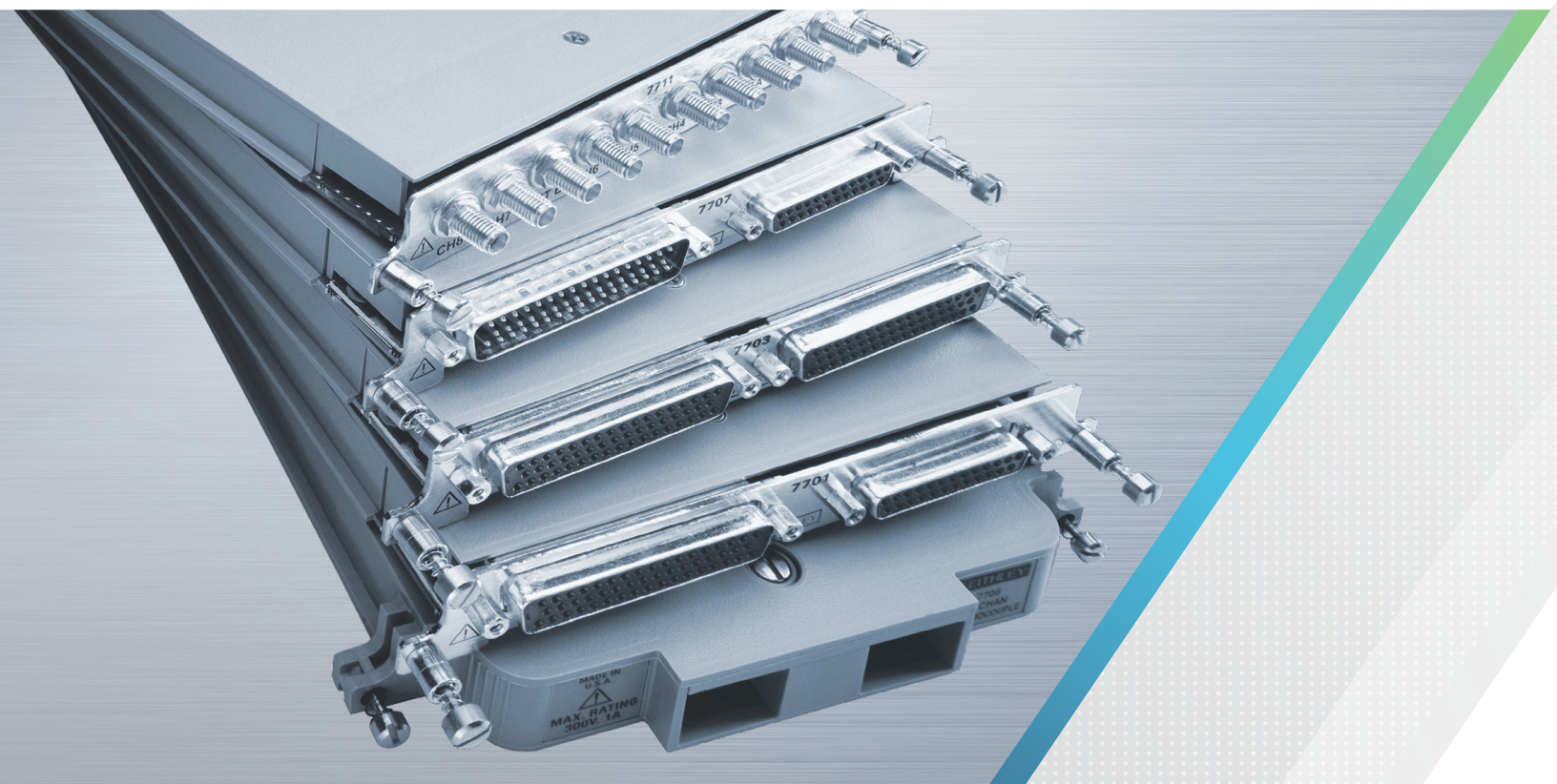


Guidelines and Tips for Multi-Channel Data Logging

Choosing a 7700 Series Switching Module for the DAQ6510
Data Acquisition Multimeter

CONFIGURATION GUIDE



KEITHLEY
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Introduction

There are 12 different 7700 Series Plug-In Switch Modules that enable the DAQ6510 to perform a wide range of tests. This guide will help you to select the appropriate switch module for your intended application.

Table 1 summarizes the specifications of these 12 plug-in switch modules.

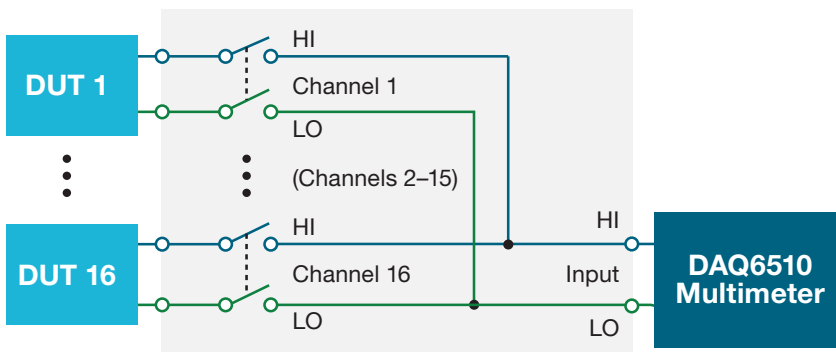
MODEL	7700	7701	7702	7703	7705	7706	7707	7708	7709	7710	7711	7712
Description	20 Channel, Differential Multiplexer Module	32 Channel, Differential Multiplexer Module	40 Channel, Differential Multiplexer Module	32 Ch. High Speed, Differential Multiplexer Module	40 Ch. Single-pole Control Module	All-in-One I/O Module	32 Ch. Digital I/O Module	40 Channel, Differential Multiplexer Module	6x8 Matrix Module	20 Channel, Solid-state Differential Multiplexer Module	2 GHz 50 Ω RF Module	3.5 GHz 50 Ω RF Module
No. Analog Inputs	20	32	40	32	40	20	10	40	48	20	8	8
Configuration	Multiplexer w/CJC 1x20 or two 1x10	Multiplexer 1x32 or two 1x16	Multiplexer 1x40 or two 1x20	Multiplexer 1x32 or two 1x16	Independent SPST	Multiplexer w/CJC 1x20 or two 1x10	Digital I/O/ Multiplexer 1x10 or two 1x5	Multiplexer w/CJC 1x40 or two 1x20	Matrix 6x8	Multiplexer w/CJC 1x20 or two 1x10	Multi-plexer Dual 1x4	Multi-plexer Dual 1x4
Connector Type	Oversized screw terminal	50 pin female D-sub and 25 pin female D-sub	Oversized screw terminal	Two 50 pin female D-sub	Two 50 pin female D-sub	Screw terminal	50 pin male D-sub and 25 pin female D-sub	Oversized screw terminal	50 pin female D-sub and 25 pin female D-sub	Quick disconnect screw terminal	SMA	SMA
Max. Voltage	300 V	150 V	300 V	300 V	300 V	300 V	300 V	300 V	300 V	60 V	60 V	42 V
Max. Switched Current	1 A	1 A	1 A	500 mA	2 A	1 A	1 A	1 A	1 A	0.1 A	0.5 A	0.5 A
Bandwidth	50 MHz	2 MHz	2 MHz	2 MHz	10 MHz	2 MHz	2 MHz	2 MHz	2 MHz	2 MHz	2 MHz	3.5 MHz
Contact Life	10 ⁸	10 ⁸	10 ⁸	10 ⁸	10 ⁸	10 ⁸	10 ⁸	10 ⁸	10 ⁸	10 ¹⁰	10 ⁶	10 ⁶
Switch Speed	3 ms	3 ms	3 ms	1 ms	3 ms	3 ms	3 ms	3 ms	3 ms	0.5 ms	10 ms	10 ms
Other Details	Max. power = 125 VA. 2 current measure channels	Max. power = 125 VA.	Max. power = 125 VA. 2 current measure channels	Reed relays	Max. power = 125 VA.	2 analog outputs. 16 digital outputs, event counter/totalizer Max. power = 125 VA.	32 digital I/O. Max. power = 125 VA.	Max. power = 125 VA.	Connects to internal DMM. Daisy chain mult. cards for up to 6x16 matrix Max. power = 125 VA.	Solid state relays, 800 ch./second scan rate	Insertion loss <1.0 dB @ 1 GHz. VSWR <1.2 @ 1 GHz.	Insertion loss <1.1 dB @ 2.4 GHz.

Table 1. 7700 Series Plug-in Switch Modules.

Switching and Measuring DCV and ACV

Each of the low frequency multiplexer plug-in switch modules and the matrix plug-in module can switch voltage and include:

- 7700 20-Channel Differential Multiplexer Module with CJC Sensors
- 7701 32-Channel Differential Multiplexer Module
- 7702 40-Channel Differential Multiplexer Module
- 7703 High Speed Differential Multiplexer Module
- 7706 All-in-One I/O Module with CJC Sensor
- 7707 32-Channel Digital I/O Module
- 7708 40-Channel Differential Multiplexer Module with CJC Sensors
- 7709 6x8 Matrix Module
- 7710 Solid-State Differential Multiplexer Module with CJC Sensor



Example Multiplexer Configuration.

There are several factors to consider when selecting the best module for your application, including:

- **Will your test system be a multiplexer or a matrix?**
A multiplexer will switch many inputs to one output. A matrix can switch any input to any output. If a matrix is needed, then select the 7709.
- **Do you need 10, 20, 32, or 40 multiplexed channels?**
 - 10 channels with 32 digital I/O lines - 7707
 - 20 channels - 7700; 7706 with analog outputs, event totalizer, digital I/O; 7710Each of these modules has CJC sensors
 - 32 channels - 7701; 7703
 - 40 channels - 7702; 7708 with CJC sensors.
- **What is the maximum voltage that needs to be measured?**
All multiplexers except the 7701 (reed relays - 150V) and the 7710 (solid state relays - 60V) can switch up to 300V. The multiplexers that can switch up to 300V use electromechanical relays.
- **How much current will need to be switched?**
Most multiplexer modules switch 1A maximum except the 7703 (0.5A) and the 7710 (0.1A).

- Do you need switching speed?**
 Select either the 7703 High Speed Differential Multiplexer (reed relays) or the 7710 Solid-State Multiplexer. The Solid-State Multiplexer has the highest speed, offering a scanning rate up to 800 channels/s.
- Do you need maximum relay contact life?** Then the Solid-State Multiplexer provides the longest relay contact life.
- Do you also need to measure temperature with thermocouples?** If you also need to measure thermocouples, you will need to choose one of the multiplexers with cold junction compensation (CJC) sensors, 7700, 7706, 7708, or 7710.
- Do you want to use mass terminated connectors?** If you DO NOT need to measure temperature with thermocouples, then consider the 10-channel (7707) or the 32-channel multiplexers (7701, 7703) which have mass terminated connectors rather than screw terminal connectors. Use of mass terminated connectors eliminates individual wiring of each channel and speeds up changeover of switch modules.

Refer to Table 2 for details on each plug-in module.

NUMBER OF CHANNELS REQUIRED	PLUG-IN MULTIPLEXER MODULE	MAXIMUM VOLTAGE AND CURRENT	SWITCH SPEED	RELAY LIFE	CONNECTOR TYPE	OTHER MODULE FEATURES
Up to 10 channels	7707	300V/1A	3ms	10 ⁸ closures	Multipin D-Sub	32 Digital I/O lines
Up to 20 channels	7700	300V/1A	3ms	10 ⁸ closures	Screw terminal	CJC Sensors, 2 Current channels
Up to 20 channels	7706	300V/2A	3ms	10 ⁸ closures	Screw terminal	2 Analog outputs, 16 Digital outputs, Event totalizer
Up to 20 channels	7710	60V/0.1A	0.5ms	10 ¹⁰ closures	Screw terminal	Solid-state relays
Up to 32 channels	7701	150V/1A	3ms	10 ⁸ closures	Multipin D-Sub	–
Up to 32 channels	7703	300V/0.5A	1ms	10 ⁸ closures	Multipin D-Sub	Reed relays
Up to 40 channels	7702	300V/1A	3ms	10 ⁸ closures	Screw terminal	2 Current channels
Up to 40 channels	7708	300V/1A	3ms	10 ⁸ closures	Screw terminal	CJC sensors

Table 2. Options for switching and measuring voltage.

TIP To minimize interference from external noise sources, use twisted wire pairs to connect the DUTs to the switch module. As a further preventive measure, use shielded wire, and ground the cable shield to an earth ground point on the DUT. If the DUT is floating, ground the cable shield to the enclosure of the DAQ6510. Ensure that each twisted pair of wires is independent of all other twisted wire pairs when using either a multiconductor cable or individual twisted wire pair cables. Keeping wire lengths as short as possible also helps to reduce noise. The DAQ6510 can also help to reduce noise. Measure over an integral multiple of the power line cycle to average power line noise out of the voltage measurement. Adding filtering can also minimize noise in the measurement.

Switching and Measuring Resistance or Continuity

The same switch modules that can switch voltage can switch and measure resistance or continuity.

The same selection criteria applies as well.

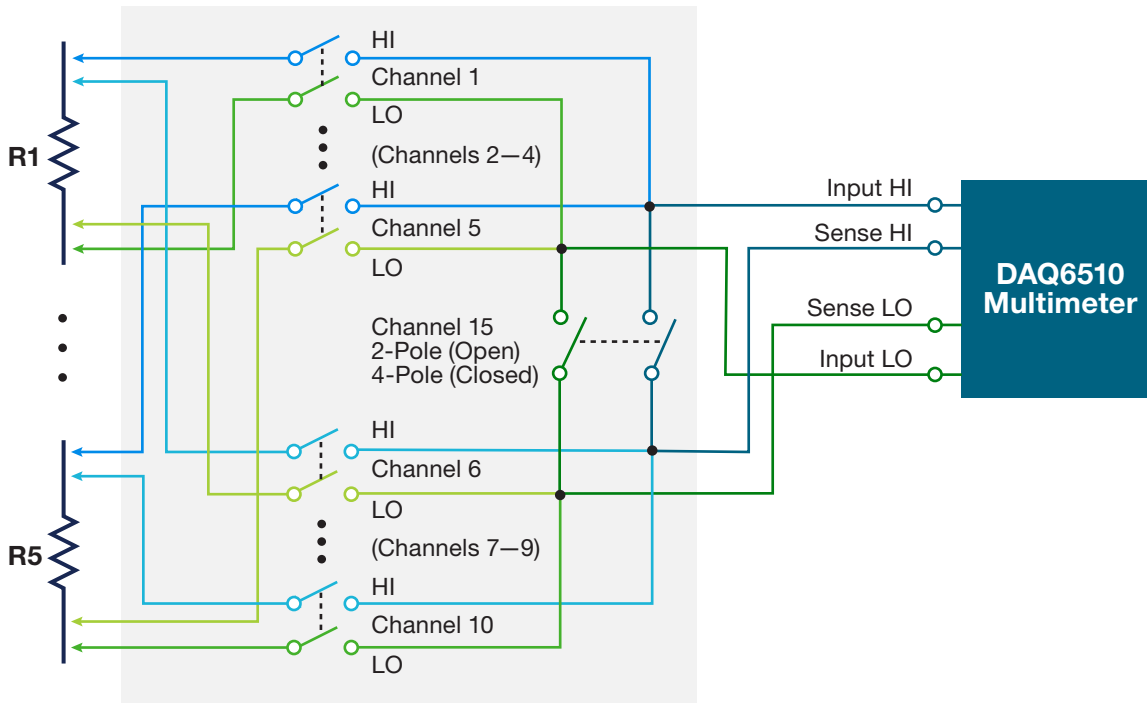
- **Multiplexer configuration or matrix configuration?** If a matrix is needed, then select the 7709 Module.
- **Do you need 10, 20, 32, or 40 multiplexed channels?**
 - 10 channels with 32 digital I/O lines - 7707.
 - 20 channels - 7700; 7706 with analog outputs, event totalizer, digital I/O; 7710.

Each of these modules has CJC sensors

 - 32 channels - 7701; 7703.
 - 40 channels - 7702; 7708 with CJC sensors.
- **Do you need switching speed?** Select either the 7703 High Speed Differential Multiplexer (reed relays) or the 7710 Solid-State Multiplexer. The Solid-State Multiplexer has the highest speed, offering a scanning rate up to 800 channels/s
- **Do you need maximum relay contact life?** Then the Solid-State Multiplexer provides the longest relay contact life.
- **If you also need to measure temperature with thermocouples,** you will need to choose one of the multiplexers with cold junction compensation sensors, 7700, 7706, 7708, or 7710.
- **Do you want to use mass terminated connectors?** If you DO NOT need to measure temperature with thermocouples, then consider the 10-channel (7707) or the 32-channel multiplexers (7701, 7703) which have mass terminated connectors rather than screw terminal connectors. Use of mass terminated connectors eliminates individual wiring of each channel and speeds up changeover of switch modules.

NUMBER OF CHANNELS REQUIRED	PLUG-IN MULTIPLEXER MODULE	SWITCH SPEED	RELAY LIFE	CONNECTOR TYPE	OTHER MODULE FEATURES
Up to 10 channels (2-pole) Up to 5 channels (4-pole)	7707	3ms	10 ⁸ closures	Multipin D-Sub	32 Digital I/O lines
Up to 20 channels (2 pole) Up to 10 channels (4-pole)	7700	3ms	10 ⁸ closures	Screw terminal	CJC sensors, 2 Current channels
Up to 20 channels (2-pole) Up to 10 channels (4-pole)	7706	3ms	10 ⁸ closures	Screw terminal	2 Analog outputs, 16 Digital outputs, Event totalizer
Up to 20 channels (2-pole) Up to 10 channels (4-pole)	7710	0.5ms	10 ¹⁰ closures	Screw terminal	Solid-state relays
Up to 32 channels (2-pole) Up to 16 channels (4-pole)	7701	3ms	10 ⁸ closures	Multipin D-Sub	–
Up to 32 channels (2-pole) Up to 16 channels (4-pole)	7703	1ms	10 ⁸ closures	Multipin D-Sub	Reed relays
Up to 40 channels (2-pole) Up to 20 channels (4-pole)	7702	3ms	10 ⁸ closures	Screw terminal	2 Current channels
Up to 40 channels (2-pole) Up to 20 channels (4-pole)	7708	3ms	10 ⁸ closures	Screw terminal	CJC sensors

Table 3. Options for switching and measurement resistance or continuity.



Multiplexer configuration for four-wire measurement.

TIP

When measuring low resistance, 100Ω or lower, we recommend using the 4-wire resistance measuring technique. Using the four-wire method, stimulus current is supplied through the source wires and the voltage across the DUT resistance is measured through the sense wires. The resistance is $V_{\text{measured}}/I_{\text{supplied}}$. This method eliminates including the resistance of the lead wires in the measurement. The test lead resistance is included in the measurement when using the two-wire measurement technique. When measuring low resistance, the test lead resistance can be a significant percentage of the DUT resistance. Use of the 4-wire technique eliminates the error associated with the test lead resistance. Note that the number of multiplexer channels is halved when performing 4-wire resistance measurements since two switch pairs are required to perform a 4-wire measurement on a DUT.

The DAQ6510 can also eliminate thermal offset voltage errors associated with the connections of dissimilar metals at the test lead-DUT lead wire interface. The DAQ6510 uses offset compensation to measure the voltage across the DUT both with the source current for the appropriate measurement range and with a very low source current. The resulting resistance computation subtracts out the thermal offset voltage. Thus, the combination of the 4-wire measurement technique with the offset compensation measurement technique provides the most accurate result.

Switching and Measuring DC or AC Current

Two switch modules, the 7700 20-Channel Multiplexer with CJC Sensors and the 7702 40-Channel Multiplexer, have two channels each for current measurement.

A 3-Amp fuse is in each channel of both modules for protection of the switch module and the instrument. The current path is maintained at all times, even when the DUT current is switched to the DAQ6510 measurement circuit.

The selection criteria between the two modules are the need to make current measurements and how many additional multiplexer channels are required. If 20 channels or less is adequate, use the 7700 multiplexer module. If more than 20 multiplexer channels are required, select the 7702 multiplexer module.

NUMBER OF CURRENT CHANNELS	CHANNEL MAXIMUM CURRENT	PLUG-IN MULTIPLEXER MODULE	OTHER MODULE FEATURES
2	3A	7700	20-channel multiplexer with CJC sensors
2	3A	7702	40-channel with multiplexer

TIP Keep test lead wires to the DUT as short as possible to reduce the voltage drop due to the current through the test lead resistance. Also be aware of the voltage burden in the DAQ6510 current measurement circuit. The voltage burden for all the 10µA, 100µA, 1mA, 10mA, 20mA, and 100mA ranges is less than 20mV. The voltage burden is over 2V for the upper 1A and 3A ranges. Instrument voltage burden and voltage drop in the test leads adds error to the current measurement.

Switching and Measuring Temperature

Using Thermocouples

To make temperature measurements over the widest range, from -200°C to +1820°C, you need to use thermocouple temperature transducers. The DAQ6510 can measure eight different thermocouple types: type J, K, N, T, E,R, S, and B. Refer to the DAQ6510 datasheet to see the measurement range of each thermocouple type. Type K, with a wide range of -200°C to 1372°C, is a commonly-used thermocouple. Thermocouples need a reference point since they convert temperature to a small voltage. The reference point is a 0°C point known as the cold junction compensation point. The following plug-in modules have cold junction compensation sensors on the module: 7700, 7706, 7708, and 7710.

The selection criteria are the number of thermocouple channels needed and what other functions are needed.

NUMBER OF CHANNELS NEEDED	PLUG-IN SWITCH MODULE	OTHER MODULE FEATURES
Up to 20 channels	7700	2 Current measurement channels
Up to 20 channels	7706	2 Analog outputs, 16 digital outputs, Event totalizer
Up to 20 channels	7710	Solid state relays, scan speed up to 800 channels/s
Up to 40 channels	7708	—

Note that if an external cold junction reference junction is used, then any of the modules used for voltage can be used to switch and measure thermocouple temperatures.

Using Resistance Temperature Detectors (RTDs)

Resistance temperature detectors vary their resistance with changes in temperature. These sensors can measure temperature over a more narrow range than thermocouples. Their range is -200°C to 850°C, and they have much higher accuracy than thermocouples.

Using Thermistors

Thermistors, like RTDs, vary their resistance with changes in temperature. Their range is the most narrow of the three sensors, -80°C to 150°C and their accuracy is a little less than the accuracy of the RTDs. RTDs and thermistors provide the most accurate results when measured using a 4-wire resistance measurement method. Thus the switch modules that make 4-wire resistance measurements are the modules that should be used with RTDs and thermistors.

The first selection decision is based on switch system configuration. If a matrix switch configuration is required, then select the 7709 matrix module.

The selection criteria are the number of channels required and other test requirements listed in the “Other Module Feature” column.

NUMBER OF RTD OR THERMISTOR CHANNELS NEEDED (4-WIRE RESISTANCE DEVICES)	PLUG-IN SWITCH MODULE	CONNECTOR TYPE	OTHER MODULE FEATURES
Up to 5 channels	7707	Multi-pin D-Sub	32 Digital I/O lines
Up to 10 channels	7700	Screw terminal	CJC sensors for thermocouples, 2 Current measurement channels
Up to 10 channels	7706	Screw terminal	2 Analog outputs, 16 digital outputs, event totalizer
Up to 10 channels	7710	Screw terminal	Solid-state relays, up to 800 channels/s scan rate
Up to 16 channels	7703	Multi-pin D-Sub	Reed relays
Up to 20 channels	7702	Screw terminal	2 current measurement channels
Up to 20 channels	7708	Screw terminal	CJC sensors for thermocouples

Table 4. Switch module options for multiplexer-based RTD and thermistor switching.

TIP When selecting a temperature sensor, realize that the thermocouple is typically the most common selection since it is the most rugged, can be located far from the measurement instrument, has a wide temperature range, and is low cost.

RTDs have higher accuracy than thermocouples; but, they are not as rugged as a thermocouple. RTDs also do not have the temperature range of a thermocouple.

Thermistors have good accuracy, and they are low cost. They also have faster response to temperature changes than RTDs. Furthermore, a thermistor has a greater change in resistance for a specific change in temperature compared with an RTD.

SENSOR TYPE	ADVANTAGES	DISADVANTAGES
Thermocouple (TC)	Relatively inexpensive; widest temperature range.	Low output voltage; Must use thermocouple wire to connect; Requires cold junction compensation circuitry.
RTD	Most accurate; wide temperature range.	Low output resistance; requires excitation source.
Thermistor	High output; inexpensive; fast response.	Limited temperature range; poor long-term stability.

Comparison of Temperature Sensors

Switching and Measuring Capacitance

Measuring capacitors, cable capacitance, and pathway capacitance requires sourcing the DUT with a constant current and measuring the voltage ramp, dV/dt . Capacitance is computed as $1/dV/dt$. Any of the modules that are suitable for switching voltage can switch capacitance. A matrix module is not recommended for making capacitance measurements since it is difficult to account for stray capacitance resulting from all the possible pathways through the matrix. The multiplexer switch modules that can measure voltage can be used for capacitance switching and measurement. The multiplexers with mass terminated connectors are the recommended modules for switching and measuring capacitance.

Key selection criteria are the number of channels required and other test requirements listed in the “Other Module Features” column.

NUMBER OF CHANNELS	PLUG-IN SWITCH MODULE	OTHER MODULE FEATURES
Up to 10 channels	7707	32 Digital I/O lines
Up to 32 channels	7701	–
Up to 32 channels	7703	Reed relays

TIP

Capacitance is a difficult measurement to obtain repeatable results, especially through a switching system. Use shielded wiring to the DUTs, and keep wiring as short as possible. Verify the performance of each signal path by testing each channel with a known DUT. Use the DAQ6510 REL function to null out offsets in each channel’s measurement path.

Switching RF Signals

To route RF signals with bandwidths out to 3.5GHz, select either the 7711 RF multiplexer or the 7712 RF multiplexer. Both modules are dual 1x4 multiplexers.

The selection criterion is bandwidth. Select based on the table below.

MAXIMUM SIGNAL BANDWIDTH	PLUG-IN MULTIPLEXER
Up to 2GHz	7711
Up to 3.5GHz	7712

TIP

Use RF cables with SMA connectors to connect to these switch modules. Avoid adapters which can add insertion loss and load mismatch reflections. Minimize cable length to reduce insertion loss and VSWR losses. If minimizing dB loss through the switch system is critical, then use rigid RF cables.

Note: The DAQ6510 only switches RF signals; the DAQ6510 does not measure RF signals.

Switching and Measuring Frequency and Period

The DAQ6510 can measure frequency and its inverse, period, out to 300kHz or down to 3.3µs. Any switch module capable of “switching voltage signals can also switch signals whose frequency or period needs to be measured. The voltage of the signals whose frequency or period must be measured must be less than or equal to the voltage rating of the selected switch module.

Selection Criteria Include:

- Multiplexer or Matrix Configuration
- Number of Channels Required
- Maximum Voltage
- Test Speed
- Relay Life
- Mass terminated connectors or screw terminals
- Other features required

If a matrix configuration is the required test setup, then select the 7709 6x8 matrix.

For a multiplexing configuration, select one of the multiplexers from Table 5.

NUMBER OF CHANNELS REQUIRED	PLUG-IN MULTIPLEXER MODULE	MAXIMUM VOLTAGE	SWITCH SPEED	RELAY LIFE	CONNECTOR TYPE	OTHER MODULE FEATURES
Up to 10 channels	7707	300V	3ms	10 ⁸ closures	Multipin D-Sub	32 Digital I/O lines
Up to 20 channels	7700	300V	3ms	10 ⁸ closures	Screw terminal	CJC sensors, 2 Current channels
Up to 20 channels	7706	300V	3ms	10 ⁸ closures	Screw terminal	2 Analog outputs, 16 Digital outputs, Event totalizer
Up to 20 channels	7710	60V	0.5ms	10 ¹⁰ closures	Screw terminal	Solid-state relays
Up to 32 channels	7701	150V	3ms	10 ⁸ closures	Multipin D-Sub	—
Up to 32 channels	7703	300V	1ms	10 ⁸ closures	Multipin D-Sub	Reed relays
Up to 40 channels	7702	300V	3ms	10 ⁸ closures	Screw terminal	2 Current channels
Up to 40 channels	7708	300V	3ms	10 ⁸ closures	Screw terminal	CJC sensors

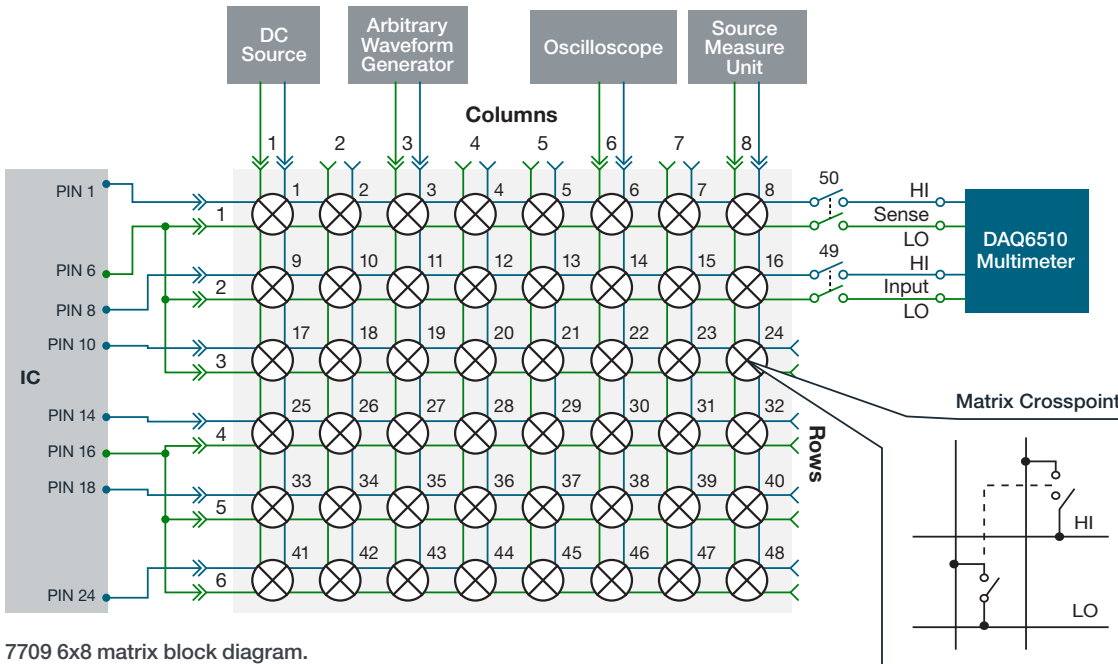
Table 5. 7700 Series Plug-in Multiplexer Modules.

TIP To reduce external interference with these measurements, follow the grounding and shielding recommendations for switching and measuring voltage.

Switching Any Input to Any Output

For testing devices such as an integrated circuit with a number of pins which require inputs for powering and stimulating and outputs that need to be measured, a matrix configuration can be the configuration that best tests the device. The 7709 matrix switch module is a 6 x 8, 2-pole matrix that allows connecting any row to any column. If more than 6 rows or 8 columns are needed, two matrix modules can be connected together to either expand the number of rows to 12 or to expand the number of columns to 16.

The 7709 matrix module can switch voltage, resistance (continuity), RTD and thermistor temperature inputs, and frequency (period).



7709 6x8 matrix block diagram.

Control Actions

In addition to multiplexing and matrix inputs, some 7700-Series modules provide control, digital I/O, event counting, and analog output.

Select the switch module based on the control requirements for the test system.

FUNCTION	PLUG-IN SWITCH MODULE	OTHER MODULE FEATURES
32 channels of digital Input and output	7707	10 channel multiplexer
16 channels Digital Output 2 channels, Analog Output 1 Event Counter	7706	20 channel multiplexer with CJC sensors
40-channel Control	7705	Independent SPST relays

For more information on multi-channel testing please visit www.tek.com

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