

# Model 7710 Multiplexer Module

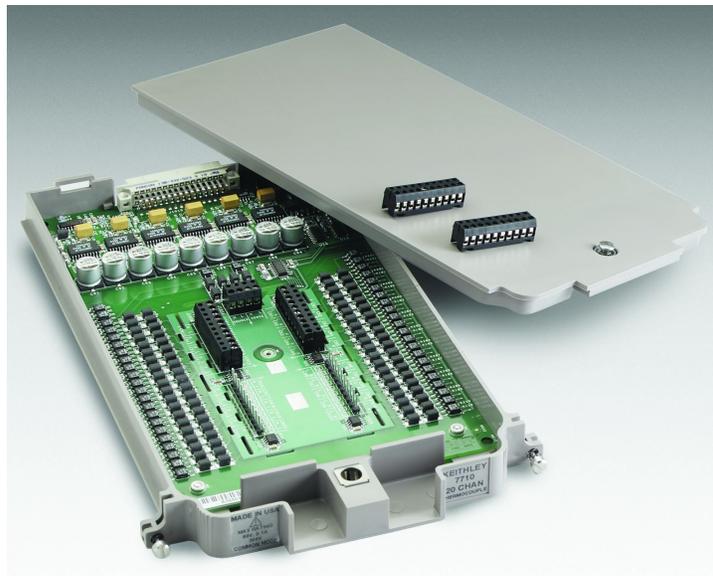
## Instructions for use with DAQ6510

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## Introduction

The 7710 20-channel Solid-state Differential Multiplexer with Automatic Cold Junction Compensation (CJC) module offers 20 channels of 2-pole or 10 channels of 4-pole relay input that can be configured as two independent banks of multiplexers. The relays are solid state, providing long life and low maintenance. It is ideal for long-term data logging applications and for demanding high-speed applications.

**Figure 1: 7710 20-Channel Differential Multiplexer Module**



*Item shipped may vary from model pictured here.*

The 7710 includes the following features:

- Fast-actuating, long-life solid-state relays
- DC and AC voltage measurement
- Two-wire or four-wire resistance measurements (automatically pairs relays for four-wire measurements)
- Temperature applications (RTD, thermistor, thermocouple)
- Built-in cold junction reference for thermocouple temperature
- Screw terminal connections

The 7710 can be used with the DAQ6510 Data Acquisition and Multimeter System.

## NOTE

If you are using this switching module with the 2700, 2701, or 2750, please see *Model 7710 Multiplexer Card User's Guide*, Keithley Instruments PA-847.



## Connections

Screw terminals on the switching module are provided for connection to device under test (DUT) and external circuitry. The 7710 uses quick-disconnect terminal blocks. You can make connections to a terminal block when it is disconnected from the module. These terminal blocks are rated for 25 connects and disconnects.

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### **WARNING**

**Connection and wiring procedures in this document are intended for use by qualified personnel only, as described by the types of product users in the [Safety precautions](#) (on page 25). Do not perform these procedures unless qualified to do so. Failure to recognize and observe normal safety precautions could result in personal injury or death.**

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The following information describes how to make connections to the switching module and define the channel designations. A connection log is provided that you can use to record your connections.

## Wiring procedure

Use the following procedure to make connections to the 7710 module. Make all connections using the correct wire size (up to 20 AWG). For maximum system performance, all measurement cables should be less than three meters. Add supplementary insulation around the harness for voltages above 42 V<sub>PEAK</sub>.

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### **WARNING**

**All wiring must be rated for the maximum voltage in the system. For example, if 1000 V is applied to the front terminals of the instrument, the switching module wiring must be rated for 1000 V. Failure to recognize and observe normal safety precautions could result in personal injury or death.**

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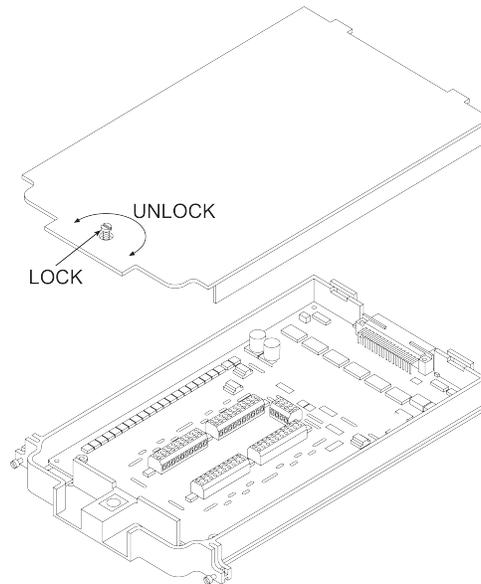
Equipment needed:

- Flat-blade screwdriver
- Needle-nose pliers
- Cable ties

#### ***To wire the 7710 module:***

1. Make sure all power is discharged from the 7710 module.
2. Using a screwdriver, turn the access screw to unlock and open the cover, as shown in the following figure.

Figure 2: Screw terminal access

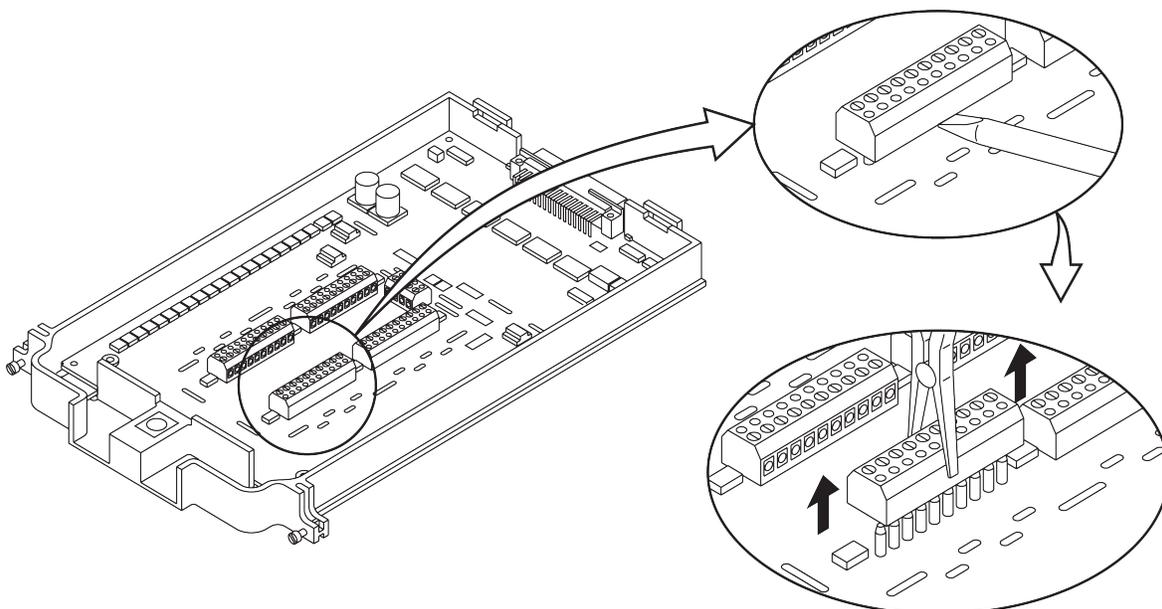


3. If needed, remove the appropriate quick-disconnect terminal block from the module.
  - a. Place a flat-head screwdriver under the connector and gently push up to loosen it, as shown in the following figure.
  - b. Use needle-nose pliers to pull the connector straight up.

## CAUTION

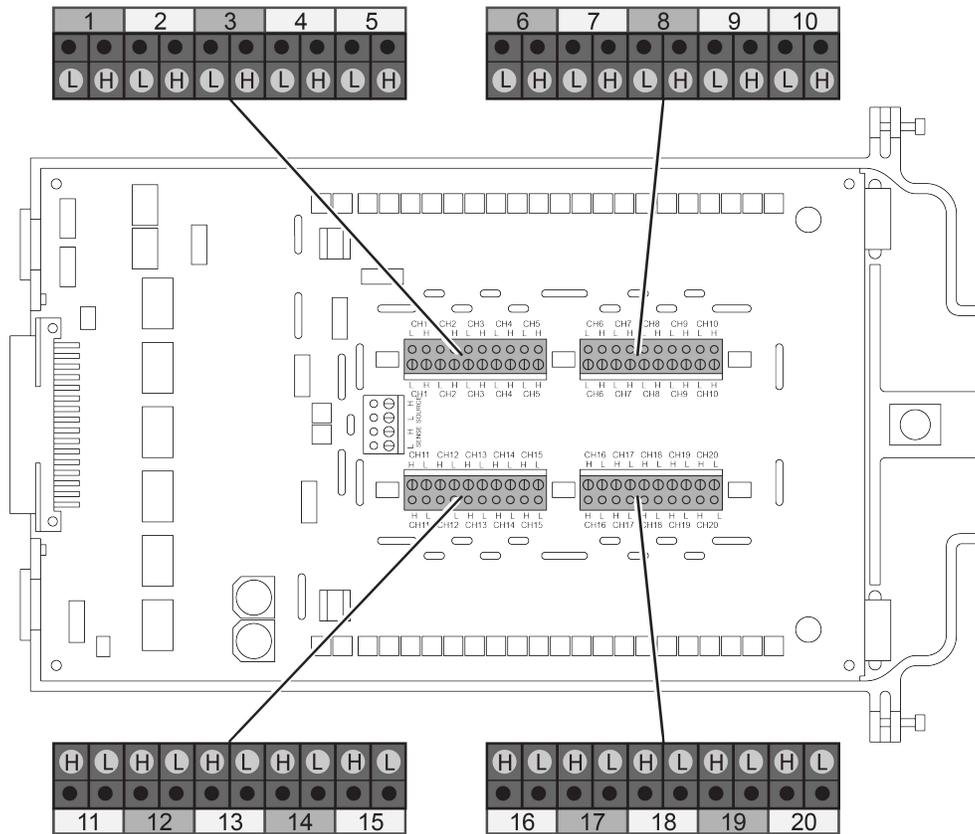
Do not rock the connector from side to side. Damage to the pins could result.

Figure 3: Proper procedure to remove terminal blocks



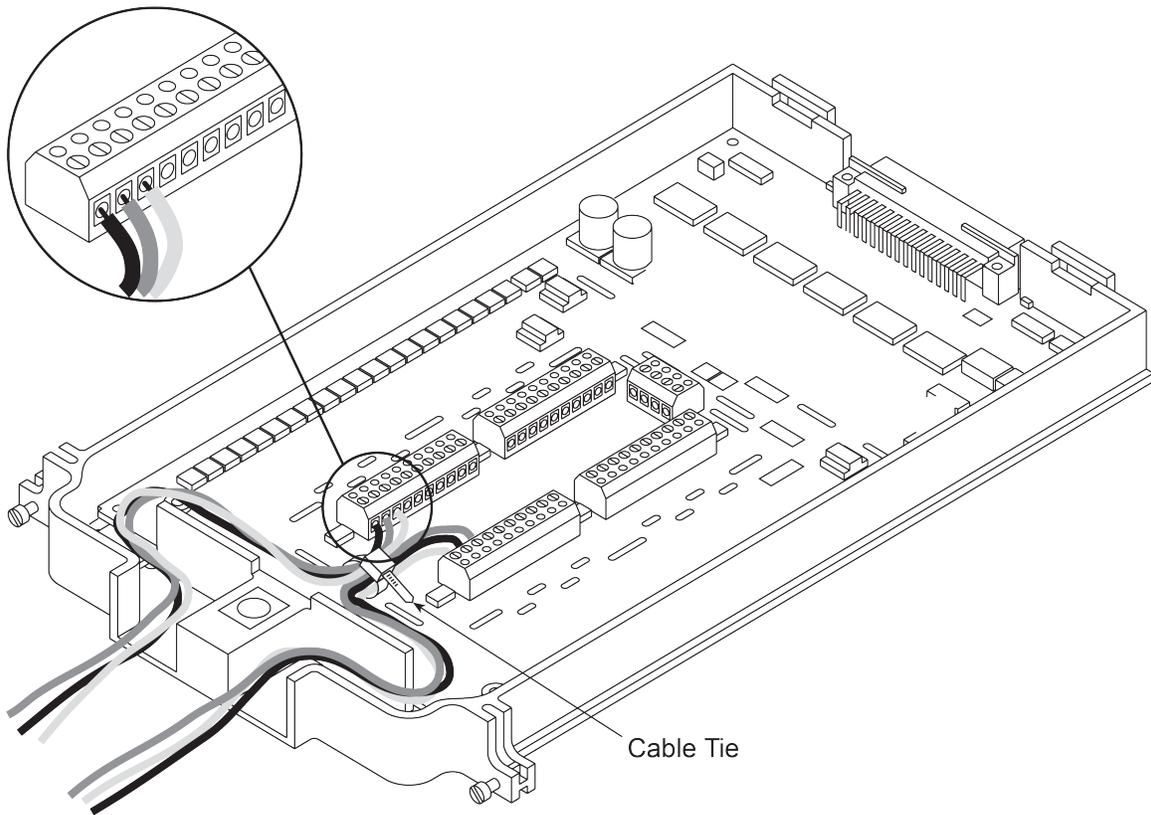
- Using a small flat-blade screwdriver, loosen the terminal screws and install the wires as needed. The following figure shows the connections, including the connections to source and sense.

**Figure 4: Screw terminal channel designations**



- Plug the terminal block into the module.
- Route wire along the wire path and secure with cable ties as shown. The following figure shows connections to channels 1 and 2.

**Figure 5: Wire dressing**



7. Fill in a copy of the connection log. See [Connection log](#) (on page 8).
8. Close the screw terminal access cover.
9. Using a screwdriver, press in the access screw and turn to lock the cover.

## Module configuration

The following figure shows a simplified schematic of the 7710 module. As shown, the 7710 has channels that are grouped into two banks of 10 channels (20 channels total). Backplane isolation is provided for each bank. Each bank includes separate cold junction reference points. The first bank contains channels 1 to 10, while the second bank contains channels 11 to 20. Each channel of the 20-channel multiplexer module is wired with separate inputs for HI/LO providing fully isolated inputs.

Connections to DMM functions are provided through the module backplane connector.

Channels 21, 22, and 23 are configured automatically by the instrument when using system channel operation.

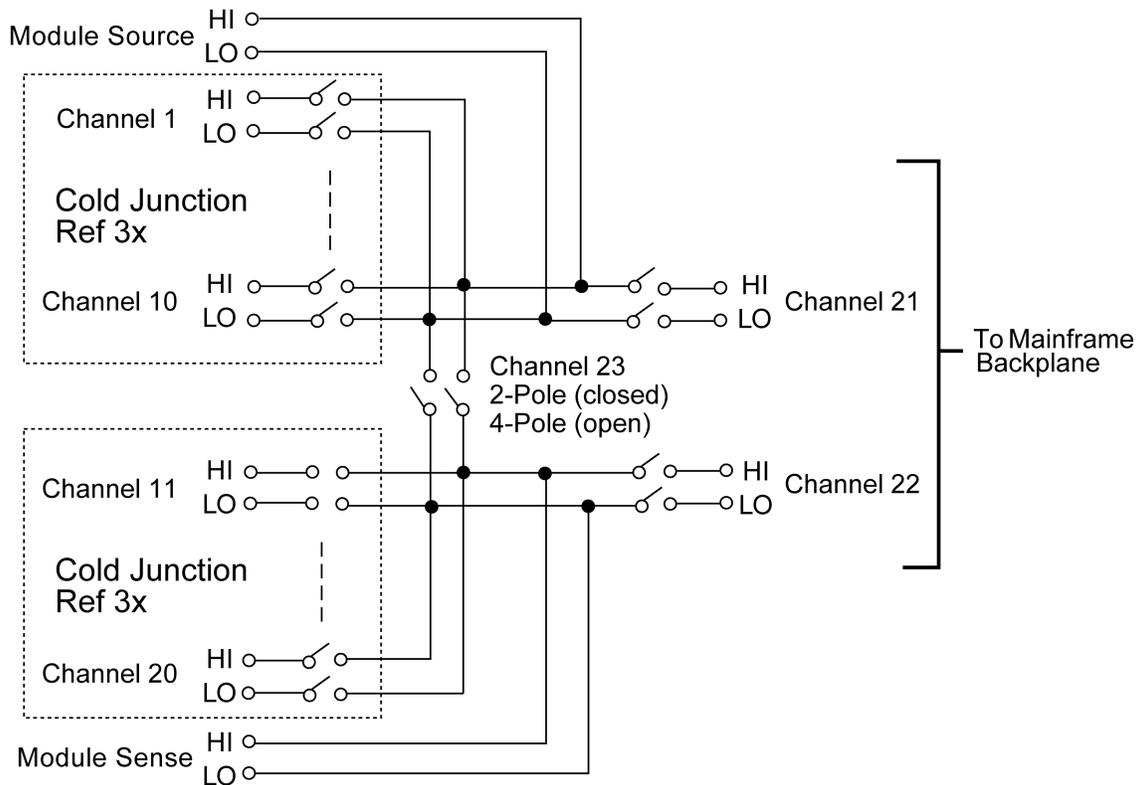
When using system channel operation for 4-wire measurements (including 4-wire ohms, RTD temperature, Ratio, and Channel Average), the channels are paired as follows:

CH1 and CH11	CH6 and CH16
CH2 and CH12	CH7 and CH17
CH3 and CH13	CH8 and CH18
CH4 and CH14	CH9 and CH19
CH5 and CH15	CH10 and CH20

## NOTE

Channels 21 to 23 in this schematic refer to designations used for control and not actual available channels. For more information, refer to the instrument reference manual.

**Figure 6: 7710 simplified schematic**

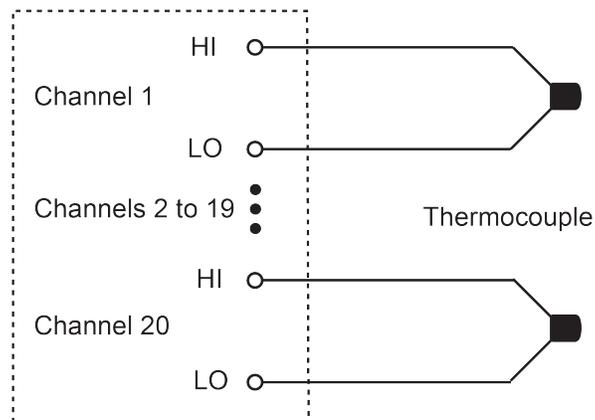


## Typical connections

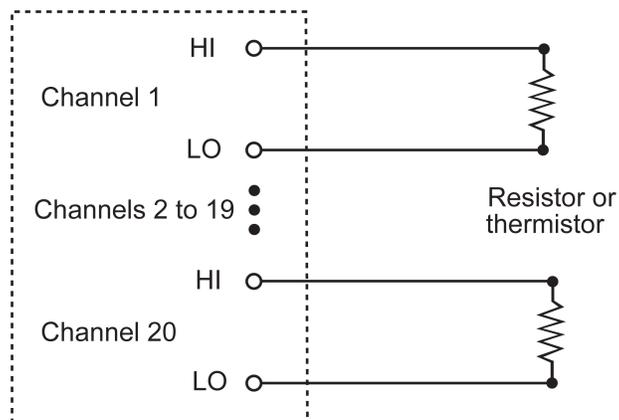
The following examples show typical wiring connections for the following types of measurements:

- Thermocouple
- Two-wire resistance and thermistor
- Four-wire resistance and RTD
- DC or AC voltage

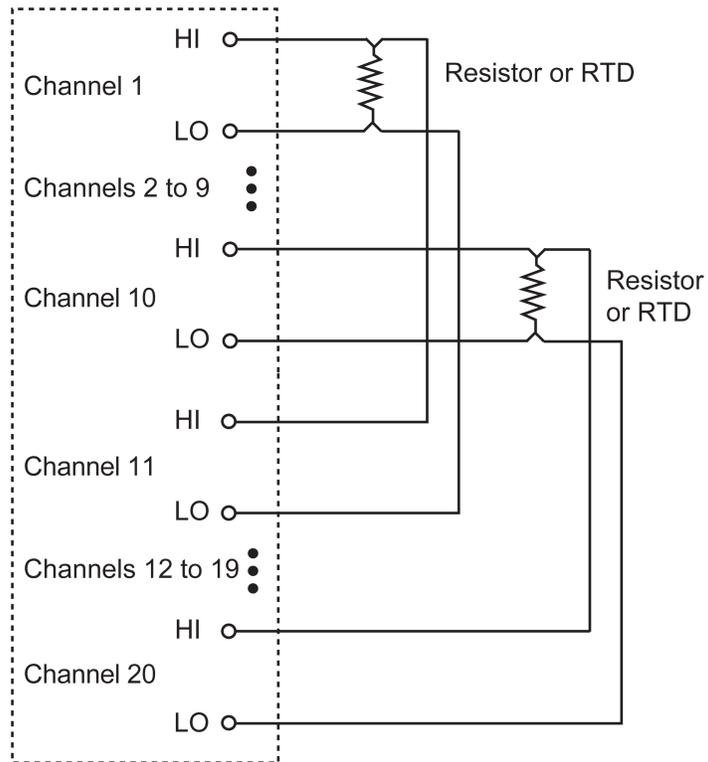
**Figure 7: Thermocouple connections**



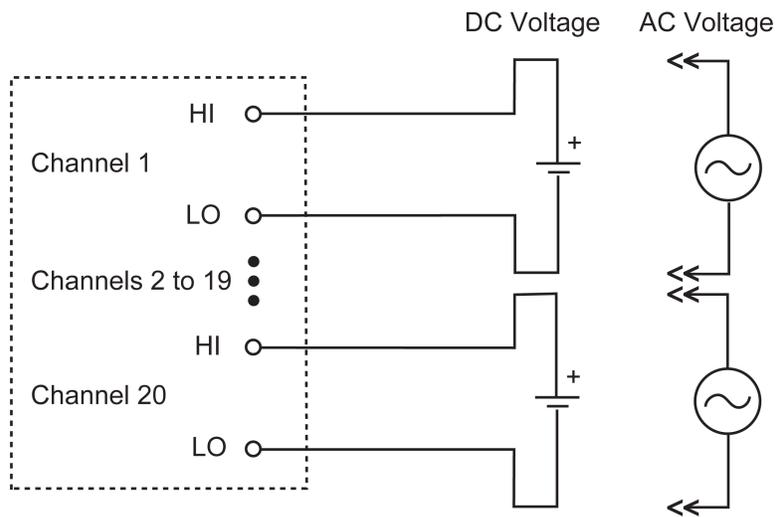
**Figure 8: Two-wire resistance and thermistor connections**



**Figure 9: Four-wire resistance and RTD connections**



**Figure 10: DC or AC voltage connections**



## Connection log

You can use the following table to record your connection information.

**Connection log for the 7710**

Channel		Color	Description
Card Source	H		
	L		
Card Sense	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		

## Installation

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### **WARNING**

**Before operating an instrument with a switching module, verify that the switching module is properly installed and the mounting screws are tightly fastened. If the mounting screws are not properly connected, an electrical shock hazard may be present.**

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If you are installing two switching modules, it is easier to install a switching module into slot 2 first, then install the second switching module into slot 1.

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### **NOTE**

If you have a Keithley Instruments Model 2700, 2701, or 2750 instrument, you can use your existing switching module in the DAQ6510. Follow the instructions in your original equipment documentation to remove the module from the instrument, then use the following instructions to install it in the DAQ6510. You do not need to remove wiring to the module.

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### **NOTE**

For inexperienced users, it is recommended that you do not connect a device under test (DUT) and external circuitry to the switching module. This allows you to exercise close and open operations without the dangers associated with live test circuits. You can also set up pseudocards to experiment with switching. Refer to “Pseudocards” in the *Model DAQ6510 Data Acquisition and Multimeter System Reference Manual* for information on setting up pseudocards.

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### **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 instrument is turned off and disconnected from line power. If the switching module is connected to a DUT, make sure power is removed from all external circuitry.**

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### **WARNING**

**Slot covers must be installed on unused slots to prevent personal contact with high-voltage circuits. Failure to recognize and observe standard safety precautions could result in personal injury or death due to electric shock.**

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## CAUTION

**Before installing or removing a switching module, make sure the DAQ6510 power is turned off and disconnected from line power. Failure to comply may result in incorrect operation and loss of data in the memory.**

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Required equipment:

- Medium flat-blade screwdriver
- Medium Phillips screwdriver

### ***To install a switching module into the DAQ6510:***

1. Turn off the DAQ6510.
2. Disconnect the power cord from the power source.
3. Disconnect the power cord and any other cables that are connected to the rear panel.
4. Position the DAQ6510 so you are facing the rear panel.
5. Use the screwdriver to remove the slot cover screws and the cover plate. Retain the plate and screws for future use.
6. With the top cover of the switching module facing up, slide the switching module into the slot.
7. Press the switching module in firmly to make sure the switching module connector is connected to the DAQ6510 connector.
8. Use the screwdriver to tighten the two mounting screws to secure the switching module to the mainframe. Do not overtighten.
9. Reconnect the power cord and any other cables.

## Remove a switching module

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### NOTE

Before you remove a switching module or begin any testing, make sure that all the relays are open. Since some relays may be latched closed, you must open all the relays before removing the switching module to make connections. Additionally, if you drop your switching module, it is possible for some relays to latch closed.

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To open all channel relays, go to the CHANNEL swipe screen. Select **Open All**.

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### **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 DAQ6510 is turned off and disconnected from line power. If the switching module is connected to a DUT, make sure power is removed from all external circuitry.**

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## **WARNING**

If a card slot is unused, you must install slot covers to prevent personal contact with high voltage circuits. Failure to install slot covers could result in personal exposure to hazardous voltages, which could cause personal injury or death if contacted.

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## **CAUTION**

Before installing or removing a switching module, make sure the DAQ6510 power is turned off and disconnected from line power. Failure to comply may result in incorrect operation and loss of data in the memory.

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Required equipment:

- Medium flat-blade screwdriver
- Medium Phillips screwdriver

### ***To remove a switching module from the DAQ6510:***

1. Turn off the DAQ6510.
2. Disconnect the power cord from the power source.
3. Disconnect the power cord and any other cables that are connected to the rear panel.
4. Position the DAQ6510 so you are facing the rear panel.
5. Use the screwdriver to loosen the mounting screws that secure the switching module to the instrument.
6. Carefully remove the switching module.
7. Install a slot plate or another switching module in the empty slot.
8. Reconnect the power cord and any other cables.

## Operating instructions

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### CAUTION

Before installing or removing a 7710 module, make sure the DAQ6510 power is turned off and disconnected from line power. Failure to comply may result in incorrect operation and loss of data from 7710 memory.

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### CAUTION

To prevent overheating or damage to the 7710 switching module relays, never exceed the following maximum signal levels between any two inputs or chassis: Any channel to any channel (1 to 20): 60 VDC or 42 V<sub>RMS</sub>, 100 mA switched, 6 W, 4.2 VA maximum.

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### WARNING

Do not exceed the maximum specifications for the 7710. Refer to the specifications provided in the datasheet. Failure to recognize and observe normal safety precautions could result in personal injury or death.

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### WARNING

When a 7710 module is inserted into the DAQ6510, it is connected to the front and rear inputs and the other modules in the system through the instrument backplane. To prevent damage the 7710 module and to prevent creation of a shock hazard, the entire test system and all of its inputs should be derated to 60 VDC (42 V<sub>RMS</sub>). Failure to recognize and observe normal safety precautions could result in personal injury or death.

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Refer to the instrument documentation for operating instructions.

This switching module does not support current measurements. If the instrument has the TERMINALS switch set to REAR and you are working with the slot that contains this switching module, the AC, DC, and digitize current functions are not available. You can measure current using the front panel or using another slot that contains a switching module that supports the AC, DC, and digitize current measurements.

If you use remote commands to attempt to measure current when configuring a channel, an error is returned.

## Fast scan using 7710 module with DAQ6510 mainframe

The following SCPI program demonstrates using the 7710 module and DAQ6510 mainframe to achieve fast scanning. It makes use of WinSocket control to communicate with the 7710 mainframe.

DAQ6510 or pseudocode	Command	Description
Pseudocode	int scanCnt = 1000	Create a variable to hold the scan count
	int sampleCnt	Create a variable to hold the full sample count (total number of readings)
	int chanCnt	Create a variable to hold the channel count
	int actualRdgs	Create a variable to hold the actual reading count
	string rcvBuffer	Create a string buffer to hold extracted readings
	timer1.start()	Start a timer to help capture elapsed time
DAQ6510	*RST	Put the instrument in a known state
	FORM:DATA ASCII	Format data as an ASCII string
	ROUT:SCAN:COUN:SCAN scanCnt	Apply the scan count
	FUNC 'VOLT:DC', (@101:120)	Set function to DCV
	VOLT:RANG 1, (@101:120)	Set the fixed range at 1 V
	VOLT:AVER:STAT OFF, (@101:120)	Disable background statistics
	DISP:VOLT:DIG 4, (@101:120)	Set front panel to show 4 significant digits
	VOLT:NPLC 0.0005, (@101:120)	Set fastest NPLC possible
	VOLT:LINE:SYNC OFF, (@101:120)	Turn off line sync
	VOLT:AZER:STAT OFF, (@101:120)	Turn off auto zero
	CALC2:VOLT:LIM1:STAT OFF, (@101:120)	Turn off limit tests
	CALC2:VOLT:LIM2:STAT OFF, (@101:120)	
	ROUT:SCAN:INT 0	Set trigger interval between scans to 0 s
	TRAC:CLE	Clear the reading buffer
	DISP:LIGH:STAT OFF	Turn the display off
	ROUT:SCAN:CRE (@101:120)	Set the scan list
	chanCnt = ROUTe:SCAN:COUNT:STEP?	Query the channel count
Pseudocode	sampleCnt = scanCnt * chanCnt	Calculate the number of readings made
DAQ6510	INIT	Initiate the scan
Pseudocode	for i = 1, i < sampleCnt	Set up a for loop from 1 to sampleCnt, but leave the incrementing of i for later
	delay 500	Delay for 500 ms to allow readings to accumulate
DAQ6510	actualRdgs = TRACe:ACTual?	Query the actual readings captured
	rcvBuffer = "TRACe:DATA? i, actualRdgs, "defbuffer1", READ	Query the readings available from i to the value of actualRdgs
Pseudocode	WriteReadings("C:\myData.csv", rcvBuffer)	Write the extracted readings to a file, myData.csv, on the local computer
	i = actualRdgs + 1	Increment i for the next loop pass
	end for	End the for loop
	timer1.stop()	Stop the timer
	timer1.stop - timer1.start	Calculate the elapsed time
DAQ6510	DISP:LIGH:STAT ON100	Turn the display on again

The following TSP program demonstrates using the 7710 module and DAQ6510 mainframe to achieve fast scanning. It makes use of WinSocket control to communicate with the 7710 mainframe.

-- Set up variables to be referenced during the scan.

```
scanCnt = 1000
sampleCnt = 0
chanCnt = 0
actualRdgs = 0
rcvBuffer = ""
```

-- Get the initial timestamp for end-of-run comparison.

```
local x = os.clock()
```

-- Reset the instrument and clear the buffer.

```
reset()
defbuffer1.clear()
```

-- Set up reading buffer format and establish scan count

```
format.data = format.ASCII
scan.scancount = scanCnt
```

-- Configure the scan channels for the card in slot 1.

```
channel.setdmm("101:120", dmm.ATTR_MEAS_FUNCTION, dmm.FUNC_DC_VOLTAGE)
channel.setdmm("101:120", dmm.ATTR_MEAS_RANGE, 1)
channel.setdmm("101:120", dmm.ATTR_MEAS_RANGE_AUTO, dmm.OFF)
channel.setdmm("101:120", dmm.ATTR_MEAS_AUTO_ZERO, dmm.OFF)
channel.setdmm("101:120", dmm.ATTR_MEAS_DIGITS, dmm.DIGITS_4_5)
channel.setdmm("101:120", dmm.ATTR_MEAS_NPLC, 0.0005)
channel.setdmm("101:120", dmm.ATTR_MEAS_APERTURE, 8.33333e-06)
channel.setdmm("101:120", dmm.ATTR_MEAS_LINE_SYNC, dmm.OFF)
channel.setdmm("101:120", dmm.ATTR_MEAS_LIMIT_ENABLE_1, dmm.OFF)
channel.setdmm("101:120", dmm.ATTR_MEAS_LIMIT_ENABLE_2, dmm.OFF)
```

-- Dim the display.

```
display.lightstate = display.STATE_LCD_OFF
```

-- Generate the scan.

```
scan.create("101:120")
scan.scaninterval = 0.0
chanCnt = scan.stepcount
```

-- Calculate the overall sample count and use it to size the buffer.

```
sampleCnt = scanCnt * chanCnt
defbuffer1.capacity = sampleCnt
```

-- Start the scan.

```
trigger.model.initiate()
```

-- Loop to capture and print readings.

```
i = 1
while i <= sampleCnt do
    delay(0.5)
    myCnt = defbuffer1.n
    -- NOTE: Can be supplemented or replaced by writing to USB
    printbuffer(i, myCnt, defbuffer1.readings)
    i = myCnt + 1
end
```

-- Turn the display on again.

```
display.lightstate = display.STATE_LCD_50
```

-- Output the elapsed time.

```
print(string.format("Elapsed Time: %2f\n", os.clock() - x))
```

## Operating considerations

### Low-ohms measurements

For resistances in the normal range ( $>100\ \Omega$ ), the 2-wire method ( $\Omega 2$ ) is typically used for ohms measurements. For low ohms ( $\leq 100\ \Omega$ ), the signal path resistance in series with the DUT could be high enough to adversely affect the measurement. Therefore, the 4-wire method ( $\Omega 4$ ) should be used for low-ohms measurements. The following discussion explains the limitations of the 2-wire method and the advantages of the 4-wire method.

### Two-wire method

Resistance measurements in the normal range ( $>100\ \Omega$ ) are generally made using the 2-wire method ( $\Omega 2$  function). The test current is forced through the test leads and the resistance being measured ( $R_{DUT}$ ). The meter then measures the voltage across the resistance value accordingly.

The main problem with the 2-wire method, as applied to low-resistance measurements is the test lead resistance ( $R_{LEAD}$ ) and the channel resistance ( $R_{CH}$ ). The sum of these resistances typically lies in the range of 1.5 to 2.5  $\Omega$ . Therefore, it is difficult to get accurate 2-wire ohms measurements below 100  $\Omega$ .

Due to this limitation, the 4-wire method should be used for resistance measurements  $\leq 100\ \Omega$ .

### Four-wire method

The 4-wire (Kelvin) connection method using the  $\Omega 4$  function is generally preferred for low-ohms measurements. The 4-wire method cancels the effects of channel and test lead resistance.

With this configuration, the test current ( $I_{TEST}$ ) is forced through the test resistance ( $R_{DUT}$ ) through one set of test leads ( $R_{LEAD2}$  and  $R_{LEAD3}$ ), while the voltage ( $V_M$ ) across the device under test (DUT) is measured through a second set of leads ( $R_{LEAD1}$  and  $R_{LEAD4}$ ) called the sense leads.

With this configuration, the resistance of the DUT is calculated as follows:

$$R_{DUT} = V_M / I_{TEST}$$

Where:  $I_{TEST}$  is the sourced test current and  $V_M$  is the measured voltage.

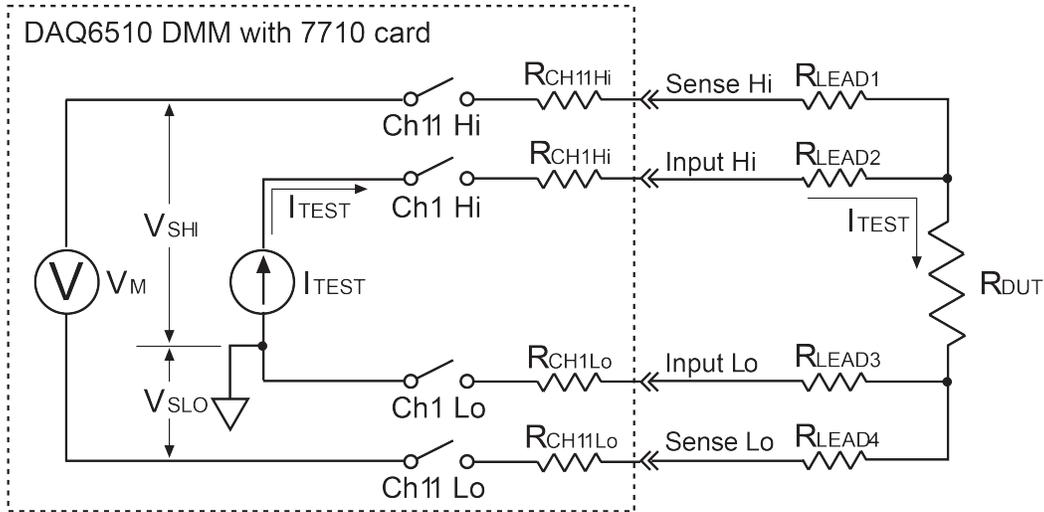
As shown in the figure in [Maximum test lead resistance](#) (on page 17), the measured voltage ( $V_M$ ) is the difference between  $V_{SHI}$  and  $V_{SLO}$ . The equations below the figure show how test lead resistance and channel resistance are canceled out of the measurement process.

## Maximum test lead resistance

The maximum test lead resistance ( $R_{LEAD}$ ), for specific 4-wire resistance ranges:

- 5  $\Omega$  per lead for 1  $\Omega$
- 10% of range per lead for 10  $\Omega$ , 100  $\Omega$ , 1 k $\Omega$ , and 10 k $\Omega$  ranges
- 1 k $\Omega$  per lead for 100 k $\Omega$ , 1 M $\Omega$ , 10 M $\Omega$ , and 100 M $\Omega$  ranges

**Figure 11: Low-ohms measurements using 4-wire method**



Assumptions:

- Virtually no current flows in the high-impedance sense circuit because of the high impedance of the voltmeter ( $V_M$ ). Therefore, the voltage drops across Channel 11 and test lead 1 and 4 are negligible and can be ignored.
- The voltage drops across Channel 1 Hi ( $R_{CH1Hi}$ ) and test lead 2 ( $R_{LEAD2}$ ) are not measured by the voltmeter ( $V_M$ ).

$$R_{DUT} = V_M / I_{TEST}$$

Where:

- $V_M$  is the voltage measured by the instrument.
- $I_{TEST}$  is the constant current sourced by the instrument to the DUT.
- $V_M = V_{SHI} - V_{SLO}$
- $V_{SHI} = I_{TEST} \times (R_{DUT} + R_{LEAD3} + R_{CH1Lo})$
- $V_{SLO} = I_{TEST} \times (R_{LEAD3} + R_{CH1Lo})$
- $V_{SHI} - V_{SLO} = I_{TEST} \times [(R_{DUT} + R_{LEAD3} + R_{CH1Lo}) - (R_{LEAD3} + R_{CH1Lo})]$
- $= I_{TEST} \times R_{DUT}$
- $= V_M$

## Voltage measurements

Path resistance can adversely affect low-ohms measurements (see [Low-ohms measurements](#) (on page 16) for more information). Series path resistance can cause loading problems for DC voltage measurements on the 100 V, 10 V, and 10 mV ranges when the 10 M $\Omega$  input divider is enabled.

High signal path resistance can also adversely affect AC voltage measurements on the 100 V range above 1 kHz.

## Insertion loss

Insertion loss is AC signal power lost between the input and the output. In general, as frequency increases, insertion loss increases.

For the 7710 module, insertion loss is specified for a 50  $\Omega$  AC signal source routed through the module to a 50  $\Omega$  load. Signal power loss occurs as the signal is routed through the signal paths of the module to the load.

Insertion loss is expressed as dB magnitudes at specified frequencies. The specifications for insertion loss are provided in the data sheet.

As an example, assume the following specifications for insertion loss:

**<1 dB @ 500 kHz** 1 dB insertion loss is approximately 20% loss of signal power.

**<3 dB @ 2 MHz** 3 dB insertion loss is approximately 50% loss of signal power.

As signal frequency increases, power loss increases.

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## NOTE

The insertion loss values used in the above example may not be the actual insertion loss specifications of the 7710. The actual insertion loss specifications are provided in the datasheet.

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## Crosstalk

An AC signal can be induced into adjacent channel paths on the 7710 module. In general, crosstalk increases as frequency increases.

For the 7710 module, crosstalk is specified for an AC signal routed through the module to a 50  $\Omega$  load. Crosstalk is expressed as a dB magnitude at a specified frequency. The specification for crosstalk is provided in the datasheet.

As an example, assume the following specification for crosstalk:

**<-40 dB @ 500 kHz** -40 dB indicates that crosstalk into adjacent channels is 0.01% of the AC signal.

As signal frequency increases, crosstalk increases.

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## NOTE

The crosstalk values used in the above example may not be the actual crosstalk specification of the 7710. The actual crosstalk specification is provided in the datasheet.

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## Heat sink temperature measurements

Measuring the temperature of a heat sink is a typical test for a system that has temperature measurement capability. However, the 7710 module cannot be used if the heat sink is being floated at a dangerous voltage level (>60 V). An example of such a test is shown below.

In the following figure, the heat sink is floating at 120 V, which is the line voltage being input to a +5V regulator. The intention is to use channel 1 to measure the temperature of the heat sink, and use channel 2 to measure the +5 V output of the regulator. For optimum heat transfer, the thermocouple (TC) is placed in direct contact with the heat sink. This inadvertently connects the floating 120 V potential to the 7710 module. The result is 115 V between channel 1 and channel 2 HI, and 120 V between channel 1 and chassis. These levels exceed the 60 V limit of the module, creating a shock hazard and possibly causing damage to the module.

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## WARNING

**The test in the following figure demonstrates how a dangerous voltage can unintentionally be applied to the 7710 module. In any test where floating voltages >60 V are present, you must be careful not to apply the floating voltage to the module. Failure to recognize and observe normal safety precautions could result in personal injury or death.**

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## CAUTION

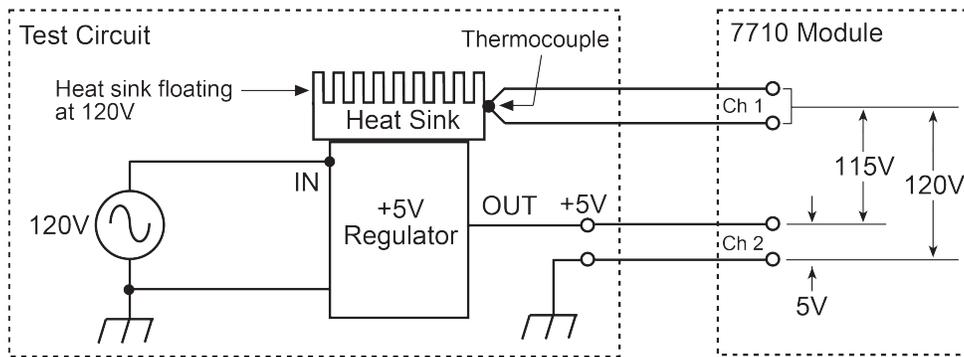
**Do not use the 7710 module to perform this type of test. It exceeds the 60 V limit creating a shock hazard and could cause damage to the module. Excessive voltages:**

**The voltage differential between Ch 1 and Ch 2 HI is 115 V.**

**The voltage differential between Ch 1 and Ch 2 LO (chassis) is 120 V.**

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**Figure 12: Example of an unsafe measurement practice**



Ch 1 configured to measure TC temperature.  
Ch 2 configured to measure 5 V regulator output.

## Module handling precautions

The solid state relays used on the 7710 module are static sensitive devices. Therefore, they can be damaged by electrostatic discharge (ESD).

### CAUTION

**To prevent damage from ESD, only handle the module by the card edges. Do not touch the backplane connector terminals. When working with the quick-disconnect terminal blocks, do not touch any circuit board traces or other components. If working in a high-static environment, use a grounded wrist strap when wiring the module.**

Touching a circuit board trace may contaminate it with body oils that can degrade the isolation resistance between circuit paths, adversely affecting measurements. It is good practice to handle a circuit board only by its edges.

## Solid state relay precautions

To prevent damage to the module, do not exceed the maximum signal level specification of the module. Reactive loads require voltage clamping for inductive loads and surge current limiting for capacitive loads.

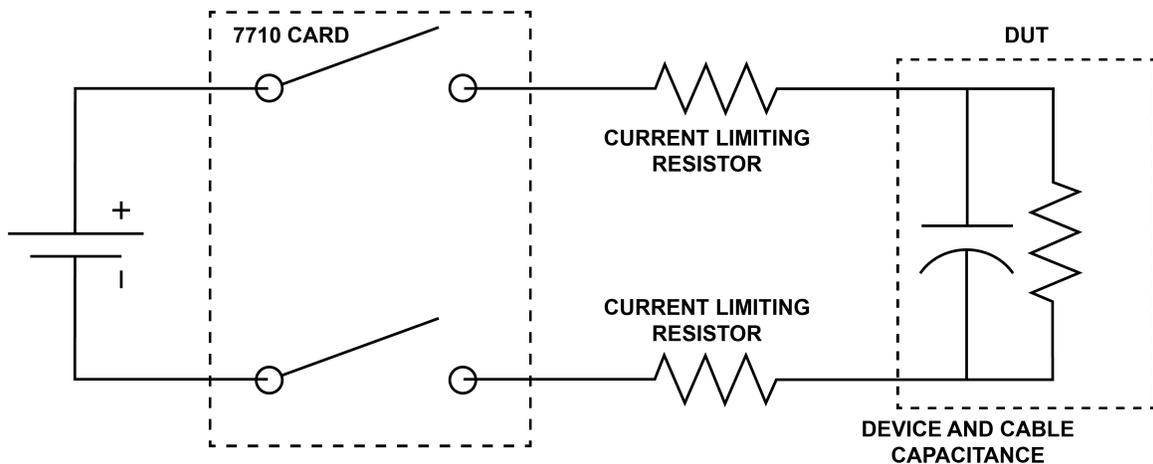
Current limiting devices can be resistors or resettable fuses. Examples of resettable fuses are polyfuses and positive temperature coefficient (PTC) thermistors. Voltage clamping devices can be Zener diodes, gas discharge tubes, and bidirectional TVS diodes.

## Limiting resistor usage

Cabling and test fixtures can contribute considerable capacitance to the signal path. Inrush currents may be excessive and require current limiting devices. Large inrush currents can flow when incandescent lamps, transformer and similar devices are initially energized and current limiting should be used.

Use current limiting resistors to limit inrush current caused by cable and DUT capacitance.

**Figure 13: Solid state relay limiting resistor**



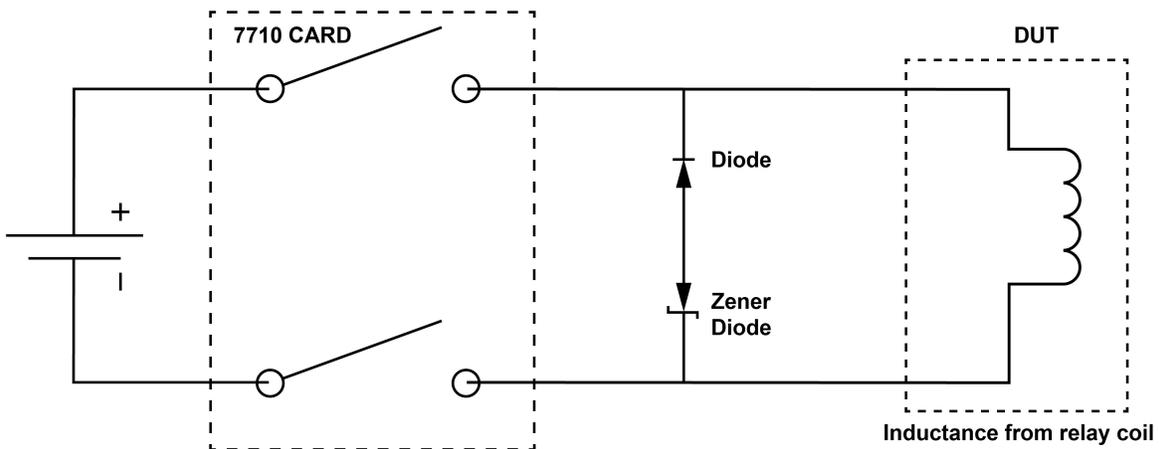
## Clamp voltage

Voltage clamping should be used if power sources have the capability of creating transient voltage spikes.

Inductive loads like relay coils and solenoids should have voltage clamping across the load to suppress counter electromotive forces. Even if transient voltages generated at the load are limited at the device, transient voltages will be generated by inductance if circuit wires are long. Keep wires as short as possible to minimize inductance.

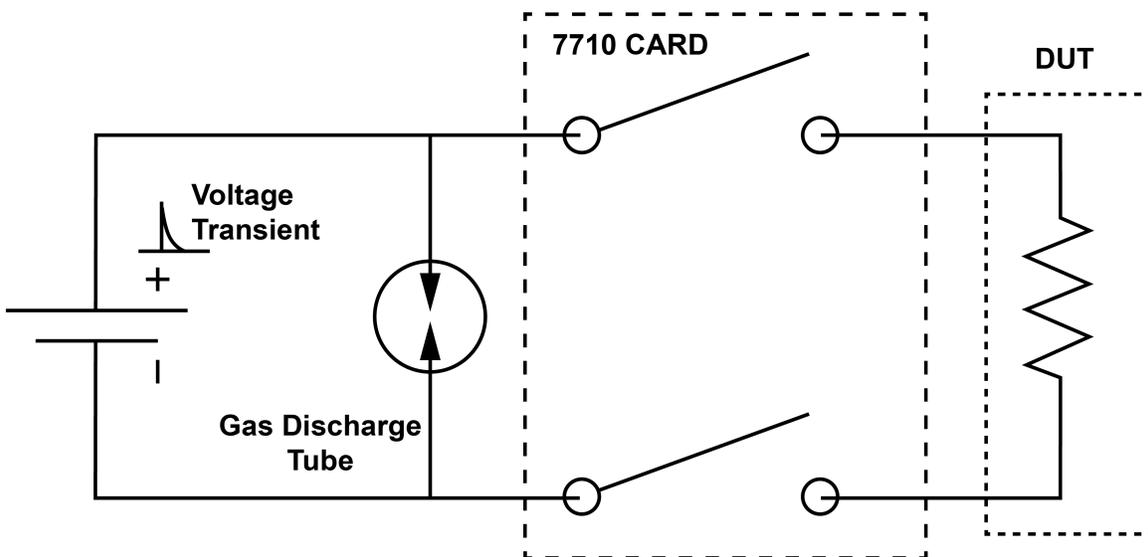
Use a diode and Zener diode to clamp voltage spikes generated by counter electromotive forces at the relay coil.

Figure 14: Diodes at relay coil to clamp spikes



Use a gas discharge tube to prevent transient spikes from damaging the relay.

Figure 15: Gas discharge tube clamp



If the device under test (DUT) changes impedance states during testing, excessive currents or voltages may appear at the solid state relay. If a DUT fails due to low impedance, current limiting may be required. If a DUT fails due to high impedance, voltage clamping may be required.

## Calibration

The following procedures calibrate the temperature sensors on the 7710 plug-in modules.

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### **WARNING**

**Do not attempt to perform this procedure unless you are qualified, as described by the types of product users in the Safety precautions. Do not perform these procedures unless qualified to do so. Failure to recognize and observe normal safety precautions could result in personal injury or death.**

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## Calibration setup

To calibrate the module, you need the following equipment.

- Digital thermometer: 18 °C to 28 °C  $\pm$ 0.1 °C
- Keithley 7797 Calibration/Extender Board

## Extender board connections

The extender board is installed in the DAQ6510. The module is connected to the extender board externally to prevent heating of the module during calibration.

### ***To make extender board connections:***

1. Remove power from the DAQ6510.
2. Install the extender board into Slot 1 of the instrument.
3. Plug the module into the P1000 connector on the rear of the 7797 Calibration/Extender Board.

## Temperature calibration

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### NOTE

Before calibrating the temperature on the 7710, remove power from the module for at least two hours to allow module circuitry to cool down. After turning on the power during the calibration procedure, complete the procedure as quickly as possible to minimize module heating that could affect calibration accuracy. Initially allow the DAQ6510 to warm up for at least one hour with the 7797 calibration card installed. If calibrating multiple modules in a row, power off the DAQ6510, quickly unplug the previously calibrated 7710, and plug in the next one. Wait three minutes before calibrating the 7710.

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**Set up calibration:**

1. Turn on the DAQ6510 power.
2. To ensure the instrument is using the SCPI command set, send:  
`*LANG SCPI`
3. On the front panel, verify that TERMINALS is set to **REAR**.
4. Allow three minutes for thermal equilibrium.

**To calibrate temperature:**

1. Accurately measure and record the cold temperature of the 7710 module surface at the center of the module with the digital thermometer.
2. Unlock calibration by sending:  
`:CALibration:PROTECTED:CODE "KI006510"`
3. Calibrate temperature on the 7710 with the following command, where `<temp>` is the cold calibration temperature measured in step 1 above:  
`:CALibration:PROTECTED:CARD1:STEP0 <temp>`
4. Send the following commands to save and lock out calibration:  
`:CALibration:PROTECTED:CARD1:SAVE`  
`:CALibration:PROTECTED:CARD1:LOCK`

## Errors that can occur during calibration

If calibration errors occur, they are reported in the event log. You can review the event log from the front panel of the instrument by using the SCPI `:SYSTEM:EVENTlog:NEXT?` command or the TSP `eventlog.next()` command.

The error that can occur on this module is 5527, Temperature Cold Cal error. If this error occurs, contact Keithley Instruments. Refer to [Factory service](#) (on page 24).

## Factory service

To return your DAQ6510 for repair or calibration, call 1-800-408-8165 or complete the form at [tek.com/services/repair/rma-request](http://tek.com/services/repair/rma-request). When you request service, you need the serial number and firmware or software version of the instrument.

To see the service status of your instrument or to create an on-demand price estimate, go to [tek.com/service-quote](http://tek.com/service-quote).

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 nonhazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by 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 products are designed for use with electrical signals that are measurement, control, and data I/O connections, with low transient overvoltages, and must not be directly connected to mains voltage or to voltage sources with high transient overvoltages. Measurement Category II (as referenced in IEC 60664) connections require protection for high transient overvoltages often associated with local AC mains connections. Certain Keithley measuring instruments may be connected to mains. These instruments will be marked as category II or higher.

Unless explicitly allowed in the specifications, operating manual, and instrument labels, do not connect any instrument to mains.

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 30 V RMS, 42.4 V peak, or 60 VDC 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 1000 V, no conductive part of the circuit may be exposed.

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.

For safety, instruments and accessories must be used in accordance with the operating instructions. If the instruments or accessories are used in a manner not specified in the operating instructions, the protection provided by the equipment may be impaired.

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

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

The **WARNING** heading in the user documentation explains hazards 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.

The **CAUTION** heading with the  symbol in the user documentation explains hazards that could result in moderate or minor injury or damage the instrument. Always read the associated information very carefully before performing the indicated procedure. Damage to the instrument 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. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. The detachable mains power cord provided with the instrument may only be replaced with a similarly rated power cord. 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 to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call a Keithley office for information.

Unless otherwise noted in product-specific literature, Keithley instruments are designed to operate indoors only, in the following environment: Altitude at or below 2,000 m (6,562 ft); temperature 0 °C to 50 °C (32 °F to 122 °F); and pollution degree 1 or 2.

To clean an instrument, use a cloth dampened with deionized water 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.

Safety precaution revision as of June 2018.