BTS-16101 Specifications

2025-03-10

Contents

BTS-16101 Specifications

Definitions

Warranted specifications describe the performance of a model under stated operating conditions and are covered by the model warranty. Warranted specifications account for measurement uncertainties, temperature drift, and aging. Warranted specifications are ensured by design or verified during production and calibration.

Characteristics describe values that are relevant to the use of the model under stated operating conditions but are not covered by the model warranty.

- ***Typical*** specifications describe the performance met by a majority of models.
- ***Nominal*** specifications describe an attribute that is based on design, conformance testing, or supplemental testing.
- ***Measured*** specifications describe the measured performance of a representative model.

Specifications are ***Typical*** unless otherwise noted.

Conditions

Specifications are valid for the system and all included instruments under the following conditions unless otherwise noted.

- Battery Test System environmental characteristics are met
- Battery Test System Software Suite 2.0 or later
- Connection to a computer with a monitor, keyboard, and mouse that satisfies the minimum requirements of the Battery Test System Software Suite
- Instrument-level conditions are met

Instrument performance is defined in the instrument specification document. Refer to the instrument specification document for the full set of specifications and information.

Hardware Reference

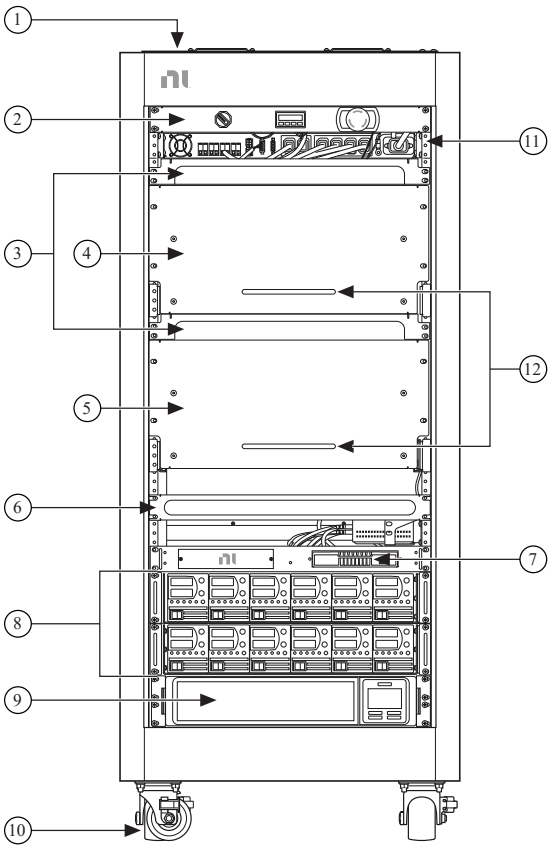
This section describes the location and function of hardware contained within the BTS-16101 measurement rack.

Measurement Rack Component Locations

Refer to the following figures to locate the BTS-16101 measurement rack components.

Note Your measurement rack configuration may vary from the following figures depending on the optional components in your system.

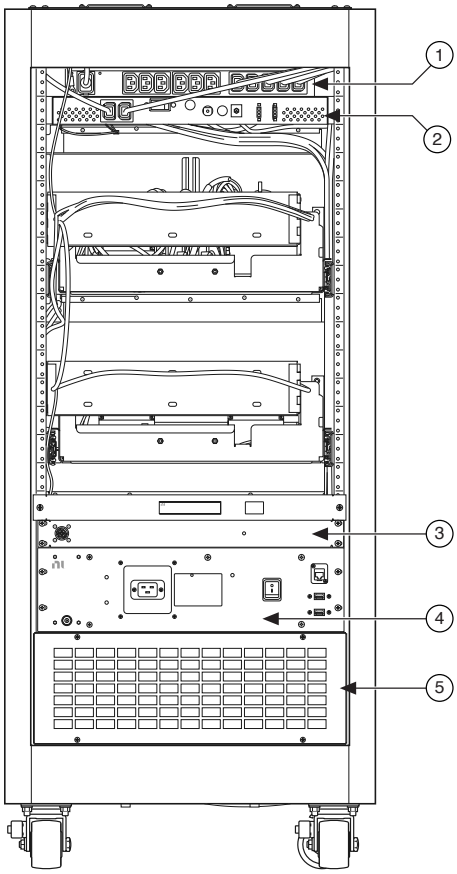
Figure 1. BTS-16101 Front View



1. Fan Panel
2. Emergency Power Off (EPO) Panel
3. 1U Open-Bottom Brush Panel Cable Entry
4. Primary Drawer
5. Secondary Drawer

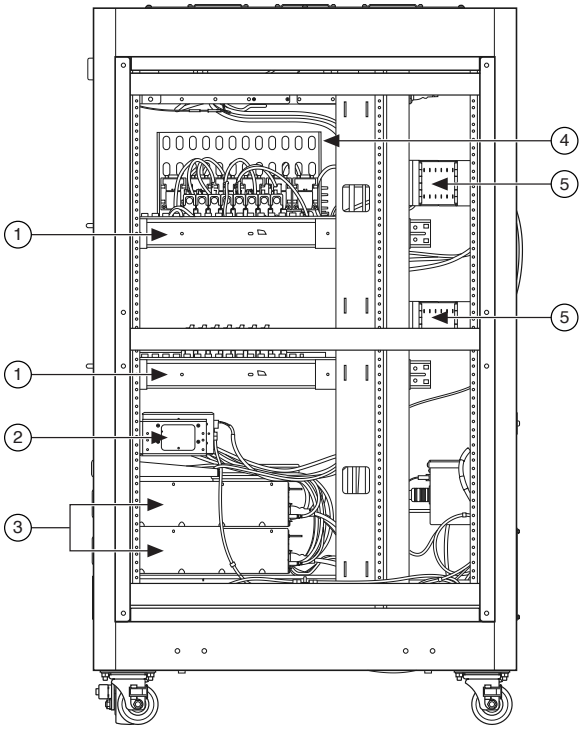
6. 1U Brush Cable Entry
7. GPIB-RS232
8. RMX-4101 Power Supplies
9. Uninterruptible Power Supply (UPS)
10. Industrial Casters
11. Power Distribution Unit (PDU)
12. Drawer Handles

Figure 2. BTS-16101 Rear View



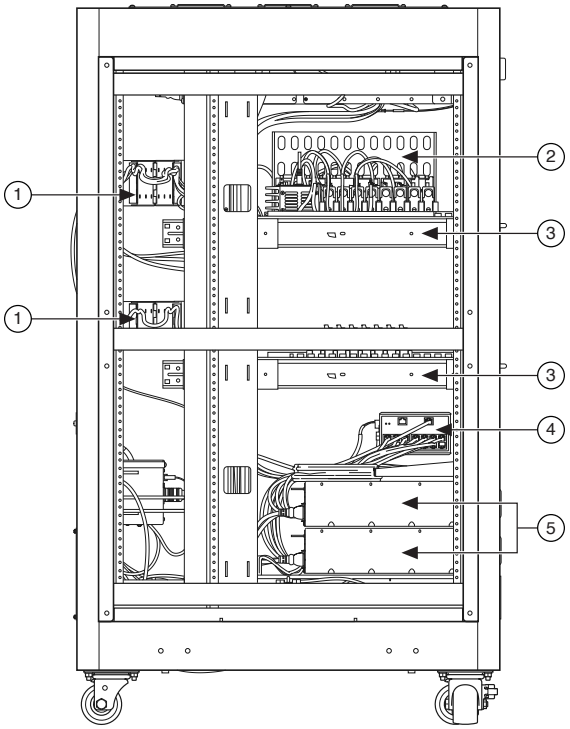
1. Auxiliary PDU
2. PDU
3. Remote EPO Connector Panel
4. 3U Power Entry Panel (PEP)
5. 4U Air Inlet Panel

Figure 3. BTS-16101 Right Side View



1. Drawer Slides
2. Ethernet Switch
3. RMX-4101 Power Supplies
4. Transceiver Cable (TRC) Mounting Brackets
5. Articulating Cable Arm

Figure 4. BTS-16101 Left Side View



1. Articulating Cable Arm
2. Transceiver Cable (TRC) Mounting Brackets
3. Drawer Slides
4. Ethernet Switch
5. RMX-4101 Power Supplies

Measurement Rack Component Features

Refer to the following topics for information on function of the components in the BTS-16101 measurement rack.

- Power Entry Panel
- Emergency Power Off Panel
- Remote EPO Connector
- Measurement Rack Drawers
- Measurement Rack Power
- Measurement Rack Ethernet Networking

Power Entry Panel

Figure 5. Power Entry Panel (PEP) Front and Rear View

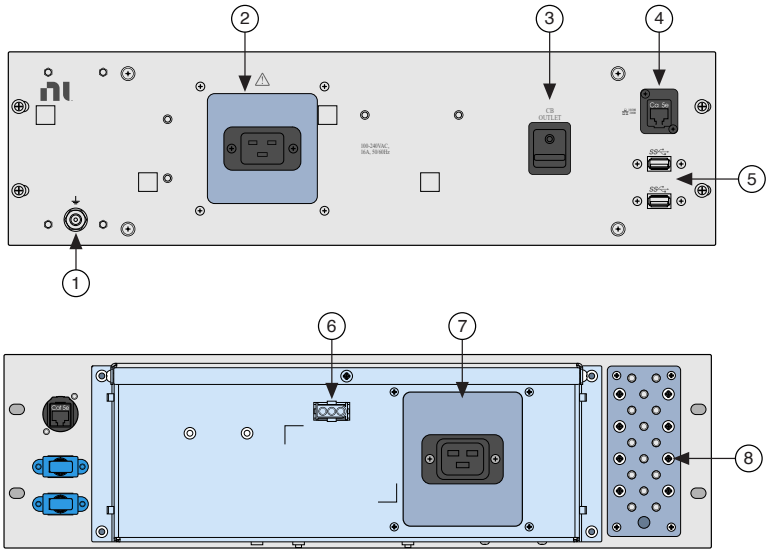


Figure Callout	Description	Use
1	Protective Earthing Ground Stud	Provides internal grounding plate connections with the external grounding lug for all rack mount equipment. High levels of leakage current may be present on the measurement rack. Connect the measurement rack to the protective earth terminal before connecting to AC power. Refer to the ***BTS-16101 Battery Test System Measurement Rack Safety, Environmental, and Regulatory Information*** document for specifications for protective earth terminal wiring. **Note** The facility installation shall provide a means for connection to

Figure Callout	Description	Use
		protective earth, and qualified personnel shall install a protective earthing conductor from the BTS-16101 protective earthing terminal to the protective earth wire in the facility.
2	Power Inlet Connector	Provides a low power (IEC 60320 C20) power entry.
3	Main Breaker (CB Outlet)	Provides circuit protection as a main breaker by controlling whether AC power will be allowed into the rack. If the Main Breaker switch is off, the rack cannot be powered on.
4	Ethernet Port	Facilitates network connectivity to internal equipment. The Gigabit Ethernet port connects to the cRIO-9047 controller.
5	USB 3.0 Ports (x2)	Provides access to extension cables within the rack. The internal USB extension cables ship unterminated for user-customizable connection to internal equipment. Use the USB cables that are included in the kit for external connection.
6	DC Output to EPO Panel	Provides DC power and inhibit control to/from the EPO panel.
7	Output Connector	Provides AC output to the uninterruptible power supply (UPS).
8	Grounding Plate	Provides a connection point for

Figure Callout	Description	Use
		the measurement rack ground.

The PEP also includes a line filter for EMI protection within the system.

Emergency Power Off Panel

When a test system encounters a serious issue or an emergency is taking place in the facility, operators need the ability to quickly and cleanly power off the test system. The emergency power off (EPO) panel mechanisms are included on the measurement rack to simplify connectivity and inhibit power switching.

Operators can use the EPO to reset a system in an error state, prevent damage to a DUT, or prevent harm to themselves.

Figure 6. EPO Panel

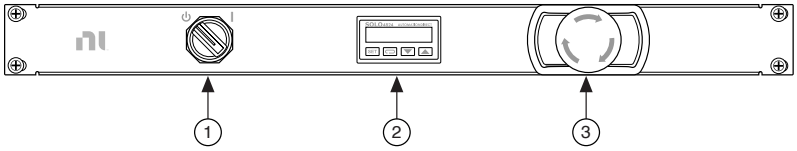


Figure Callout	Description	Use
1	Main Power Switch	Provides the primary way of controlling whether the system is active. It toggles between two positions—Standby (⏻) and On (❙). Learn more about these states in Measurement Rack Power States.
2	Temperature Controller (AutomationDirect SL4824-RR-D)	Measures temperature based on the location of the attached thermocouple. **Notice** When temperature setpoint is reached, the temperature controller does not move the system into a shutdown state.
3	Emergency Power Off Button	Provides a way to control whether the system is powered. The following behavior occurs when you press the EPO button:

Figure Callout	Description	Use
		• The EPO immediately cuts AC power from the power entry panel (PEP) and power distribution unit (PDU) when a user or system monitor recognizes an unacceptable operating condition. The uninterruptible power supply (UPS) remains powered so that the measurement instruments in the rack continue logging data. DC power is passing out of the PEP and into the thermostat EPO panel, as described in Measurement Rack Power States. • The remote EPO connector is triggered to move external equipment to an EPO state, as described in Remote EPO Connector. To release the EPO button after it is pressed, rotate it clockwise.

Remote EPO Connector

The remote emergency power off (EPO) connector provides access to the power distribution unit (PDU) ***Disable*** loop. It also provides dry contacts for remote shutdown of external equipment. This connection allows immediate action to complete the following:

- When the EPO button on the measurement rack is depressed, the remote EPO connector switches all external equipment on the external safety loop to the EPO state.
- When an external instrument on the external safety loop enters an EPO state, the remote EPO connector switches the measurement rack into the Remote EPO state. For more information about this state, refer to Measurement Rack Power States.

When the external instrument exits its EPO state, the remote EPO connector switches the measurement rack out of the Remote EPO state into its previous state.

The Remote EPO connector has connections for the EPO button and the external safety loop.

Figure 7. Remote EPO Connector

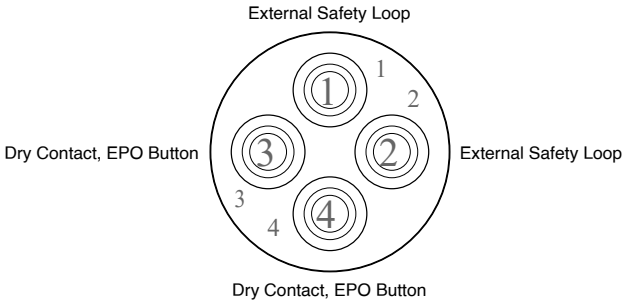


Table 1. Remote EPO Connector Terminals

Terminal	Connection	Normal State	EPO State
1	External safety loop	Closed	Open
2	External safety loop	Closed	Open
3	Dry contact, EPO button	Closed (default)	Open
4	Dry contact, EPO button	Closed (default)	Open

Use the following mating components to create interlock cabling for an external safety loop.

Table 2. Remote EPO Connector Mating Components

Component	Manufacturer/Part Number
Plug assembly, size 11 reverse sex series 1, CPC (1 ea)	TE connectivity 206429-1
Kit, cable clamp, standard shell sixe 11, CPC (1 ea)	TE connectivity 1-206062-4
Strip, III+SKT, 18-16, 30AU/FL (4 ea)	TE connectivity 66099-4

Note You must install the EPO loopback dongle included the accessory kit if you are not creating an external safety loop.

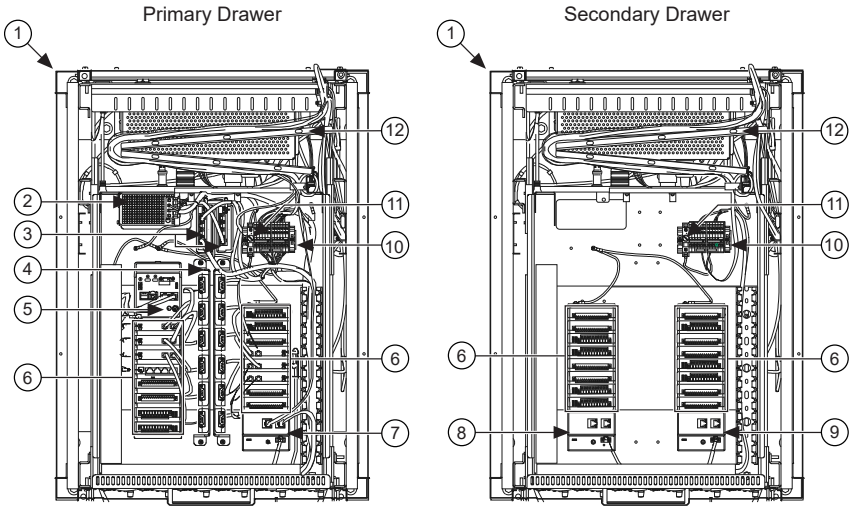
Measurement Rack Drawers

The measurement rack features up to two sliding drawers which allow for easier cable

routing and improves the utilization of space within the rack.

Note The secondary drawer is an optional feature and the optional components in each drawer may vary depending on your configuration. The following figure is an example of a measurement rack configuration that includes the secondary drawer.

Figure 8. Internal Top-Down View of Drawers



1. Sliding Drawer
2. PS-16 Power Supply
3. cRIO-9805 Ethernet Switch
4. Transceiver Cable Mounting Brackets (Optional)
5. cRIO-9047 Controller
6. C Series Modules (Optional)
7. cDAQ1 (Optional)
8. cDAQ2 (Optional)
9. cDAQ3 (Optional)
10. Terminal Block
11. DC Power Fuse
12. Articulating Cable Arm

Note In the preceding figure, cDAQ1, cDAQ2, and cDAQ3 refer to the cDAQ-9189 chassis.

The drawers contain the following features:

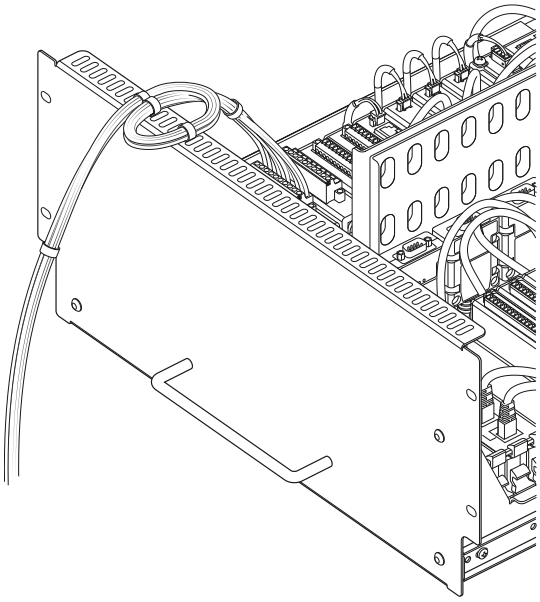
- Articulating arm that enables the full range of motion of the drawer and organizes cables from the drawer components to other components within the rack
- Wire ducts for easier cable routing and organization
- Optional mounting brackets for TRC-8543/8546 NI-XNET CAN/LIN transceiver cables that can be mounted in either drawer
- DC power fuse and terminal block

Notice To ensure the specified EMC performance, a ferrite bead must be installed on the input power cable nearest to the DC terminal blocks in the secondary drawer.

Cable Management

To reduce strain on the instrumentation connectors, NI recommends that you provide extra cable length or a service loop on the side of the instrument or at the tie-down points on the drawer front panel, as shown in the following figure.

Figure 9. Sliding Drawer Tie-Down Points



Measurement Rack Power

This section covers the following power-related components and topics:

Measurement Rack Power States

Table 3. Measurement Rack States of Operation

Power State	PEP	PDU	UPS	Temperature Controller
Off	Off	Off	Off	Off
Standby	On (AC)	Off	Off	On
EPO	DC only	Off	On	On
Remote EPO	On (AC)	Off	On	On
On	On (AC)	On	On	On

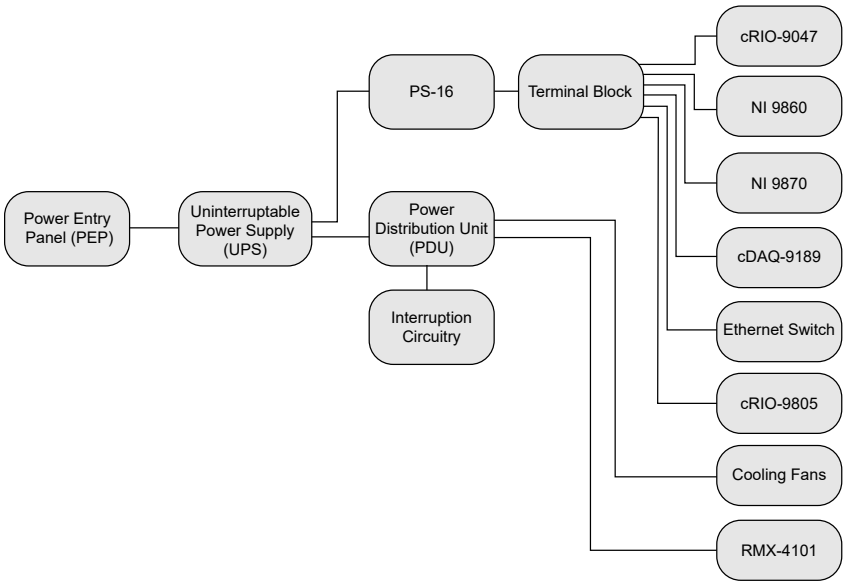
Table 4. Power State Descriptions

Power State	Description	Action
Off	The system is entirely disabled with no power passing through the line filter or any internal test system components.	To enter Off state: 1. Switch the main breaker (CB outlet) on the power entry panel (PEP) to the OFF position. 2. Disconnect MAINs power from the PEP. To exit Off state, follow the process in .
Standby	Power to the power distribution unit (PDU) and uninterruptible power supply (UPS) is shut off. Power is passing out of the PEP and into the thermostat emergency power off (EPO) panel.	To enter Standby state: 1. Move the main power switch on EPO panel to the Standby (⏻) position. 2. Safety shutoff thermostats

Power State	Description	Action
		on fan panel detect an unsafe air exit temperature. To exit Standby state, move the main power switch to the ON (I) position.
EPO	Immediately cuts AC power from the PEP and PDU. The UPS remains powered so that the measurement instruments in the rack continue logging data. DC power passes out of the PEP and into the thermostat EPO panel. Entering this state also triggers the remote EPO connector, which, when connected to an external safety loop, automatically shuts off external equipment.	To enter EPO state, press the EPO button. To exit EPO state, turn clockwise to release the EPO button.
Remote EPO	Immediately cuts power from the PDU. The UPS remains powered so that the measurement instruments in the rack continue logging data. Power passes out of the PEP and into the thermostat EPO panel.	The system enters Remote EPO state when other equipment connected to an external safety loop through the remote EPO connector enter an EPO state. The system exits Remote EPO state after the external instrument exits its EPO state. The rack switches into its previous state.
On	A change to this state begins the main power on sequence of the test system. The PDU receives AC power through the UPS from the PEP and enables	To enter the On state, follow the process in Powering on the System.

Power State	Description	Action
	outlets to other system equipment. The EPO panel is powered.	

Figure 10. Power Block Diagram



Connecting Power and Powering Up

Refer to AC MAINs Cables for information about connecting power to the rack. Refer to Powering on the System for information about powering up the system.

Power Distribution Unit

A power distribution unit (PDU) takes an input power signal and distributes it to several outlets that can power components of the system. These internal power outlets from the PDU have a rated voltage and current for both alternating and direct current.

The measurement rack features a single-phase PDU that supports global voltages (100 V to 240 V, 50 Hz to 60 Hz) and has a 20 A (IEC C19) input connector which cables directly to the uninterruptible power supply (UPS).

Refer to the ***MPD 41145X Family Product Manual***, which ships with the Battery Test System, for more information about the PDU.

Uninterruptible Power Supply

Use the uninterruptible power supply (UPS) to power critical components in your system during power loss, brownouts, EPO state, and during normal operation.

The UPS delivers power with a dependable voltage and current supply. It acts as a battery power supply after a power outage or significant brownout. The UPS is available as the following model options:

- APC SRT 2200XLA—120 V
- APC SRT 2200XLI—240 V

Refer to the ***APC UPS Operation Manual***, which ships on disc with the Battery Test System, for more information about the UPS.

Powering On/Off the UPS

Press the POWER ON/OFF button to power on the UPS. The button LED color indicates power status.

Table 5. UPS POWER ON/OFF LED Indications

LED State/Color	Status
Off	The UPS and the output power are off.
White	The UPS and the output power are on.
Red	The UPS is on and the output power is off.

PS-16 Power Supply

The PS-16 is located in the primary drawer in the measurement rack and powers the following components:

- cRIO-9047 controller
- Measurement rack internal Ethernet switch
- cDAQ-9189 chassis
- cRIO-9805 Ethernet switches
- NI-XNET (CAN/LIN) C Series modules
- Serial C Series modules

The PS-16 can also power remote temperature input devices in your system.

DC Power Fuse

The DC power fuse in the primary and secondary drawer provide protection for your system components from short circuits. When a fuse opens, all instruments connected to the terminal block in a drawer—cRIO-9047, cDAQ-9189, all C Series modules, cRIO-9805, GPIB-RS232, and FieldDAQ devices—lose power.

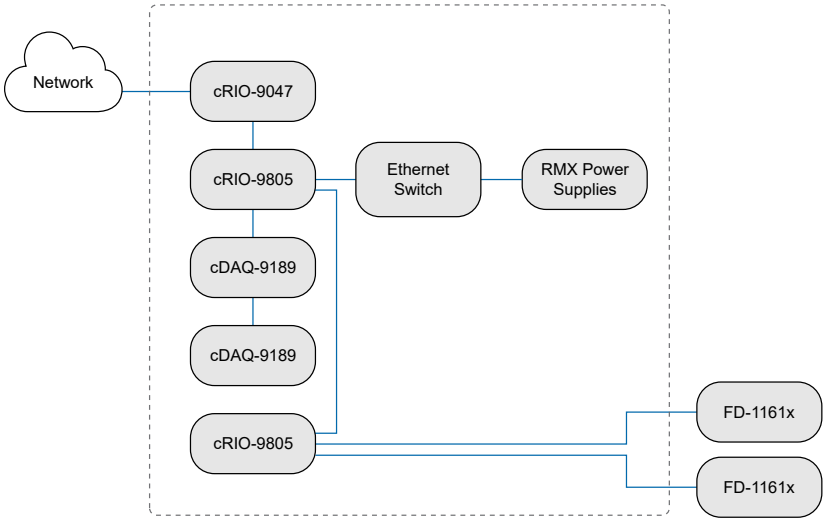
The DC power fuse is a Schurter 8020.50755 A, 500 V AC(6.3×32 mm)fast-acting fuse.

Measurement Rack Ethernet Networking

The measurement rack contains up to three Ethernet switches to network the components in your system:

- Ethernet Switch—The 16-port Moxa Ethernet switch provides networking connection between the cRIO-9047 controller and RMX-4101 power supplies. Refer to the ***EDS-205A/208A Series Quick Installation Guide***, which ships with the Battery Test System, for more information.
- cRIO-9805—Up to two, four-port TSN-enabled Ethernet switches provide time-sensitive networking (802.1AS) connection between the cRIO-9047 controller, cDAQ-9189 chassis, and FieldDAQ devices enabling sub-microsecond-level synchronization between measurement I/O devices.

Figure 11. Ethernet Networking Block Diagram



cRIO-9047 is Not Communicating with the Network

- Ensure that the Ethernet connections between the cRIO-9047 and the host computer, and between the host computer and the router are secure.
- Configure the IP and other network settings by completing the following steps.
  1. Use the USB-to-Type-A cable (included in the Battery Test System kit) to connect the cRIO-9047 USB device port to a host computer. The USB driver creates a virtual network interface card and assigns an IP address to the cRIO-9047 in the format of 172.22.11.x.
  2. In Measurement & Automation Explorer (MAX), expand your system under Remote Systems.

     Note If you do not see the cRIO-9047 under **Remote Systems**, right-click**Remote Systems**, and select **Troubleshoot Remote System Discovery** to walk through troubleshooting steps.

  3. Select the Network Settings tab to configure the IP and other network settings.
  4. (Optional) Use the standard measurement rack Ethernet port to reconnect the cRIO-9047 to the host computer. The cRIO-9047 attempts to initiate a DHCP network connection at power up.

     Note If the cRIO-9047 cannot obtain an IP address, it connects to the network with a link-local IP address with the form 169.254.x.x. The host computer communicates with the cRIO-9047 over a standard Ethernet connection.

- Temporarily disable any network firewalls or other security software.

Verify the cRIO-9047 controller IP configuration by completing the following steps:

1. Put the cRIO-9047 in safe mode and enable the RS-232 serial port by holding down the RESET button on the controller front panel for 5 seconds.

   The STATUS LED starts blinking three times every few seconds. Refer to the ***cRIO-904x User Manual*** for more information about safe mode.

2. Connect a monitor to the mini DisplayPort to view the IP address.

> **Note** The controller also broadcasts the IP address through the RS-232 serial port. Refer to the ***cRIO-904x User Manual*** for more information about serial port configuration on the cRIO-9047 controller.

3. Set a new DHCP connection by holding the RESET button on the controller front panel down for 5 seconds. The STATUS LED repeats the same behavior from Step 1.

   If the cRIO-9047 fails to set a new DHCP address, it assigns itself a link-local IP address. If the DHCP connection is successful and appropriate for your application, skip to Step 6.

4. In MAX, expand your system under **Remote Systems**.
5. Select the Network Settings tab to configure the IP and other network settings.
6. Reboot the cRIO-9047 by pressing the RESET button on the controller front panel.

cDAQ-9189 Chassis Disconnects from Network

If your cDAQ-9189 chassis becomes disconnected from the network, try the following solutions:

- After moving the chassis to a new network, NI-DAQmx may lose connection to the chassis. In this case, click **Reconnect** to provide NI-DAQmx with the new hostname or IP address.
- The cDAQ chassis icon indicates whether it is recognized and present on the network. If a connected chassis appears as disconnected in the configuration tree in MAX, select **Self-Test** or **Reset Chassis**. If successful, the chassis icon changes to blue/grey.

For additional troubleshooting resources for the cDAQ-9189 chassis, refer to ***Finding a Network DAQ Device in MAX*** in the ***Measurement & Automation Explorer Help for NI-DAQmx***.

Measurement Rack Characteristics

Physical

Dimensions	
Length	800.0 mm (31.50 in.)
Width	584.2 mm (23.00 in.)
Height	1,358.9 mm (53.50 in.)
Weight	
Without instrumentation	145.0 kg (320.00 lb)
Maximum	277.8 kg (610.24 lb)

Note Refer to the ***Battery Test System User Manual*** for additional measurement rack integration requirements.

The main breaker (CB Outlet) on the power entry panel PEP-116 is rated for an impact energy level of IK06 (1J), when tested with a direct vertical impact per IEC 61010-1, 3rd Ed., Table 15 and Clause 8.2. The main breaker should be guarded against impacts exceeding 1J.

AC Input

Nominal voltage	
120 V UPS	100 VAC to 120 VAC

	2,200 VA
240 V UPS	200 VAC to 240 VAC 2,200 VA
Maximum current	16 A
Frequency	50/60 Hz

Internal Power Distribution

Maximum output current DC ratings	
DC1 output	
Voltage	12 VDC
120 V UPS	10.4 A
240 V UPS	12.5 A
DC2 output	
Voltage	24 VDC
120 V UPS	5.2 A
240 V UPS	6.25 A

DC3 output	
Voltage	24 VDC
120 V UPS	5.2 A
240 V UPS	6.25 A
DC4 output	
Voltage	48 VDC
120 V UPS	2.6 A
240 V UPS	3.13 A
PS-16 power supply[1]	
Output power	240 W
Output voltage	24 V
Output current	10 A
Output over-voltage protection	35 VDC, typical 39 VDC, maximum
Output over-current protection	Electronically limited

Internal outlets	
Output[2]	10 A per receptacle
Total AC output, 120 V UPS	
Low speed fan panel	15.2 A
DC supply fully loaded	8.7 A
Total AC output, 240 V UPS	
Low speed fan panel	15.5 A
DC supply fully loaded	12.4 A
Maximum current	16 A

Remote EPO Pins

During remote EPO installation, pin 1 and pin 2 must be shorted with dry contacts to enable power distribution unit outputs.

Pin 3, pin 4	
Maximum operating voltage	48 V
Maximum operating current	5 A

1. Refer to the NI PS-16 Power Supply User Manual and Specifications on ni.com/manuals for more information and specifications.
2. The combined current output from the AP6020 PDU is limited to 10 A.

Environment

Temperature	
Operating	5 °C to 40 °C
Storage	0 °C to 65 °C
Humidity	
Operating	10% to 80%, noncondensing
Storage	10% to 80%, noncondensing
Pollution Degree	2
Maximum altitude	2,000 m (800 mbar)
Ventilation clearance requirements	
Above top of fan panel	762 mm (30 in.)
Adjacent to the intake panel	304.8 mm (12 in.)

Protective Earthing

Protective earth terminal wiring	
Grounding wire	2.1 mm^2 (14 AWG)
Ring lug	

Size	M8
Length	20 mm (0.8 in.)
Minimum protective earth terminal torque	1.29 N · m (11.5 lb · in.)

Measurement Rack I/O

The instrumentation and hardware inside the measurement rack provide additional accessible I/O. The available I/O depends on the measurement rack configuration.

External ethernet	
Number of ports	1
Type	RJ45
Standard	IEEE 802.3u Ethernet, 10BASE-T, 100BASE-TX
Speed	10 Mbps, 100 Mbps
USB ports[3]	2 USB 3.0, disconnected

DC Power Supply

The RMX-4101 power supply is installed in the measurement rack and provides power to the DUT or other external devices. The measurement rack can contain up to 12

3. The USB ports on the power distribution panel are not connected to internal hardware and are available for expansion.

RMX-4101 power supplies. Refer to the RMX-410x User Manual on ni.com/manuals for more information.

RMX-4101 Specifications

Maximum output voltage	60 VDC
Output current	3.5 A
Output power	210 W
Overvoltage trip point	5 V to 66 V

High Voltage Interlock Loop

Digital Input

The NI-9422 is a digital input module that processes high voltage interlock loop (HVIL) digital signals or external ECU digital signals sent to the measurement rack. Refer to the NI-9422 Operating Instructions and Specifications on ni.com/manuals for more information and specifications.

NI-9422 Specifications

Number of channels	8 digital input channels
Input type	Sinking/sourcing
Digital logic levels	
OFF state	

Input voltage	≤5 V
Input current	≤0.17 mA
ON state	
Input voltage	11 V to 60 V
Input current	≥1.2 mA
I/O protection	
Input voltage	250 V_{rms} maximum
Input current	4 mA maximum, internally limited
Input delay time	
OFF to ON	250 µs maximum, 4 µs typical
ON to OFF	250 µs maximum, 130 µs typical
Isolation	
Channel-to-channel	
Continuous	250 V_{rms}, Measurement Category II
Withstand	1,390 V_{rms}, verified by a 5 second dielectric withstand test
Channel-to-earth ground	

Continuous	250 V_{rms}, Measurement Category II
Withstand	2,300 V_{rms}, verified by a 5 second dielectric withstand test

Pulse Width Modulation

The NI-9423 and NI-9437 are digital input modules that process HVIL pulse width modulation signals or external ECU digital signals sent to the measurement rack. Refer to the NI-9423 Datasheet and the NI-9437 Datasheet on `ni.com/manuals` for more information and specifications.

NI-9423 Specifications

Number of channels	8 digital input channels
Input type	Sinking
Digital logic levels	
OFF state	
Input voltage	≤5 V
Input current	≤150 µA
ON state	
Input voltage	11 V to 30 V
Input current	≥3 mA

Maximum input delay time	1 µs
Isolation	
Channel-to-channel	None
Channel-to-earth ground	
Continuous	250 V_{rms}, Measurement Category II
Withstand	2,300 V_{rms}, verified by a 5 second dielectric withstand test

NI-9437 Specifications

Number of channels	8 digital input channels
Input type	Sinking
Input voltage threshold	
OFF state	
24 V to 250 V	65% * V_{SUP} - 4 V
ON state	
24 V to 250 V	73% * V_{SUP} - 0.75 V
Input current (10 V ≤ V_{IN} ≤ 60 V)	
Maximum	1.8 mA

Minimum	1.3 mA
Input power (60 V ≤ V_{IN} ≤ 300 V)	
Maximum	150 mW
Minimum	75 mW
Maximum input delay time	1 µs
Isolation	
Channel-to-channel	None
Channel-to-V_{SUP}	None
Channel-to-earth ground, V_{SUP}-to-earth ground, COM-to-earth ground	
Continuous	300 V_{rms}, Measurement Category II
Withstand	3,000 V, verified by a 5 second dielectric withstand test

Current Input

The NI-9227 is an analog input module that processes HVIL current input sent to the measurement rack. Refer to the NI-9227 Operating Instructions and Specifications on `ni.com/manuals` for more information and specifications.

NI-9227 Specifications

Number of channels	4 analog input channels
ADC resolution	24 bits
Type of ADC	Delta-Sigma (with analog prefiltering)
Sampling mode	Simultaneous
Internal master timebase (f_M)	
Frequency	12.8 MHz
Accuracy	±100 ppm maximum
Data rate range (f_S) using internal master timebase	
Minimum	1.613 kS/s
Maximum	50 kS/s
Data rate range (f_S) using external master timebase	
Minimum	390.625 S/s
Maximum	51.36 kS/s
Safe operating input range	5 A_{rms}

Isolation	
Channel-to-channel	
Continuous	250 V_{rms}, Measurement Category II
Withstand	1,390 V_{rms}, verified by a 5 second dielectric withstand test
Channel-to-earth ground	
Continuous	250 V_{rms}, Measurement Category II
Withstand	2,300 V_{rms}, verified by a 5 second dielectric withstand test

High Voltage Interlock Loop Control

External Relay

The NI-9482 is a single pole single throw (SPST) electromechanical relay that controls the continuity of the high voltage interlock loop (HVIL) during test execution. Refer to the NI-9482 User Manual and Specifications on `ni.com/manuals` for more information and specifications.

NI-9482 Specifications

Number of channels	4 electromechanical relay channels
Relay type	SPST
Power-on output state	Channels off
Switching capacity (resistive load)	

Switching voltage	60 VDC maximum, 250 V_{rms} maximum
Switching current, per channel, one channel on	
30 VDC	2.5 A maximum
60 VDC	1 A maximum
250 V_{rms}	2 A maximum
Switching current, per channel, two channels on	
30 VDC	2 A maximum
60 VDC	1 A maximum
250 V_{rms}	2 A maximum
Switching current, per channel, all channels on	
30 VDC	1.5 A maximum
60 VDC	1 A maximum
250 V_{rms}	1.5 A maximum
Resistance per channel, channel on	0.2 Ω

Switching rate	1 operation per second
Relay release time	10 ms maximum
Relay operate time	15 ms maximum
Relay bounce time	3 ms
Channel A-to-channel B safety voltage	250 V_{rms} maximum, Measurement Category II
Isolation	
Channel-to-channel	
Continuous	250 V_{rms}
Withstand	1,400 V_{rms}, verified by a 5 second dielectric withstand test
Channel-to-earth ground	
Continuous	250 V_{rms}
Withstand	2,300 V_{rms}, verified by a 5 second dielectric withstand test

DUT Voltage Measurement

Module Voltage Measurement

The NI-9225 and NI-9228 are analog input modules that measure battery module voltage output by the DUT. Refer to the NI-9225 Operating Instructions and

Specifications and the NI-9228 Datasheet on ni.com/manuals for more information and specifications.

NI-9225 Specifications

Number of channels	3 analog input channels
ADC resolution	24 bits
Type of ADC	Delta-Sigma (with analog prefiltering)
Sampling mode	Simultaneous
Internal master timebase (f_M)	
Frequency	1.613 kS/s
Accuracy	±100 ppm maximum
Data rate range (f_S) using internal master timebase	
Minimum	1.613 kS/s
Maximum	50 kS/s
Typical operating voltage range	300 V_{rms}
Isolation	
Channel-to-channel	

Continuous	600 V_{rms}, Measurement Category II
Withstand	2,300 V_{rms}, verified by a 5 second dielectric withstand test
Channel-to-earth ground	
Continuous	300 V_{rms}, Measurement Category II
Withstand	2,300 V_{rms}, verified by a 5 second dielectric withstand test

NI-9228 Specifications

Number of channels	8 analog input channels
ADC resolution	24 bits
Type of ADC	Delta-Sigma (with analog prefiltering)
Sampling mode	Simultaneous
Conversion time	
High resolution timing mode	
Conversion rate	500 ms
Sample rate	2 S/s
Medium resolution timing mode	

Conversion rate	83.3 ms
Sample rate	12 S/s
Medium speed timing mode	
Conversion rate	10 ms
Sample rate	100 S/s
High speed timing mode	
Conversion rate	1 ms
Sample rate	1,000 S/s
Input voltage ranges, AI+ to AI-	
Typical	±63.8 V
Minimum	±63.2 V
Isolation	
Channel-to-channel	
Continuous	250 V_{rms}, Measurement Category II
Withstand	1,500 V_{rms}, verified by a 5 second dielectric test
Channel-to-earth ground	

Continuous	250 V_{rms}, Measurement Category II
Withstand	3,000 V_{rms}, verified by a 5 second dielectric test

Cell Voltage Measurement

The NI-9224 is an analog input module that measures cell voltage output by the DUT up to 250 V. Refer to the NI-9224 Datasheet on `ni.com/manuals` for more information and specifications.

NI-9224 Specifications

Number of channels	8 analog input channels
ADC resolution	24 bits
Type of ADC	Delta-Sigma
Sampling mode	Simultaneous
Conversion time	
High resolution timing mode	
Conversion time	500 ms
Sample rate	2 S/s
Medium resolution timing mode	

Conversion time	83.3 ms
Sample rate	12 S/s
Medium speed timing mode	
Conversion time	10 ms
Sample rate	100 S/s
High speed timing mode	
Conversion time	1 ms
Sample rate	1,000 S/s
Input voltage ranges, AI+ to AI-	
Typical	±10.54 V
Minimum	±10.40 V
Overvoltage protection, AI+ to AI-	250 V_{rms}
Input coupling	DC
Isolation	
Channel-to-channel	

Continuous	250 V_{rms}, Measurement Category II
Withstand	1,500 V_{rms}, verified by a 5 second dielectric test
Channel-to-earth ground	
Continuous	250 V_{rms}, Measurement Category II
Withstand	3,000 V_{rms}, verified by a 5 second dielectric test

Digital Signal Input and Output

The NI-9422 is a digital input module that processes high voltage interlock loop (HVIL) digital signals or external ECU digital signals sent to the measurement rack. Refer to the NI-9422 Operating Instructions and Specifications on `ni.com/manuals` for more information and specifications.

NI-9422 Specifications

Number of channels	8 digital input channels
Input type	Sinking/sourcing
Digital logic levels	
OFF state	
Input voltage	≤5 V
Input current	≤0.17 mA

ON state	
Input voltage	11 V to 60 V
Input current	≥1.2 mA
I/O protection	
Input voltage	250 V_{rms} maximum
Input current	4 mA maximum, internally limited
Input delay time	
OFF to ON	250 µs maximum, 4 µs typical
ON to OFF	250 µs maximum, 130 µs typical
Isolation	
Channel-to-channel	
Continuous	250 V_{rms}, Measurement Category II
Withstand	1,390 V_{rms}, verified by a 5 second dielectric withstand test
Channel-to-earth ground	
Continuous	250 V_{rms}, Measurement Category II
Withstand	2,300 V_{rms}, verified by a 5 second dielectric withstand test

The NI-9375 is a combination digital input, digital output module that processes external ECU signal inputs and ignition signal outputs during test execution. Refer to the NI-9375 Datasheet on `ni.com/manuals` for more information and specifications.

NI-9375 Specifications

Number of channels	16 digital input channels 16 digital output channels
Digital input	
Input type	Sinking
Input voltage range	0 VDC to 30 VDC
Digital logic levels	
OFF state input voltage	≤5 V
OFF state input current	≤150 µA
ON state input voltage	≥10 V
ON state input current	≥330 µA
Hysteresis input voltage	1.7 V minimum
Hysteresis input current	50 µA minimum

Input impedance	30 kΩ ±5%
Setup time	1 µs maximum
Transfer time	7 µs maximum
Digital output	
Output type	Sourcing
Continuous output current	
All channels on	125 mA maximum (per channel)
One channel on	500 mA maximum
Per module	0.25 A
Transfer time	7 µs maximum
Isolation	
Channel-to-channel	None
Channel-to-earth ground	
Continuous	250 V_{rms}, Measurement Category II
Withstand	3,000 V_{rms}, verified by a 5 second dielectric withstand test

The NI-9475 is a digital output module that generates static digital signals and pulse width modulated signals for DUT inputs. Refer to the NI-9475 Datasheet on `ni.com/manuals` for more information and specifications.

NI-9475 Specifications

Number of channels	8 digital input channels
Output type	Sourcing
Power-on output state	Channels off
External power supply voltage range (V_{SUP})	0 VDC to 60 VDC
Output impedance (R_0)	0.14 Ω maximum
Continuous output current (I_0), per channel	1 A maximum
Output voltage	V_{SUP} - (I_0 * R_0)
I/O protection	
Voltage	60 VDC maximum
Reversed voltage	None
Short-circuit trip time	10 µs at 13 A

Output delay time (full load)	1 µs maximum
V_{SUP}-to-COM safety voltage	60 VDC maximum, Measurement Category I
Isolation	
Channel-to-channel	None
Channel-to-earth ground	
Continuous	60 VDC, Measurement Category I
Withstand	1,000 V_{rms}, certified by a 5 second dielectric withstand test

Temperature Measurement

Cell Temperature Inputs

The NI-9212 is a channel-to-channel isolated thermocouple input module that measures the temperature of various points on the DUT during test execution. Refer to the NI-9212 and TB-9212 Datasheet on `ni.com/manuals` for more information and specifications.

NI-9212 Specifications

Number of channels	8 isolated thermocouple channels 2 internal cold-junction compensation channels
ADC resolution	24 bits

Type of ADC	Delta-Sigma
Sampling mode	Simultaneous
Voltage measurement range	78.125 mV
Temperature measurement ranges	Works over temperature ranges defined by NIST[4] (J, K, T, E, N, B, R, S thermocouple types)
Timing mode	
High resolution	
Conversion time	550 ms
Sample rate	1.8 S/s
Best 50 Hz rejection	
Conversion time	140 ms
Sample rate	7.1 S/s
Best 60 Hz rejection	
Conversion time	120 ms
Sample rate	8.3 S/s

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High speed	
Conversion time	10.5 ms
Sample rate	95 S/s
Isolation	
Channel-to-channel	
Continuous	250 V_{rms}, Measurement Category II
Withstand	1,500 V_{rms}, verified by a 5 second dielectric test
Channel-to-earth ground	
Continuous	250 V_{rms}, Measurement Category II
Withstand	3,000 V_{rms}, verified by a 5 second dielectric test

The NI-9213 is a high-density thermocouple input module that measures the temperature of various points on the DUT during test execution. Refer to the NI-9213 Datasheet on `ni.com/manuals` for more information and specifications.

NI-9213 Specifications

Number of channels	16 thermocouple channels 1 internal autozero channel 1 internal cold-junction compensation channel

ADC resolution	24 bits
Type of ADC	Delta-Sigma
Sampling mode	Scanned
Voltage measurement range	78.125 mV
Temperature measurement ranges	Works over temperature ranges defined by NIST[4] (J, K, T, E, N, B, R, S thermocouple types)
Timing mode	
High resolution	
Conversion time	55 ms
Sample rate	1 S/s
High speed	
Conversion time	740 µs
Sample rate	75 S/s
Isolation	
Channel-to-channel	None
Channel-to-earth ground	

Continuous	250 V_{rms}, Measurement Category II
Withstand	3,000 V_{rms}, verified by a 5 second dielectric test

Remote Temperature Measurement

The FD-11613 and FD-11614 are thermocouple devices that are installed inside the environmental chamber to measure temperatures within the chamber during test execution. Refer to the FD-11613 Specifications and FD-11614 Specifications on `ni.com/manuals` for more information and specifications.

FD-11613 Specifications

Number of channels	8 isolated thermocouple channels 2 cold-junction compensation channels
ADC resolution	24 bits
Type of ADC	Delta-Sigma
Sampling mode	Simultaneous
Voltage measurement range	78.125 mV
Temperature measurement ranges	Works over temperature ranges defined by NIST[] (J, K, T, E, N, B, R, S thermocouple types)

Timing mode	
High resolution	
Conversion time	550 ms
Sample rate	1.8 S/s
Best 50 Hz rejection	
Conversion time	140 ms
Sample rate	7.1 S/s
Best 60 Hz rejection	
Conversion time	120 ms
Sample rate	8.3 S/s
High speed	
Conversion time	11.7 ms
Sample rate	85 S/s
Isolation	
Channel-to-channel	
Continuous working voltage	60 VDC

Transient overvoltage	1,000 V_{rms}, verified by 5 second withstand
Channel-to-earth ground	
Continuous working voltage	60 VDC (Dry locations)
Transient overvoltage	1,000 V_{rms}, verified by 5 second withstand
Operating temperature	-40 °C to 85 °C (-40 °F to 185 °F)

FD-11614 Specifications

Number of channels	16 isolated thermocouple channels 4 cold-junction compensation channels
ADC resolution	24 bits
Type of ADC	Delta-Sigma
Sampling mode	Simultaneous
Voltage measurement range	78.125 mV
Temperature measurement ranges	Works over temperature ranges defined by NIST[] (J, K, T, E, N, B, R, S thermocouple types)

Timing mode	
High resolution	
Conversion time	550 ms
Sample rate	1.8 S/s
Best 50 Hz rejection	
Conversion time	140 ms
Sample rate	7.1 S/s
Best 60 Hz rejection	
Conversion time	120 ms
Sample rate	8.3 S/s
High speed	
Conversion time	11.7 ms
Sample rate	85 S/s
Isolation	
Channel-to-channel	
Continuous working voltage	60 VDC

Transient overvoltage	1,000 V_{rms}, verified by 5 second withstand
Channel-to-earth ground	
Continuous working voltage	60 VDC (Dry locations)
Transient overvoltage	1,000 V_{rms}, verified by 5 second withstand
Operating temperature	-40 °C to 85 °C (-40 °F to 185 °F)

DUT and Instrument Communication

The NI-9860 and NI-9870 facilitate communication of information between the DUT and instrumentation inside the measurement rack. Refer to the NI-9860 Getting Started Guide and NI-9870 Getting Started Guide on `ni.com/manuals` for more information and specifications.

NI-9860 Specifications

Communication protocol	CAN LIN
Number of ports	2
Connector type	NI-XNET hardware selectable interface port
Transceiver cable	
Supported cable type	NI-XNET transceiver cables (CAN/LIN)

Maximum baud rate	5 Mbps (high speed CAN) 125 Kbps (low speed CAN)

NI-9870 Specifications

Communication protocols	RS-232 RS-485
Number of ports	4
Maximum baud rate	921.6 kb/s
Maximum cable length	250 pF equivalent
UART buffers per port	64 B FIFO
Data bits	5, 6, 7, 8
Stop bits	1, 1.5, 2
Flow control	XON/OFF, RTS/CTS, None
Post-to-earth ground isolation	
Continuous	60 VDC, Measurement Category I

Withstand	1,000 V_{rms}, verified by a 5 second dielectric withstand test

The GPIB-RS232 is an instrument control device that provides GPIB-to-RS232 and RS232-to-GPIB protocol conversions. The GPIB-RS232 uses an RS-232 port on the cRIO-9047 controller. Refer to the NI GPIB-Serial Converter Specifications on `ni.com/manuals` for more information and specifications.

GPIB-RS232 Specifications

Voltage range	9 VDC to 28 VDC
Current consumption at 12 VDC	300 mA typical, 800 mA maximum