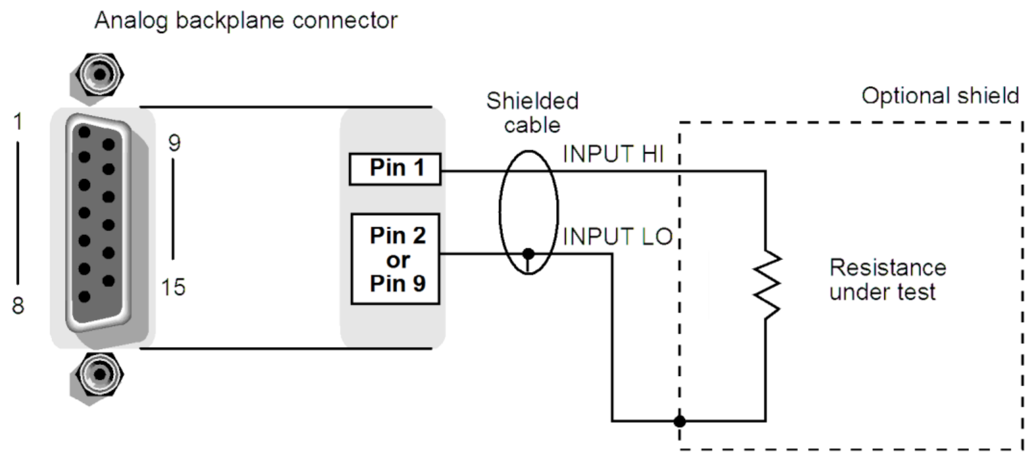
Connections

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.

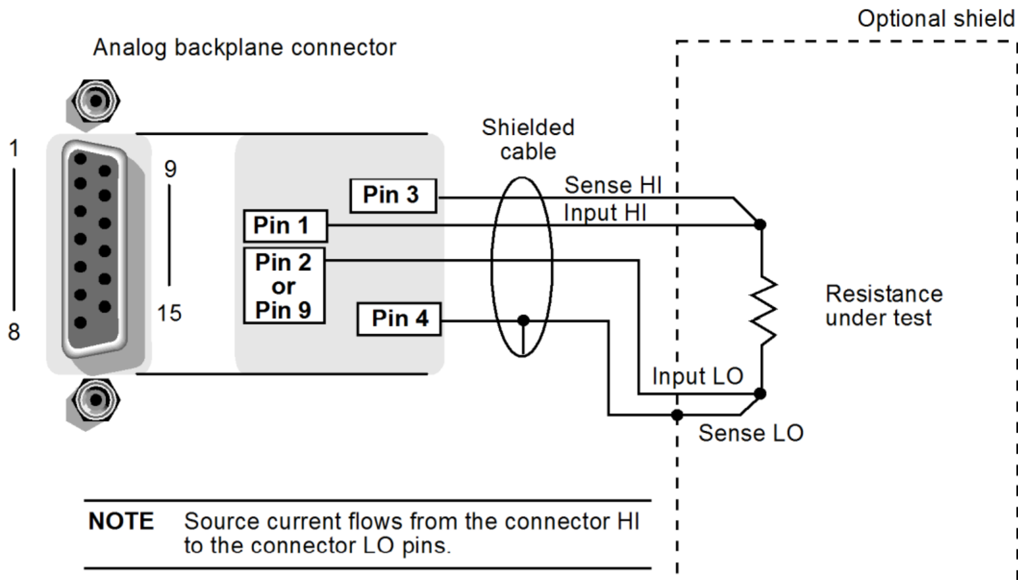
Figure 5-14: Two-wire resistance measurements



NOTE Source current flows from the connector HI to the connector LO pins.

For 4-wire resistance (Ω4), connect the leads to INPUT HI and LO, and sense Ω4 HI and LO.

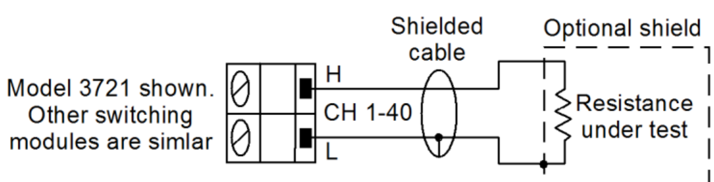
Figure 5-15: Four-wire resistance measurement



Switching module

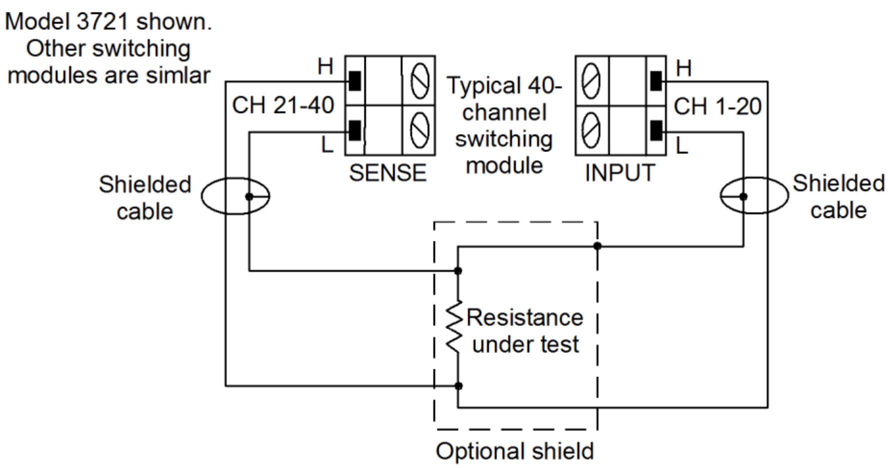
Connections for the switching module are shown below. As shown, each of the 40 channels can be used to perform 2WΩ measurements.

Figure 5-16: 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 5-17: 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 5-29), 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 ≈ 0VDC from chassis ground.

Perform the following steps to measure resistance:

1. Press the **OPENALL** key to open all switching channels. Refer to DCV for DMM function, range, and other settings.
2. Connect the resistance(s) to be measured. Refer to DCV for DMM configuration assignments to channels and open close instructions. Refer to the DCV section on triggering procedures.
3. To measure other switching channels, repeat steps 5 and 6.
4. 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 = ∆V/∆I

where:

∆V = V2 - V1

∆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.

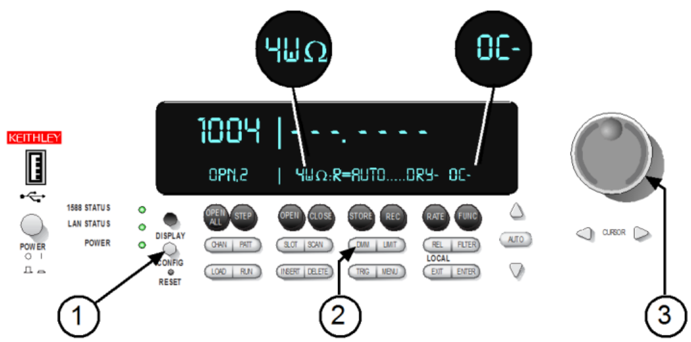
The above 2-point measurement process and reading calculation eliminates the resistance contributed by the presence of V_{EMF}.

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 5-18: Enabling offset-compensated ohms



NOTE The Series 3700 is in 4-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 navigation wheel (3) to scroll to the "OFFSETCOMP" menu item and press the navigation wheel to select.
4. Turn the navigation wheel to select the ON/OFF settings for Offset Compensation as desired and press the navigation wheel to set.
5. Press the **EXIT** key to leave the menu.

Figure 5-19: 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 Ω4 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 5-29) 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 5-33).
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 5-32) procedure.

Offset compensation can be enabled for any 4-wire range. The internal DMM will perform offset compensation for the <=10k-ohm ranges and automatically disable for >=100K-ohm ranges. Send the following ICL commands and the Model 3706 returns the reading and a "1" or a logic "True", but the DMM only performed a standard 4-wire measurement.

```
dmm.func="fourwireohms"
dmm.range=100e3
dmm.offsetcompensation=1
print(dmm.measure())
print(dmm.offsetcompensation)
```

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 (that is, DCV). When 4WΩ is again selected, offset-compensated ohms will be enabled.

`dmm.offsetcompensation` is a common ICL command and is shared with `fourwireohms`, `drycircuit`, `threertd` and `fourrtd`. To activate `dmm.offsetcompensation`, select the desired function first, and then send `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.

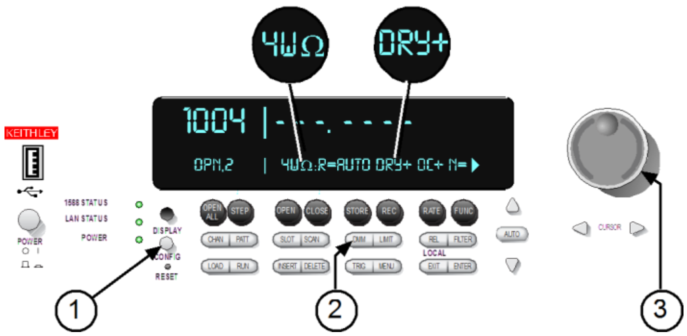
NOTE When dry circuit ohms is enabled, offset-compensated ohms is automatically enabled (OC+ annunciator). If you do not wish to use offset-compensated ohms, after setting dry circuit ohms, disable offset-compensated ohms using the information in *Enabling/disabling offset-compensated ohms* (on page 5-33).

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.

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

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

Figure 5-20: Enabling dry-circuit ohms



NOTE The Series 3700 is in 4-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 navigation wheel (3) to scroll to the "DRYCIRCUIT" menu item.
4. Press the navigation wheel (3) to display ON/OFF settings for dry circuit ohms.
5. Select "ON" or "OFF" and press the navigation wheel (3) again.
6. Press the **EXIT** key to leave the menu.

Figure 5-21: 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 5-29) 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 5-36)).
   - 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 5-33)).
3. Make 4-wire connections to the DUT. See 4-wire connection information contained in *analog backplane connector (rear panel)* (on page 5-29) and *Switching module* (on page 5-30).
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 navigation 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 (that is, 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.

When using dry circuit ohms, the DUT is shunted by 100kΩ and 0.9µF for the 1, 10, and 100-ohm ranges. For the 1K and 10K ranges, it is shunted by a 10M-ohm and 0.015uF. This allows the current source to have minimal overshoot voltage under transient conditions. When used with a switching system, the overshoot is <40mV in 20µsec.

Measurement methods

The Series 3700 uses two methods to measure resistance:

- **Constant-current source method** (1Ω through 1MΩ 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** (10MΩ and 100MΩ ranges): Test current is generated by a 6.4V reference through a 10MΩ reference resistor.

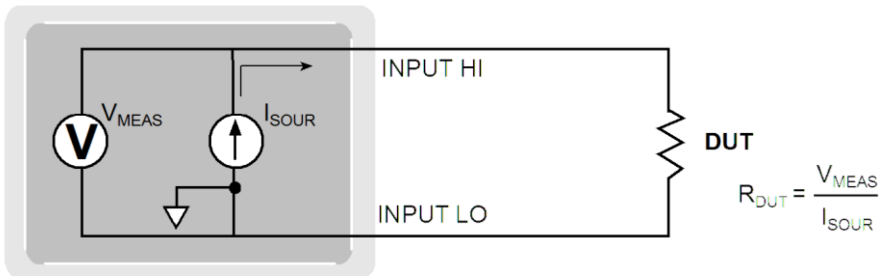
Constant-current source method

For the 1Ω to 1MΩ 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. Because the voltmeter of the Series 3700 has very high input impedance (>10GΩ), virtually all the test current (1mA) flows through the DUT. For DUT ≤1kΩ, 4-wire ohms measurements should be used as shown. Because 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).

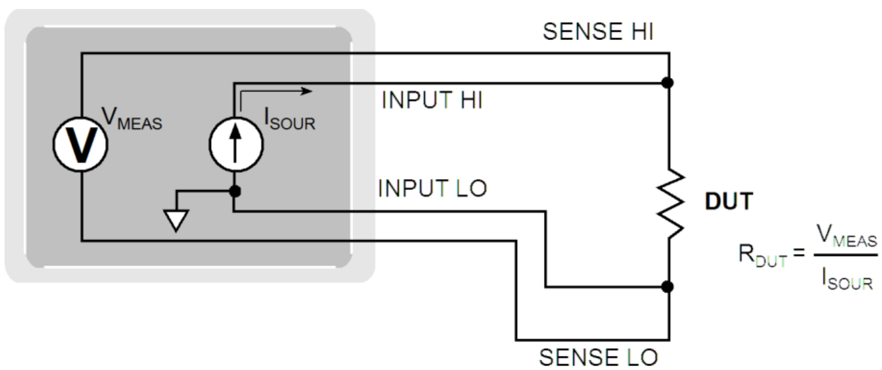
The 2-wire constant-current method is shown below.

Figure 5-22: Two-wire constant-current source method



The 4-wire constant-current method is shown below.

Figure 5-23: Four-wire constant-current source method

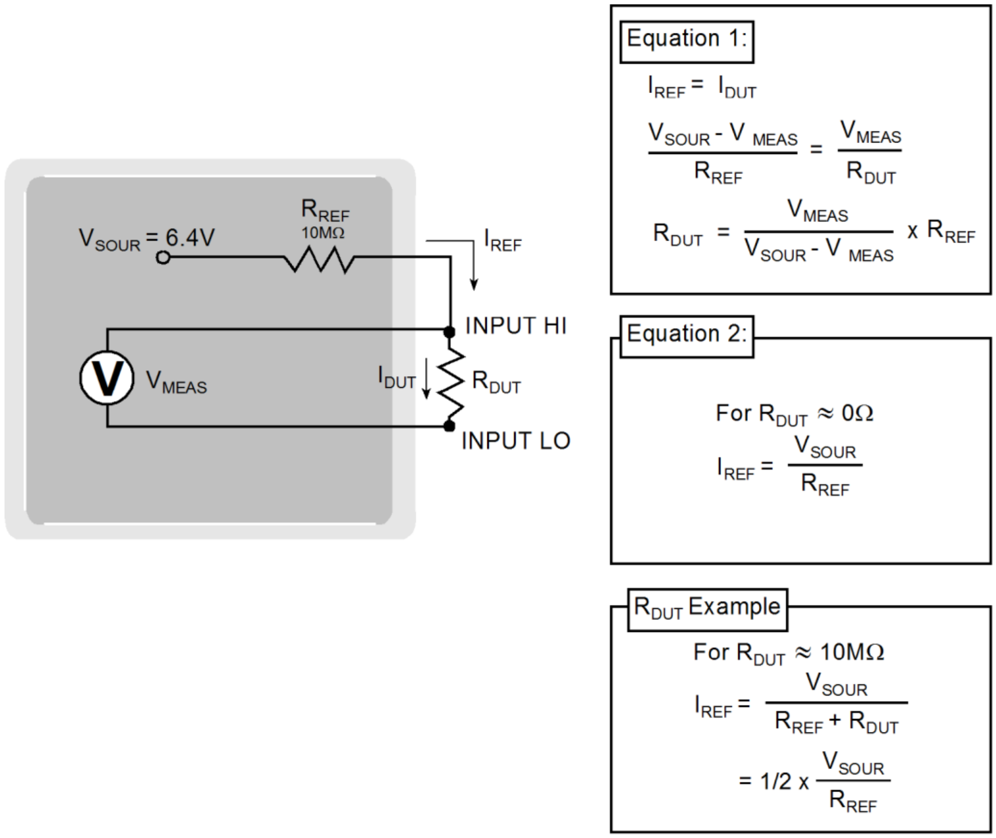


Ratiometric method

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}. Because 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 5-24: Two-wire ratiometric method



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

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

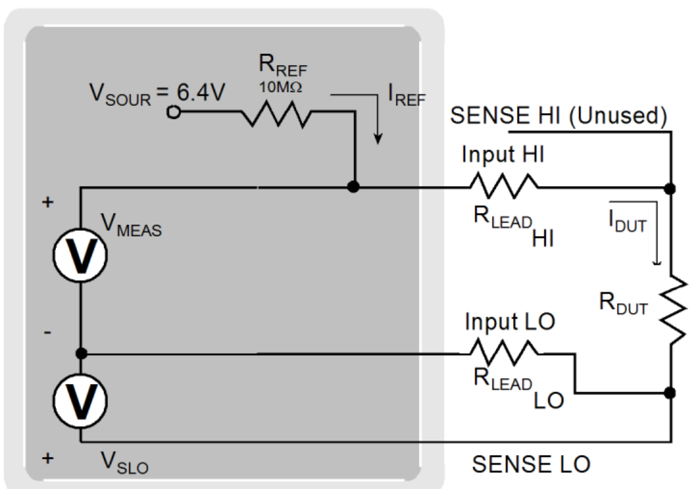
Note that V_{MEAS} is measured by the Series 3700. With V_{MEAS}, I_{SOUR}, R_{REF} known, the Series 3700 calculates the resistance of the DUT and displays the result. R_{REF} is learned during calibration and V_{SOUR} is routinely self-calibrated when the `dmm.autozero` attribute is enabled (`dmm.autozero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

Note 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. Because matched inputs are used, the voltage drop is 2 x V_{LEAD}. Therefore:

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

Figure 5-25: Four-wire ratiometric method



Equation

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

$$= \frac{V_{MEAS}}{R_{LEAD_{HI}} + R_{DUT} + R_{LEAD_{LO}}}$$

Assume:

$$R_{LEAD_{HI}} = R_{LEAD_{LO}}$$

Assume:

$$V_{SLO} = R_{LEAD_{LO}} \times I_{REF}$$

$$\therefore R_{LEAD_{LO}} = \frac{V_{SLO}}{I_{REF}}$$

Substitute:

$$I_{REF} = \frac{V_{MEAS}}{2(R_{LEAD_{LO}}) + R_{DUT}}$$

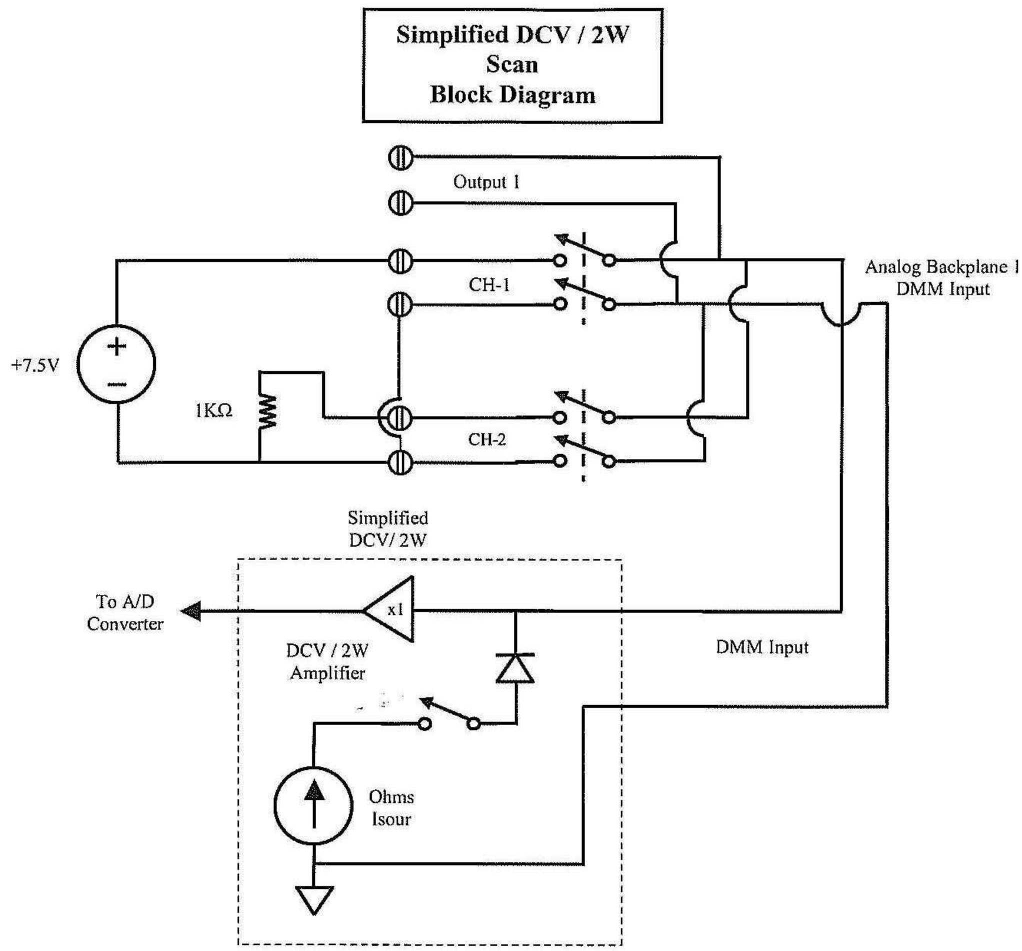
$$= \frac{V_{MEAS}}{2(V_{SLO}/I_{REF}) + R_{DUT}}$$

$$= \frac{V_{MEAS} - 2V_{SLO}}{R_{DUT}}$$

$$R_{DUT} = \frac{V_{MEAS} - 2V_{SLO}}{I_{REF}}$$

$$= \frac{V_{MEAS} - 2V_{SLO}}{V_{SOUR} - V_{MEAS}} \times R_{REF}$$

Figure 5-26: Fast Alternating Scan block diagram



Fast Alternating Scan, DCV, and 2W

The following example illustrates how to configure a Model 3706 and 3723 switch card for fast alternating function scans. The example shows channel 1 measuring +7.5VDC and channel 2 measuring a 1K-ohm resistor. Scanning, which includes a relay close, DMM configuration, DMM measure, and channel open, is achieved at rates <1.6msec/channel.

```
-- Script name.
loadscript test_func_chg

-- Resets the Model 3706 to factory defaults.
reset()

-- Break-before-make off. Fastest close method.
channel.connectrule=channel.OFF
dmm.func="dcvolts"
dmm.range=10
dmm.nplc=0.0005
dmm.autozero=0

-- 0 or dmm.OFF
dmm.autodelay=dmm.OFF

-- 1 or dmm.ON
dmm.autodelay=dmm.ON

-- DMM settings defined as 'my-dcv'.
dmm.configure.set('my-dcv')
dmm.func="twowireohms"
dmm.range=1000
dmm.nplc=0.0005
dmm.autozero=0

-- 0 or dmm.OFF
dmm.autodelay=dmm.OFF

-- 1 or dmm.ON
dmm.autodelay=dmm.ON

-- DMM settings defined as 'my-2w'.
dmm.configure.set('my-2w')

-- DMM takes a 1 reading on each channel.
scan.measurecount=1

-- Channel 4 defined as 'my-dcv'.
dmm.setconfig('4004', 'my-dcv')

-- Channel 24 defined as 'my-2w'.
dmm.setconfig('4024', 'my-2w')

-- Buffer size set to 20 readings.
buf=dmm.makebuffer(20)
buf.clear()
buf.appendmode=1

-- Scan list created with channels 4 and 24.
```

```
scan.create('4004, 4024')
-- Backplane channel 4911 and 4921 will be automatically
   paired.
-- Scan will loop 10 times.
scan.scancount=10
-- Starts scan.
scan.execute(buf)
for x=1,buf.n do printbuffer(x,x,buf,
   buf.relativetimestamps) end
-- Prints the reading and relative time from start of scan.
-- buf.timestamp includes date and real time.
-- Note that x,x prints reading and time vertically for
   easy copy / paste to Excel.
channel.open('allslots')
endscript
```

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 5-27: Simplified normal 4W open detection schematic

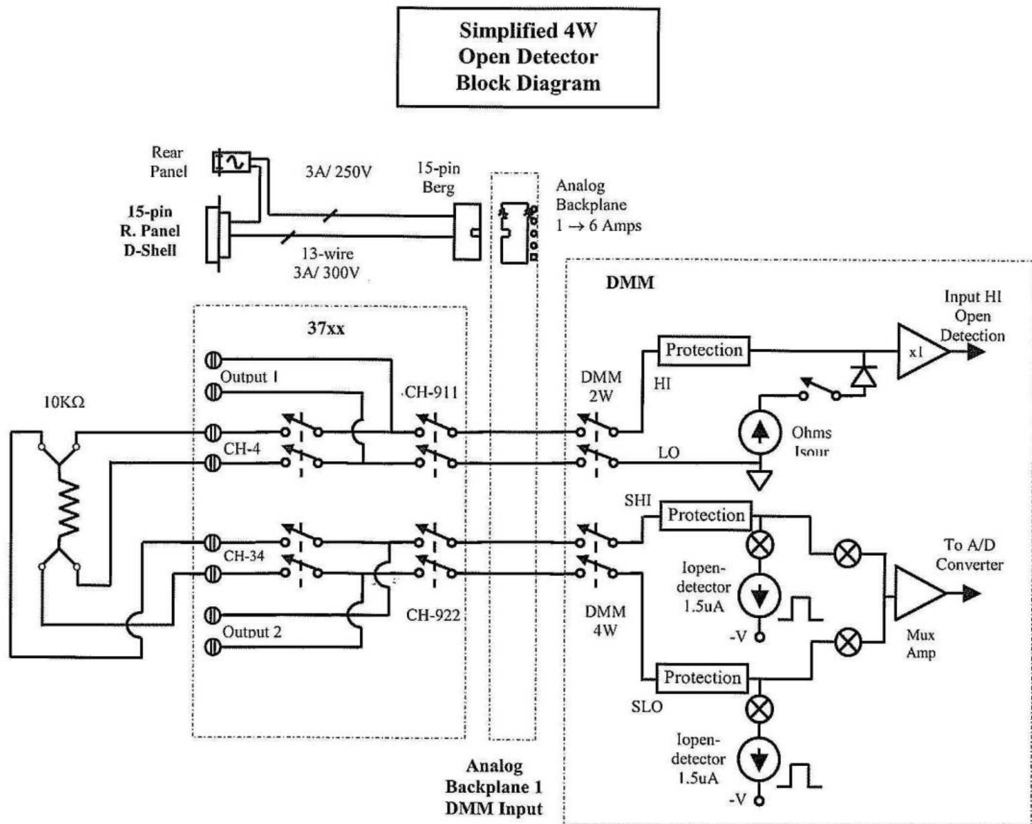
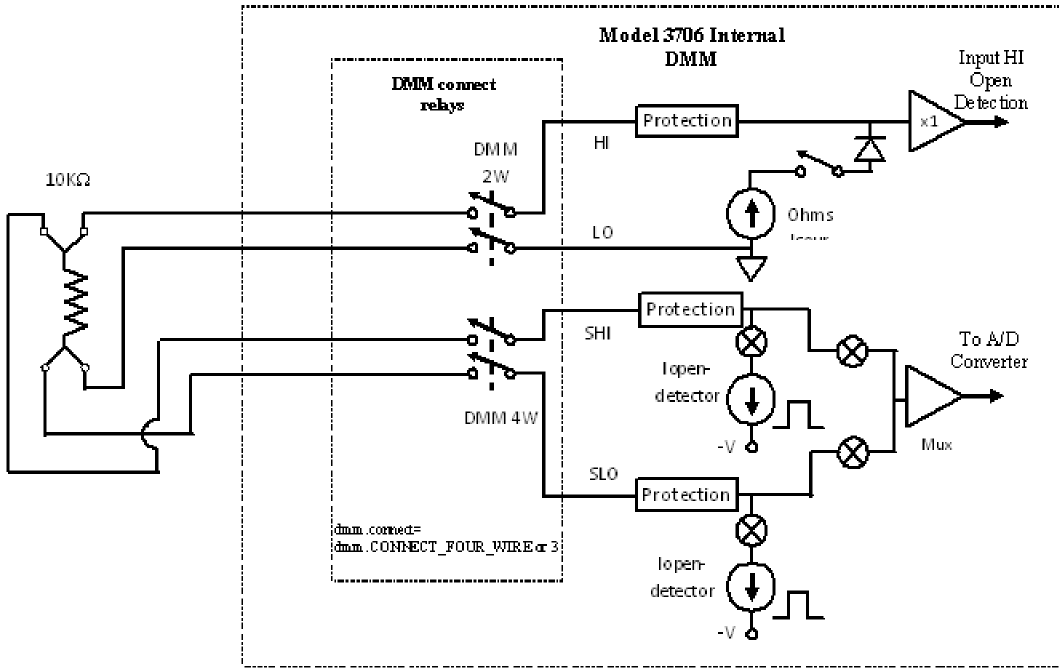


Figure 5-28: Model 3706 Internal DMM



ISOUR open voltage

1Ω through 1MΩ 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 10kΩ), open circuit voltage on the ohm $I_{SOUR\ VOPEN-HI-LEAD}$ terminal is >7.1V.
- For the higher ohms ranges (100kΩ through 1MΩ), open circuit voltage on the ohm $I_{SOUR\ VOPEN-HI-LEAD}$ 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.

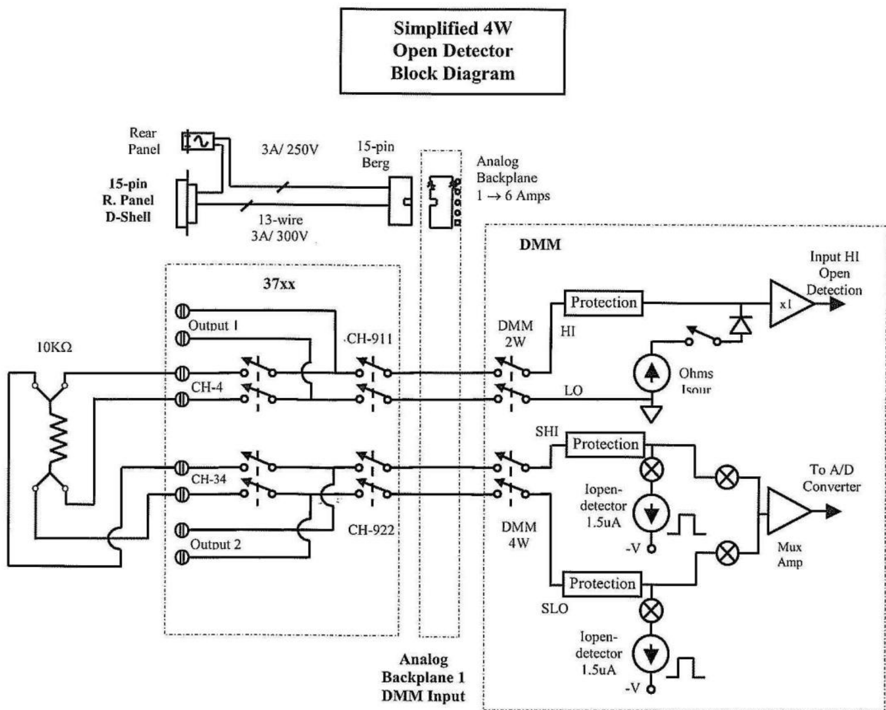
Range	V_{MEAS} SHI or SLO High Limit Open Lead Detection	V_{MEAS} SHI or SLO Low Limit Open Lead Detection
1Ω-100Ω	> 128mV	< -10mV
1kΩ-100kΩ	> 1.28V	< -100mV

Range	V_{MEAS} SHI or SLO High Limit Open Lead Detection	V_{MEAS} SHI or SLO Low Limit Open Lead Detection
1MΩ	> 12.8V	< -1.0V

Calculated measurement open voltage

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

Figure 5-29: 4W open detector with 3700 card



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 $\mathbf{V}_{MEAS}$ 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)	
1-10kΩ	4.0	0.5	60	min	max
				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	5.0[1]	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–100 MΩ	0.06	1.0	0.0083	250	0.06
			0.010	240	

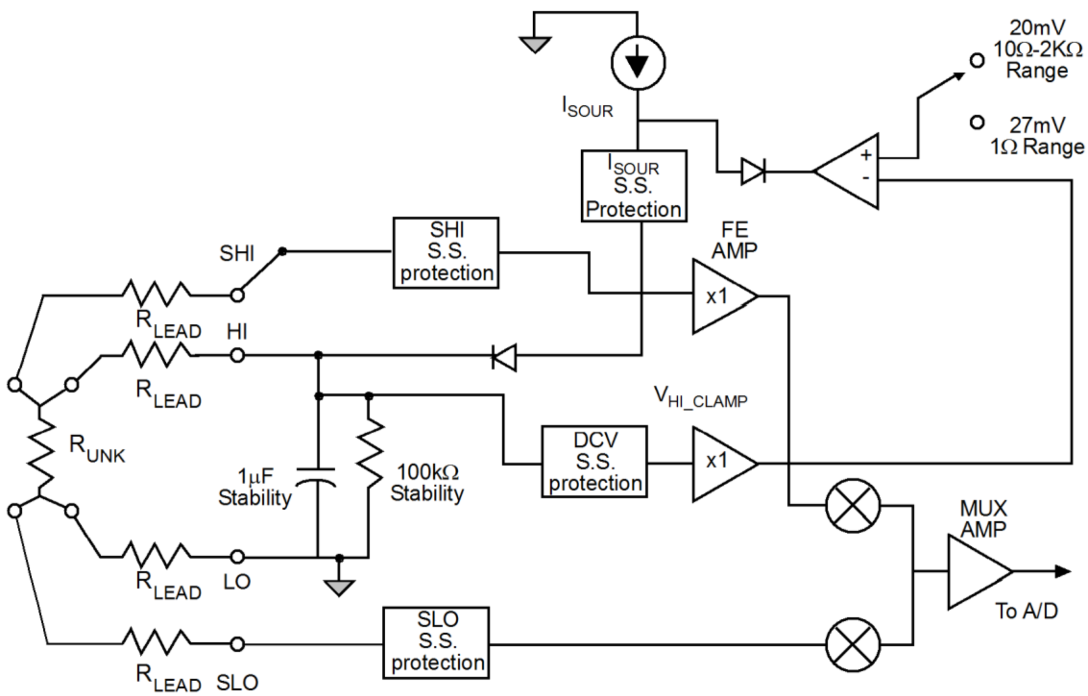
1. For 10MΩ and 100MΩ, $V_{measurement}$ is made on Input HI. Input Sense HI is unused.
2. Default condition for 4-wire is `dmm.opendetector=dmm.ON`.
3. For `dmm.drycircuit=dmm.ON`, $I_{OPENLEAD}$ is disabled, but `print(dmm.opendetector)` returns 1.0.
4. Additional cable and Model 3700 card capacitance can increase settle times, resulting in additional measurement uncertainty. Keithley Instruments recommend the use of Teflon or other low-dielectric absorption wire insulation for these measurements.

4-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.opendetector = 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 4-wire dry-circuit open lead detection.

Figure 5-30: 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, note 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

Type	Range	Resolution
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
- External 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 5-58). 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 5-58)).

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.

Thermocouple readings may be configured to use an external reference junction setting. The Series 3700 assumes the external reference junction is connected to channel 1 of a slot. It is recommend that this channel be configured for thermistor or RTD temperature reading. However, the unit does not error check against this. Each time a reading is taken on the external reference junction channel (channel 1 of a slot) it will be used as the new external reference junction value in subsequent external reference readings. External reference readings work with `dmm.close` as well as scanning.

For non-simulated thermocouple measurements, first perform a thermistor or RTD measurement prior to enabling external reference junction.

External reference junction

Thermocouple readings may be configured to use an external reference junction setting. The Series 3700 assumes the external reference junction is connected to channel 1 of a slot. It is recommend that this channel be configured for thermistor or RTD temperature reading. However, the unit does not error check against this. Each time a reading is taken on the external reference junction channel (channel 1 of a slot) it will be used as the new external reference junction value in subsequent external reference readings. External reference readings work with `dmm.close` as well as scanning.

For non-simulated thermocouple measurements, first perform a thermistor or RTD measurement prior to enabling external reference junction.

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 *Open lead detection* (on page 5-45). 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 $_{VMEAS}$ 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 5-58)).
- 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 $I_{SOUR\ VOPEN-HI-LEAD}$ 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`.

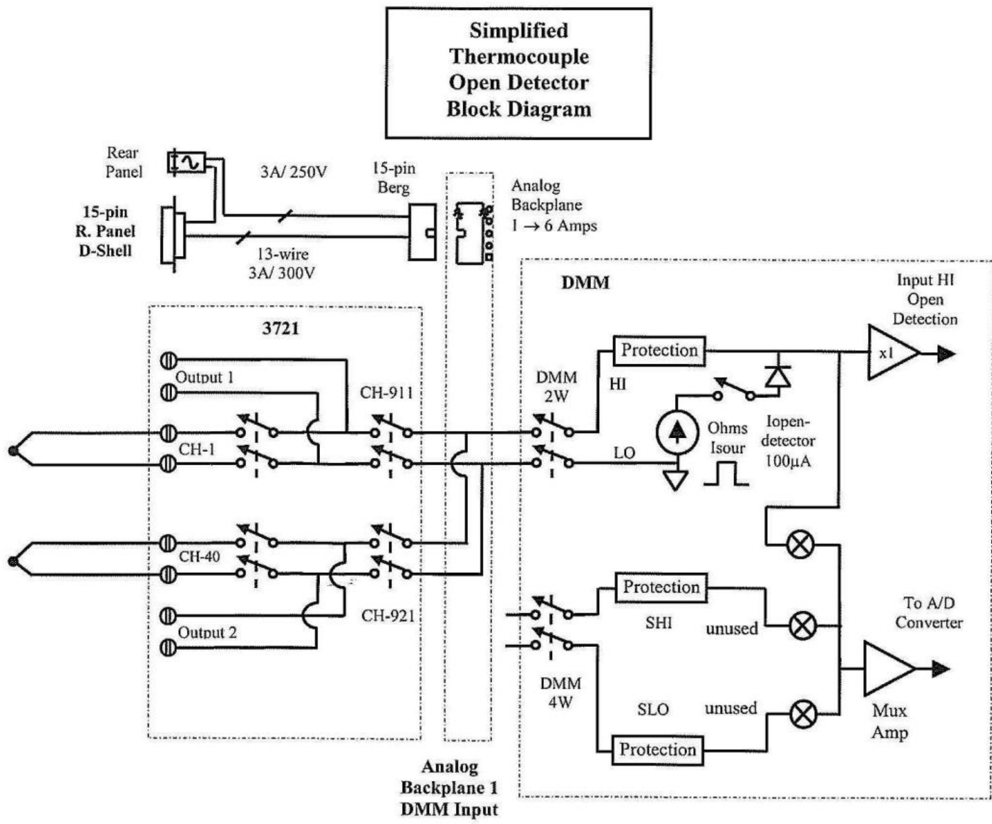
The thermocouple open detection times are listed in the following table.

Ion source settle (msec)	**IOPENLEAD measure (msec)**	**Phase internal DMM comm. (msec)**	**Ioff source settle (msec)**	**Line freq (Hz)**	**T/C measurement time (msec)**		**Internal DMM comm. (msec)**
1.0	0.8	0.4	1.0	60	min	max	0.06
					0.0083	250	
				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 5-31: Thermocouple Open Detector drawing



Thermocouple connections

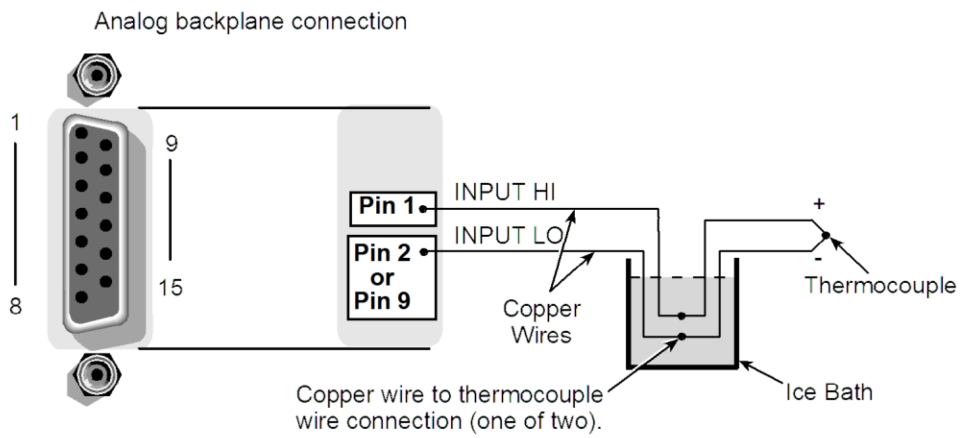
Connections for thermocouples are shown below. Thermocouples are color coded to identify the positive (+) and negative (-) leads (see the table). Note that the negative (-) lead for U.S. type T/Cs is red.

T/C type	Positive (+)	Negative (-)
J	White	Red
	Yellow	Blue
	Red	Blue
	Red	White
	Yellow	Black
K	Yellow	Red
	Brown	Blue
	Red	Green
	Red	White
	Yellow	Purple
N	Orange	Red
	--	--
	--	--
	--	--
	--	--
T	Blue	Red
	White	Blue
	Red	Brown
	Red	White
	Yellow	Blue

T/C type		Positive (+)	Negative (-)
E	U.S.	Purple	Red
	British	Brown	Blue
	DIN	Red	Black
	Japanese	Red	White
	French	Yellow	Blue
R	U.S.	Black	Red
	British	White	Blue
	DIN	Red	White
	Japanese	Red	White
	French	Yellow	Green
S	U.S.	Black	Red
	British	White	Blue
	DIN	Red	White
	Japanese	Red	White
	French	Yellow	Green
B	U.S.	Gray	Red
	British	--	--
	DIN	Red	Gray
	Japanese	Red	Gray
	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 because 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 5-32: 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 5-33: Simulated reference junction switching module

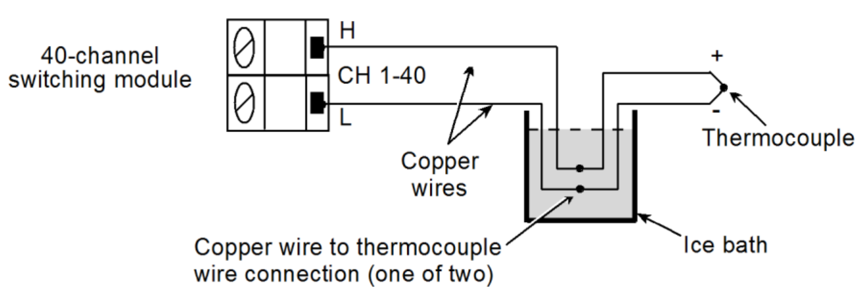
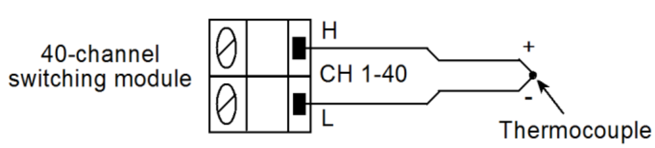


Figure 5-34: Internal reference junction (40 channel switching module)



Thermocouple temperature measurement configuration

To configure temperature measurements from the front panel:

NOTE Refer to DCV section DMM function configuration.

1. Set thermocouple device attributes:
   - Turn the navigation wheel to scroll to the "THERMO" menu item and press the navigation wheel or the **ENTER** key.
   - Turn the navigation wheel to scroll to the "THERMOCOUPLE" temperature connection and press the **ENTER** key.
   - Turn the navigation wheel to select the desired thermocouple type (J, K, T, E, R, S, B, or N) and press the navigation wheel or the **ENTER** key.
2. Set thermocouple device reference junction type:
   - Turn the navigation wheel to scroll to the "REFJUNCT" menu item and press the navigation wheel or the **ENTER** key.
   - Select the desired Reference Junction: SIMULATED, INTERNAL, or EXTERNAL. See *Reference junctions* (on page 5-53) for more information.
   - Press the navigation wheel or the **ENTER** key to set the selection.
3. If a SIMULATED reference junction was selected in step 5:
   - Turn the navigation wheel to scroll to the "SIMREF" menu item and press the navigation wheel or the **ENTER** key.
   - Using the navigation wheel, dial in the desired reference temperature (default values are units dependent: 023.00°C, 296.15°K, and 073.40°F).
   - Press the navigation wheel or the **ENTER** key to set the selection.
4. Press the **EXIT** key twice to leave the "TEMP ATTR MENU."

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

```
loadscript test_temp
reset()
dmm.func=dmm.TEMPERATURE
dmm.transducer=dmm.TEMP_THERMOCOUPLE           -- or 1
dmm.thermocouple=dmm.THERMOCOUPLE_J            -- or 0
dmm.opendetector=dmm.ON                        -- or 1
dmm.units=dmm.UNITS_FAHRENHEIT                 -- or 4
dmm.refjunction=dmm.REF_JUNCTION_INTERNAL      -- or 1
dmm.configure.set("my_temp_j")
dmm.setconfig("4001:4010", "my_temp_j")
scan.measurecount=1
buf=dmm.makebuffer(20)
buf.clear()
buf.appendmode=1
scan.create("4001:4010")
scan.scancount=2
```

```
scan.execute(buf)
for x=1, buf.n do printbuffer (x,x,buf) end
channel.open("allslots")
endscript
```

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. Because 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 5-35: Thermistor analog backplane connection

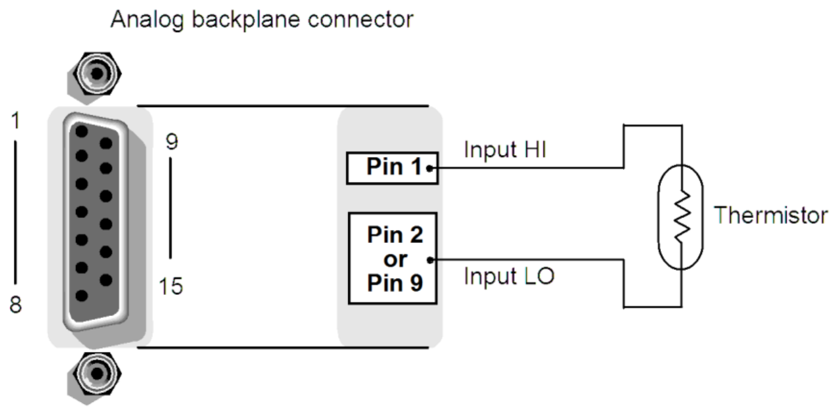
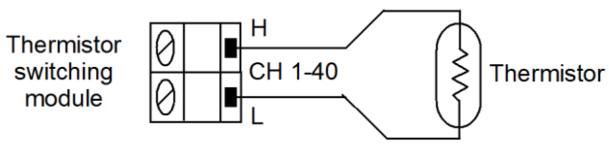


Figure 5-36: Thermistor switching module connection



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 navigation wheel to scroll to the "UNITS" menu item (right most menu item) and press the **ENTER** key.
   - Turn the navigation wheel to select desired units (Celsius, Kelvin, or Fahrenheit) and press the **ENTER** key.
4. Set THERMO device attributes:
   - Turn the navigation wheel to scroll to the "THERMO" menu item and press the **ENTER** key.
   - Turn the navigation wheel to scroll to the "THERMISTOR" temperature connection and press the **ENTER** key.
   - Turn the navigation 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.

For example, this sample ICL command configures a thermistor type 2252 and assigns it to a 4-channel scan list.

```
reset()
dmm.func=dmm.TEMPERATURE
dmm.transducer= dmm.TEMP_THERMISTOR            -- or 2
dmm.thermistor=2.252e3                         -- 5e3 or
   10e3
dmm.units=dmm.UNITS_FAHRENHEIT                 -- or 4
dmm.configure.set("my_thermist")
dmm.setconfig("4011:4014", "my_thermist")
scan.measurecount=1
buf=dmm.makebuffer(20)
buf.clear()
buf.appendmode=1
scan.create("4011:4014")
scan.scancount=5
scan.execute(buf)
for x=1, buf.n do printbuffer (x,x,buf) end
channel.open("allslots")
```

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).

`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 5-37: Three-wire RTD connections

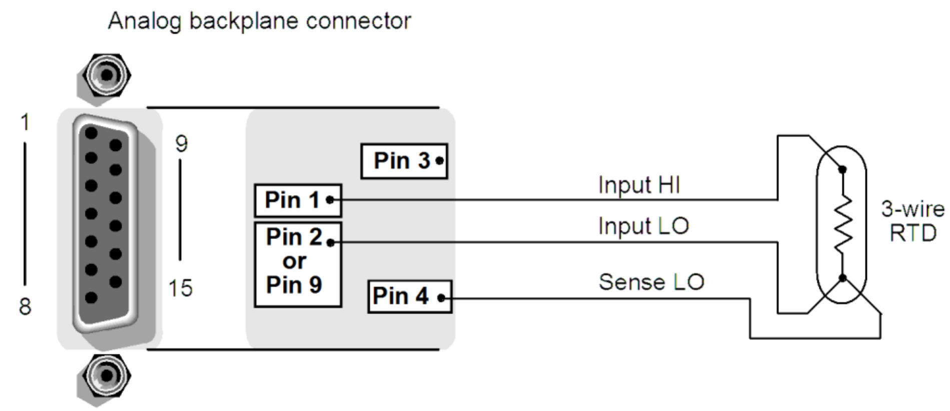
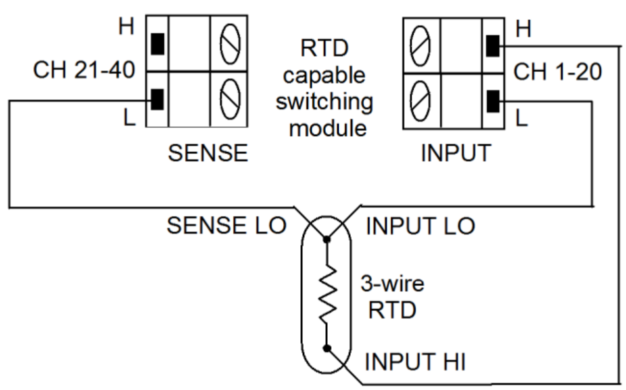


Figure 5-38: Three-wire RTD switching module connections



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 5-39: Four-wire RTD connections

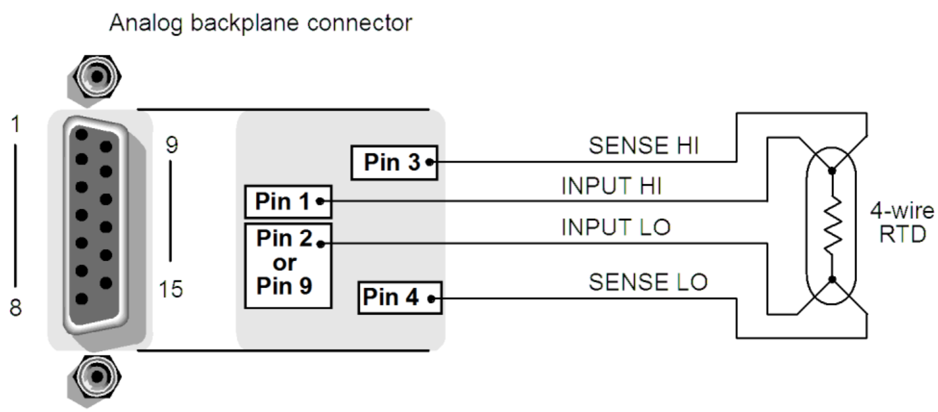
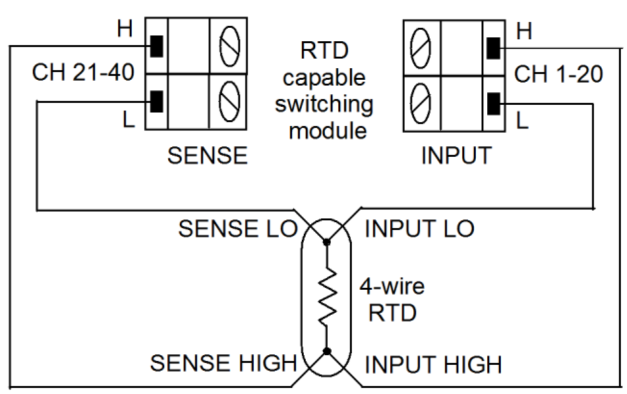


Figure 5-40: Four-wire RTD switching module connections



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

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 navigation wheel to scroll to the "UNITS" menu item (right most menu item).
   - Press the **ENTER** key.
   - Using the navigation wheel, select desired units (Celsius, Kelvin, or Fahrenheit).
   - Press the **ENTER** key.
4. Set four wire RTD device attributes:
   - Turn the navigation wheel to scroll to the "THERMO" menu item and press the **ENTER** key.
   - Turn the navigation wheel to scroll to the "THREERTD" or "FOURRTD" temperature connection and press the **ENTER** key.
   - Turn the navigation 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.

For example, these ICL commands configure temperature function to a custom RTD and assign it to a 10-channel scan list.

```
reset()
dmm.func=dmm.TEMPERATURE

-- or 3, or dmm.TEMP_FOURRTD, or 4
dmm.transducer= dmm.TEMP_THREERTD

-- dmm.fourrtd also supported
dmm.threertd=dmm.RTD_USER

-- allowed values are 0 to 0.01
dmm.rtdalpha= 0.003

-- allowed values are 0 to 1.00
dmm.rtdbeta= 0.105

-- allowed values are 0 to 5.00
dmm.rtddelta = 1.51

-- allowed values are 0 to 10,000
dmm.rtdzero= 125

-- default dmm.ON
dmm.offsetcompensation=dmm.OFF
dmm.configure.set("my_rtd_user")
dmm.setconfig("4001:4010", "my_rtd_user")
scan.measurecount=1
buf=dmm.makebuffer(20)
buf.clear()
buf.appendmode=1
scan.create("4001:4010")
scan.scancount=2
scan.execute(buf)
for x=1, buf.n do printbuffer (x,x,buf) end
channel.open("allslots")
```

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.

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 5-68).
4. Connect the temperature transducer(s) to be measured.
5. If using a switching module, perform the following steps to close the desired channel. Note 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 navigation 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 <= 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□x10^7 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 5-41: FREQ and PERIOD input connections

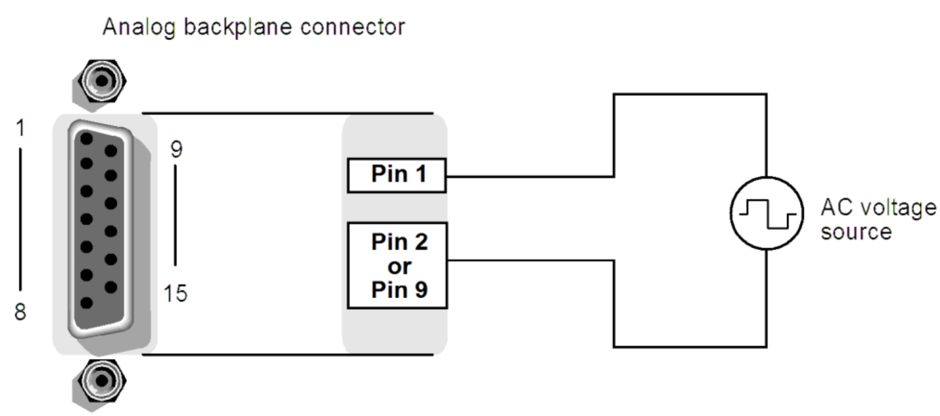
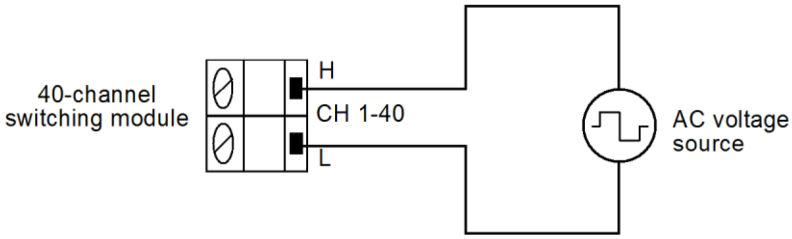


Figure 5-42: FREQ and PERIOD connections (switching module)



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 **CONFIG** key, and then select the **DMM** key. Select the FUNC menu by pressing **ENTER**. Scroll through the menu until FREQ or PERIOD is displayed, using the navigation wheel or left right arrows.
3. Set threshold voltage:
   - Turn the navigation wheel to scroll to the "THRESHOLD" menu item (right most menu item) and press the **ENTER** key.
   - Using the navigation wheel, dial in the desired voltage to be used as a threshold (0V - 303V, default is the 10V range).
   - Press the **ENTER** key to set.
   - Press the **EXIT** key to leave the "FREQ ATTR MENU."
4. Apply the AC voltage(s) to be measured (see CAUTION).

NOTE	When observing the displayed readings, if 000.0000mHz or 000.0000mS is displayed, select a lower range until a normal reading is displayed. Use the lowest possible range for the best resolution.

5. Press the **TRIG** key and observe the displayed reading.
6. To measure other switching channels, repeat steps 5 and 6.
7. 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."

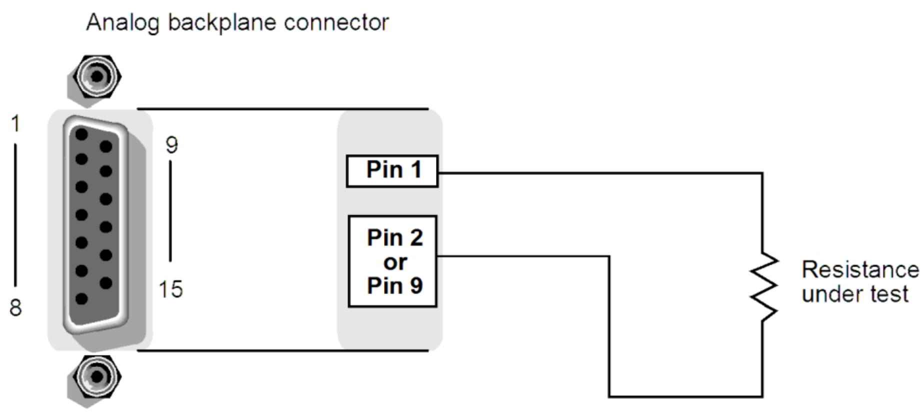
NOTE The reading rate for continuity is fixed at 0.006 PLC. Limits and digital outputs cannot be used when testing continuity with the continuity (CONT) function. If you need to use these operations, use the Ω2 function to test continuity.

NOTE The continuity function does not support REL. Use mx + b, with b as an offset, to compensate for cable and 3700 card path resistance.

Continuity testing connections

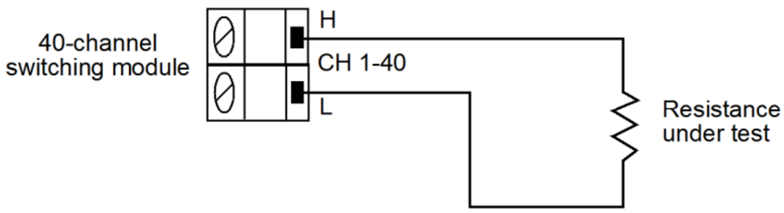
When using the rear analog backplane connector, connect the test leads to the INPUT HI and LO terminals as shown below.

Figure 5-43: Continuity connections



Connections to test continuity using a switching module are shown below. Because this is a 2-wire ohms measurement, Channels 1 through 40 of a 40-channel switching module can be used.

Figure 5-44: 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). Refer to DCV measurements for function configuration and menus.

1. Set threshold resistance:
   - Turn the navigation wheel to scroll to the "THRESHOLD" menu item (right most menu item) and press the **ENTER** key.
   - Using the navigation 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."
2. Apply the resistance to be tested. If using a switching module, perform the following steps to close the appropriate channel.
   a. Use the navigation wheel to dial in the channel number.
   b. Press the **CLOSE** key.
3. Press the **TRIG** key and observe the displayed reading.
4. 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."

5. To disable continuity testing, select a different function (for example, DCV).
6. 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.

Also see the bus command `dmm.threshold` for more information on threshold attributes.

`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).

Accuracy calculations

The following information discusses how to calculate accuracy for both DC and AC characteristics.

Calculating DC characteristics accuracy

DC characteristics accuracy is calculated as follows:

For >=1plc, Accuracy = ±(ppm of reading + ppm of range)

(ppm = parts per million and 10ppm = 0.001%)

As an example of how to calculate the actual reading limits, assume that you are measuring 5V on the 10V range. You can compute the reading limit range from one-year DCV accuracy specifications as follows:

Accuracy = ±(25ppm of reading + 2ppm of range)

±[(25ppm × 5V) + (2ppm × 10V)]

±(125µV + 20µV)

±145µV

Thus, the actual reading range is 5V+/-320uV or from 4.99968V to 5.00032V.Thus, the actual reading range is: 5V± 145µV or from 4.999855V to 5.000145V.

For <=1plc, Accuracy = +/-(ppm of reading + ppm of range + rms noise addr)

For example, to calculate the accuracy of the above example at 0.006plc:

Accuracy =	+/- ((25ppm of reading) + (2ppm of range) + (2.5 x 7ppm of range))
	= +/- ((25ppm x 5V) + (2ppm x 10V) + (2.5 x 7ppm x 10V))
	= +/- (125uV + 20uV + 175uV)
	= +/- 320uV

DC current and resistance calculations are performed in exactly the same manner using the pertinent specifications, ranges, and input signal values.

Calculating AC characteristics accuracy

AC characteristics accuracy is calculated similarly, except that AC specifications are given as follows:

Accuracy = (% of reading + % of range)

As an example of how to calculate the actual reading limits, assume that you are measuring 120V, 60Hz on the 300V range. You can compute the reading limit range from ACV one-year accuracy specifications as follows:

Accuracy =	±(0.06% of reading + 0.03% of range)
	±[(0.0006 × 120V) + (0.0003 × 300V)]
	±(0.072V + 0.09V)
	±0.162V

In this case, the actual reading range is: 120V± 0.162V or from 119.838V to 120.162V.

AC current calculations are performed in exactly the same manner using the pertinent specifications, ranges, and input signal values.

Calculating dB characteristics accuracy

The relationship between voltage and dB is as follows:

$$dBm = 20_{log}\left(\frac{V_{in}}{V_{ref}}\right)$$

As an example of how to calculate the actual readings limits for dB, with a user-defined VREF of 10V, you must calculate the voltage accuracy and apply it to the above equation.

To calculate a -60dB measurement, assume 10mV RMS for a VREF of 10V. Using the 100mV range, one-year, 10Hz - 20kHz frequency band, and SLOW rate, the voltage limits are as follows:

Accuracy =	±[(0.06% of reading) + (0.03% of range)]
	±[(0.0006 × 10mV) + (0.0003 × 100mV)]
	±(6µV + 30µV)
	±36µV

Thus, the actual reading accuracy is 10mV ±36mV or 10.036mV to 9.964mV. Applying the voltage reading accuracy into the dB equation yields:

$$dBm = 20_{log}\left(\frac{10.036mV}{10V}\right) = -59.96879dB$$

$$dBm = 20_{log}\left(\frac{9.964mV}{10V}\right) = -60.03133dB$$

Thus, the actual reading accuracy is -60dB + 0.031213dB to -60dB - 0.031326dB.

dBm and dB for other voltage inputs can be calculated in exactly the same manner using pertinent specifications, ranges, and other reference voltages.

Additional derating factors

In some cases, additional derating factors must be applied to calculate certain accuracy values. For example, an additional derating for the following conditions:

1. -0.4mV with open inputs and the 10M-ohm divider enabled
2. +/-(8ppm or reading + 5uV) with autozero off for +/-1 degree C and <=10minutes
3. For 2-wire ohms, add 100m-ohm to "ppm of range" with REL
4. Add 0.1% to 10M-ohm range when measuring through a Model 3700 card >50%RH humidity

Before calculating accuracy, study the associated specifications very carefully to see if any derating factors apply.

Optimizing measurement accuracy

The configurations listed below assume that the multimeter after an ICL command reset().

Enclosed are two charts that represent RMS Noise versus Aperture Time (or NPLC) and Reading Rate versus Aperture Time (or NPLC). Refer to these charts when selecting best accuracy at a given reading rate. Generally, increasing the Aperture time reduces the RMS noise. For Aperture times >100msec or 5PLC, thermal offsets can increase the RMS noise.

Figure 5-45: Readings Rate versus Aperture Time

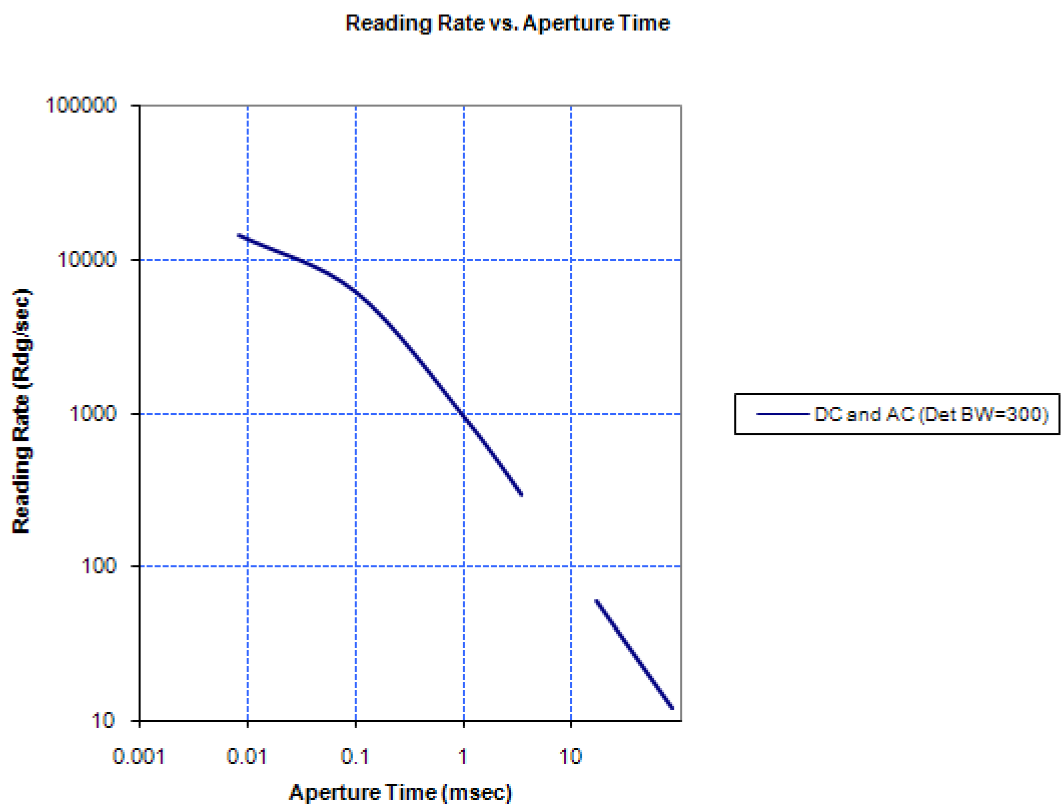
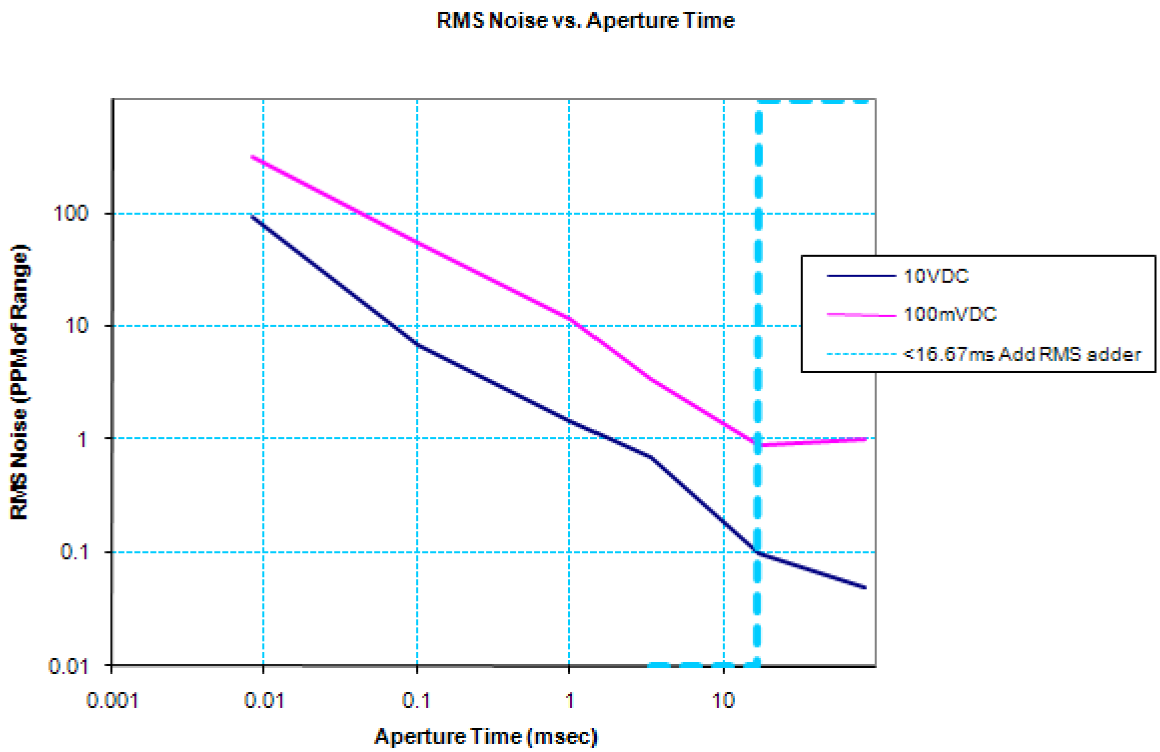


Figure 5-46: RMS Noise vs. Aperture Time



DC voltage, DC current, and resistance

- 1 or 5 PLC, filter off, fixed range.
- Use REL on DC voltage and 2-wire resistance measurements when appropriate.
- Use 4-wire, offset compensation On, and Line Sync On for resistance measurements, especially through a 3700 switch card for best accuracy.

AC voltage and AC current

Select Detectorbandwidth 3, autodelays On, and fixed range.

Temperature

1 or 5 PLC.

Optimizing measurement speed

The configurations listed below assume that the multimeter is configured after the ICL command reset().

DC voltage, DC current, and resistance

Select:

- `dmm.autozero=dmm.OFF`
- `dmm.autodelay=dmm.OFF`
- `dmm.nplc=0.0005`
- `dmm.filter=dmm.OFF`
- `dmm.autorange=dmm.OFF`
- `dmm.measurecount>=1000`

For resistance, assumed 2-wire ohms.

AC voltage and AC current

Select:

- `dmm.detectorbandwidth=300`
- `dmm.autodelays=dmm.OFF`
- `dmm.autozero=dmm.OFF`
- `dmm.autorange=dmm.OFF`
- `dmm.filter=dmm.OFF`
- `dmm.nplc=0.0005`

Temperature

Select:

- `dmm.transducer=dmm.TEMP_THERMOCOUPLE`
- `dmm.opendetector=dmm.OFF`
- `dmm.nplc=0.0005`
- `dmm.autozero=dmm.OFF`
- `dmm.filter=dmm.OFF`
- `dmm.autodelay=dmm.OFF`

Section 6

Model 3750 Additional Information

In this section:

Digital I/O

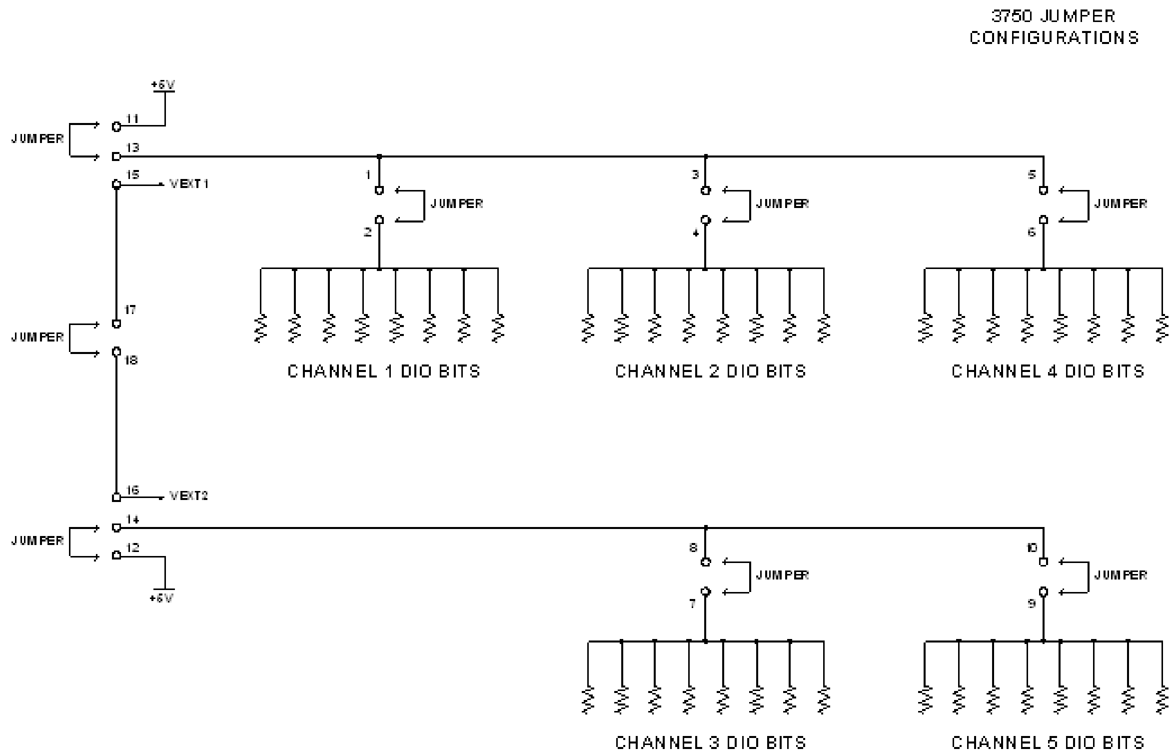
CAUTION Do not exceed the maximum rated voltages and currents for the digital I/O banks. Do not apply negative voltages to any of the inputs. Unused inputs should not be left floating, but should be tied to either a ground or a positive DC voltage.

The Model 3750 offers 40 digital I/O bits arranged in 5 banks. Each bank is referenced as a channel from 1 through 5. The 8 bits in each bank or channel can be programmed as either input or output. Additional features include scanning capabilities, such as writing a unique output pattern or reading inputs as part of a scan. Also, pattern matching is available that supports generating events that can then be used for triggering system events, such as starting a scan.

Simplified jumper configuration model

Digital outputs can be jumpered to either an internal +5 V or an external voltage. The diagram below shows a simplified schematic.

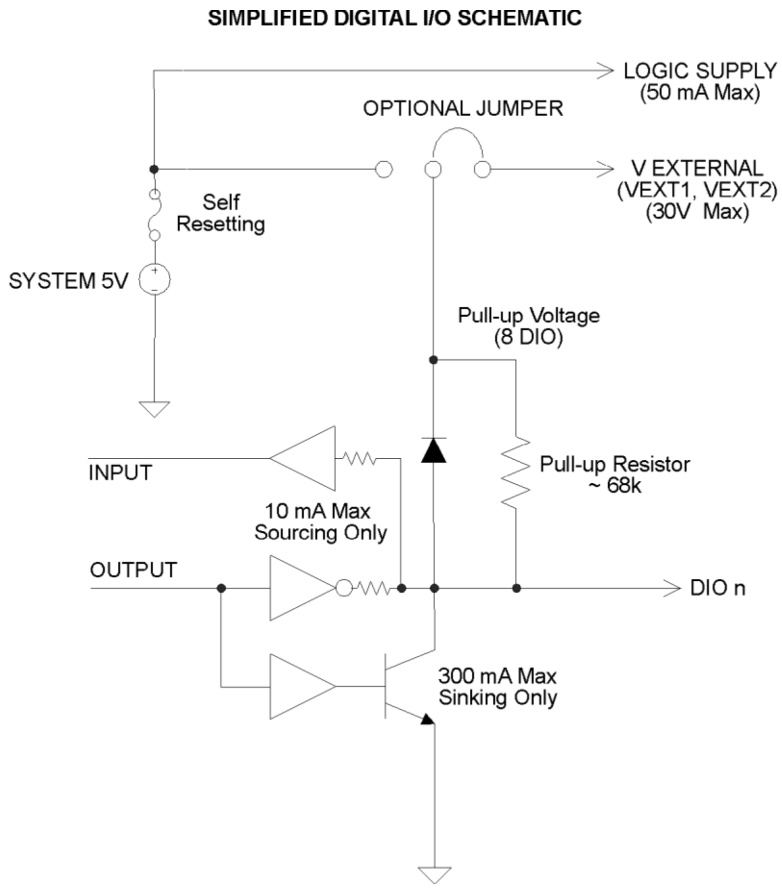
Figure 6-1: Simplified schematic of the jumper configuration



The factory default jumpers are set as follows:

- Connects the digital lines on each bank to the internal pull-up resistors.
- Connects those pull-up resistors to the internal +5 V.
- Connects VEXT1 to VEXT2. Removing the jumper allows for two different external voltage sources. They are grouped according to the D-SUB connector from which they are accessed (that is, Channels 1, 2, and 4 are on one D-SUB, while Channels 3 and 5 are on the other).

Figure 6-2: Simplified schematic of a digital I/O channel



The figure shows a simplified schematic for one bit of a digital I/O channel. Each I/O bit has an optional pullup resistor in parallel with a diode that is used to clamp flyback voltages from inductive devices like electro-mechanical relays. However, when the optional jumper is removed, both the pullup resistor and diode are removed from the circuit. The pullup resistor is considered “weak” and can easily be overdriven by the external circuit.

CAUTION	When driving the digital I/O channel with 5 V or higher, be sure to avoid driving the line higher than the pullup voltage (5 V or VEXT). Otherwise, the internal flyback diode will become forward biased, possibly causing a high current situation.

Sourcing current to an external load

When outputs are set to logic high, they are capable of sourcing up to 10 mA of current and maintaining a logic high state on the output. The outputs are protected against short circuits to ground, but do not generate a fault condition if that occurs. The logic high outputs cannot sink current.

Sinking current and overload protection

When outputs are set to logic low and the output current becomes greater than about 500 mA, the output driver limits the current at this level to restrict internal power dissipation. The Model 3750 detects this condition and generates a fault condition. The action following the fault condition is determined by the auto protect mode state. Do not allow such current limit situations to exist in the normal course of operation. Ensure that the external circuits limit the sinking current to a level within the specifications.

Using auto protect mode

Built into the Model 3750 is the capability to auto protect the digital outputs. It is a selectable mode (turned on by default) that protects the outputs by re-configuring them as inputs in order to limit the stresses on both the external driving circuits and the internal output drivers.

Using external user logic circuits

Limited +5 V is available and is intended for powering logic circuits. It is fused to prevent damage if the output is shorted. The fuse is a resettable type whose recovery time depends on ambient temperature. The higher the temperature, the longer it takes to reset. The maximum time presented in the Model 3750 specifications is for a "worst case" scenario. Checking for +5 V after the fault has been cleared avoids this lengthy delay in most cases.

Programming overview

There are five banks of 8 bits each on the Model 3750 card. The following examples apply to the card as shipped, as the jumpers are set to the position that pulls them up internally to +5 V.

To read the banks

After power up, the digital I/O default state is configured as digital input. Use the `channel.setmode()` command to explicitly set a bank as inputs:

```
channel.setmode("1005", channel.MODE_INPUT)
```

To read the eight bits associated with bank 5, use the `channel.read()` command:

```
chan5 = channel.read("1005")
```

To read up to four banks at the same time, use the optional `<width>` parameter. For example, to read four banks at the same time, use:

```
big_read = channel.read("1001", 4)
```

This causes banks 1, 2, 3, and 4 to be read at the same time and returned. The specified channel to the command is returned in the least significant byte and subsequent ascending channels are returned in the adjacent bytes. For example, if `big_read` contains the value 0x44332211, this means that bank 1 was 0x11, bank 2 was 0x22, bank 3 was 0x33, and bank 4 was 0x44.

To write to the banks

Because the default state of a digital I/O bank is configured as an input, the mode needs to be changed so that it is ready to accept `write` commands by using the `channel.setmode()` command:

```
channel.setmode("1005", channel.MODE_OUTPUT)
```

To write a single bank of 8 bits associated with Channel 5, send the channel.write() command:

```
channel.write("1005", 9)
```

Writing the value of 9 causes bits 1 and 4 to go high, while the rest remain low.

To write multiple banks at the same time, use the optional `width` parameter to indicate how many banks to affect. For example, the following command outputs 0x01 to bank 1, 0x02 to bank 2, 0x03 to bank 3, and 0x04 to bank 4.

```
channel.write("1001", 0x04030201, 4)
```

To read and write banks using a scan

Any input bank or totalizer channel that is included in a scan list is read when that channel is scanned. The value is saved to the buffer specified for the scan. For digital inputs, the width defaults to 1. For totalizers, the full count is read. For example, to read totalizer 1 on card 2 after scanning all channels of a Slot 1 multiplexer, use the `scan.create()` command:

```
scan.create('1001:1060, 2006')
```

To read more than one bank at a time, the `width` needs to be specified with the `scan.add()` command. For example, to read 32 bits of digital input on Slot 2 after scanning 60 channels on Slot 1:

```
scan.create('1001:1060')
scan.add('2001', 4)
```

To write to either a digital output or an analog channel, use the `scan.addwrite()` command, which includes a parameter for the data value to be written and an optional width parameter. For example, to program DAC Channel 1 on the Slot 2 card to go to +5 V after scanning 60 channels on Slot 1:

```
scan.create('1001:1060')
scan.addwrite('2010', '5')
```

Power consumption information

You can power off the totalizers if they are not being used, which reduces the power required of the card. The card has a default static power draw of 3300 mW, which includes powering the totalizer channels and both analog output channels. If the totalizer channels are powered off, they reduce the 3300 mW draw by 730 mW. This power can then be used for closing relays on other cards within the bank. See *Series 3700 Module Schematics and Connections* (on page 9-1) for more information on power handling information and examples.

NOTE The four totalizers are either all powered on or all powered off. Changing the power state of one affects them all. The command for controlling power is `channel.setpowerstate(<ch_list>, <state>)`, where `<state>` is either `'channel.ON'` or `'channel.OFF'`. See `channel.setpowerstate()` for more information.

Counter/totalizer

CAUTION	Do not exceed the maximum voltage and currents as listed on the Model 3750 specifications. Unused inputs should not be left floating but should be tied to ground or an appropriate DC voltage.

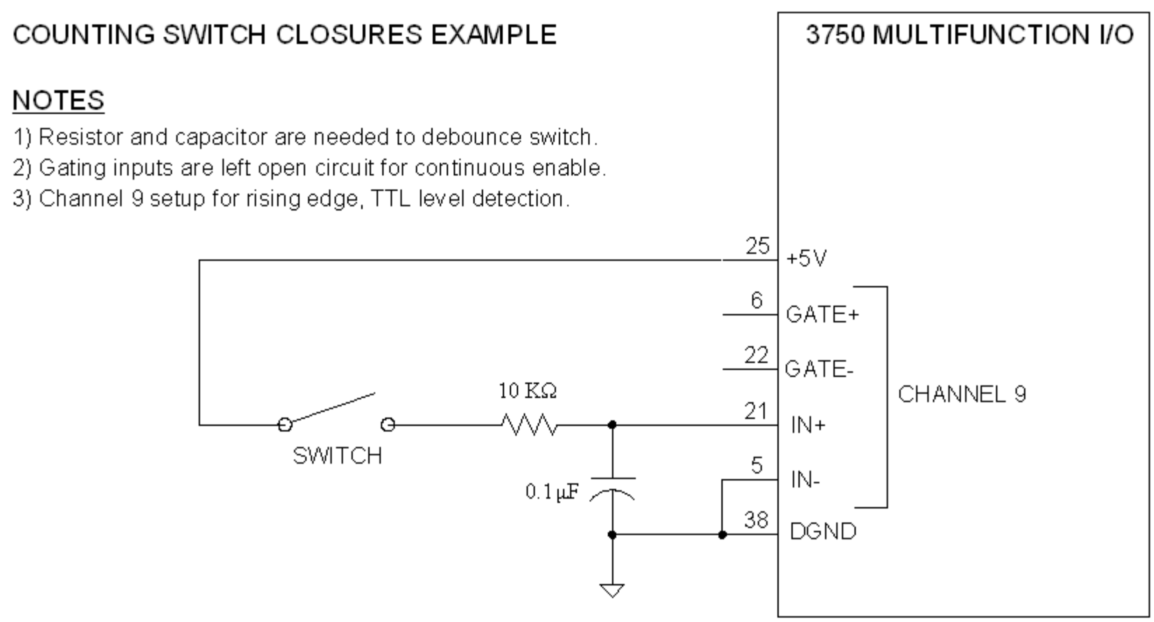
There are four separate totalizer channels, numbered 6 through 9, on a Model 3750 card. The threshold voltage is programmable and can be either 0 V or a TTL level (1.5 V). Counting occurs when the rising or falling edge on the input signal passes through the defined threshold. The edge to be counted can be programmed to be either rising or falling. The power on default is rising edge, TTL level threshold.

NOTE	When setting up the edge to be detected or changing the threshold, any existing counts are cleared.

Using the card to count closures

The following examples demonstrate how to use the card to count closures of a door switch connected to the first totalizer in Slot 1, using the Channel 1005.

Figure 6-3: Switch count example



- To read the current total closure counts:

```
channel.setmode('1009',
channel.MODE_RISING_TTL_EDGE)
count = channel.read('1009')
```

- To reset the counter to zero using an explicit command:

```
channel.write('1009', 0)
```

- To preset the counter to a value (for example, 100) using an explicit command:

```
channel.write('1009', 100)
```

- To automatically reset the counter back to zero for a read command:

```
channel.setmode('1009',
channel.MODE_RISING_TTL_EDGE_READ_RESET)
```

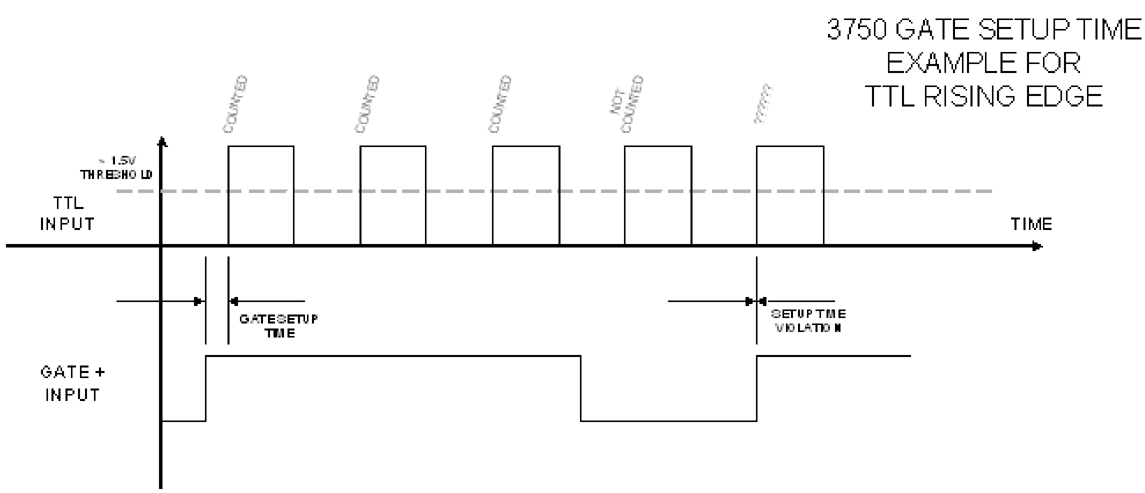
Using the gating function

The gate input determines whether the totalizer ignores or counts when the appropriate totalizer threshold is crossed. Gating is enabled by default; that is, the two inputs that control gating are biased to the appropriate level so that no connections have to be made for the totalizer to count. Gating of the count is accomplished in one of two ways:

- Driving the GATE + input below a TTL threshold (inhibit counting).
- Driving the GATE - input above a TTL threshold (inhibit counting).

The following diagram illustrates how gating works using the GATE + input with a totalizer configured for TTL threshold and a rising edge trigger.

Figure 6-4: Model 3750 Gate Setup Time Example



MINIMUM GATE INPUT SETUP TIME:

The minimum time required for the gate signal to be asserted/deasserted before the input signal crosses the programmed threshold.

NOTE The minimum gate input setup time must be satisfied for the event to be counted.

Analog output

There are two channels of isolated analog outputs on the Model 3750 card. Each channel can be configured for either voltage output or current output. Voltage output provides for +/- 12 V and is capable of providing up to 20 mA of current. Current output can be either 0-20 mA or 4-20 mA. The voltage outputs also support programming of up to 1% over the full scale range. This can be used to compensate for constant voltage drops in the system and cabling.

Each channel has its own separate common return line that provides the reference point for the output. These lines are labeled as “VCOM” for the voltage output and “ICOM” for the current output. If the outputs are to be referenced to some other point such as earth ground, the respective common return signals must be connected appropriately.

Each output is connected through an onboard output relay. Both the output signal and its corresponding return are connected at the same time that the output becomes enabled. Disabling the output opens this output relay.

The following examples use the first analog output channel of a card in Slot 1, so the nomenclature for the channel is `'1010'`.

Configuring the card for output type

The analog output channels default to voltage outputs. To configure them as current outputs:

```
channel.setmode('1010', channel.MODE_CURRENT_1)
```

NOTE MODE_CURRENT_1 specifies 0-20 mA and MODE_CURRENT_2 specifies 4-20 mA.

To reconfigure the analog output as a voltage output:

```
channel.setmode('1010', channel.MODE_VOLTAGE_1)
```

NOTE The analog output channels can only operate in one mode at a time. Specify either voltage output or current output.

The outputs default to being disabled. To enable them:

```
channel.setoutputenable('1010', channel.ON)
```

Once the channel is enabled, any values written to the channel are seen on the output pins. To disable the outputs:

```
channel.setoutputenable('1010', channel.OFF)
```

Using the card when configured as voltage outputs

To set the analog voltage output level to -3.5 volts:

```
channel.setmode('1010', channel.MODE_VOLTAGE_1)
channel.setoutputenable('1010', channel.ON)
channel.write('1010', -3.5)
```

Once the output voltage is set and the output is enabled, the output attempts to drive the external circuitry to the value specified. If the output voltage attempts to deliver more than the specified overload current, a fault condition exists.

To determine whether the output is in a fault condition:

```
circuit_fault = channel.getstate('1010',
   channel.IND_OVERLOAD)
```

If this returned value is true, then the output is either currently in a fault condition or was in a fault condition in the past if the fault state is latched. See *Latching values* (on page 6-23) for more information.

If auto protect mode is enabled, the output relay disconnects after approximately one second of sensing a persistent fault condition. This output disable removes any overload current-related fault condition. We strongly recommend that the voltage output is used in auto protect mode. When enabled, this mode prevents the output from experiencing prolonged stresses during some fault conditions. These stresses can cause potentially long thermal recovery times after the fault has been cleared.

To use the output in auto protect mode:

```
channel.setmode('1010', channel.MODE_PROTECT_VOLTAGE_1)
```

Using the card when configured as current outputs

To set a current output to 10mA:

```
channel.setmode('1010', channel.MODE_CURRENT_1)
channel.setoutputenable('1010', channel.ON)
channel.write('1010', 10e-3)
```

Once the output current is set and the output is enabled, the output attempts to drive the external circuitry to the value specified. If the output current drives a load that causes the output voltage to exceed the specified compliance voltage, a fault condition exists.

To determine whether the output is in a fault condition:

```
circuit_fault = channel.getstate('1010',
   channel.IND_OVERLOAD)
```

If this returned value is true, then the output is either currently in a fault condition or was in a fault condition in the past if the fault state is latched. See *Latching values* (on page 6-23) for more information.

If auto protect mode is enabled, the output relay disconnects after approximately one second of sensing a persistent fault condition. This output disable removes any overload current-related fault condition. We strongly recommended that you use the current output in auto protect mode. When enabled, this mode prevents the output from experiencing prolonged stresses during some fault conditions. These stresses can cause potentially long thermal recovery times after the fault has been cleared.

To use the output in auto protect mode:

```
channel.setmode('1010', channel.MODE_PROTECT_CURRENT_1)
```

Output loading precautions

In addition to the maximum specified loads for the output voltage and current, note several other precautions:

- Excessive amounts of capacitance present on the voltage output nodes can affect their normal behavior. For example, exceeding the specified output capacitance for the voltage output can cause a stability problem and result in a noisy output. The Model 3750 voltage output stage is compensated for a significant amount of capacitance that far exceeds the normal expected amount due to cables, circuits, and loads.
- Another consideration for the voltage output is load current. Inevitable resistance in the series path of the voltage output experiences a voltage drop when current flows. At levels of 10 mA or more, this can be a significant portion of the accuracy specification.

  For example, only 0.1 Ohms of stray resistance causes 1 mV of error at 10 mA of load current.

  To avoid this additional error, keep circuit loading to a minimum and use short heavy connections where possible. For voltage drops that are constant, programming additional voltage can help compensate.
- For current outputs, excessive amounts of series resistance can also cause a problem if the output voltage rises to near the compliance level. At voltages above the specified compliance level, the output may experience higher offsets and ultimately result in a clamped value.
- Because both outputs are electrically isolated from earth potential, they can float or be driven to some arbitrary reference point. Do not exceed the maximum ratings stated for the card on any of the channels under all operating conditions.

Hardware configuration

To configure digital I/O pull-up resistors and VEXT sources, you must remove and partially disassemble the Model 3750 as shown.

CAUTION	Be sure to use proper anti-static procedures while handling the Model 3750. Take care not to stress or flex the printed circuit board and do not touch other circuitry.

1. Remove the top shield cover:
   - Unscrew the number 4-40 screw (1) as shown in the "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. Set jumpers per options listed below.
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 number 4-40 screw (1).
4. The card can now be returned to service.

Figure 6-5: Removing the top shield

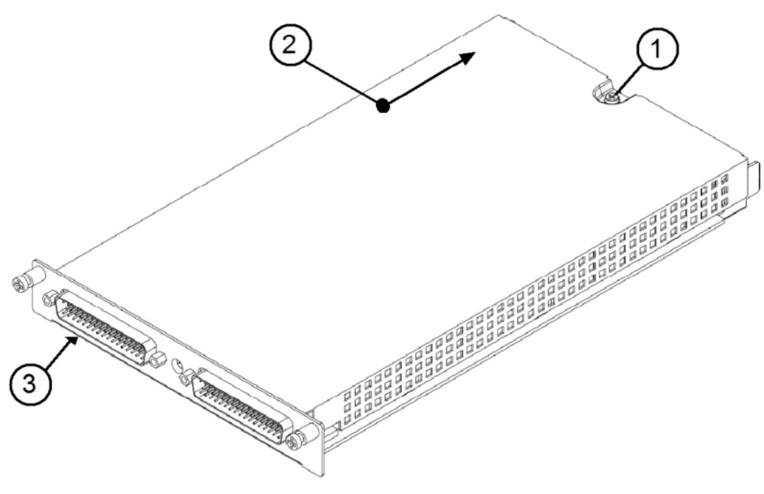
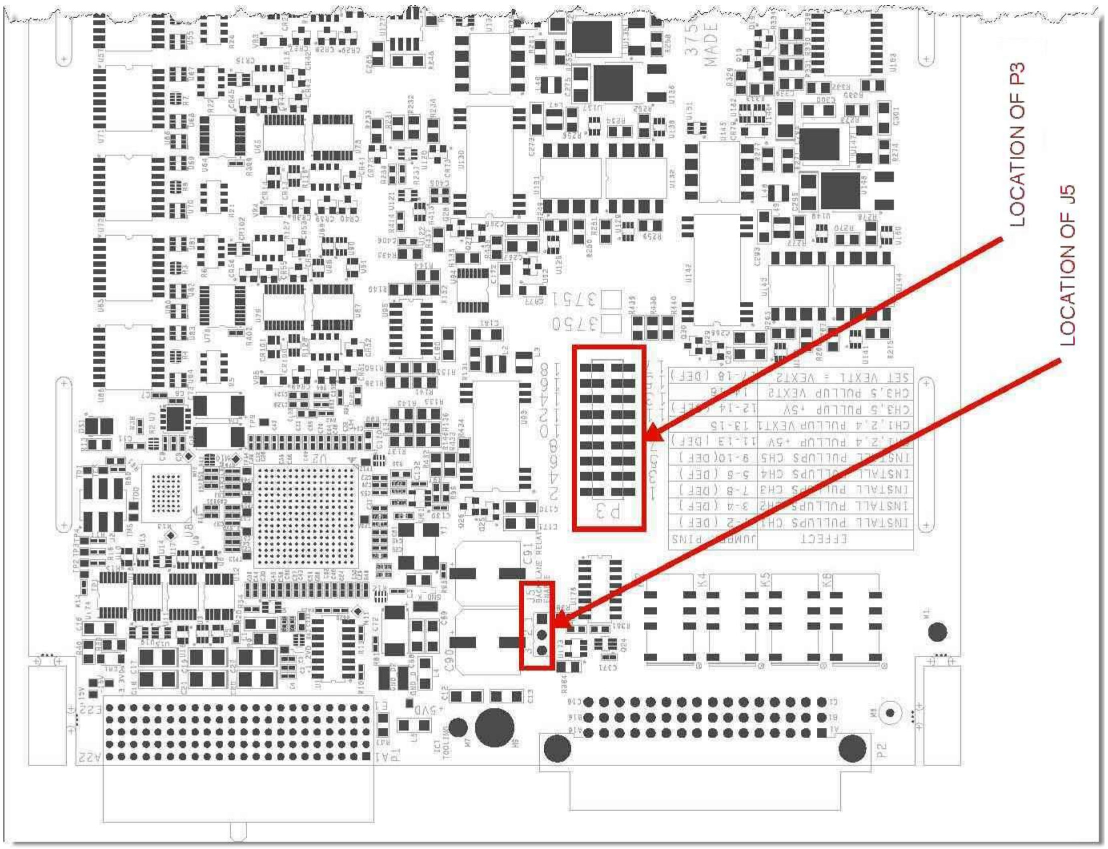


Figure 6-6: Location of P3 and J5 jumpers



The connector labeled P3 contains all of the jumpers needed to configure digital I/O and VEXT1, VEXT2. The connector labeled J5 contains a single jumper option that configures the backplane relays. See the following table for individual jumper locations and effects.

Desired effect	P3 pin numbers
Install all 8 pull-up resistors on CH1	Jumper 1 - 2
Install all 8 pull-up resistors on CH2	Jumper 3 - 4
Install all 8 pull-up resistors on CH3	Jumper 7 - 8
Install all 8 pull-up resistors on CH4	Jumper 5 - 6
Install all 8 pull-up resistors on CH5	Jumper 9 - 10
CH1, CH2, CH4 connect pull-up voltage to +5 V	Jumper 11 - 13
CH1, CH2, CH4 connect pull-up voltage to VEXT1	Jumper 13 - 15
CH3, CH5 connect pull-up voltage to +5 V	Jumper 12 - 14
CH3, CH5 connect pull-up voltage to VEXT2	Jumper 14 - 16

Desired effect	P3 pin numbers
Connect VEXT1 to VEXT2	Jumper 17 - 18

For backplane configuration at J5, jumper pins 2-3 to allow the Model 3750 to make backplane connections during calibration with a system DMM. If you do not want to ever physically allow the Model 3750 to make backplane connections, jumper pins 1-2. By populating this jumper in this way, an additional amount of safety is provided to a system that may have high voltage connections made to the backplane.

Calibration

To maintain specified performance over time, the analog output channels and the counter channels might need to be calibrated. The Model 3750 supports automatic in-system calibration if a DMM is present. Otherwise, an external DMM of 6.5 digits of accuracy or better can be used.

NOTE When performing a user calibration, final accuracy is determined by the standards used. Always verify the calibration results with a calibrated instrument capable of making measurements that exceed the specifications of the Model 3750.

We recommend that the Model 3750 is calibrated in the end application whenever possible so that the thermal and electrical operating environments can be accounted for. Best results will be obtained whenever this can be done and up to 8x improvements in offsets are typical.

Preparing for calibration

Before performing the calibration steps, be sure that the Model 3750 is properly disconnected from all external circuits. If an in-system DMM is to be used, disconnect the external ABUS from other mainframes and instruments that might be connected. If possible, disconnect all Model 3750 cables as well. Excessive capacitance on the counter channels can cause that part of calibration to fail. If a Model 3750-ST accessory is used, you can keep this connected as long as external circuits are disconnected.

Prior to calibration, the channel must be unlocked for calibration.

```
channel.calibration.unlock(<ch_list>, <password>)
```

The actual calibration is performed in several steps. In each step, the hardware outputs a value and expects a measured value to be entered. Once all the steps are complete, the Model 3750 calculates new calibration constants to be used until the next calibration takes place.

The following topics describe a list of steps to be performed to calibrate the Model 3750.

Calibration steps for analog output channels

For DAC channels, a calibration sequence includes these steps:

1. Set Voltage, -12 to +12 range, generate Negative Point 1.
2. Send reading.
3. Set Voltage, -12 to +12 range, generate Negative Point 2.
4. Send reading.
5. Set Voltage, -12 to +12 range, generate Positive Point 1.
6. Send reading.
7. Set Voltage, -12 to +12 range, generate Positive Point 2.
8. Send reading.
9. Set Current, 0 mA to +20 mA range, generate Point 1.
10. Send reading.
11. Set Current, 0 mA to +20 mA range, generate Point 2.
12. Send reading.
13. Set Current, +4 mA to +20 mA range, generate Point 1.
14. Send reading.
15. Set Current, +4 mA to +20 mA range, generate Point 2.
16. Send reading.

Calibration steps for counter/totalizer channels

For totalizer channels, a calibration sequence includes these steps:

1. Calibrate 0 V Totalizer Threshold
2. Calibrate 1.5 V Totalizer Threshold

You must save the calibration after calibrating and before locking. Use `channel.calibration.save()` to execute this function.

NOTE All calibration progress is lost if the calibration data is not saved!

After calibration, the channel must be locked.

```
channel.calibration.lock(<ch_list>, <password>)
```

Calibration example script

The following script creates two functions. You can use "`cal_dac`" and "`cal_tot`" to calibrate the analog outputs channels and counter channels respectively.

```
loadscript cal
-- Create a function called cal_dac that takes slot number
-- and channel number as parameters.
-- Be sure to disconnect all external circuits before
   executing calibration!
function cal_dac(slot_num,chan_num)
  channel_num = (1000 * slot_num) + chan_num
-- first unlock the calibration
  channel.calibration.unlock("slot" .. slot_num,"KI3706")
-- Setup internal DMM
  dmm.func="dcvolts"
  dmm.range=10
  dmm.nplc=1
  dmm.filter.count=100
  dmm.filter.enable=1
-- Perform the 16 steps of calibration using the internal
-- DMM readings changing ranges where appropriate
-- Provide delays before taking readings to allow
-- for settling
```

```
-- Write the reading/value into the appropriate step number
  channel.calibration.step("" .. channel_num,1)
  delay(6)
  rdg=dmm.measure()
  print(rdg)
  channel.calibration.step("" .. channel_num,2,rdg)
  dmm.range=1
  channel.calibration.step("" .. channel_num,3)
  delay(6)
  rdg=dmm.measure()
  print(rdg)
  channel.calibration.step("" .. channel_num,4,rdg)
  dmm.range=10
  channel.calibration.step("" .. channel_num,5)
  delay(6)
  rdg=dmm.measure()
  print(rdg)
  channel.calibration.step("" .. channel_num,6,rdg)
  dmm.range=1
  channel.calibration.step("" .. channel_num,7)
  delay(6)
  rdg=dmm.measure()
  print(rdg)
  channel.calibration.step("" .. channel_num,8,rdg)
-- The current mode calibration follows
-- in a similar fashion
  dmm.func="dccurrent"
  dmm.range=.001
  dmm.nplc=1
  dmm.filter.count=100
  dmm.filter.enable=1
  channel.calibration.step("" .. channel_num,9)
  delay(6)
  rdg=dmm.measure()
  print(rdg)
  channel.calibration.step("" .. channel_num,10,rdg)
  dmm.range=.1
  channel.calibration.step("" .. channel_num,11)
  delay(6)
  rdg=dmm.measure()
  print(rdg)
  channel.calibration.step("" .. channel_num,12,rdg)
  dmm.range=.01
  channel.calibration.step("" .. channel_num,13)
  delay(6)
  rdg=dmm.measure()
  print(rdg)
  channel.calibration.step("" .. channel_num,14,rdg)
  dmm.range=.1
  channel.calibration.step("" .. channel_num,15)
  delay(6)
  rdg=dmm.measure()
  print(rdg)
  channel.calibration.step("" .. channel_num,16,rdg)
-- Final steps are to save & lock the calibration.
-- New calibration data is not used
```

```
-- if it is not saved.
  channel.calibration.save()
  channel.calibration.lock()
-- Cleanup to restore analog channels to
-- an idle, unconnected state
  channel.setmode("" .. (1000 * slot_num +
     10),channel.MODE_PROTECT_VOLTAGE_1)
  channel.setmode("" .. (1000 * slot_num +
     11),channel.MODE_PROTECT_VOLTAGE_1)
  channel.setoutputenable("" .. (1000 * slot_num + 10)
     ,channel.OFF)
  channel.setoutputenable("" .. (1000 * slot_num + 11)
     ,channel.OFF)
  channel.write("" .. (1000 * slot_num + 10), 0)
  channel.write("" .. (1000 * slot_num + 10), 0)
end
-- Create a function called cal_tot that takes
-- slot number and channel number as parameters
-- No external measurements need to be taken
-- to calibrate the counter channels.
-- Be sure to disconnect all external circuits
-- before executing calibration!
function cal_tot(slot_num,chan_num)
  channel_num = (1000 * slot_num) + chan_num
  channel.calibration.unlock("slot" .. slot_num,"KI3706")
  channel.calibration.step("" .. channel_num,1)
  channel.calibration.step("" .. channel_num,2)
  channel.calibration.save()
  channel.calibration.lock()
end
endscript
```

Before running these calibration scripts, you must build the functions `cal_dac()` and `cal_tot()` by typing `cal()`. Now you can calibrate any channel using this script.

Typing `cal_dac(1,10)` runs an internal DMM calibration on Slot 1, Channel 10.

Typing `cal_tot(2,6)` runs the totalizer calibration for Slot 2, Channel 6.

Power consumption information

You can power off each analog channel if it is not being used to reduce the power required of the card with `channel.setpowerstate()`. The card has a default static power draw of 3300 mW, which includes powering the totalizer channels and both analog output channels. If an analog channel is powered off, it reduces the 3300 mW draw by 820 mW for each channel that is powered off. This power can then be used for closing relays on other cards within a bank. See *Series 3700 Module Schematics and Connections* (on page 9-1) for more information on power handling information and examples.

The command for controlling power is `channel.setpowerstate(<ch_list>, <state>)`, where `<state>` is either `'channel.ON'` or `'channel.OFF'`.

NOTE If an analog channel has been turned off, the specified warmup time is required after being turned back on in order to meet its specified accuracies.

Using match counts

Match counts apply to digital inputs and counter/totalizer channels.

Setting and meeting match counts

Matching allows you to set a state or generate an event when achieving a match, instead of continually reading the totalizer count. For example, you can set a totalizer count match and the summary does not change until that match count is met.

For example, we want to know when a totalizer count reaches 50 for the first totalizer in Slot 1 (that is, Channel 1006). First set the match type for that channel:

```
channel.setmatchtype('1006', channel.MATCH_EXACT)
```

Next, program the match count:

```
channel.setmatch('1006', 50)
```

Once the match count is met in the totalizer, the `channel.IND_MATCH` bit is set and can be read using

```
match_value = channel.getstate('1006')
```

Because the default setting for the state is for it to latch, the value remains even after the count moves beyond the match value. To clear it, use:

```
channel.resetstatelatch('1006', channel.IND_MATCH)
```

Using match counts to generate an event

A match can cause an event in the system that can then be used to initiate a scan. For example:

```
-- Define a scan
scan.create("6001:6030")
channel.trigger[1].set('1006', channel.IND_MATCH)
scan.trigger.arm.stimulus = channel.trigger[1].EVENT_ID

-- Start the scan so that it is waiting for the event
scan.background()
```

Once the count matches, the event triggers and satisfies `arm.stimulus`, which allows the scan to proceed.

Latching values

Channels support a status/state concept. The status of a channel indicates what conditions are present on that channel at that point in time. Examples of channel status are:

- An overload condition exists on that channel
- A channel is presently matching a pre-determined match condition
- The counter/totalizer channel’s count has overflowed.

To read the present status of a channel, send:

```
status_now = channel.getstate('1001')
```

If the digital I/O matches a present match value, the `status_now` value would be `channel.IND_MATCH`.

Status latching builds on this so that the status read by `channel.getstate()` remembers what has happened. For example, status latching tracks if the condition EVER happened since its last reset so that you know that the status occurred but is not now present. Manipulating the status so that it either latches or not is accomplished with the following commands:

```
channel.setstatelatch()
channel.resetstatelatch()
```

The setting of the state latch can be read using `channel.getstate()`.

Power consumption implications

The Model 3750 draws a significant amount of power from the Model 3706 mainframe in order to perform all of its functions. In cases where multiple Model 3750 cards are used, it is possible that not all Model 3750 functions can be executed at the same time. The Model 3706 mainframe keeps track of power requirements in real time and provides a notification if a power limit has been exceeded. This notification is in the form of one or more error messages.

See *Power budgeting and calculation* (on page 9-2) for more information.

While operating the Model 3750, if a requested operation would consume an amount of power that is not available, one of the following errors is generated:

- #5513 "Not enough total power to complete requested card operation."
- #5514 "Not enough bank power to complete requested card operation."
- #5515 "Not enough slot power to complete requested card operation."

These errors mean that there was not enough available reserve power to complete the requested operation on a total, bank, and slot basis, respectively. As a result, the requested operation would not have been performed. To perform the requested operation, more available reserve power is needed as described in *Options for working with power consumption limitations* (on page 6-24).

Options for working with power consumption limitations

If the system is experiencing power limitations, there are two ways to possibly improve the power capability of the system.

- Turn off modes of operation or functions when they are not in use. For example, backplane relays on switch cards and any non-latching relay types that do not need to remain closed all the time. This conserves power and results in more reserves available. Another example is to turn all digital I/O as inputs when they are not needed as outputs.
- Balance the power across banks. In the Model 3706 mainframe, the power limitations are on a bank (3-slot) basis. By placing equal numbers of Model 3750 cards in each bank, the power constraints for the troublesome bank may be relaxed. For example, a 4-card system would have Model 3750 cards installed in slots 2,3 and 5,6, instead of slots 1, 2, 3, and 4. Additionally, system planning could result in a system where a Model 3750 that uses the highest amount of power would be located in the bank with the most reserve available.

See *Power budgeting and calculation* (on page 9-2) for more information.

Section 7

Upgrade Procedure Using USB Flash Drive

In this section:

Firmware upgrade from a 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, depending on the cards in the system and if a DMM is installed.

The normal upgrade procedure only upgrades to a higher level software version. If any part of the system is already at a higher software revision, that part of the system is skipped during the upgrade. A separate operation is available to upgrade to earlier revision firmware.

The upgrade process upgrades not only the mainframe, but also the digital multimeter (DMM) and any cards in the system. Make sure all available cards are populated in the mainframe before beginning the upgrade procedure.

Upgrade procedure

NOTE You can upgrade a single card at a later time by populating the mainframe with that card and re-running the upgrade procedure. The upgrade procedure verifies that other parts of the system are already at the latest revision and only upgrades the additional installed card.

CAUTION Do not turn off unit or remove flash drive during the upgrade procedure. Wait until the unit completes the upgrade procedure and the opening display is displayed.

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).

   NOTE Verify that the USB flash drive is blank.

2. Power on the Series 3700.
3. Install a USB flash drive in the front panel connector.
4. On the front panel, press the **MENU** key.

   NOTE If your model does not have a front panel, upgrade over the bus with the appropriate command (upgrade.unit() or upgrade.previous()).

5. Turn the navigation wheel to scroll to "UPGRADE" and press the navigation wheel.
6. The question UPGRADE UNIT? is displayed. Select "Previous" to install a previous version or select "Yes" to upgrade to a newer version and press the navigation wheel.
7. The Series 3700 upgrade status is displayed on the front panel, including the percentage. When the file has been unpacked, the upgrade status will be displayed as it is upgraded (first cards installed in the slots including the DMM if installed, and then the Main Series 3700).

   NOTE For models without a front panel, the lan status and clock status LEDs blink in unison during the upgrade process.

The Series 3700 reboots automatically when the upgrade is complete.

Section 8

Maintenance

In this section:

Introduction

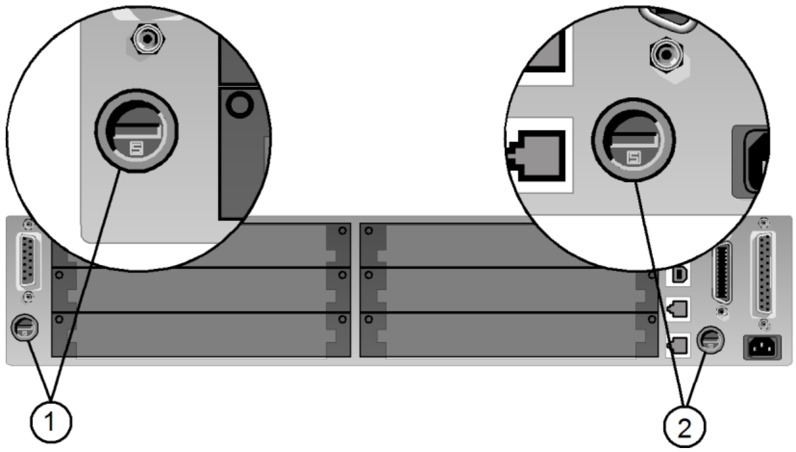
The information in this section deals with routine maintenance of Keithley Instruments Series 3700 System Switch Multimeter instruments that can be performed by the operator.

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 flat-tip 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 front panel keys test lets you check the functionality of each front panel key.

To run the front panel keys test:

1. Display the MAIN MENU by pressing the **MENU** key.
2. Turn the navigation 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 the navigation wheel 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.

Section 9

Series 3700 Module Schematics and Connections

In this section:

Maximum power usage with Series 3700 cards

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.

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)	12300 mW (max)

From the table, the total power available for slots 1, 2 and 3 is 12,300 mW (12.3 W). Similarly, the total power available for slots #4, 5, and 6 is 12.3 W. Attempting to exceed these power levels results in the system performing as many of the operations as possible until these power limits are reached. An error message is then created and the remaining operations are not 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
3724	1150	20	100
3730	780	NA	100
3740	1000	NA (Independent)	100
		200 (High Current)	100

Model	Quiescent Power (Milliwatts)	Channel Relay Power Consumption (Milliwatts) Each	Backplane Relay Power Consumption (Milliwatts) Each
3750	3300 **NOTE**: The 3300 is reduced when power is disabled to each analog output channel (820 each) or disabled to the totalizers (730 for all 4; cannot be individually disabled) See *Example 5* (on page 9-7), *Example 6* (on page 9-8), and *Example 7* (on page 9-8).	0 each (Digital Input channel) 365 each (Digital Output channel) 470 each (Analog Output) 0 each (Totalizers)	

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

$$\text{Total Bank \#1 Power} = \text{Slot 1 } P_{TS} + \text{Slot 2 } P_{TS} + \text{Slot 3 } P_{TS}$$

$$\text{Total Bank \#2 Power} = \text{Slot 4 } P_{TS} + \text{Slot 5 } P_{TS} + \text{Slot 6 } P_{TS}$$

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 is 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: Because 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: Because 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 #	**Card**	**Channel relays closed**	**Backplane relays closed**
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 are not performed and an error is 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: Because each bank has not exceeded maximum power, this is OK.

Example 5

This example demonstrates how to calculate the card power of the 3750.

Setup	Power	Notes
	3300	Static power required of card under default conditions (that is, all functions enabled)
CH 1,2,3 set as INPUT	0	
CH 4 set as OUTPUT	365	
CH 5 set as OUTPUT	365	
CH 10 = V mode	470	

Setup	Power	Notes
CH 11 = I mode	470	
Total Power	4970 m W	**NOTE**: Since total power per bank cannot exceed 12300 mW, only 2 3750 cards per bank can be populated when used in the example configuration. This leaves spare power (12300 – (4970 * 2)) for controlling relays on a third card in the bank.

Example 6

This example demonstrates how to calculate the card power of the 3750 when used only as digital outputs.

Setup	Power	Notes
	3300	Static power required of card under default conditions (that is, all functions enabled)
CH 1 through 5 set as OUTPUT	365 * 5 = 1825	
CH 6 through 9 = disabled	-730	Static power is reduced by disabling the totalizers (channels cannot be individually disabled).
CH 10 = disabled	-820	Static power is reduced by disabling analog output channel.
CH 11 = disabled	-820	Static power is reduced by disabling analog output channel.
Total Power	2755 mW	**NOTE**: Bank power would not be exceeded if 3 cards per bank were used in this manner.

Example 7

This example demonstrates how to calculate the card power of the 3750 for digital inputs and two analog voltage outputs.

Setup	Power	Notes
	3300	Static power required of card under default conditions (that is, all functions enabled).
CH 1 through 5 set as INPUT	0	
CH 6 through 9 = disabled	-730	Static power is reduced by disabling the totalizers (channels cannot be individually disabled).
CH 10 = V mode	470	
CH 11 = V mode	470	
Total Power	3510 mW	**NOTE**: Bank power would not be exceeded if 3 cards per bank were used in this manner.

Pseudocards

A pseudocard can be "installed" in any empty slot. With the 3720 pseudocard "installed," the instrument operates as if a Model 3720 Thermocouple MUX card is installed in the slot. This allows you to configure a scan and exercise its operation before the switching module is installed in the Series 3700. Use the following commands to install Series 3700 pseudocards in empty slots:

For no pseudocard selection (use to remove an existing pseudocard):

```
slot.PSEUDO_NONE or 0
```

Model 3720 for Dual 1x30 multiplexer card simulation:

```
slot.PSEUDO_3720 or 3720
```

Model 3721 for Dual 1x20 multiplexer card simulation:

```
slot.PSEUDO_3721 or 3721
```

Model 3722 for Dual 1x48 multiplexer card simulation:

```
slot.PSEUDO_3722 or 3722
```

Model 3723 Dual 1x30 reed multiplexer card simulation:

```
slot.PSEUDO_3723 or 3723
```

Model 3724 Dual 1x30 FET multiplexer card simulation:

```
slot.PSEUDO_3724 or 3724
```

Model 3730 6 x 16 high-density matrix card simulation:

```
slot.PSEUDO_3730 or 3730
```

Model 3740 32-channel isolated switch card:

```
slot.PSEUDO_3740 or 3740
```

Model 3750 multifunction I/O card simulation:

```
slot.PSEUDO_3750 or 3750
```

For example, to set the attribute to "install" the Model 3720 pseudocard in Slot 6:

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

When queried, the return value has "Pseudo" before the card description. For example:

```
print(slot[3].idn) → 3720,Pseudo Dual 1x30
   Multiplexer,00.00a
```

NOTE The revision level of a pseudocard is always returned as 00.00 a.

Query the slot[X] attributes to determine the capabilities of the installed switching modules. For example, send the following query to determine if Slot 1 supports common-side 4-wire Ω channels:

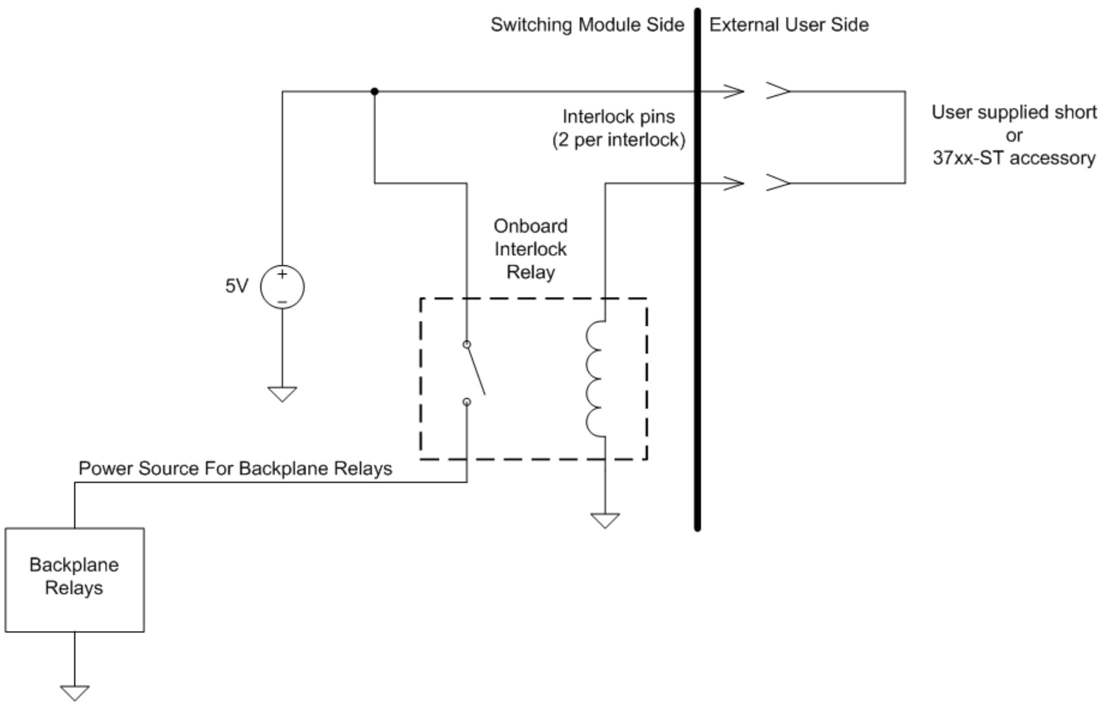
```
CommonSideOhms1 = slot[1].commonsideohms
```

Hardware interlocks

Some switching modules are capable of switching high voltage signals. For safety reasons, hardware interlocks are provided. The hardware interlocks are present on the switching module itself and are designed to keep the switching module disconnected from the system backplane. This has the implication that when the interlock circuit is disengaged, no measurements can be performed through a switching module. Channel relays can continue to operate, however.

Below is a simplified schematic of the interlock circuit present on the applicable switching modules.

Figure 9-1: Simplified interlock circuit



Engaging hardware interlocks

To engage the hardware interlocks, you must provide a low resistance path between the two applicable interlock pins as shown in the diagram. This path routes a 5 V power source to an onboard interlock relay which in turn enables power to the backplane relays. If a 37xx-ST accessory terminal board is used, this low resistance path is provided to automatically engage the interlock circuit.

NOTE Do not use the supplied 5 V power source for anything other than energizing the interlock relay. It is not designed for external circuit use.

Be sure to provide a low resistance path between the interlock pins for reliable operation. Significant resistance if present can cause the interlock circuit to fail to engage.

Interlock status

Some switching modules have more than one interlock. At any time, the current status of each interlock can be determined by using the appropriate ICL command shown below. When the interlock status reports engaged, associated backplane relays are allowed to be energized. When the interlock status reports disengaged, associated backplane relays are prevented from being energized.

Figure 9-2: slot[X].interlock.state ICL command

slot[X].interlock.state	
Attribute	Indicates the interlock state of a card.
Usage	To read the interlock state: `value = slot[X].interlock.state` *[X]*: Slot number (1 to 6) *value*: Represents whether the interlocks are engaged or not. Interpret the interlock state values as follows: `nil`: no card is installed or card installed does not support interlocks `0`: interlocks 1 and 2 are disengaged on card. `1`: interlock 1 is engaged while interlock 2, if it exists, is disengaged. `2`: interlock 1 is disengaged while interlock 2 is engaged. `3`: interlocks 1 and 2 are engaged on card.

See Section 9 of the Reference Manual for more interlock related commands and details.

Interlock pin numbers

The following table shows the interlock pin numbers for all applicable switching modules.

Model	Interlock Circuit	Interlock Pins	Backplane relays affected	Other relays affected
3720	Multiplexer #1	76, 78	n911 through n916	
	Multiplexer #2	76, 78	n921 through n926	
3721	Multiplexer #1, Amps, DMM	33, 50	n911 through n917	n041, n042 (Amps), n928 (DMM HI / SHI)
	Multiplexer #2	1, 34	n921 through n927	
3722	No Interlocks Present	-	-	
3723	Multiplexer #1	76, 78	n911 through n916	
	Multiplexer #2	76, 78	n921 through n926	
3724	Multiplexer #1	76, 78	n911 through n916	
	Multiplexer #2	76, 78	n921 through n926	
3730	Matrix #1	48, 50	n911 through n916	
3740	Independent Switch Bank #1	48, 50	n911 through n916	
3750	No interlocks present			

WARNING	***Take special care not to inadvertently wire high voltage analog signals to the interlock pins. Instrument damage or loss of functionality can occur.***

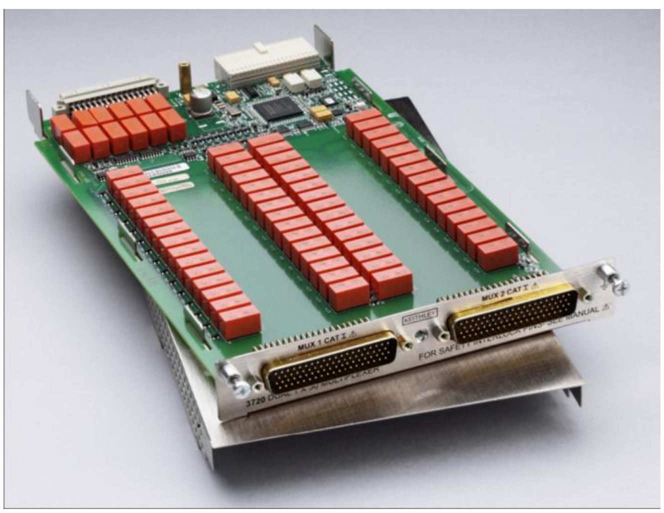
Model 3720 dual 1x30 multiplexer card

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 9-3: Model 3720



Available accessories: Model 3720

3720-MTC-1.5: 78-pin female-to-male D-sub cable assembly, 1.5 m (4.9 ft)

3720-MTC-3: 78-pin female-to-male D-sub cable assembly, 3 m (9.8 ft)

3720-ST: Screw Terminal panel with CJC sensor

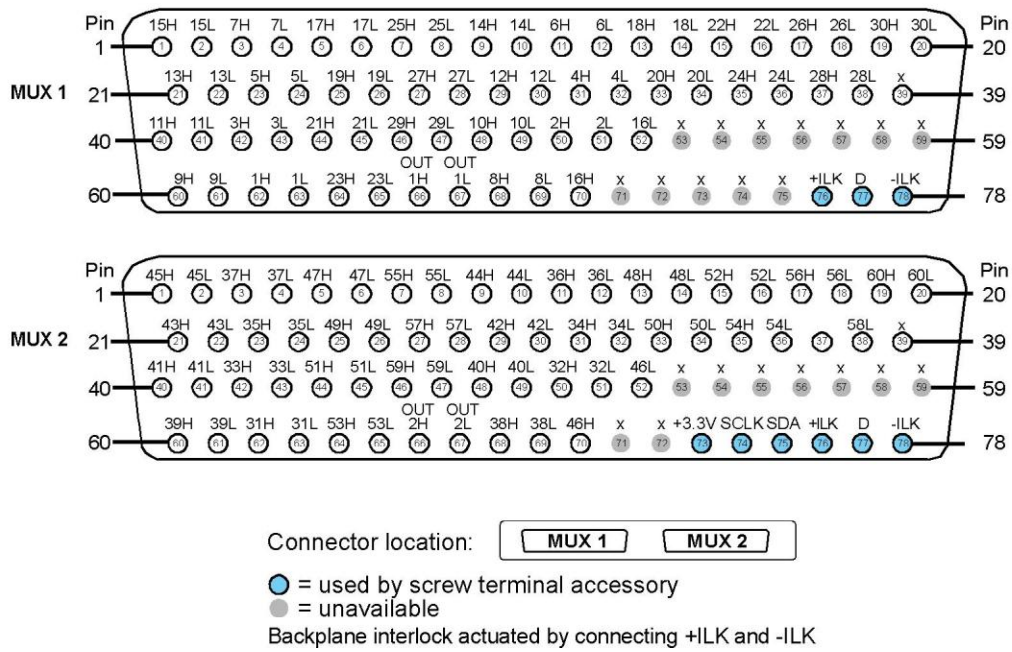
3791-KIT78-R: 78-pin female D-sub connector kit (solder cup contacts). See *Connection information: Model 3720* (on page 9-14).

7401: Type K thermocouple wire kit

Connection information: Model 3720

Refer to the following figure for Model 3720 D-sub connection information.

Figure 9-4: D-sub connection information for the Model 3720



Schematics: Model 3720

The following figure provides a switching schematic for the Model 3720.

Figure 9-5: Schematic of the Model 3720

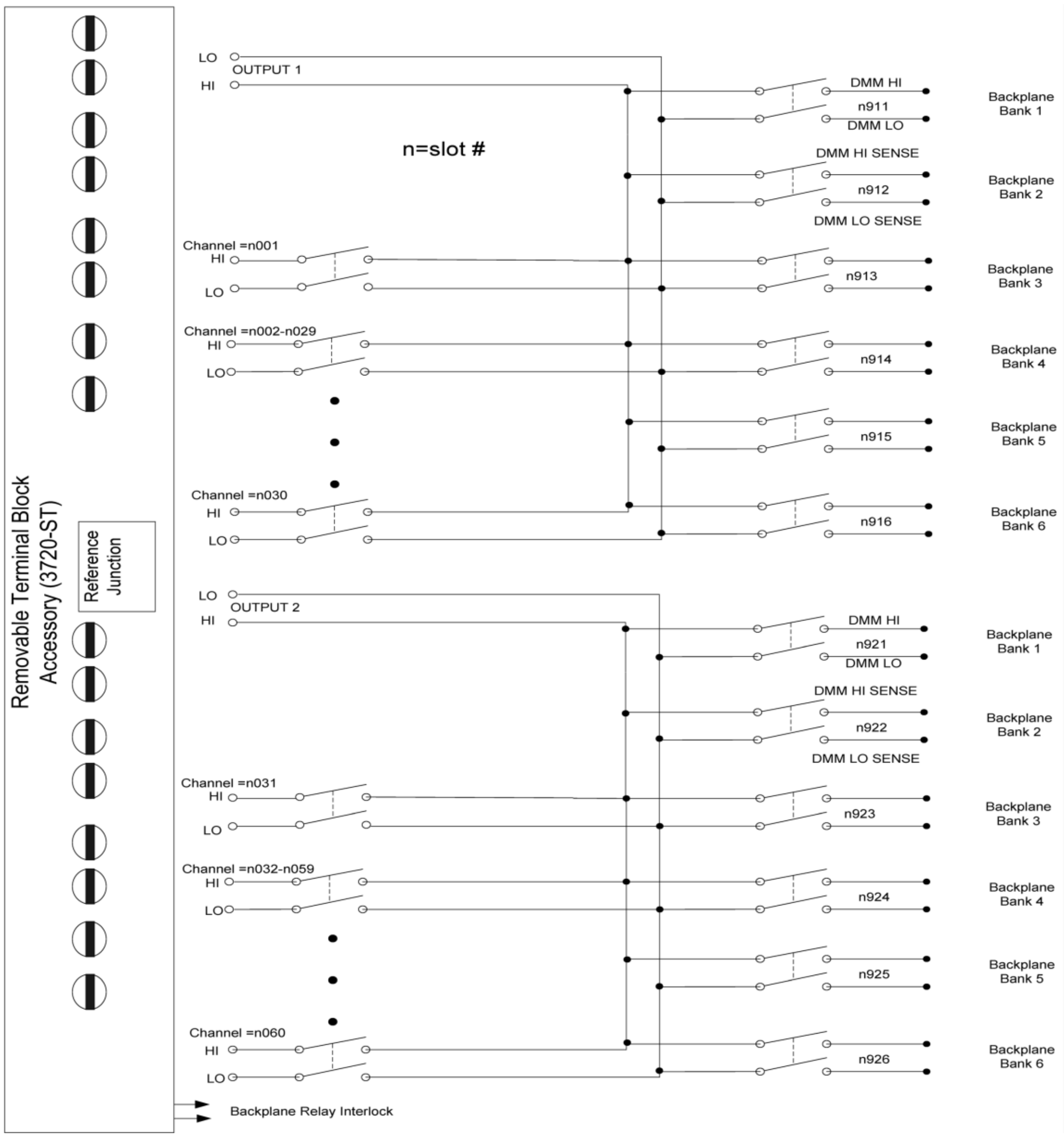
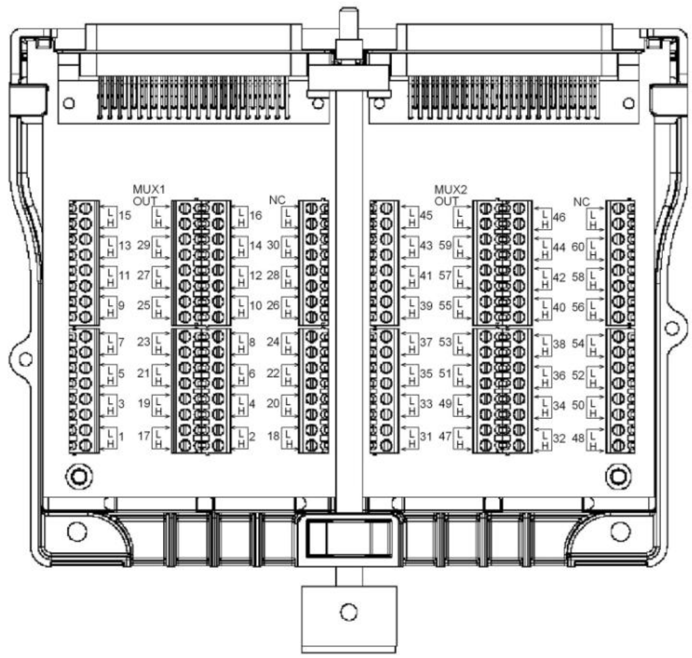


Figure 9-6: Models 3720, 3723, and 3724 screw terminal



Model 3720 connection log

The following figures provide a sample of a connection log that can be used to record the wiring scheme for this module.

Figure 9-7: Sample Model 3720 connection log (1 of 2)

Channel		Color	Description
OUTPUT 1	H		
	L		
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 9-8: Sample Model 3720 connection log (2 of 2)

Channel (cont.)		Color	Description
CH30	H		
	L		
OUTPUT 2	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		

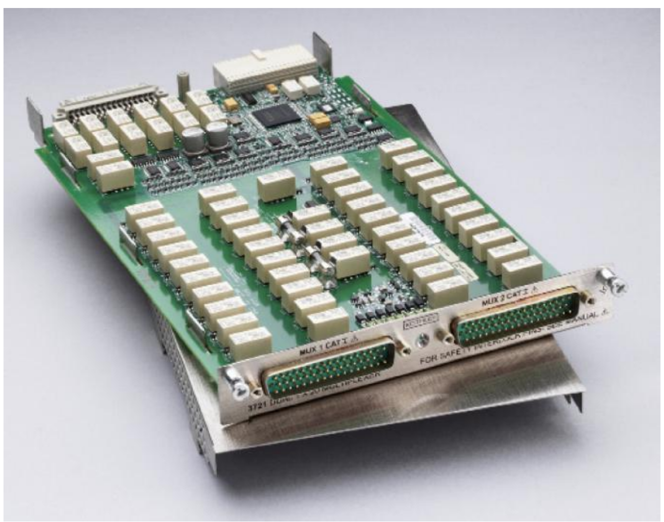
Model 3721 dual 1x20 multiplexer card

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 4-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 9-9: Model 3721



Available accessories: Model 3721

3721-MTC-1.5:	50-pin female-to-male D-sub cable assembly, 1.5 m (4.9 ft)
3721-MTC-3:	50-pin female-to-male D-sub cable assembly, 3 m (9.8 ft)
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 9-21)
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

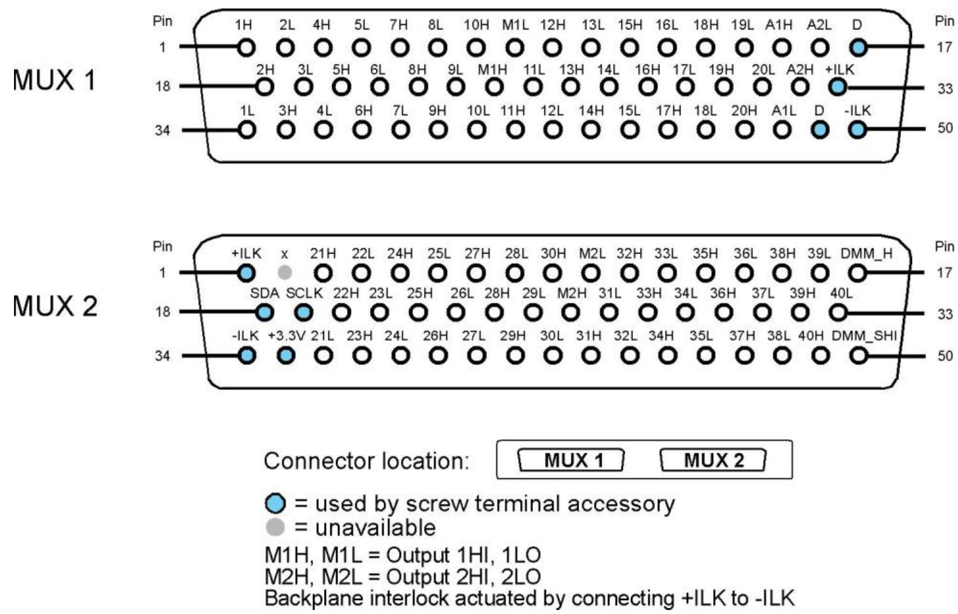
When viewing this table, remember:

- Multiplexer number 1 channels are labeled 1 through 20 and the multiplexer output is labeled MUX 1 OUT.
- Multiplexer number 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.

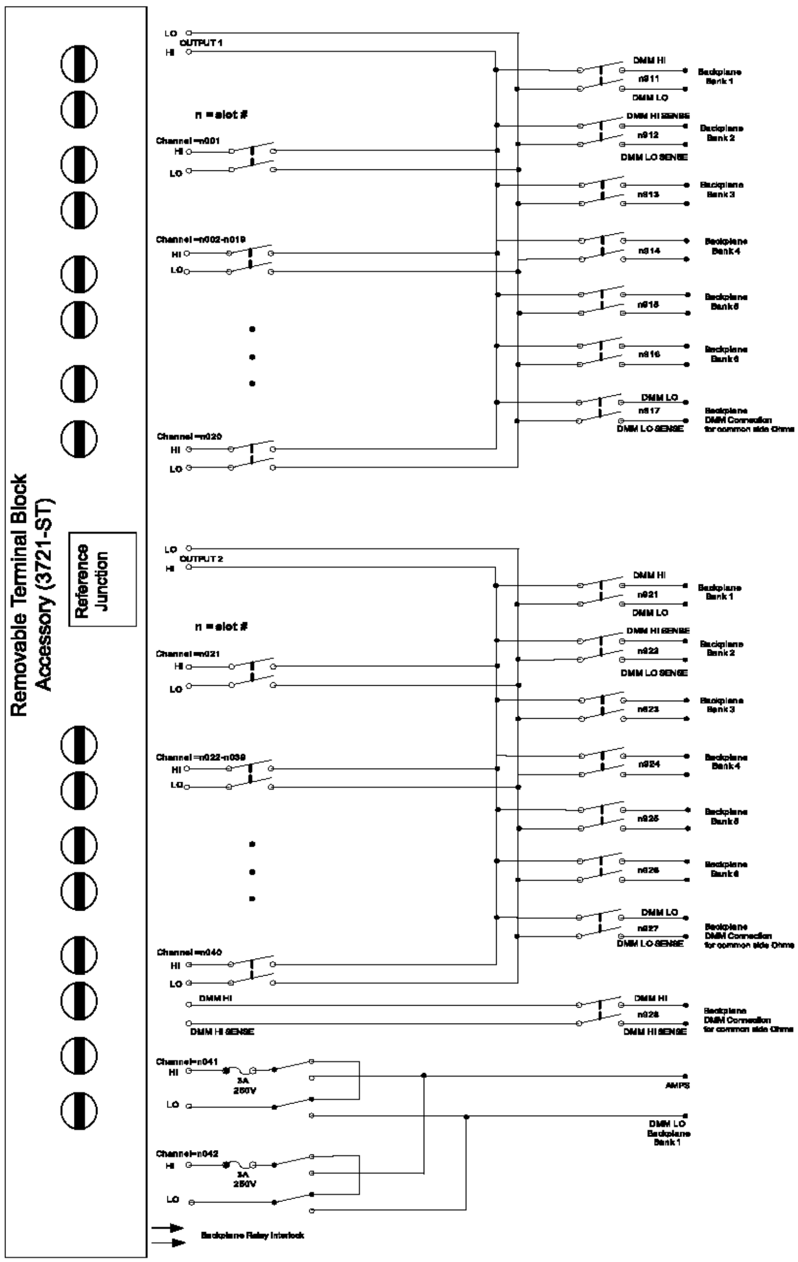
Figure 9-10: D-sub connection information for the Model 3721



Schematics: Model 3721

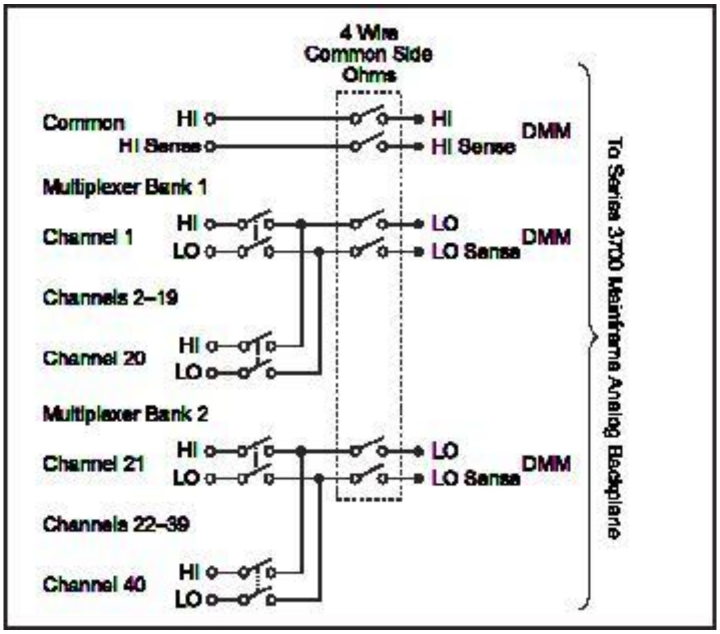
The following figure provides a switching schematic for the Model 3721 in two-pole mode.

Figure 9-11: Schematic of the Model 3721 in two-pole mode



The following figure provides a switching schematic for the Model 3721 in 4-wire common side ohm mode.

Figure 9-12: Schematic of the Model 3721 in four-wire common side ohm mode



Programming Note

The 3721 card that has three additional backplane relays for common side ohms functionality. Using `'slotX'` or `"allslots"` to query settings on this card returns information for channels 1 to 40, 911 to 916, 921 to 926 then 917, 927, and 928 in the response message. Therefore, the three additional common side ohms backplane relays are listed last.

For example, to print out the channel images on this card when in Slot 2 after a reset send the following:

```
reset()
print(channel.getimage('slot2'))
```

2001;2002;2003;2004;2005;2006;2007;2008;2009;2010;2011;2012;2013;2014;2015;2016;2017;2018;2019;2020;2021;2022;2023;2024;2025;2026;2027;2028;2029;2030;2031;2032;2033;2034;2035;2036;2037;2038;2039;2040;2041;2042;2911;2912;2913;2914;2915;2916;2921;2922;2923;2924;2925;2926;2917;2927;2928

NOTE The common side ohm backplane relays (2917, 2927, and 2928) are listed last.

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 can 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 number 4-40 screw (1) as shown in the "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. Set jumpers per options listed below.
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 number 4-40 screw (1).
4. The card can now be returned to service.

Figure 9-13: Removing the top shield

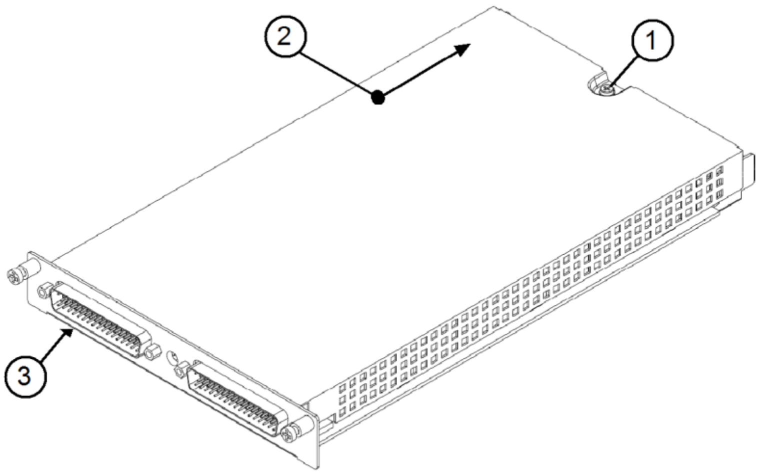
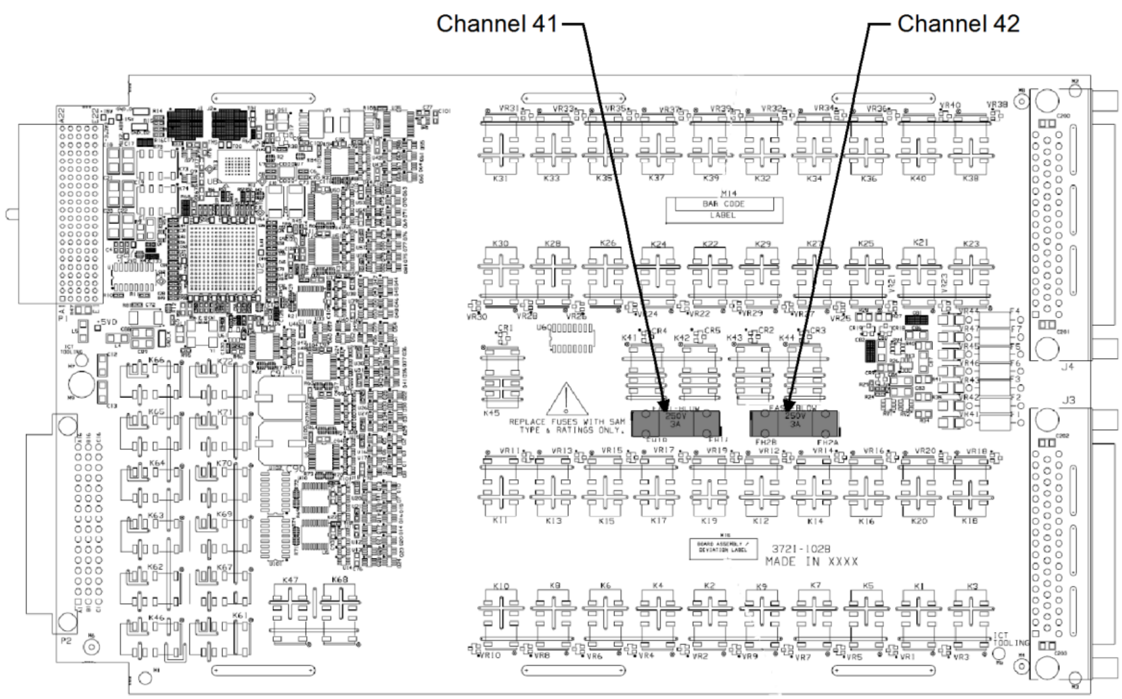
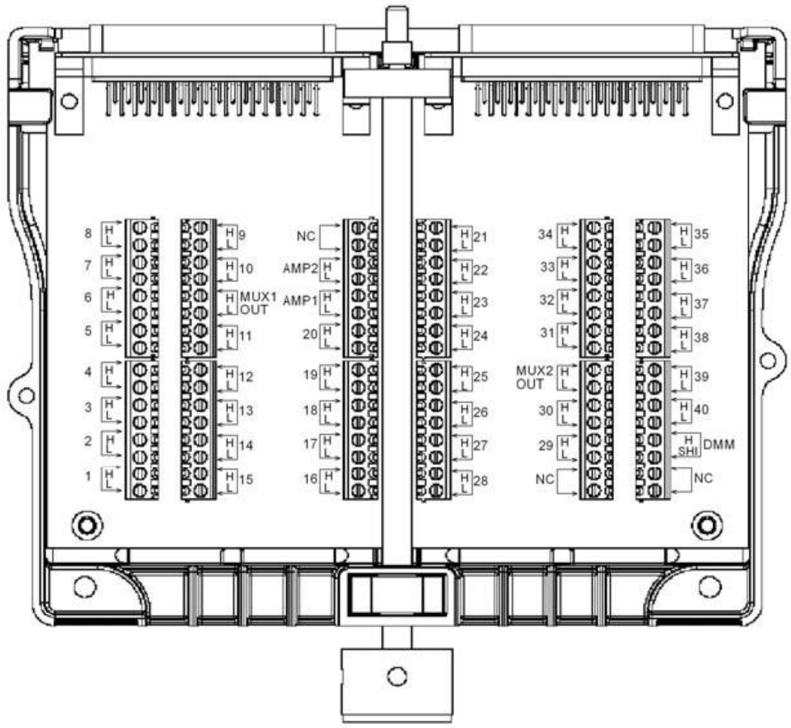


Figure 9-14: Fuse location



Rating	Type	Size	Keithley Instruments part number
250 V, 3A	Fast blow	5 x 20 mm	FU-99-1

Figure 9-15: Model 3721-ST



Model 3721 connection log

The following figures provide a sample of a connection log that can be used to record the wiring scheme for this module.

Figure 9-16: Sample Model 3721 connection log (1 of 2)

Channel		Color	Description
OUTPUT 1	H		
	L		
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		
OUTPUT 2	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 9-17: Sample Model 3721 connection log (2 of 2)

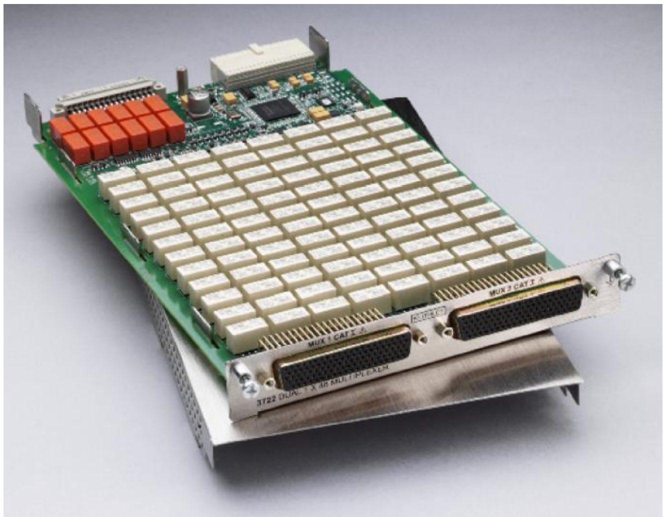
Channel (cont.)		Color	Description
CH30	H		
	L		
CH31	H		
	L		
CH32	H		
	L		
CH33	H		
	L		
CH34	H		
	L		
CH35	H		
	L		
CH36	H		
	L		
CH37	H		
	L		
CH38	H		
	L		
CH39	H		
	L		
CH40	H		
	L		
AMPS41	H		
	L		
AMPS42	H		
	L		

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 300 V, 1 A 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 9-18: Model 3722



Available accessories: Model 3722

3722-MTC-1.5: 104-pin, male-to-female D-sub cable assembly, 1.5 m (4.9 ft)

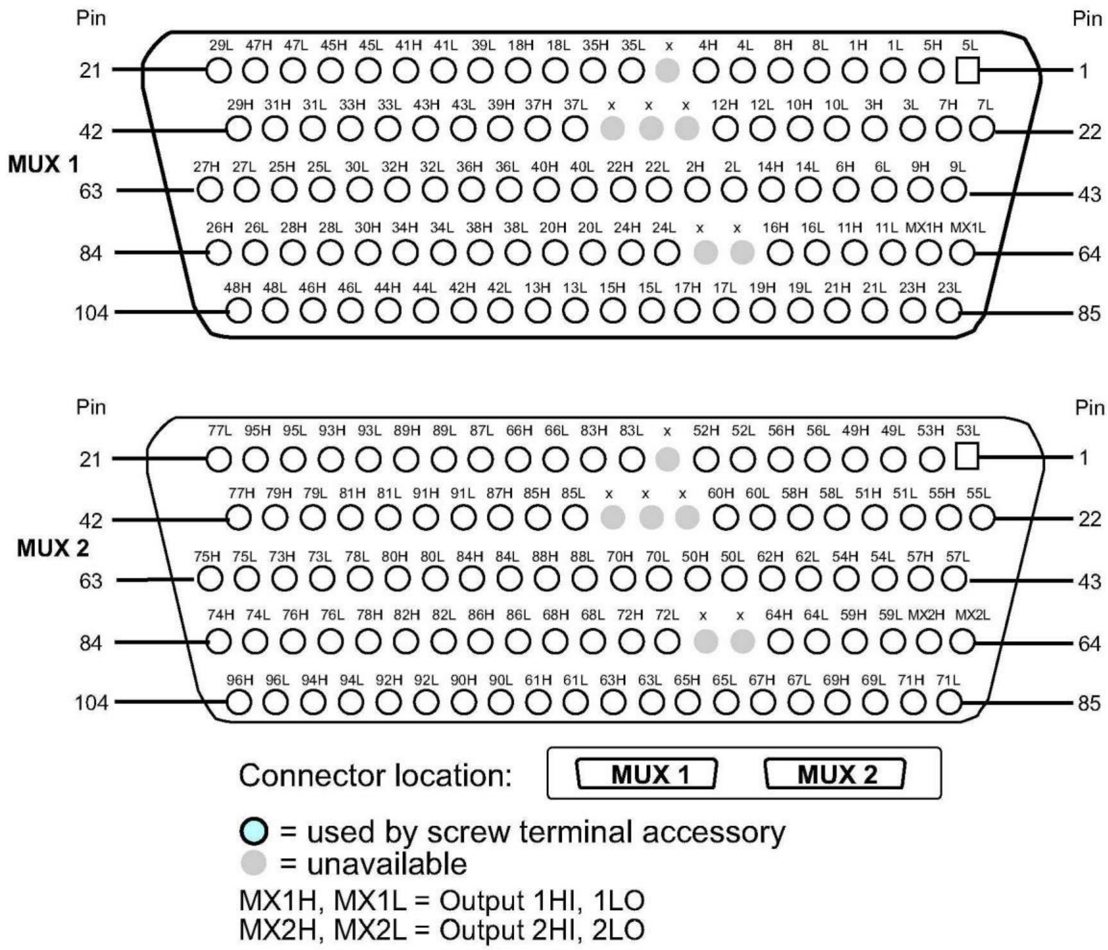
3722-MTC-3: 104-pin, male-to-female D-sub cable assembly, 3 m (9.8 ft)

3792-KIT104-R: 104-pin, male, D-sub connector kit (solder-cup contacts). See *Connection information: Model 3722* (on page 9-30).

Connection information: Model 3722

Refer to the following figure for Model 3722 D-sub connection information.

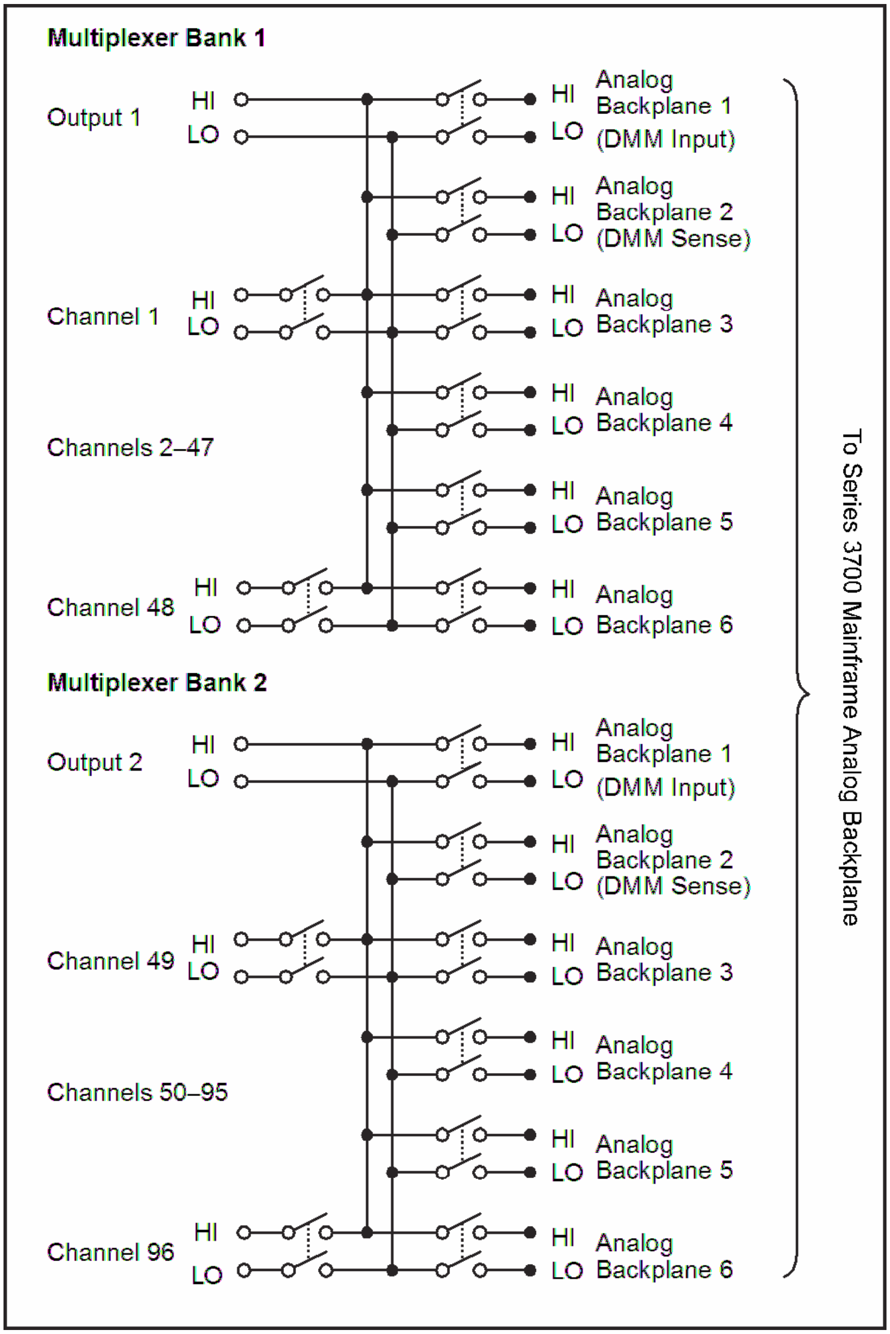
Figure 9-19: D-sub connection information the Model 3722



Schematics: Model 3722

The following figure provides a switching schematic for the Model 3722.

Figure 9-20: Schematic for the Model 3722



Model 3722 connection log

The following figures provide a sample of a connection log that can be used to record the wiring scheme for this module.

Figure 9-21: Sample Model 3722 connection log (1 of 3)

Channel		Color	Description
OUTPUT 1	H		
	L		
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 9-22: 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		
OUTPUT 2	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			
	L		
CH62	H		
	L		
CH63	H		
	L		

Figure 9-23: Sample Model 3722 connection log (3 of 3)

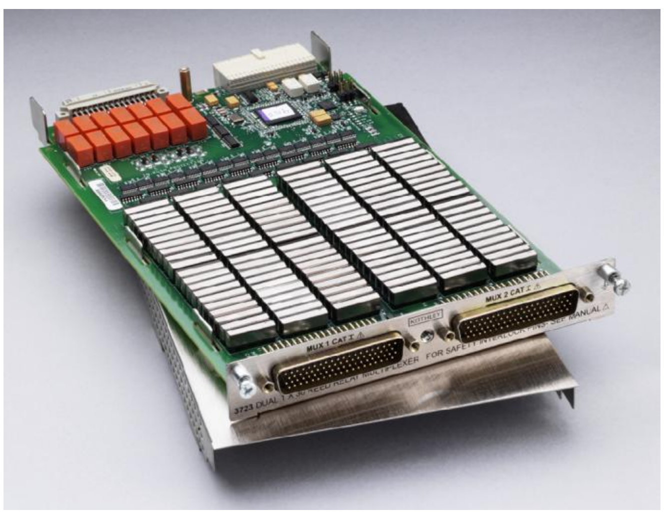
Channel (cont.)		Color	Description
CH64	H		
	L		
CH65	H		
	L		
CH66	H		
	L		
CH67	H		
	L		
CH68	H		
	L		
CH69	H		
	L		
CH70	H		
	L		
CH71	H		
	L		
CH72	H		
	L		
CH73	H		
	L		
CH74	H		
	L		
CH75	H		
	L		
CH76	H		
	L		
CH77	H		
	L		
CH78	H		
	L		
CH79	H		
	L		
CH80	H		
	L		
CH81	H		
	L		
CH82	H		
	L		
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 9-24: Model 3723



Available accessories: Model 3723

3720-MTC-1.5:	78-pin, female-to-male, D-sub cable assembly, 1.5 m (4.9 ft)
3720-MTC-3:	78-pin, female-to-male, D-sub cable assembly, 3 m (9.8 ft)
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 9-36).

Connection information: Model 3723

Refer to the following figure for Model 3723 D-sub connection information.

Figure 9-25: D-sub connection information for the Model 3723 (two-pole mode)

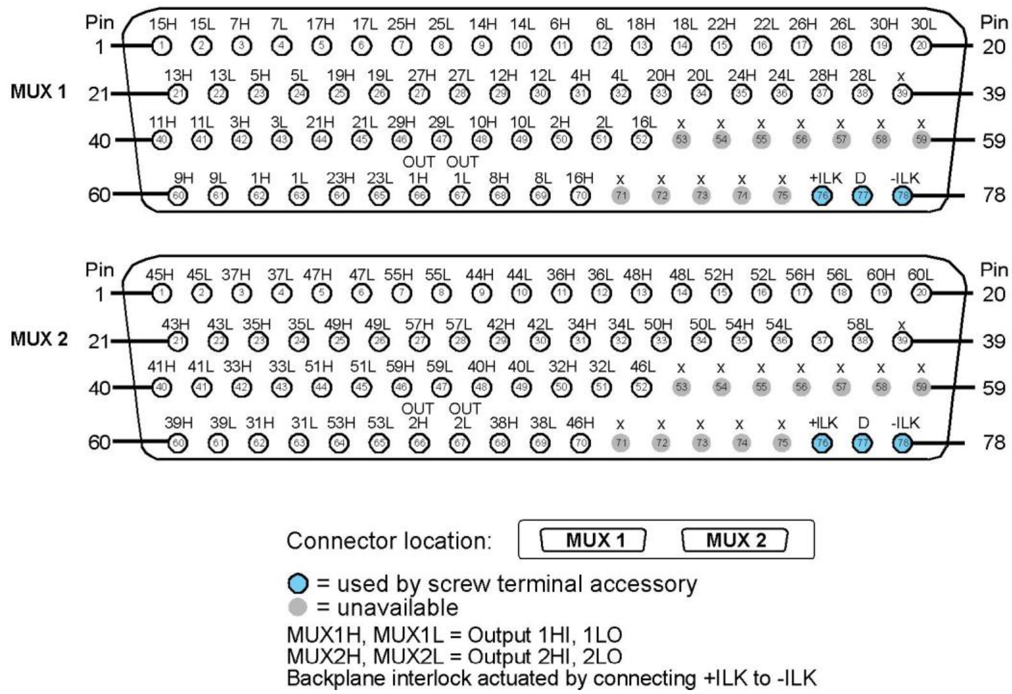
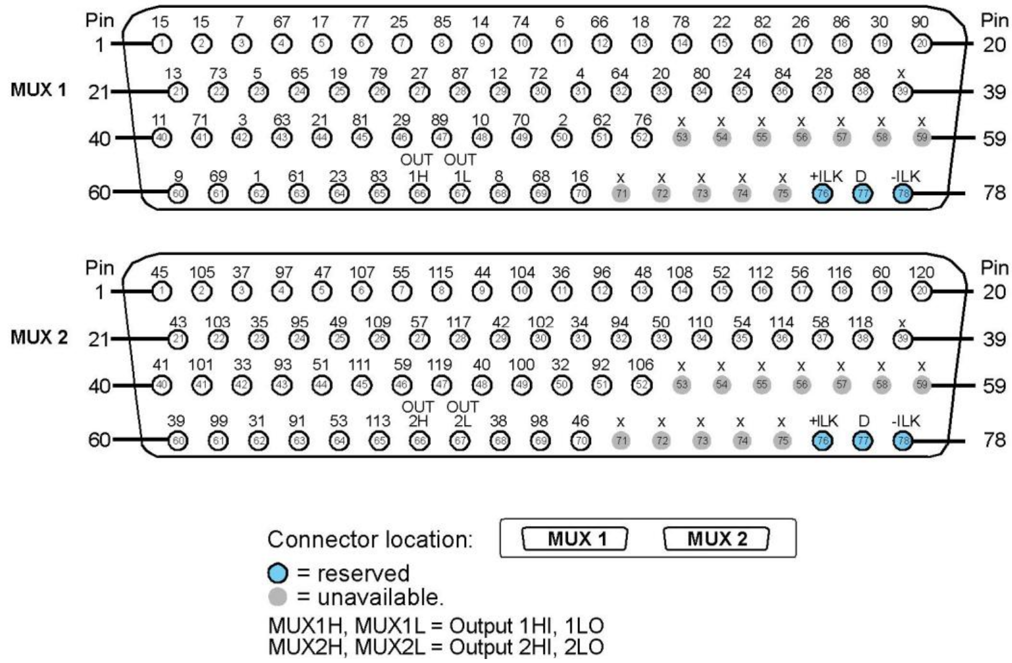


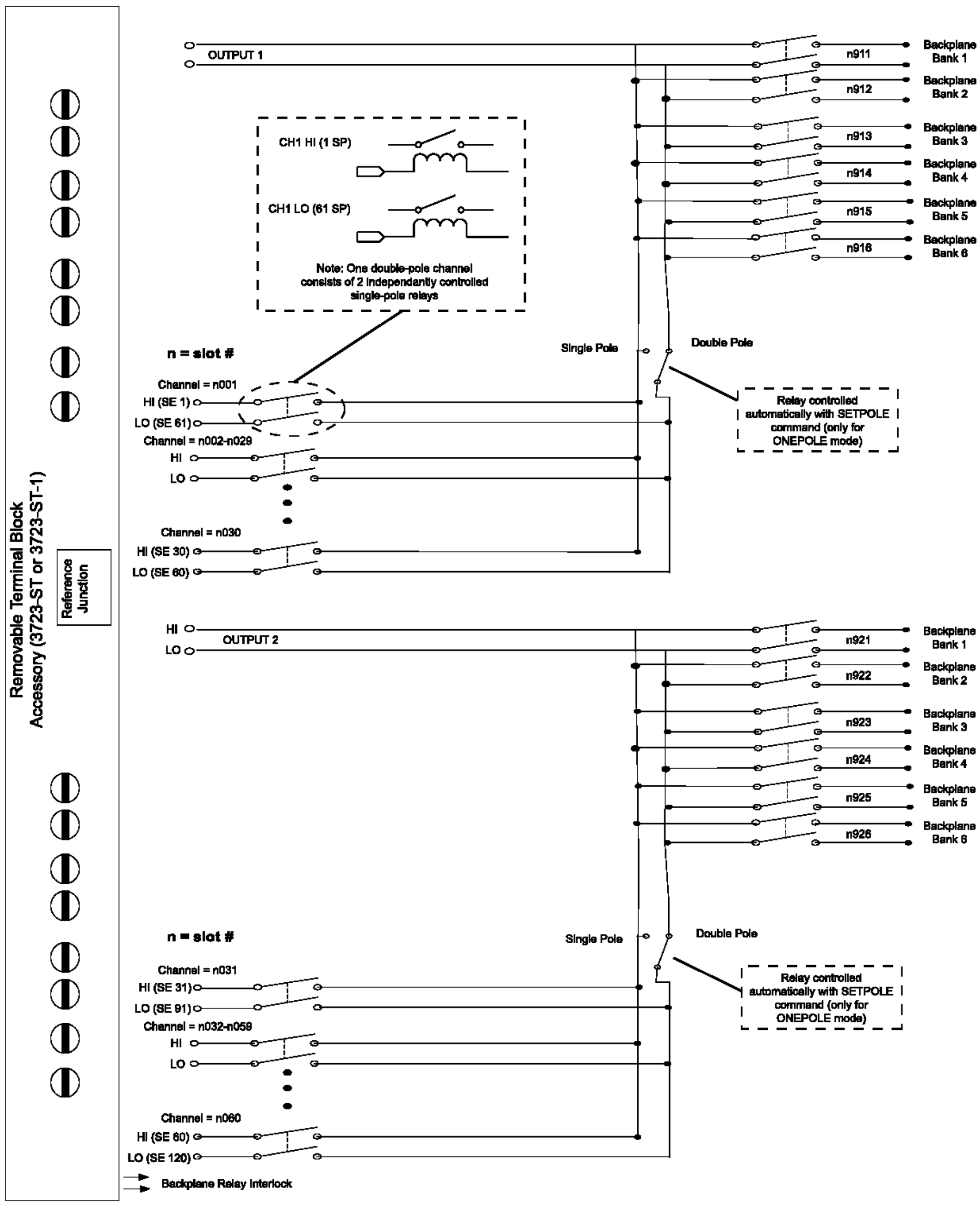
Figure 9-26: D-sub connection information for the Model 3723 (one-pole mode)



Schematics: Model 3723

The following figure provides a switching schematic for the Model 3723 in two-pole mode.

Figure 9-27: 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 9-28: Schematic: Model 3723 in one-pole mode

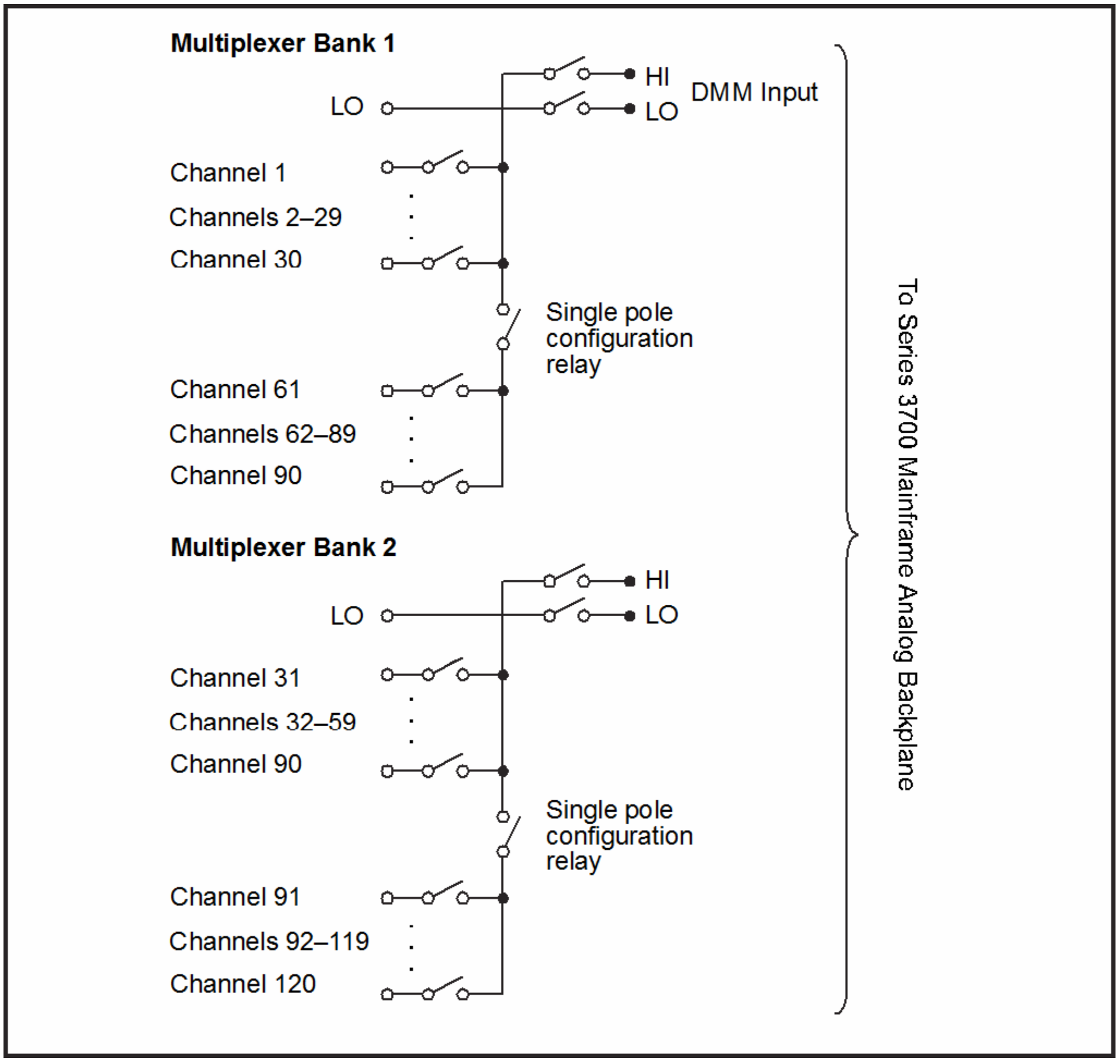


Figure 9-29: Models 3720, 3723, and 3724 screw terminal

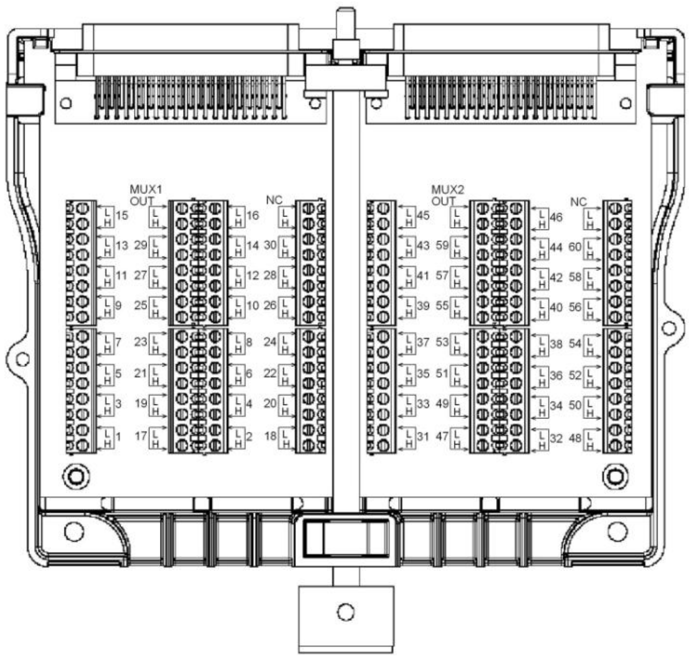
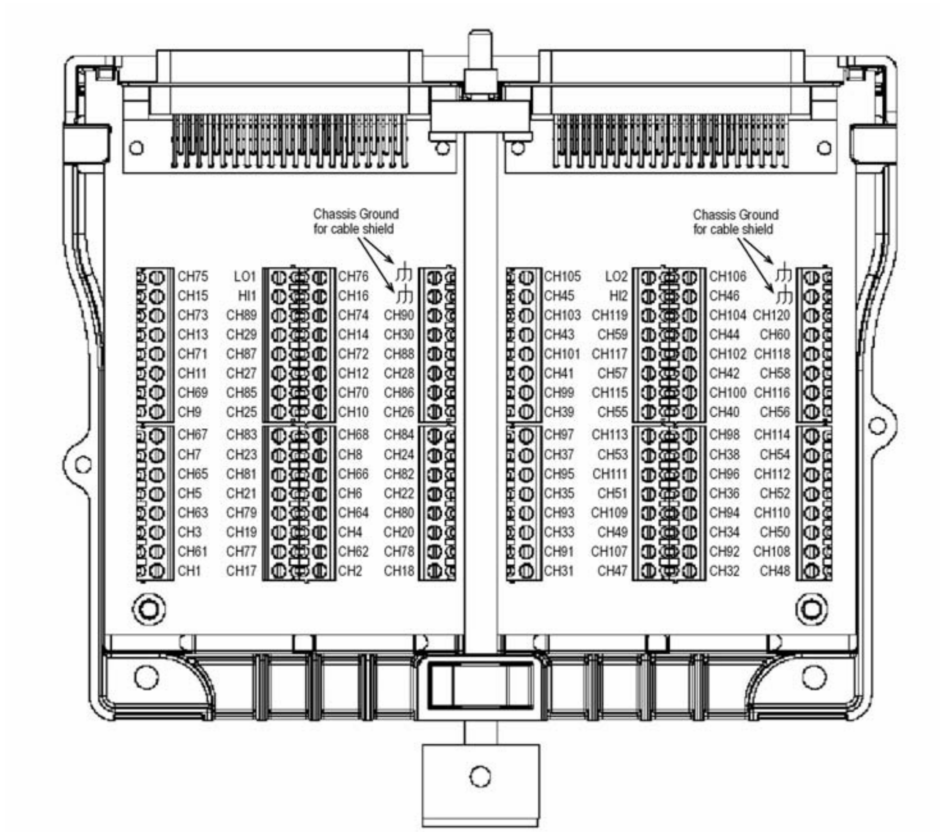


Figure 9-30: Model 3723-ST-1



Model 3723 connection log (60-channel)

The following figures provide a sample of a connection log that can be used to record the wiring scheme for this module.

Figure 9-31: Sample Model 3723 connection log (60-channel) (1 of 2)

Channel		Color	Description
OUTPUT 1	H		
	L		
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 9-32: Sample Model 3723 connection log (60-channel) (2 of 2)

Channel (cont.)		Color	Description
CH30	H		
	L		
OUTPUT 2	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 provide a sample of a connection log that can be used to record the wiring scheme for this module.

Figure 9-33: 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 9-34: 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 9-35: 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 9-36: 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		

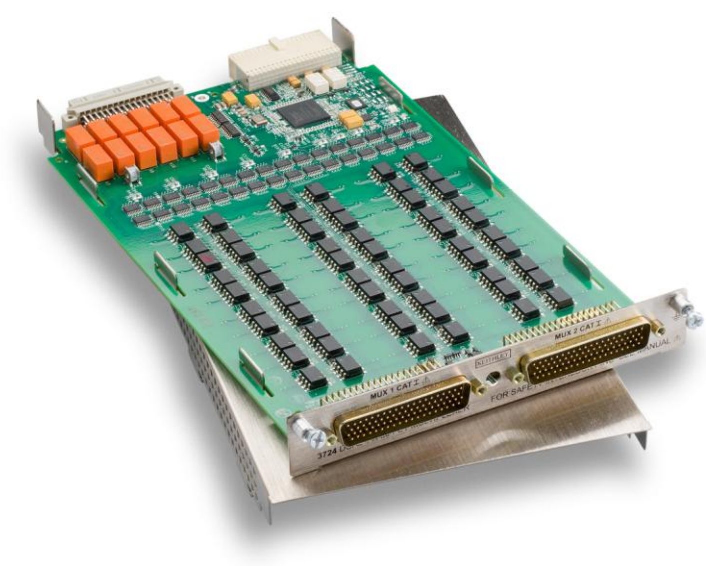
Model 3724 Dual 1x30 FET Multiplexer Specifications

The Model 3724 has two independent banks of 1×30 2-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 3724 include its ability to be reconfigured to coordinated four-pole operation for additional measurement flexibility. Furthermore, the Model 3724 supports thermocouple-type temperature measurements with the Model 3724-ST (screw terminal) accessory, providing automatic cold junction compensation (CJC).

The Model 3724 uses two 78-pin male D-sub connectors for signal connections. For screw terminal or automatic CJC, use the detachable Model 3724-ST accessory.

Figure 9-37: Model 3724 Dual 1x30 FET Multiplexer

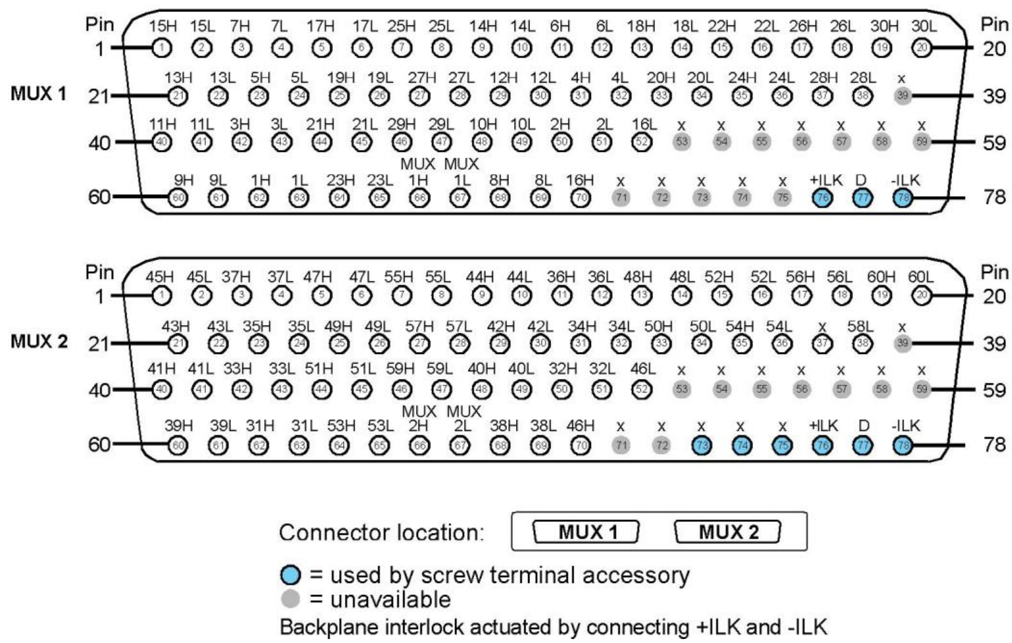


Available accessories: Model 3724

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, 3 m (9.8 ft)
3720-MTC-1.5	78-pin D-sub female-to-male cable, 1.5 m (4.9 ft)
3724-ST	Screw terminal block
3791-CIT	Contact insertion and extraction tool

Connection information: Model 3724

Figure 9-38: Model 3724 connection information



Schematics: Model 3724

Figure 9-39: Model 3724 schematic

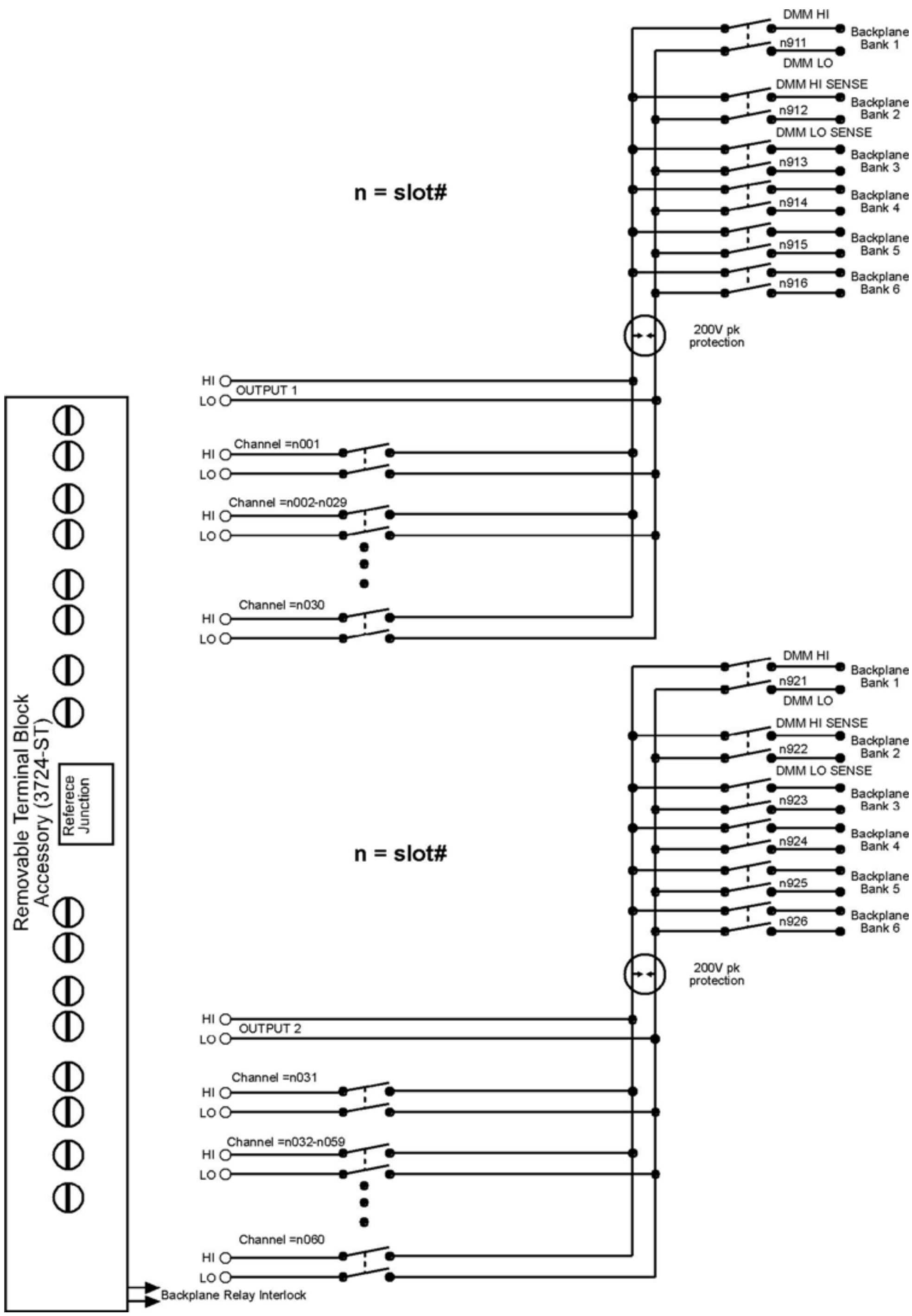
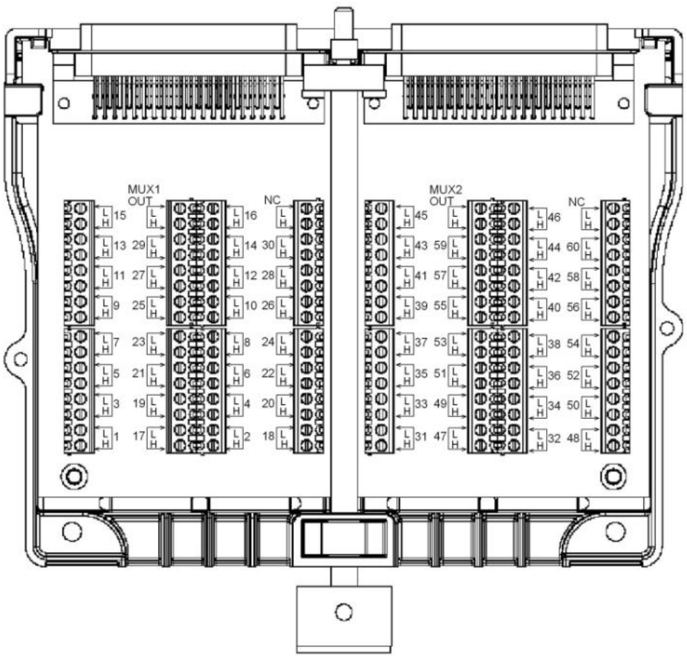


Figure 9-40: Models 3720, 3723, and 3724 screw terminal



Model 3724 connection log

The following table provides a sample of a connection log that can be used to record the wiring scheme for this module.

Channel		Color	Pin Number
OUTPUT 1	H		
	L		
CH1	H		
	L		
CH2	H		
	L		
CH3	H		
	L		
CH4	H		
	L		
CH5	H		
	L		
CH6	H		
	L		
CH7	H		
	L		

Channel		Color	Pin Number
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		

Channel		Color	Pin Number
	L		
CH30	H		
	L		
OUTPUT 2	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		

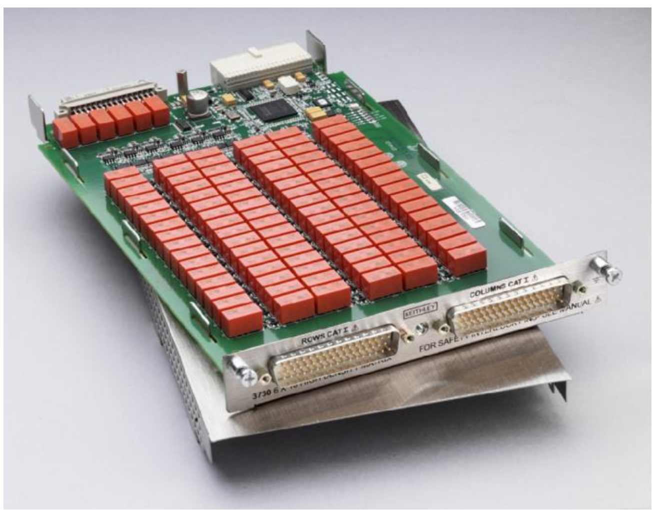
Channel		**Color**	**Pin Number**
CH50	H		
	L		
CH51	H		
	L		
CH52	H		
	L		
CH53	H		
	L		
CH54	H		
	L		
CH55	H		
	L		
CH56	H		
	L		
CH57	H		
	L		
CH58	H		
	L		
CH59	H		
	L		
CH60	H		
	L		

Model 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 9-41: Model 3730



Available accessories: Model 3730

3721-MTC-1.5: 50-pin, female-to-male, D-sub cable assembly, 1.5 m (4.9 ft)

3721-MTC-3: 50-pin, female-to-male, D-sub cable assembly, 3 m (9.8 ft)

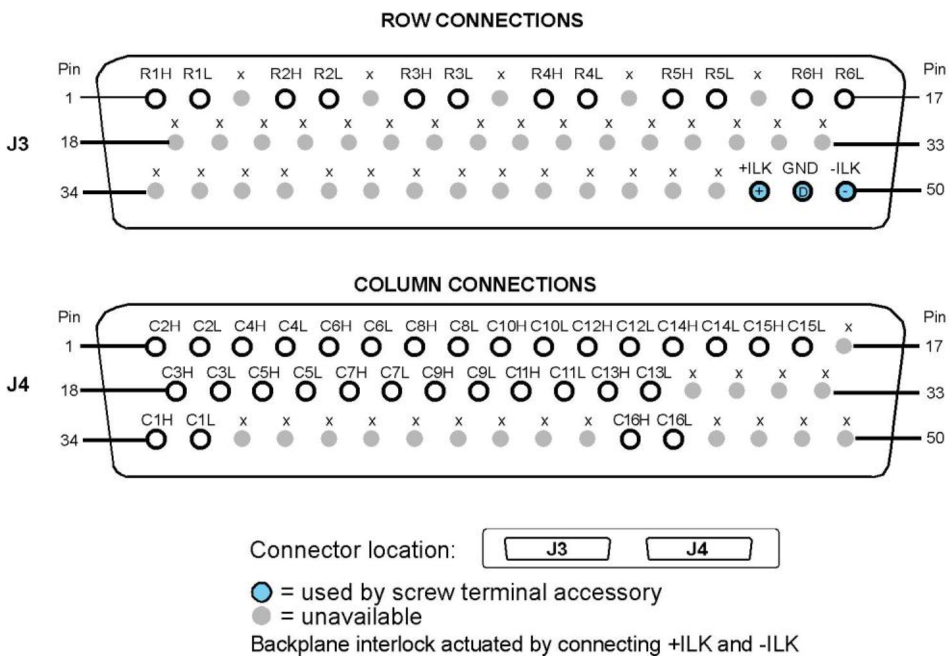
3730-ST: Screw terminal panel

3790-KIT50-R: 50-pin, female, D-sub connector kit (solder cup contacts). See *Connection information: Model 3730* (on page 9-56).

Connection information: Model 3730

Refer to the following figure for Model 3730 D-sub connection information.

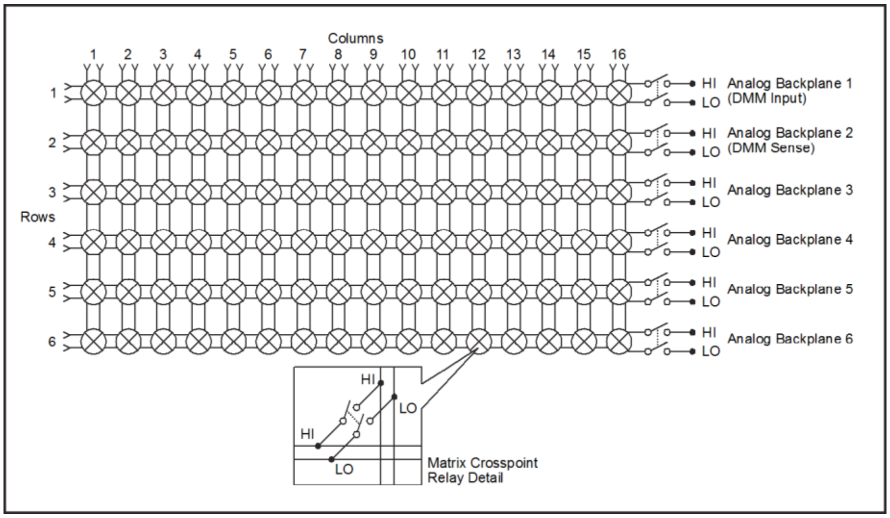
Figure 9-42: D-sub connection information for the Model 3730



Schematics: Model 3730

The following figure provides a switching schematic for the Model 3730.

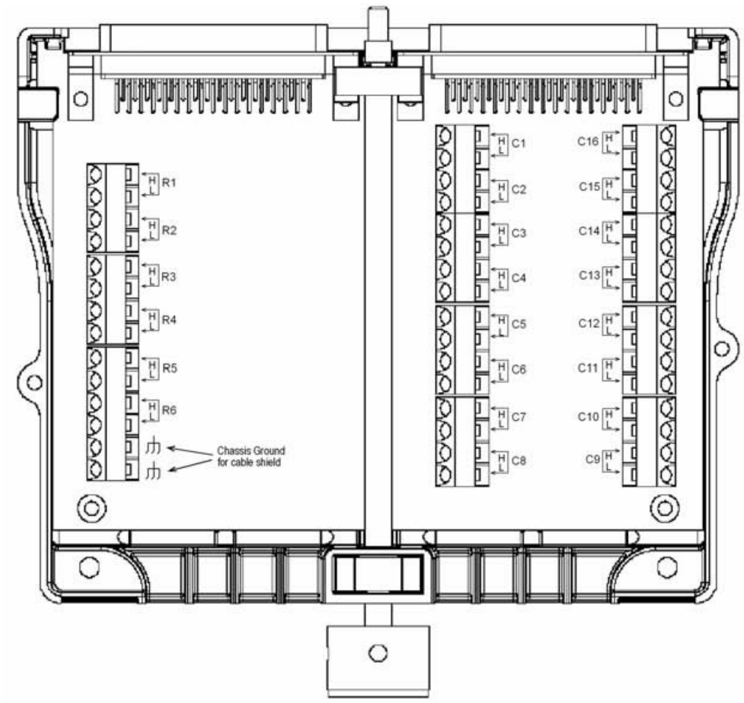
Figure 9-43: Schematic of the Model 3730



The channels on the 3730 are matrix channels. Unlike MUX channels, matrix channels do not have a DMM configuration associated with them. Therefore, specifying a matrix channel in the channel list parameter to the `dmm.setconfig()` function generates an error. To connect a DMM configuration to matrix channels, create a channel pattern with desired channels and analog backplane relays.

NOTE	For channel patterns, the system does not verify if the pathway is correct or if the correct analog backplane relays are specified for the desired function.

Figure 9-44: Model 3730-ST



Model 3730 connection log

The following figures provide a sample of a connection log that can be used to record the wiring scheme for this module.

Figure 9-45: Sample Model 3730 connection log

Connection		Color	Description
ROW 1	H		
	L		
ROW 2	H		
	L		
ROW 3	H		
	L		
ROW 4	H		
	L		
ROW 5	H		
	L		
ROW 6	H		
	L		
COLUMN 1	H		
	L		
COLUMN 2	H		
	L		
COLUMN 3	H		
	L		
COLUMN 4	H		
	L		
COLUMN 5	H		
	L		
COLUMN 6	H		
	L		
COLUMN 7	H		
	L		
COLUMN 8	H		
	L		
COLUMN 9	H		
	L		
COLUMN 10	H		
	L		
COLUMN 11	H		
	L		
COLUMN 12	H		
	L		
COLUMN 13	H		
	L		
COLUMN 14	H		
	L		
COLUMN 15	H		
	L		
COLUMN 16	H		
	L		

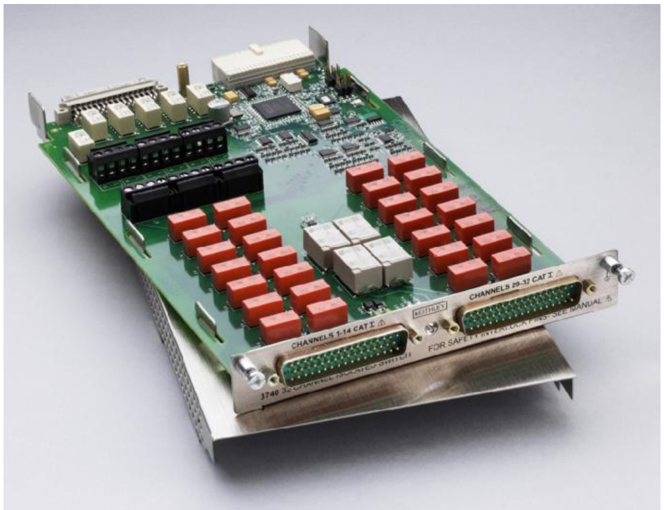
Model 3740 32-channel isolated switch card

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 7 A, 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 notifies 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 9-46: Model 3740



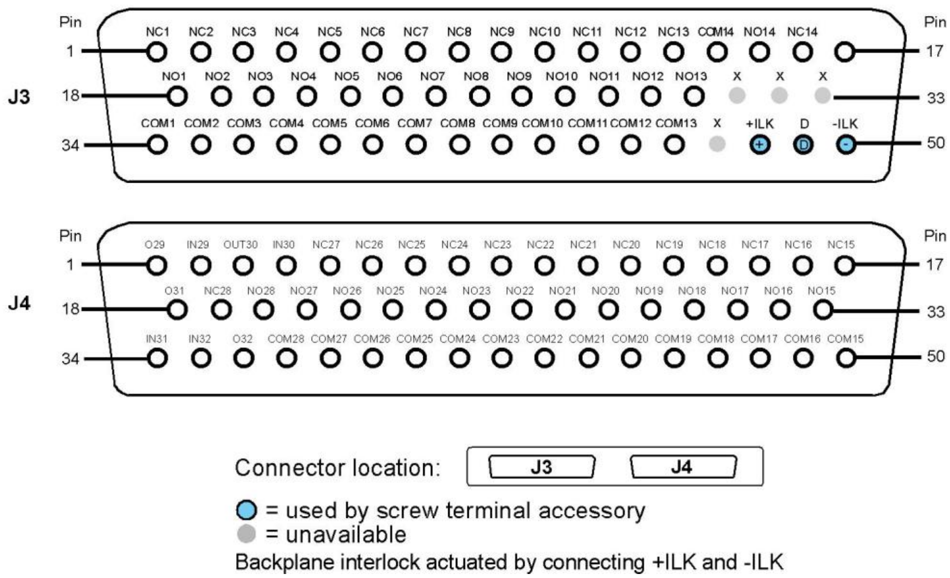
Available accessories: Model 3740

3721-MTC-1.5:	50-pin, female-to-male, D-sub cable assembly, 1.5 m (4.9 ft)
3721-MTC-3:	50-pin, female-to-male, D-sub cable assembly, 3 m (9.8 ft)
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 9-61).

Connection information: Model 3740

Refer to the following figure for Model 3740 D-sub connection information.

Figure 9-47: D-sub connection information for the Model 3740



Schematics: Model 3740

The following figure provides a switching schematic for the Model 3740.

Figure 9-48: Schematic for the Model 3740

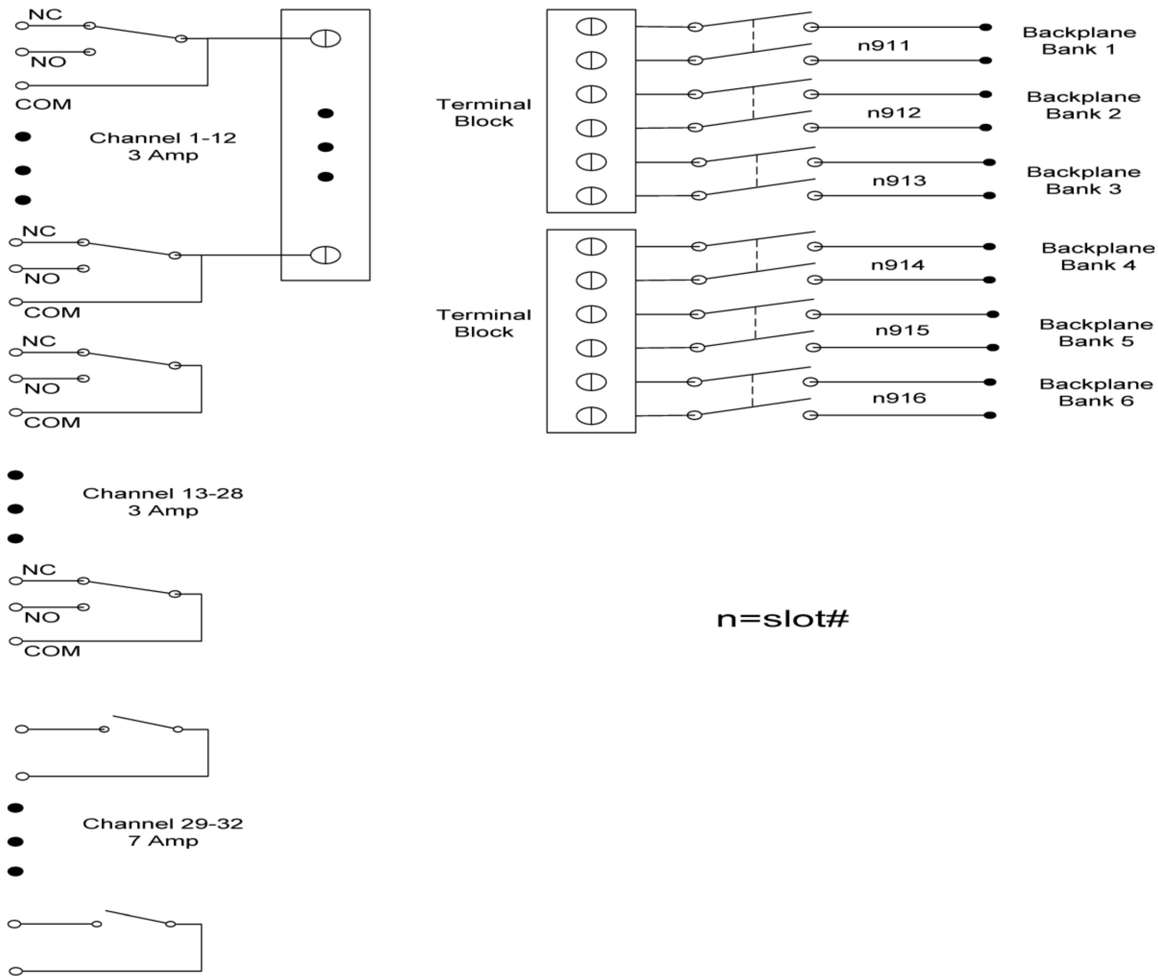
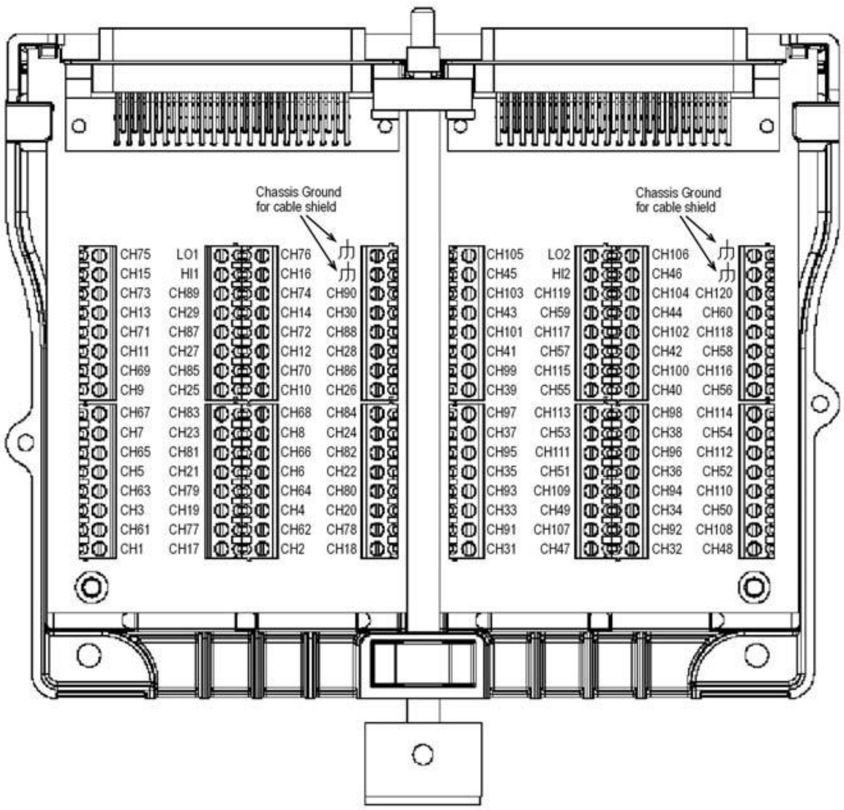


Figure 9-49: Model 3740-ST



Model 3740 connection log

The following figures provide a sample of a connection log that can be used to record the wiring scheme for this module.

Figure 9-50: Sample Model 3740 connection log (1 of 2)

Channel		Color	Description
CH1	NC		
	NO		
	COM		
CH2	NC		
	NO		
	COM		
CH3	NC		
	NO		
	COM		
CH4	NC		
	NO		
	COM		
CH5	NC		
	NO		
	COM		
CH6	NC		
	NO		
	COM		
CH7	NC		
	NO		
	COM		
CH8	NC		
	NO		
	COM		
CH9	NC		
	NO		
	COM		
CH10	NC		
	NO		
	COM		
CH11	NC		
	NO		
	COM		
CH12	NC		
	NO		
	COM		
CH13	NC		
	NO		
	COM		
CH14	NC		
	NO		
	COM		
CH15	NC		
	NO		
	COM		
CH16	NC		
	NO		
	COM		
CH17	NC		
	NO		
	COM		
CH18	NC		
	NO		
	COM		
CH19	NC		
	NO		
	COM		
CH20	NC		
	NO		
	COM		

Figure 9-51: Sample Model 3740 connection log (2 of 2)

Channel (continued)		Color	Description
CH21	NC		
	NO		
	COM		
CH22	NC		
	NO		
	COM		
CH23	NC		
	NO		
	COM		
CH24	NC		
	NO		
	COM		
CH25	NC		
	NO		
	COM		
CH26	NC		
	NO		
	COM		
CH27	NC		
	NO		
	COM		
CH28	NC		
	NO		
	COM		
CH29	H		
	L		
CH30	H		
	L		
CH31	H		
	L		
CH32	H		
	L		

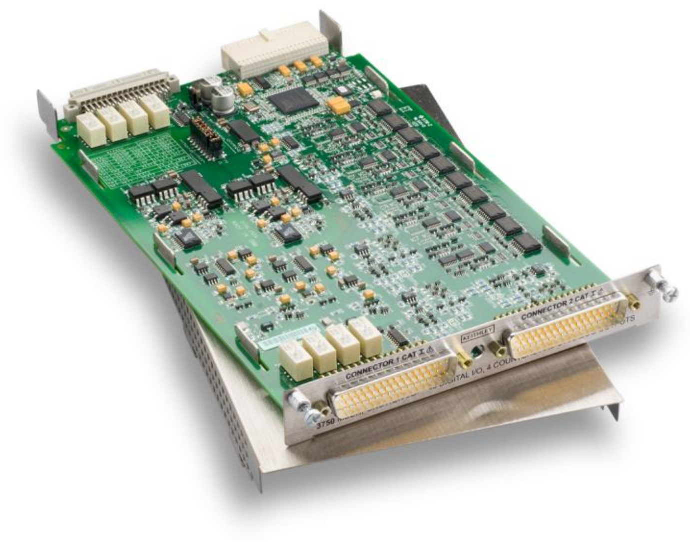
Model 3750 Multifunction I/O Card

The Model 3750 Multifunction I/O Card has 40 bidirectional digital I/O bits arranged in five banks of eight bits each. Each bank can be configured as either inputs or outputs. One bank of I/O is equivalent to one system channel.

The two analog outputs of the Model 3750 can be individually configured as either voltage outputs (+/- 12 V) or as current outputs (0 mA to 20 mA or 4 mA to 20 mA).

Four 32-bit counters are provided with a maximum input range of 1 MHz. Each counter has a gate input for control of event counting.

Figure 9-52: Model 3750 Multifunction I/O Card

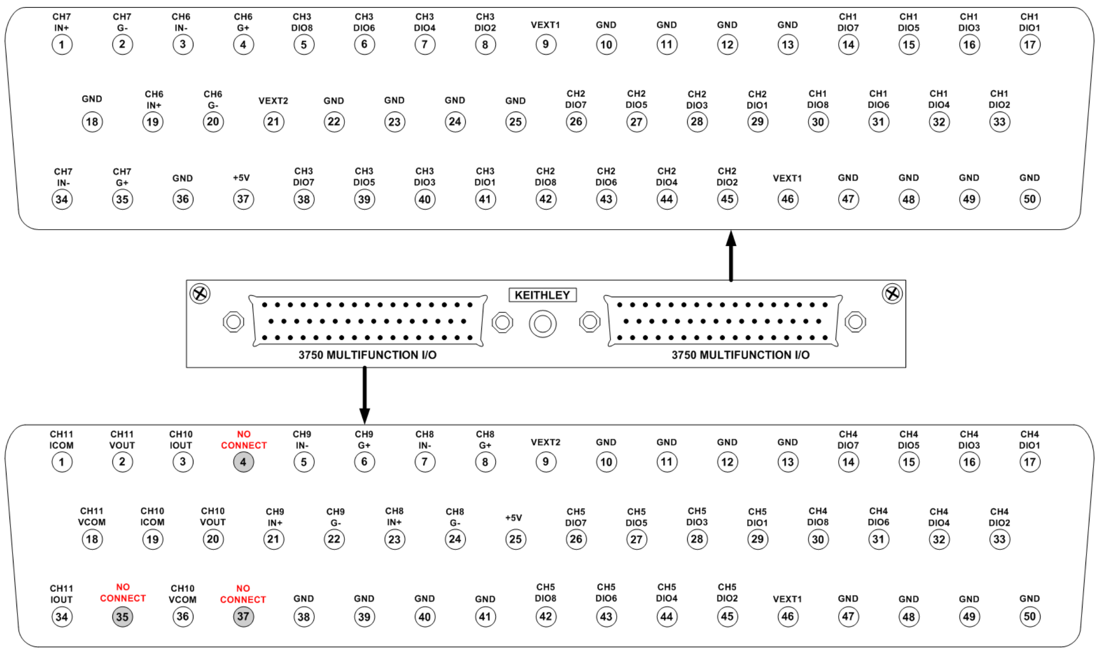


Available accessories: Model 3750

3750-ST	Screw terminal panel
3790-KIT50-R	50-pin, female, D-sub connector kit (solder cup contacts). See *Connection information: Model 3730* (on page 9-56).
3721-MTC-3	50-pin, female-to-male, D-sub cable assembly, 3 m (9.8 ft)
3721-MTC-1.5	50-pin, female-to-male, D-sub cable assembly, 1.5 m (4.9 ft)

Connection information: Model 3750

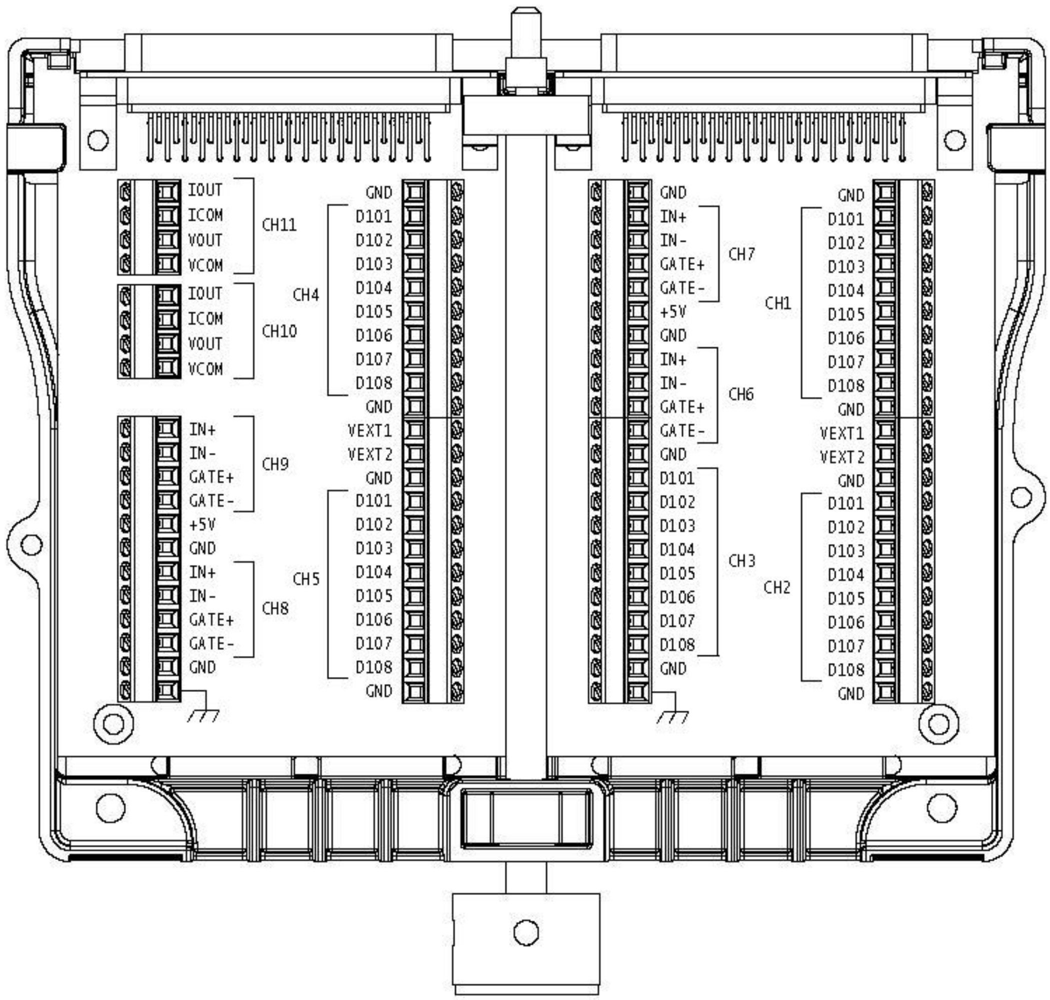
Figure 9-53: Model 3750 connection information



3750 MALE D-SUB PIN ASSIGNMENTS

Schematics: Model 3750

Figure 9-54: Model 3750 screw terminal schematic



Model 3750 connection log

The following figures provide a sample of a connection log that can be used to record the wiring scheme for this module.

Channel	Color	Pin Number
CH1 - DIO1		
CH1 - DIO2		

Channel	**Color**	**Pin Number**
CH1 - DIO3		
CH1 - DIO4		
CH1 - DIO5		
CH1 - DIO6		
CH1 - DIO7		
CH1 - DIO8		
CH2 - DIO1		
CH2 - DIO2		
CH2 - DIO3		
CH2 - DIO4		
CH2 - DIO5		
CH2 - DIO6		
CH2 - DIO7		
CH2 - DIO8		
CH3 - DIO1		
CH3 - DIO2		
CH3 - DIO3		
CH3 - DIO4		
CH3 - DIO5		
CH3 - DIO6		
CH3 - DIO7		
CH3 - DIO8		
CH4 - DIO1		
CH4 - DIO2		
CH4 - DIO3		
CH4 - DIO4		
CH4 - DIO5		
CH4 - DIO6		
CH4 - DIO7		
CH4 - DIO8		
CH5 - DIO1		
CH5 - DIO2		
CH5 - DIO3		

Channel	Color	Pin Number
CH5 - DIO4		
CH5 - DIO5		
CH5 - DIO6		
CH5 - DIO7		
CH5 - DIO8		
CH6 - Gate+		
CH6 - Gate-		
CH6 - Input+		
CH6 - Input-		
CH7 - Gate+		
CH7 - Gate-		
CH7 - Input+		
CH7 - Input-		
CH8 - Gate+		
CH8 - Gate-		
CH8 - Input+		
CH8 - Input-		
CH9 - Gate+		
CH9 - Gate-		
CH9 - Input+		
CH9 - Input-		
CH10 - Vout		
CH10 - V com		
CH10 - Iout		
CH10 - I com		
CH11 - Vout		
CH11 - V com		
CH11 - Iout		
CH11 - I com		
GND		
+5v		
Vext 1		
Vext 2		

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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.

12/06

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12/06