

Keithley Instruments
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Instructions for use with DAQ6510**Introduction**

The 7712 switching module offers a 50 Ω dual 1 \times 4 multiplexer configuration with 10 rear-panel SMA connectors. Multiple multiplexers can be cascaded to build scalable matrix and multiplexer systems for a large number of devices under test and RF source/measurement instruments. One channel in each multiplex bank is always closed to the corresponding OUT connector. The 3.5 GHz RF switching capability of the 7712 makes it ideal for testing wireless modules operating in the 2.4 GHz and lower industrial, scientific, and medical (ISM) radio bands.

Figure 1: Model 7712

Item shipped may vary from model pictured here.

The 7712 includes the following features:

- 3.5 GHz bandwidth
- Dual 1 \times 4 multiplexer configuration
- Onboard switch closure counter

NOTE

If you are using this switching module with the 2700, 2701, or 2750, please see *Model 7711 and 7712 User's Guide*, Keithley Instruments document number PA-818.



Installation

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.

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

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.

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.

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.

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.

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.

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

NOTE

Before you remove a switching module or begin any testing, make sure that all of the relays are open. Since some relays may be latched closed, you must open all of 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.

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

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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.

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.

Connections

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.

⚠ 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 14). 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.

Wiring procedure

The default closed channels are 1 and 5. At power-up, channels 1 and 5 are always closed. If you are using a saved setup that calls for another channel to be closed, the switching module is switched to that channel after the firmware has completed the power-on sequence. Therefore, the lowest channel is closed for at least a brief time at power-up. You need to verify that nothing is connected to channels 1 and 5 that could be damaged.

The connectors on the switching module are standard SMA connectors. When making or breaking connections, use a torque wrench to produce mating torque of 0.9 Nm (8 in. lb).

⚠ WARNING

Do not exceed the maximum specifications for the 7712 switching module. Refer to the specifications provided in the data sheet. Failure to recognize and observe normal safety precautions could result in personal injury or death.

⚠ WARNING

Do not touch live radio frequency (RF) conductors, even at low voltages. RF behaves differently than DC or low frequency AC. Low voltage RF can cause severe burns. RF signals spread out over body areas, generating substantial currents at the points of contact with RF conductors.

Figure 2: 7712 switching module



Make connections with the correct wire size. If BNC connections are required, use the SMA to BNC adapter cables available as accessories.

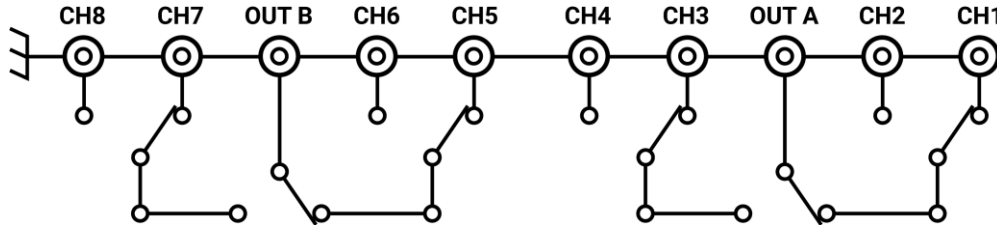
⚠ WARNING

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.

Configuration

The switching module has channels that are grouped into dual 1 × 4 multiplexers. The multiplexer allows one channel of each set of four to be closed at a time (1 of 4 tree structure). Channels 1 and 5 are normally closed to OUT A and OUT B, respectively.

Figure 3: Configuration schematic



Refer to [Close and open channels](#) (on page 10).

Expansion

One switching module configuration is a dual 1 × 4 multiplexer. A single switching module can also be configured as a 4 × 4 blocking matrix. The switching module can be combined with additional modules to further expand its multiplexing and matrix switching capabilities. Specifications may degrade when the switching module is used in multiple module configurations. Refer to the following table for examples of multiplexer and blocking matrix expansion.

Matrix and multiplex expansion

Number of switching module	Multiplexer			Blocking Matrix	
	1 × 4	1 × 8	1 × 12	4 × 4	4 × 8
1	X	—	—	X	—
2	X	X	X	X	X

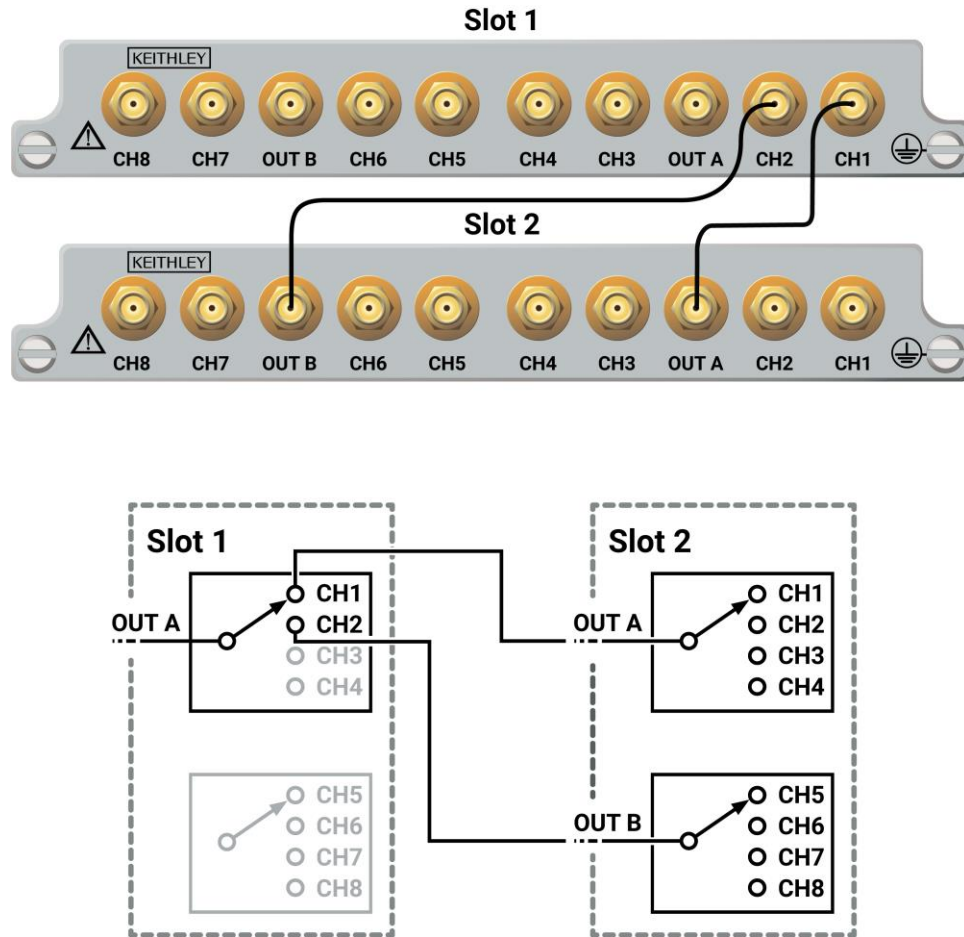
Multiplexer examples

SP8T MUX

This example creates a 1 × 8 SP8T MUX (single-pole eight-throw multiplexer) using two switching modules. Channels 1 and 2 are connected to OUT A and OUT B of the second switching module in slot two. Terminate unused channels with a 50 Ω load.

The schematic is shown in the power-up state. Channels 1 and 5 are closed for slots 1 and 2. Grayed channels are not used.

Figure 4: MUX 1 × 8 expansion



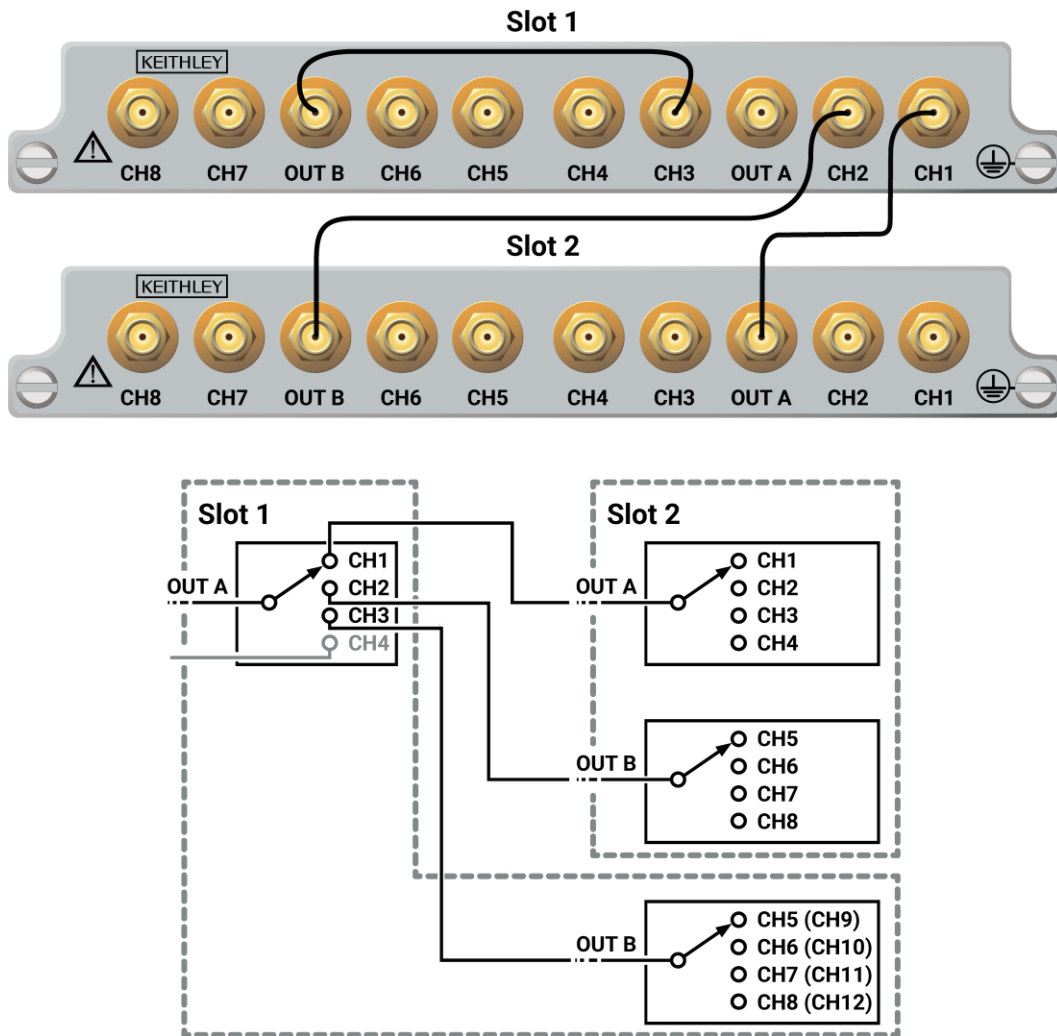
SP12T MUX

To create a 1 × 12 SP12T MUX (single-pole 12-throw multiplexer) using two switching modules, channels 1 and 2 are connected to OUT A and OUT B of the second switching module in slot 2. Terminate unused channels with a 50 Ω load.

The schematic is shown in the power-up state. Channels 1 and 5 are closed for slots 1 and 2. Grayed channels are not used.

Channels 5 to 8 on the switching module in slot 1 correspond to crosspoint channels 9 to 12 of the 1 × 12 SP12T MUX in slot 2.

Figure 5: MUX 1 × 12 expansion



NOTE

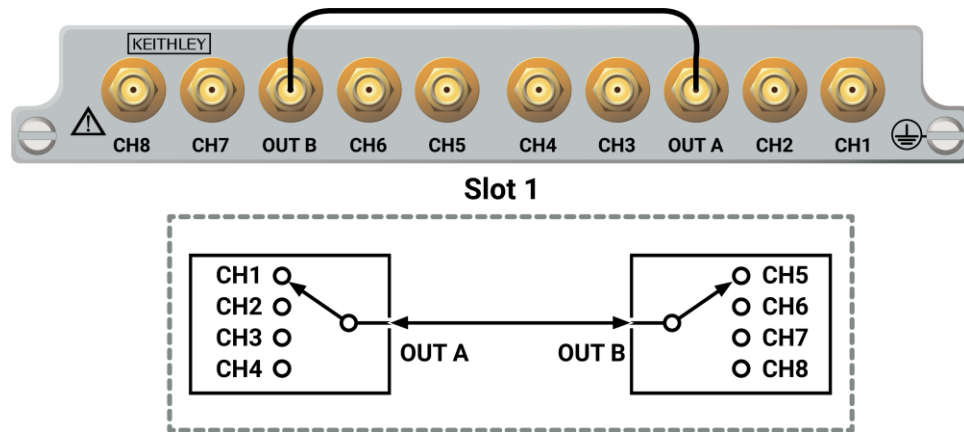
Channels 3 and 4 may also be connected to other banks that will create a 1 × 12 multiplexer.

Single switching module 4 × 4 blocking matrix

This configuration provides a convenient way to connect four DUTs to four different test instruments. In this configuration, channels 1 to 4 may be routed to channels 5 to 8. Use a short coaxial cable to connect OUT A to OUT B.

The schematic is shown in the power-up state. Channels 1 and 5 are closed.

Figure 6: Single 4 × 4 blocking matrix



Measurement considerations

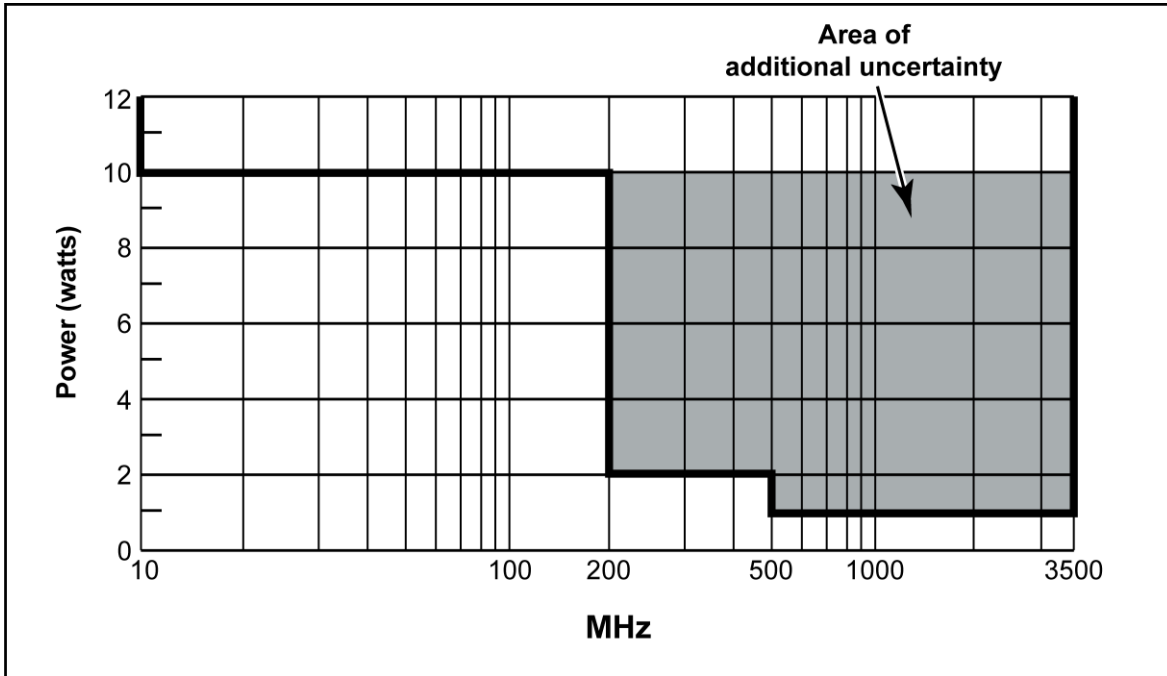
Termination of unused connectors

To minimize noise within the system, terminate unused channels with 50 Ω loads. If 50 Ω loads are not available, terminating unused connectors with a cable may also reduce noise within the system.

Power handling

The graph shows the maximum amount of power per channel that can be routed using the switching module while maintaining proper digital multimeter accuracy. Power levels of up to 10 watts at frequencies greater than 200 MHz can be used, but this may cause measurement errors. For example, routing 10 watts of power at 1 GHz may cause the switching module to have an additional 6 μV offset uncertainty when measuring DC voltages. The precision low-level circuitry may cause uncertainty of 30 μV . Move the switching module to slot 2 to reduce uncertainty.

Figure 7: Carry power versus frequency



Operation

NOTE

This switching module cannot be included in scan lists.

Detailed information on how to close and open switching module channels is provided in the *Model DAQ6510 Data Acquisition and Multimeter System Reference Manual*. The following summarizes basic operation and provides operating information specific to the switching module.

Close and open channels

WARNING

Careless multiple channel 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. Operating channels independently should be restricted to experienced test engineers who recognize the dangers associated with multiple independent channel closures. Do not attempt to perform this procedure unless qualified as described by the types of product users in the [Safety precautions](#) (on page 14). 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.

Multiple channel operation provides direct control of the channels of one or two switching modules. OUT A automatically switches as appropriate for channels 1 to 4 and OUT B automatically switches as appropriate for channels 5 to 8 for each module. When you close two channels in a single module (one for OUT A and one for OUT B), the appropriate channels will close; other channels or channels on other switching modules are not affected by channel closures.

Performance verification

WARNING

Do not attempt to perform this procedure unless qualified to do so, as described by the types of product users in the [Safety precautions](#) (on page 14). 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.

The following tests verify the RF characteristics of the switching module. S-parameters are obtained by measuring voltage standing wave ratio (VSWR) and insertion loss among the common output and channel.

The following equipment is recommended for the tests in this section:

- Tektronix TTR506A Vector Network Analyzer (6 GHz)
- Tektronix test port cables, Type-N(m) to Type-SMA(m), 1 m (012-1770-00)
- Tektronix 3.5 mm SOLT mechanical calibration kit 0 to 32 GHz, Spinner BN 53 38 54 (CALMECH-35MM)

Prepare for verification

To prepare for verification:

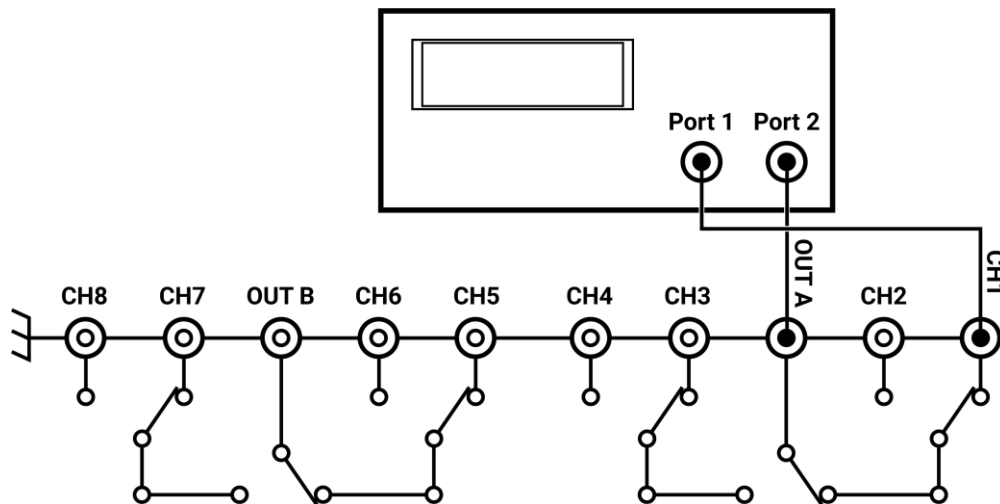
1. Turn on the network analyzer and the DAQ6510 with the switching module installed.
2. Allow the analyzer to warmup for at least one hour.
3. Calibrate the network analyzer from 500 MHz to 3.5 GHz using the appropriate calibration kit. The calibration routine should include a load, short, open, and pass-through procedure. Use SMA style connectors in the calibration process.

VSWR

To verify VSWR:

1. Connect network analyzer Port 1 to channel 1 and Port 2 to OUT A.
2. On the DAQ6510, close channel 1.
3. On the network analyzer, display the VSWR graph.
4. On the network analyzer, select S11 or S22 measurement.
5. Verify specifications at 500 MHz, 1 GHz, 2.5 GHz, and 3.5 GHz. Refer to the Model 7712 data sheet for acceptable limits.
6. Move the Port 1 connection to each channel and repeat steps 3 to 5 for the remaining channels 2 to 4, closing the channel for each.
7. Connect the network analyzer Port 1 to channel 5 and Port 2 to OUT B.
8. On the DAQ6510, close channel 5.
9. On the network analyzer, select S11 or S22 measurement.
10. On the network analyzer, display the VSWR graph.
11. Verify specifications at 100 MHz, 500 MHz, 1 GHz, 2.5 GHz, and 3.5 GHz. Refer to the Model 7712 data sheet for acceptable limits.
12. Move the Port 1 connection to each channel and repeat steps 9 to 11 for the remaining channels 6 to 8, closing the channel for each.

Figure 8: Insertion loss verification, channels 1 to 4

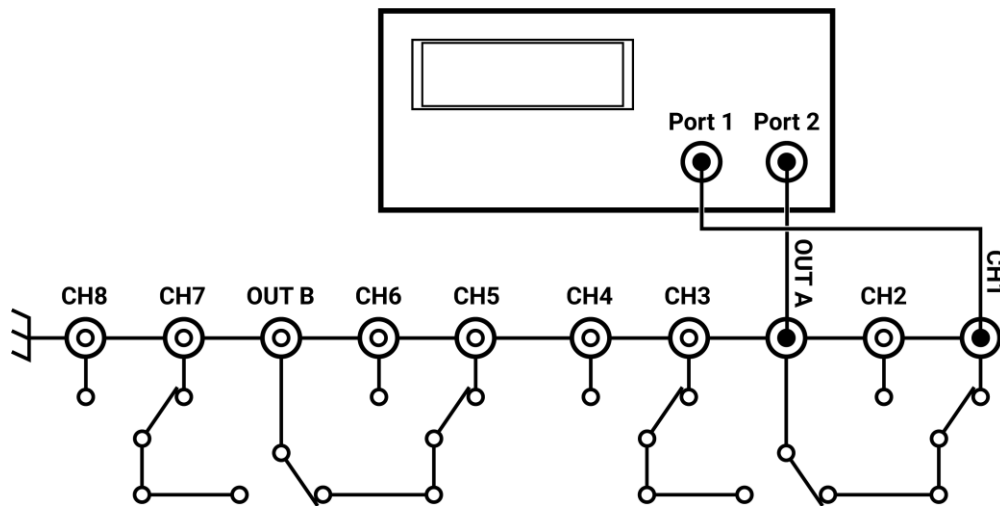


Insertion loss

To verify insertion loss:

1. Connect network analyzer Port 1 to channel 1 and Port 2 to OUT A.
2. On the DAQ6510, close channel 1.
3. On the network analyzer, display the Log Magnitude plot.
4. On the network analyzer, select S12 or S21 measurement.
5. Verify specifications at 500 MHz, 1 GHz, 2.5 GHz, and 3.5 GHz. Refer to the Model 7712 data sheet for acceptable limits.
6. Move the Port 1 connection to each channel and repeat steps 3 to 5 for the remaining channels 2 to 4, closing the channel for each.
7. Connect the network analyzer Port 1 to channel 5 and Port 2 to OUT B.
8. On the DAQ6510, close channel 5.
9. On the network analyzer, select S12 or S21 measurement.
10. On the network analyzer, display the Log Magnitude plot.
11. On channel 5 to 8, verify specifications at 500 MHz, 1 GHz, 2.5 GHz, and 3.5 GHz. Refer to the Model 7712 data sheet for acceptable limits.
12. Move the Port 1 connection to each channel and repeat steps 9 to 11 for the remaining channels 6 to 8, closing the channel for each.

Figure 9: Insertion loss verification, channels 1 to 4

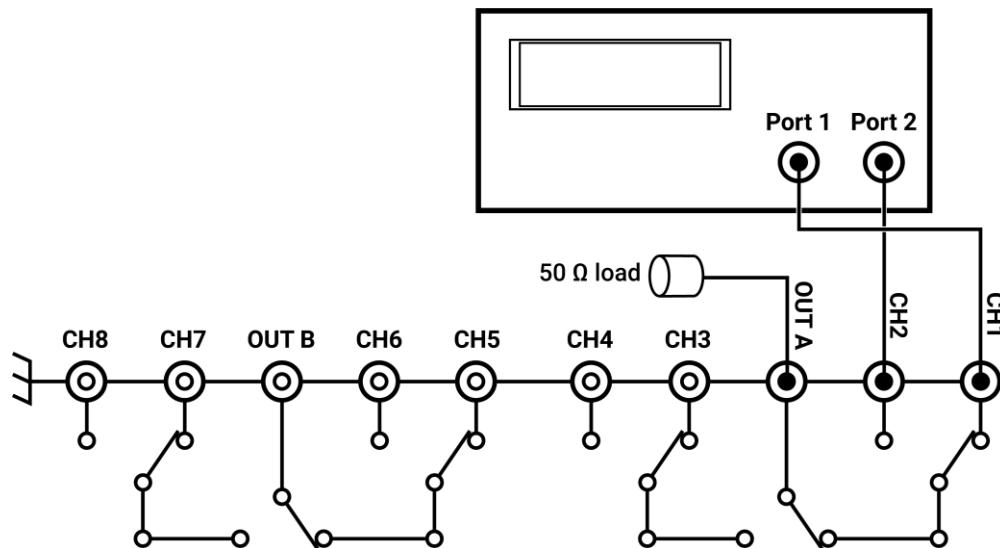


Crosstalk

To verify crosstalk:

1. Connect network analyzer Port 1 to channel 1 and Port 2 to channel 2.
2. Connect a 50 Ω load to OUT A
3. On the DAQ6510, close channel 1.
4. On the network analyzer, display the Log Magnitude plot.
5. On the network analyzer, select S12 measurement.
6. On channels 1 to 4, verify specifications at 500 MHz, 1 GHz, 2.5 GHz, and 3.5 GHz. Refer to the Model 7712 data sheet for acceptable limits. There are six possible combinations for channels 1 to 4 (1 to 2, 1 to 3, 1 to 4, 2 to 3, 2 to 4, and 3 to 4).
7. Connect network analyzer Port 1 to channel 5 and Port 2 to channel 6.
8. Connect a 50 Ω load to OUT B.
9. On the DAQ6510, close channel 5.
10. On the network analyzer, select the S12 measurement.
11. On the network analyzer, display the Log Magnitude plot.
12. On channels 5 to 8, verify specifications at 500 MHz, 1 GHz, 2.5 GHz, and 3.5 GHz. Refer to the Model 7712 data sheet for acceptable limits. There are six possible combinations for channels 5 to 8 (5 to 6, 5 to 7, 5 to 8, 6 to 7, 6 to 8, and 7 to 8).

Figure 10: Crosstalk



Factory service

To return the switching module to Keithley Instruments for repair:

- Call the Repair Department at 1-800-833-9200 or send an email to RMAREQUEST@tektronix.com for a Return Material Authorization (RMA) number.
- Carefully pack the instrument in the original packing carton.
- Write ATTENTION REPAIR DEPARTMENT and the RMA number on the shipping label.

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.

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.


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.

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 protective earth (safety 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 protective earth (safety ground) using the wire recommended in the user documentation.

The  symbol on an instrument means caution, risk of hazard. The user must refer to the operating instructions located in the user documentation in all cases where the symbol is marked on the instrument.

The  symbol on an instrument means warning, risk of electric shock. 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 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 2017.