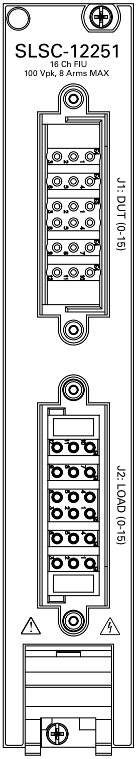
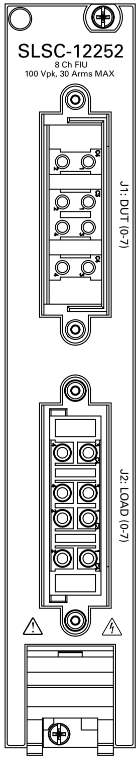
USER MANUAL

SLSC-12251 and SLSC-12252

Fault Insertion Unit, 16 CH, 8 Amps and 8 CH, 30 Amps





Contents

NATIONAL INSTRUMENTS™

Overview

This document contains information about the SLSC-12251 (16 channel, 8 amperes) and SLSC-12252 (8 channel, 30 amperes) Fault Insertion Units (FIU). The SLSC-12251 and SLSC-12252 are switch matrices with current monitoring, which allows for connections from each channel to any of the following: Bus A, Bus B, a load, or a paired channel. These devices also provide a voltage that is proportional to the current through the channel. This voltage can be measured with another device.

Driver Support

Earliest driver support version for the SLSC-12251 and SLSC-12252.

Table 1. SLSC-12251 and SLSC-12252 Driver Support

Driver	Earliest Version Support
NI-SLSC	18.5

Cables and Accessories

The following table lists cables and accessories available for your SLSC device. For a complete list of accessories and ordering information, refer to ni.com.

Table 2. SLSC-12251 and SLSC-12252 Cables and Accessories

Cable/Accessory	Compatibility	Part Number
RTI-12306	SLSC-12251 and SLSC-12252	785378-01
TB-12396	SLSC-12251	786640-01
TB-12397	SLSC-12251 (<33 V_{dc})	786639-01
TB-12398	SLSC-12252	786638-01

Table 2. SLSC-12251 and SLSC-12252 Cables and Accessories (Continued)

Cable/Accessory	Compatibility	Part Number
TB-12399	SLSC-12252 (<33 V_{dc})	786446-01
SP18M-SP18F Cable	SLSC-12251	147945-01
SP8M-SP8F Cable	SLSC-12252	148299-01

Safety Guidelines

Caution Observe all instructions and cautions in the user documentation. Using the model in a manner not specified can damage the model and compromise the built-in safety protection. Return damaged models to NI for repair.

Safety Voltages

Connect only voltages that are below these limits.

Channel-to-channel isolation	
Continuous working voltage[1]	100 V peak
Channel-to-earth isolation	
Continuous working voltage	100 V peak
Transient overvoltage[2]	920 V peak

Caution If you are using the SLSC-12251/12252 with voltages greater than 60 V_{dc}, the SLSC chassis must be made touch safe by panel mounting it in a closed rack to prevent user access to the rear of the device.

These test and measurement circuits are rated for measurements performed on circuits not directly connected to the electrical distribution system referred to as MAINS.

MAINS is a hazardous live electrical supply system to which equipment is designed to be connected to for the purpose of powering equipment. This product is rated for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

[1] Working voltage rating is the highest RMS value of the AC or DC voltage across the insulation that can continuously occur when the equipment is supplied at rated voltage.

[2] The short duration overvoltage of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped.

EMC Guidelines

This product was tested and complies with the regulatory requirements and limits for electromagnetic compatibility (EMC) stated in the product specifications. These requirements and limits provide reasonable protection against harmful interference when the product is operated in the intended operational electromagnetic environment.

This product is intended for use in industrial locations. However, harmful interference may occur in some installations, when the product is connected to a peripheral device or test object, or if the product is used in residential or commercial areas. To minimize interference with radio and television reception and prevent unacceptable performance degradation, install and use this product in strict accordance with the instructions in the product documentation.

Furthermore, any changes or modifications to the product not expressly approved by National Instruments could void your authority to operate it under your local regulatory rules.

Notice To ensure the specified EMC performance, operate this product only with shielded cables and accessories.

Notice To ensure the specified EMC performance, the length of all I/O cables must be no longer than 3 m (10 ft).

Environmental Characteristics

Temperature and Humidity

Operating temperature	0 °C to 40 °C[3]
Storage temperature range	-40 °C to 85 °C
Operating relative humidity range	10% to 90%, noncondensing
Storage relative humidity range	5% to 95%, noncondensing
Pollution Degree	2
Maximum altitude	2,000 m (800 mbar) (at 25 °C ambient)

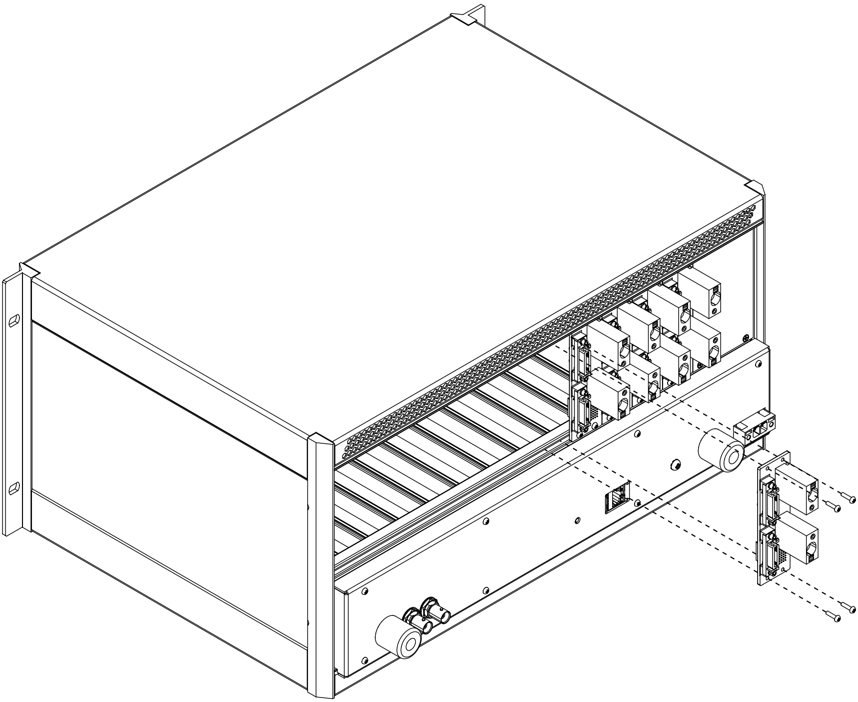
Shock and Vibration

Operating shock	30 g peak, half-sine, 11 ms pulse
Operating vibration, random	5 Hz to 500 Hz, 0.3 g_{rms}
Non-operating vibration, random	5 Hz to 500 Hz, 2.4 g_{rms}

[3] The chassis internal ambient temperature may reach 85 °C with all slots at the maximum allowed power dissipation. In the SLSC-12001 chassis this corresponds to an external ambient of 40 °C.

Installing the SLSC-12251/12252 and RTI-12306

Figure 1. Installing the RTI-12306 into the SLSC Chassis



Caution Do not touch the contacts or remove the I/O boards or cables while the system is energized.

Note Install the SLSC-12251/12252 module and its corresponding RTI-12306 in the chassis at the same time to ensure proper mating alignment. Complete the following procedure to ensure proper installation of the module and RTI-12306.

1. Power off the main DC power source or disconnect the power source from the chassis before installing any modules or RTIs.
2. Ensure that the chassis is powered off. The POWER LED should be off. If the POWER LED is not off, do not proceed until it is off.

   Notice The SLSC chassis and the SLSC-12251/12252 do not support hot plug-in. The entire chassis must be powered off when a module is inserted or removed.

3. Loosen the screws on the upper rear panel of the chassis.

4. Position the RTI-12306 at the desired slot and insert the securing screws, but do not fully tighten them.
5. Insert an SLSC-12251/12252 module into the same slot as its corresponding RTI-12306 while firmly holding the RTI-12306 in place until the RTI-12306 is firmly connected to the module.
6. Repeat steps 4 and 5 for all required RTIs.
7. Fully tighten the screws for all RTIs and the upper rear panel of the chassis.

   Note Waiting until all RTIs and modules are installed to fully tighten the screws ensures proper alignment for future connections between modules and RTIs.
8. Fully tighten the two module mounting screws on each newly installed module.
9. Power on the SLSC chassis.

Getting Started with Software

Use the following three examples to familiarize yourself with the NI-SLSC API. These examples can be found at file path `<LabVIEW installation path>\examples\SLSC\Example Modules\`[4] or in `Example Finder: Example Finder>>SLSC>>NI Module Examples`.

SLSC-12251 & 12252 FIU Module Configuration.vi

This VI demonstrates how to use the NI-SLSC API to configure the switches of the SLSC-12251 and SLSC-12252 FIU modules.

SLSC-12251 & 12252 FIU Module Fault Monitor.vi

This VI demonstrates how to use the NI-SLSC API to find specific fault locations on the SLSC-12251 and SLSC-12252 FIU modules when a fault occurs.

SLSC-12251 & 12252 FIU Module Current Sensing.vi

Use this conceptual example to integrate current sensing functionality into your own system.

Note To use this VI you must connect a voltage measurement device to the RTI that is attached to the module.

I/O Organization

DUT connector J1 is the input connection to each channel. LOAD connector J2 is the output connection to each channel. Bus A and Bus B are common connections available to all channels through the RTI-12306.

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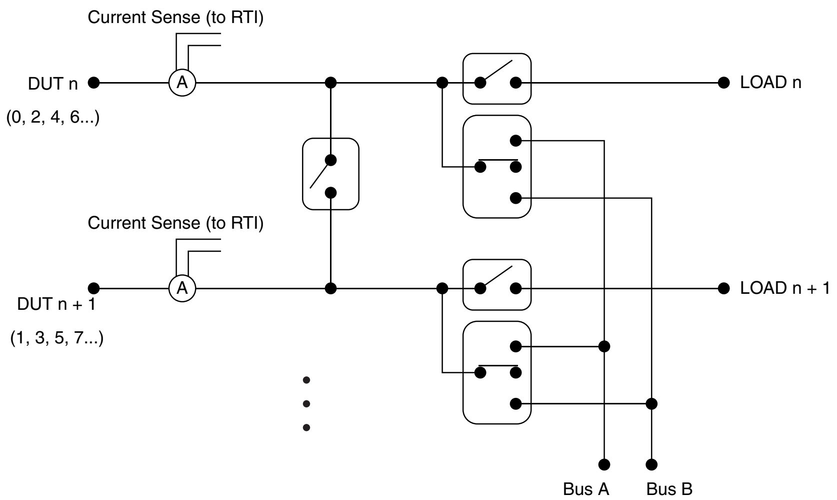
[4] A common installation path for the 32-bit version of LabVIEW is `C:\Program Files (x86)\National Instruments\LabVIEW xxxx\examples\SLSC\Example Modules\`.

Each switch is organized into two physical channels, Channel_n and ChannelPair_n, where the range of n is defined in the following table.

Table 3. Range of Channel Index n

Physical Channel	Connections	SLSC-12251	SLSC-12252
Channel_n	DUTn to LOADn, Bus A, or Bus B	0:15	0:7
ChannelPair_n	DUTn to DUTn+1, where n is even	0:7	0:3

Figure 2. Channel Connection Pairs



Note All switches are open during power-up and after the module is reset.

Properties

Table 4. Fault Monitoring Properties

Property Name	Data Type	Property Type	Description
NI.FIU.BoardFault	Boolean	Device	True when there is any fault on the board.
NI.FIU.BoardFault.BoardOverTemperature	UInt32	Device	Starting with the LSB, each bit represents one of the board's 4 quadrant digital temperature sensors, true when that sensor exceeds the high temperature digital setpoint.
NI.FIU.BoardFault.OverTemperatureOnChannel	UInt32	Device	Starting with the LSB, each bit represents a channel, true when that channel's analog temperature sensors exceed the high temperature analog transition range.
NI.FIU.BoardFault.OverTemperatureOnChannelToChannel	UInt32	Device	Starting with the LSB, each bit represents a channel pair, true when that channel pair's analog temperature sensor exceeds the high temperature analog transition range.
NI.FIU.BoardFault.OvercurrentOnBusA	Boolean	Device	True when Bus A exceeds the Bus High Current Limit for longer than its delay time.
NI.FIU.BoardFault.OvercurrentOnBusB	Boolean	Device	True when Bus B exceeds the Bus High Current Limit for longer than its delay time.

Table 4. Fault Monitoring Properties (Continued)

Property Name	Data Type	Property Type	Description
NI.FIU.BoardFault.OvercurrentHigh	UInt32	Device	Starting with the LSB, each bit represents a DUT channel, true when that DUT channel exceeds the DUT High Current Limit for longer than its delay time.
NI.FIU.BoardFault.OvercurrentLow	UInt32	Device	Starting with the LSB, each bit represents a DUT channel, true when that DUT channel exceeds the DUT Low Current Limit for longer than its delay time.

Table 5. Measurement Properties

Property Name	Data Type	Property Type	Description
NI.FIU.Calibration.Date	Double	Device	Time, in seconds elapsed since 12:00 a.m., Friday, January 1, 1904, Universal Time, of the last calibration date of the device.
NI.FIU.Calibration.ExpirationDate	Double	Device	Time, in seconds elapsed since 12:00 a.m., Friday, January 1, 1904, Universal Time, the next recommended calibration date of the device.
NI.FIU.CurrentTransducer.Gain	Double	Physical Channel: Channel_n	The gain used to calculate the current from the current transducer, based on the voltage input.

Table 5. Measurement Properties (Continued)

Property Name	Data Type	Property Type	Description
NI.FIU.CurrentTransducer.Offset	Double	Physical Channel: Channel_n	The offset used to calculate the current from the current transducer, based on the voltage input.
NI.FIU.TemperatureSensorN	Double	Device	Degrees Celsius of the board's 4 quadrant digital temperature sensors (0:3).

Table 6. Switch Control Properties

Property Name	Data Type	Property Type	Description
NI.FIU.Preset.BusSource	Int32, String	Physical Channel: Channel_n	Allows pre-setting DUT channel connectivity to Bus A, Bus B or none. An Update command is required for the change to take place. Enumeration: 0 : "NoBus" : Channel is not connected to any Bus 1 : "BusA" : Channel is connected to Bus A 2 : "BusB" : Channel is connected to Bus B
NI.FIU.Preset.InterChannel	Int32, String	Physical Channel: ChannelPair_n	Allows pre-setting DUT channel connection to its partner channel. An Update command is required for the change to take place. Enumeration: 0 : "IndependentChannels" : Channel n is not connected to n + 1 1 : "ConnectedChannels" : Channel n is connected to n + 1

Table 6. Switch Control Properties (Continued)

Property Name	Data Type	Property Type	Description
NI.FIU.Preset.Load	Int32, String	Physical Channel: Channel_n	Allows pre-setting DUT channel connectivity to its load. An Update command is required for the change to take place. Enumeration: 0 : "NoLoad" : Channel is not connected to its Load 1 : "Load" : Channel is connected to its Load
NI.FIU.Update	N/A	Command	Executing this command allows the channel to change to the preset values.
NI.FIU.State.BusSource	Int32, String	Physical Channel: Channel_n	Read-only property that represents the actual connection states for a channel. See Preset property for enumeration.
NI.FIU.State.InterChannel	Int32, String	Physical Channel: ChannelPair_n	Read-only property that represents the actual connection states for a channel pair. See Preset property for enumeration.
NI.FIU.State.Load	Int32, String	Physical Channel: Channel_n	Read-only property that represents the actual connection states for a channel. See Preset property for enumeration.

Table 7. Version Control Property

Property Name	Data Type	Property Type	Description
NI.FIU.ModuleControllerVersion	UInt32	Device	Read only Module Controller Version number.

Fault Monitoring and Identification

The module continuously senses the current and temperature throughout the channels of the board. If any current or temperature exceeds the specified limits, a fault is declared and the `NI.FIU.BoardFault` Boolean property is set to true. When a fault is detected, all switches are opened, which stops all current and prevents damage to the module. The module must be reset to clear the fault condition. Any attempt to change a switch's state after a fault will error out if the module is not reset first.

Poll the `NI.FIU.BoardFault` property during normal operation to check if a fault condition exists.

After a fault condition occurs, when the `NI.FIU.BoardFault` property is true, you can identify the specific fault condition by reading the `NI.FIU.BoardFault.*` properties.

Note Values for fault currents, duration, and temperature limits can be found in the *SLSC-12251 Specifications* and *SLSC-12252 Specifications*.

Measuring the Current

Uncalibrated differential voltage signals that are proportional to the DUT channel's current are available on the RTI-12306 connector, which allows the signals to be measured by another device. The external voltage measurement can be used with each channel's stored gain and offset coefficients to calculate the calibrated current as follows:

I(Amps) = `NI.FIU.CurrentTransducer.Gain` × $V_{measured}$+ `NI.FIU.CurrentTransducer.Offset`

where `NI.FIU.CurrentTransducer.Gain` and `NI.FIU.CurrentTransducer.Offset` are properties of Channel_n.

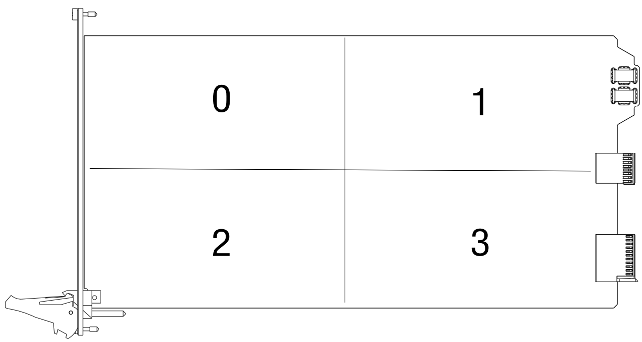
Note It is important to use the corresponding channel offset and gain for the current sensors because the values are adjusted to meet the specified accuracy.

Measuring the Temperature

The module's four digital temperature sensors measure the temperature conditions in the board. For temperature measurement, read the `NI.FIU.TemperatureSensorN` property where N = 0,1,2,3.

The physical locations of the temperature sensors are as follows:

Figure 3. Temperature Sensor Locations on SLSC-12251 and SLSC-12252 Boards



Switch Control

Change the state of a switch by completing the following steps:

1. Preset the new state of the switch by setting the `NI.FIU.Preset*` properties for each physical channel `Channel_n` and `ChannelPair_n`. There is no limit to the number of preset switch states that can be written, but subsequent writes to the same physical switch will overwrite any previous values.
2. After completing all preset writes, update the switch state with the `NI.FIU.Update` command.
3. The device will transition the switch states in the following sequence, starting at t = 0 ms upon execution of the `NI.FIU.Update` command.

t = 0.12 ms	Connect LOADs to DUTs
t = 0.32 ms	Disconnect DUTs from BusA/B and pair channels
t = 0.52 ms	Connect DUTs to BusA/B and pair channels
t = 0.72 ms	Disconnect LOADs from DUTs

4. The current state of the switch can be confirmed by reading the `NI.FIU.State.*` properties.

Modifying the `NI.FIU.Preset*` properties will not change the state of the switch. A switch transition on the pending preset values is only triggered upon execution of the `NI.FIU.Update` command. This allows concurrent switch operations in different physical channels.

Calibration

The factory calibration values for each channel's gain and offset coefficients may be overwritten by the user. NI recommends calibrating the board under the following conditions:

1. Power on the module for at least one hour. Ensure that normal air flow is unblocked around the SLSC chassis. Leave at least one switch closed during this time. Validate that the switch is closed by reading back the `NI.FIU.State.*` properties, which ensures the board is operating as expected.
2. Use one of the below paths to calibrate the device:
   - DUTn to Bus A
   - DUTn to Bus B
   - DUTn to LOADn
3. Close the chosen channel and provide a known DC current through that path.

4. Record the applied current value and the corresponding differential voltage output for that channel.

   Note Averaging data in multiples of 0.1 seconds helps remove 50 Hz or 60 Hz noise.

5. Repeat the previous step at five or more DC current points from ±8 A on the SLSC-12251 and ±30 A on the SLSC-12252.
6. Repeat Step 3 and Step 4 for all channels.
7. Use the data for a least squares fit to determine the gain and offset coefficients.
8. Read back and save the capabilities section of the Non-Volatile Memory (NVMEM).
9. Modify the saved data in the following ways:
   a. Update the `NI.FIU.CurrentTransducer.Offset` and `NI.FIU.CurrentTransducer.Gain` property values of each channel for which the calibration values were measured.
   b. Use the "Get Time/Date in Seconds" VI to generate the timestamp in double format to write to the `NI.FIU.Calibration.Date` property.
   c. Add the number of seconds of the calibration interval to the timestamp to generate the value to write to the `NI.FIU.Calibration.ExpirationDate` property.
10. Write the modified data back to the capabilities section of the device's NVMEM. Use the device's serial number and the password `ni` to write this section.

Driving Inductive Loads

When a channel is providing current to an inductive load and the current is interrupted by opening the switch, the inductor voltage rapidly increases due to $V_{inductor} = L\ di/dt$. This inductive kickback, or flyback voltage, is usually limited by placing a catch diode across the inductor. If a catch diode is not used, the FET switch will enter Avalanche breakdown. Avalanche breakdown occurs when the flyback voltage exceeds approximately 120% of its rated breakdown voltage $V_{(BR)DSS}$.

When using an inductive load with no catch diode, it is possible to generate voltages on the LOAD terminals in excess of 120 V, even if a non-hazardous voltage level is driving the inductor.

In addition to the hazard of generating high voltages in a low voltage system, Avalanche breakdown operation is also limited by the energy dissipation available per switch event.

Note Refer to the *SLSC-12251 Specifications* and *SLSC-12252 Specifications* for specific values related to Avalanche breakdown operation.

This energy is lower than the 25 °C specifications rating of the FET because the SLSC chassis can reach internal temperatures of up to 85 °C. Using this energy rating and the Avalanche test current I_{AV} of 150 A from the FET datasheet, the test inductance used to determine the Avalanche characteristics can be found using the following equation:

$$E_{AS} = \frac{1}{2}L \times (I_{AS})^2$$

where E_{AS} = 300 mJ and I_{AS} = 150 A, giving L = 0.0267 mH.

The temperature rise in the FET switch is given from the following equation:

$$\Delta T_M = F_2 \times i(0)^{\frac{3}{2}} \times L^{\frac{1}{2}}$$

where F_2 is a constant, and i(0) is the initial inductor current.

Use this equation once for the datasheet test case where I = 150 A and L = 0.0267 mH. Use this equation again for the inductor and max current used on the actual load. By equating the temperature rise for these two use cases, the constant F_2 cancels, and the maximum current for a given load inductance can be determined using the following equation:

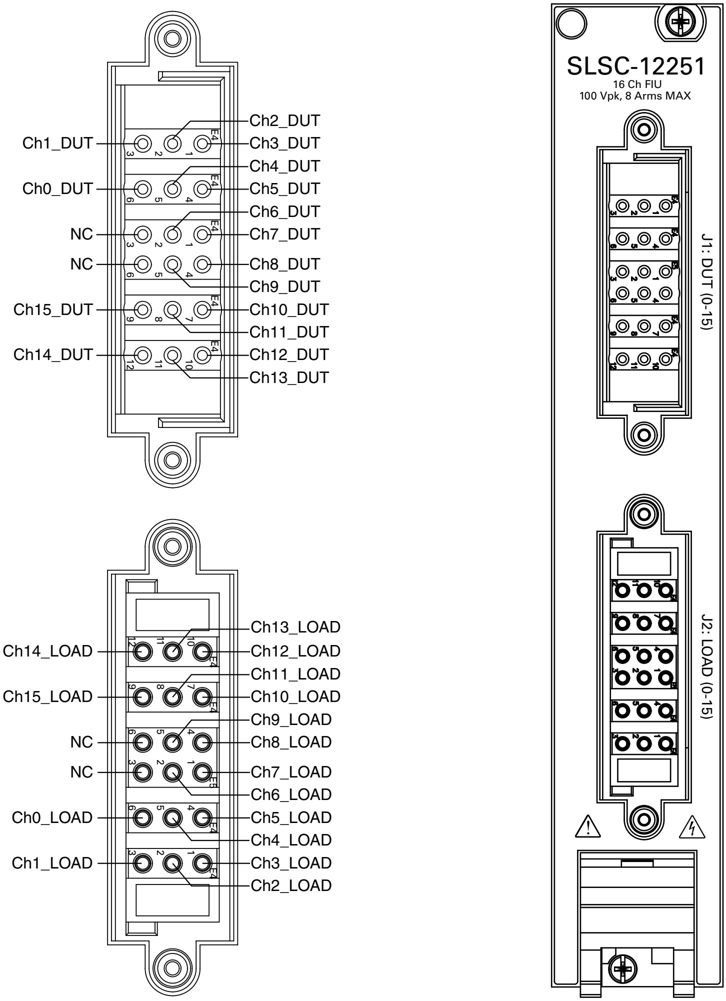
$$IL_{MAX} = 150A \times \left(\frac{0.0267mH}{L_{Load}}\right)^{\frac{1}{3}}$$

where L_{LOAD} is in mH.

For example, IL_{MAX} = 9.65 A with a 100 mH inductor. The FET switch will be damaged if more than this current is actively interrupted while driving this inductor.

Pinouts

Figure 4. SLSC-12251 Pinout



Note The input to each channel is Chx_DUT. The output to each channel is Chx_LOAD. NC indicates not connected and should not be used.

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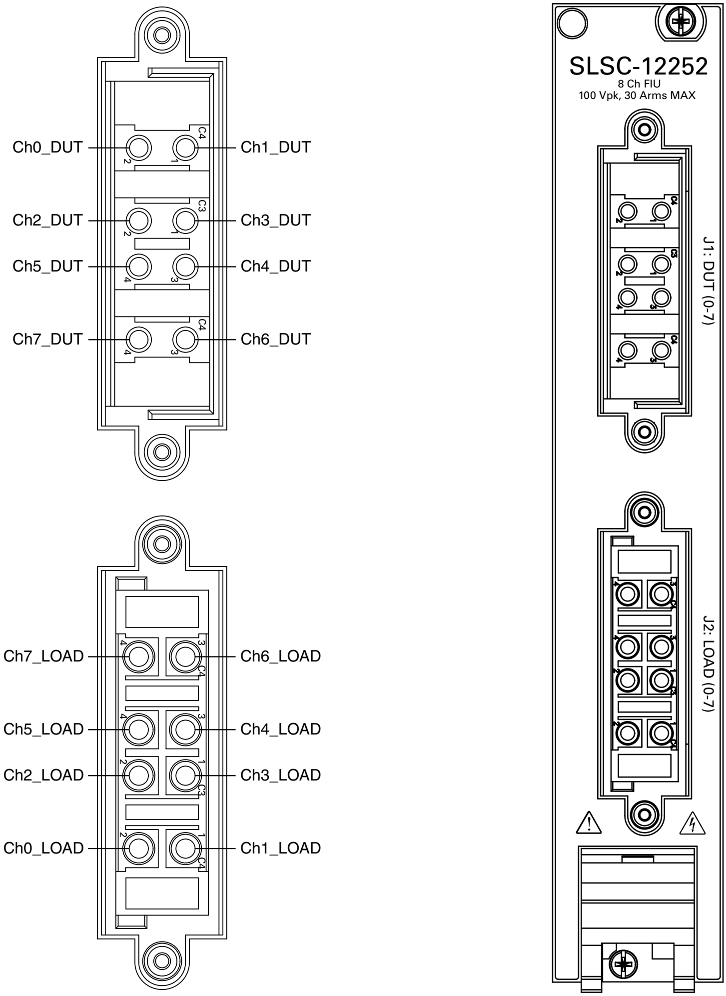
Figure 5. SLSC-12252 Pinout



Note The input to each channel is Chx_DUT. The output to each channel is Chx_LOAD. NC indicates not connected and should not be used.

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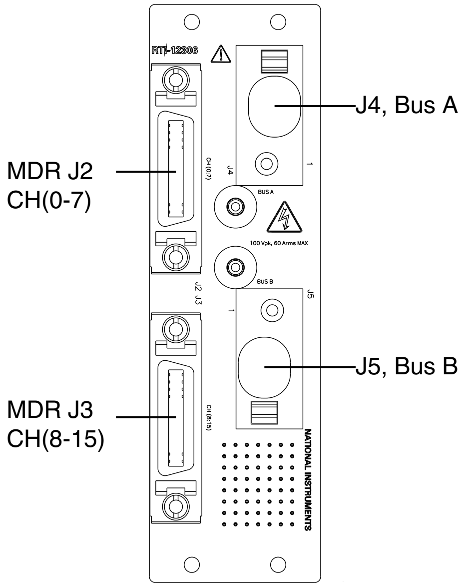
Accessories

RTI-12306

The RTI-12306 is the required rear transition interface for use with SLSC-12251 and SLSC-12252 devices. The RTI-12306 provides connections to Bus A, Bus B, and all current sensor outputs through the MDR connectors.

RTI-12306 Front View

Figure 6. RTI-12306 Front View



RTI-12306 Bus Connections

Wire gauge	6 AWG to 18 AWG (NI recommends using a stranded wire with a ferrule or a solid core wire.)
Maximum voltage	100 V_{peak}
Maximum current	60 A_{rms}

RTI-12306 MDR Pinout

Figure 7. RTI-12306 MDR Pinout

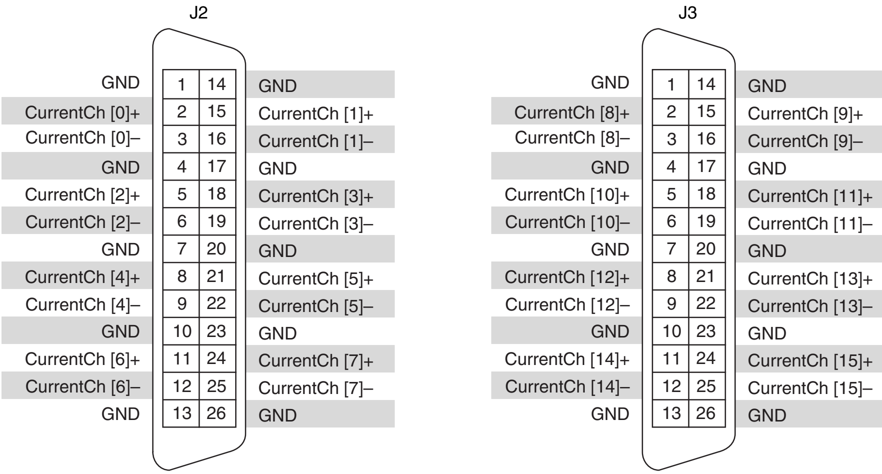


Table 8. RTI-12306 MDR Pinout Signal Descriptions

Signal	Description
CurrentCh[n]+	Voltage proportional to current on Channel_n, plus common mode voltage. The full scale range is ±2 +2.5 V.
CurrentCh[n]–	Common mode voltage of Channel_n (2.5 V).
GND	Ground reference for all signals.

Terminal Blocks

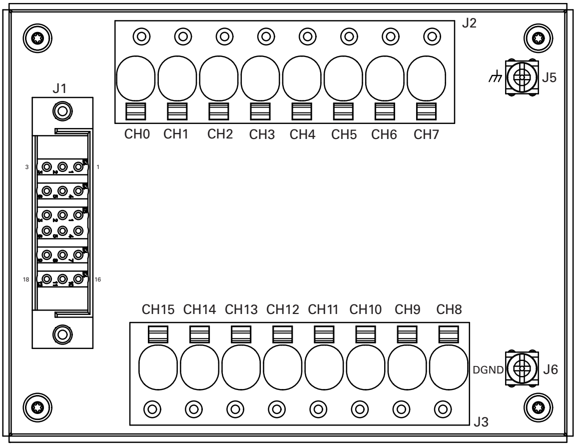
The following terminal blocks connect to the LOAD connectors on the SLSC-12251/12252 through SPxM-SPxF cables and provide easy spring terminal connections to the LOAD channels. The low voltage (<33 V) terminal block options also provide an HD44 connection for routing low current sense LOAD signals to an SLSC-12201 module.

On all terminal blocks, terminal J5 can be used for Chassis Ground, which is tied to the metal case standoffs and connector jack-sockets. Terminal J6 is DGND, which is the GND reference of the signals on the HD44 connector.

TB-12396

The TB-12396 is a terminal block for use with SLSC-12251 devices.

Figure 8. TB-12396 Front View



TB-12397

The TB-12397 is a terminal block for use with the SLSC-12251 when all signals are <33Vdc. The HD44 connector J4 allows for sense connections (low current only) of the channels to another device such as the SLSC-12201.

Figure 9. TB-12397 Front View

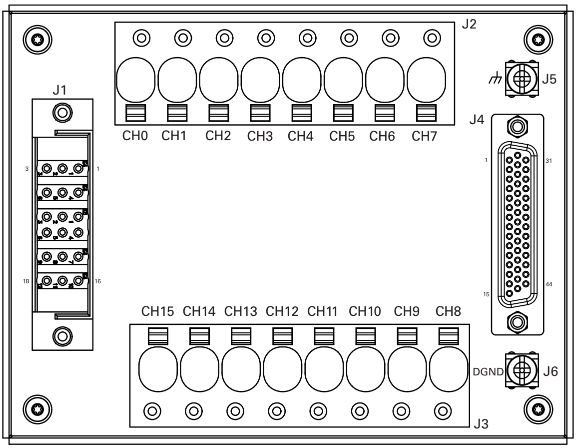
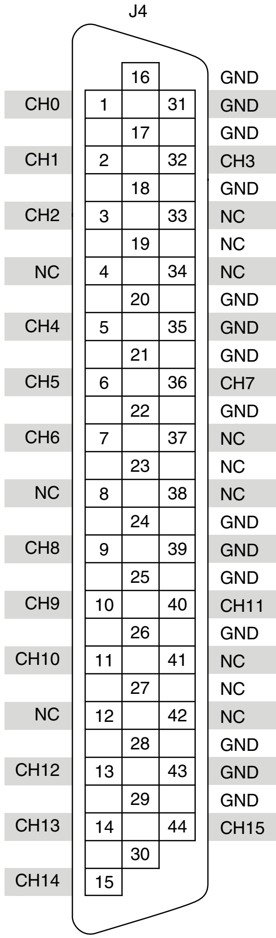


Figure 10. TB-12397 DSUB Pinout

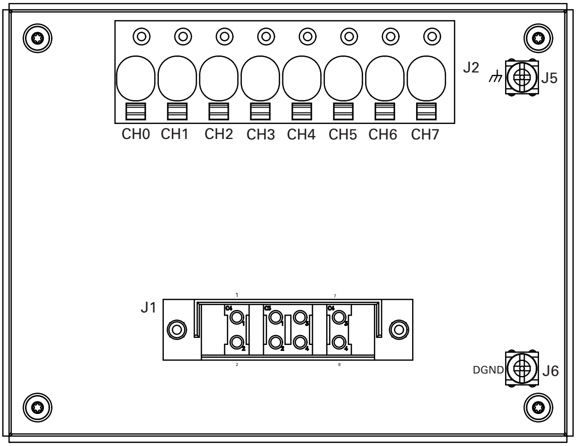


Note NC indicates not connected and should not be used.

TB-12398

The TB-12398 is a terminal block for use with SLSC-12252 devices.

Figure 11. TB-12398 Front View



TB-12399

The TB-12399 is a terminal block for use with the SLSC-12252 when all signals are <33Vdc. The HD44 connector J4 allows for sense connections (low current only) of the channels to another device such as the SLSC-12201.

Figure 12. TB-12399 Front View

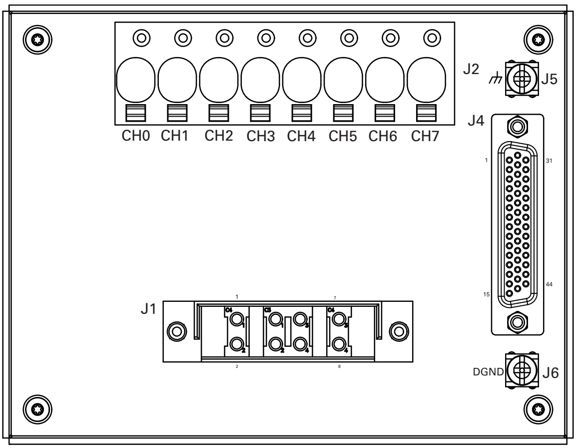
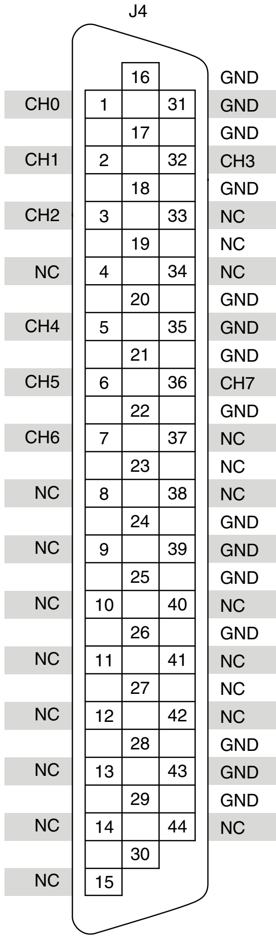


Figure 13. TB-12399 DSUB Pinout



Note NC indicates not connected and should not be used.

Panel Mounting a Terminal Block

The TB-12396, TB-12397, TB-12398, and TB-12399 come pre-equipped with a removable DIN rail clip for mounting to a standard DIN rail. The terminal blocks can also be rear panel mounted using the provided pattern of M4 x 0.7 threaded holes.

Figure 14. Terminal Block with DIN Rail Clip

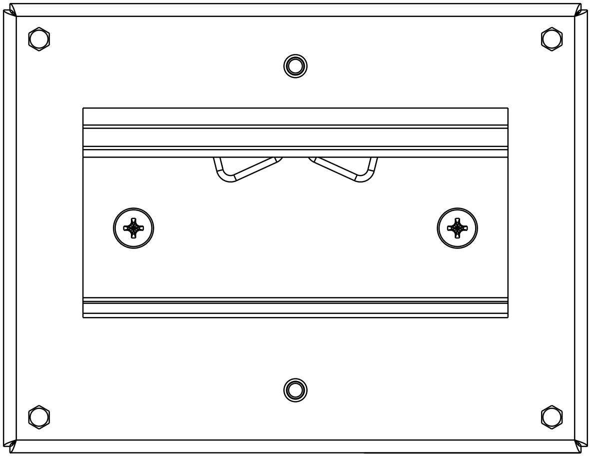
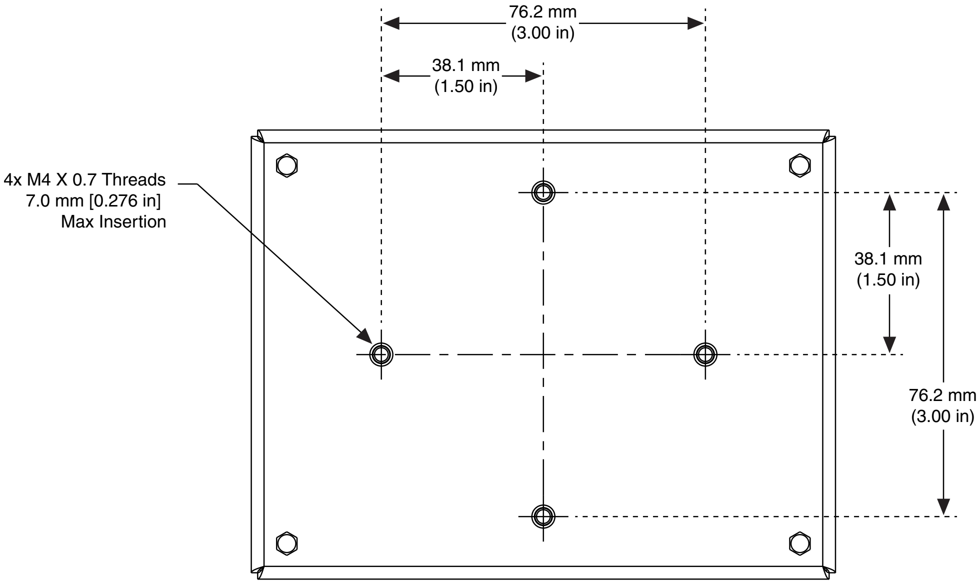


Figure 15. Terminal Block Rear Hole Pattern



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