

USER GUIDE

NI sbRIO-960x

Single-Board RIO OEM Devices

This document provides dimensions, pinouts, connectivity information, and specifications for the National Instruments sbRIO-9601 and sbRIO-9602. The devices are referred to inclusively in this document as the sbRIO-960x.



Caution National Instruments makes no product safety, electromagnetic compatibility (EMC), or CE marking compliance claims for the sbRIO-960x. The end-product supplier is responsible for conformity to any and all compliance requirements.



Caution Exercise caution when placing the sbRIO-960x inside an enclosure. Auxiliary cooling may be necessary to keep the device under the maximum ambient temperature rating of 55 °C.

The following figure shows the sbRIO-960x.

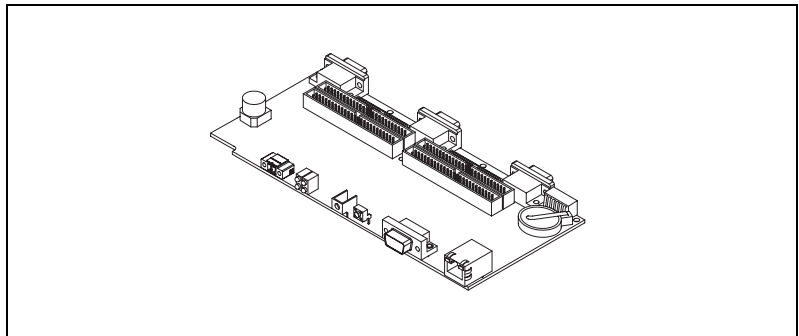


Figure 1. sbRIO-960x

What You Need to Get Started

This section lists the software and hardware you need to start programming the sbRIO-960x.

Software Requirements

You need a development computer with the following software installed on it. Go to ni.com/info and enter the info code `rdsoftwareversion` for information about software version compatibility.

- LabVIEW
- LabVIEW Real-Time Module
- LabVIEW FPGA Module
- NI-RIO Software

Hardware Requirements

You need the following hardware to use the sbRIO device.

- sbRIO-960x
- 19–30 VDC power supply
- Ethernet cable

Dimensions

This section contains dimensional drawings of the sbRIO devices. For three-dimensional models, go to ni.com/singleboard and look on the **Resource** tab for the sbRIO device you are using.



Note The plated mounting holes are all connected to P1, the ground lug. Connect P1 or one of the plated mounting holes securely to earth ground.

The following figure shows the dimensions of the sbRIO-960x.

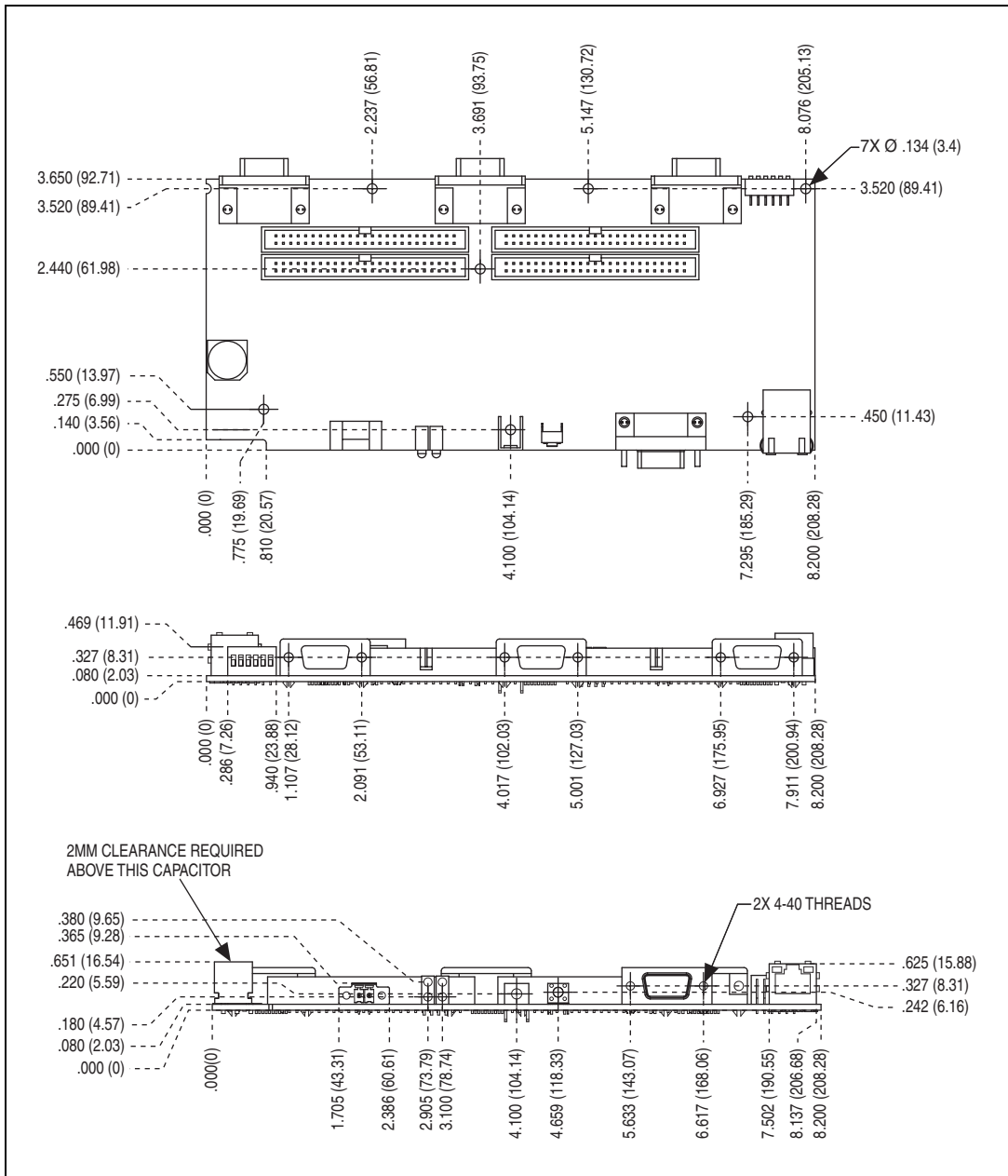


Figure 2. sbRIO-960x Dimensions in Inches (Millimeters)

You can install up to three board-only C Series I/O modules on the sbRIO-960x. The following figure shows the dimensions of the sb-RIO-960x with three board-only C Series I/O modules installed.

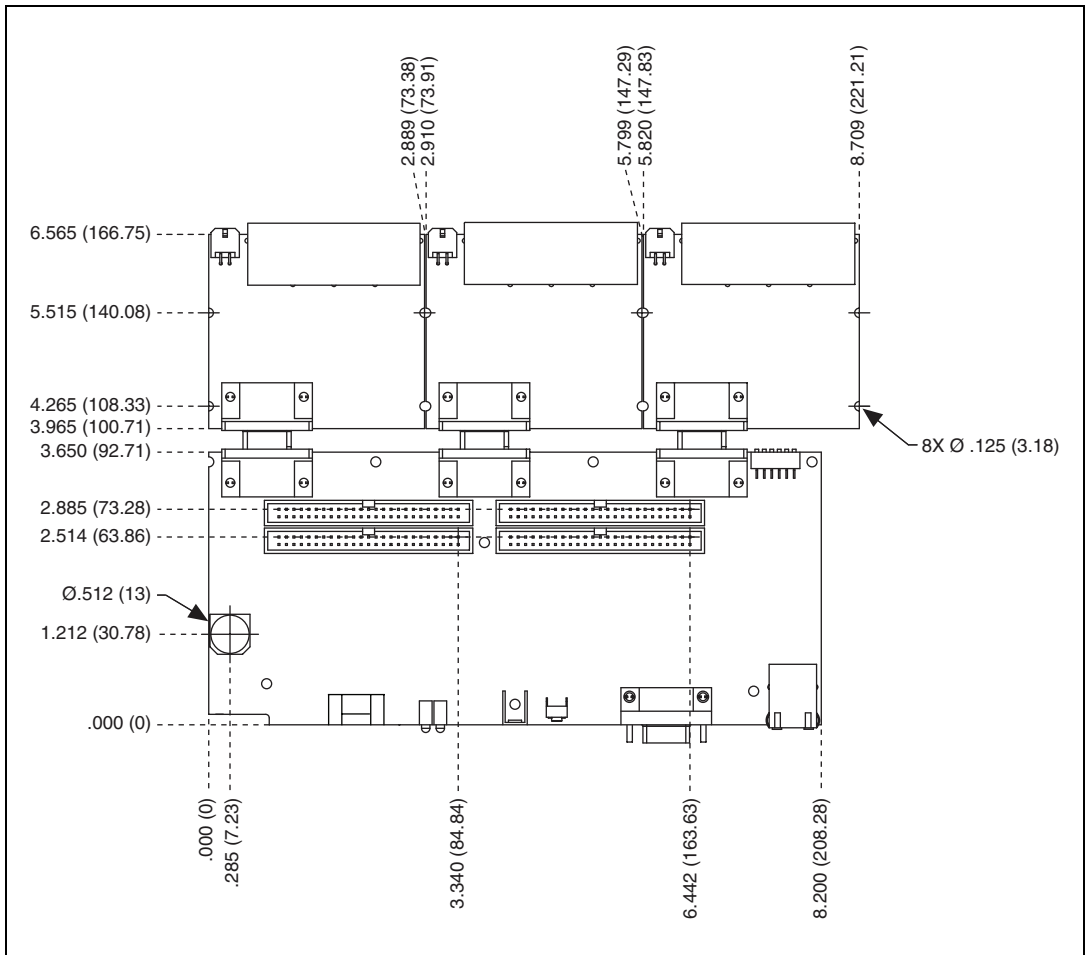


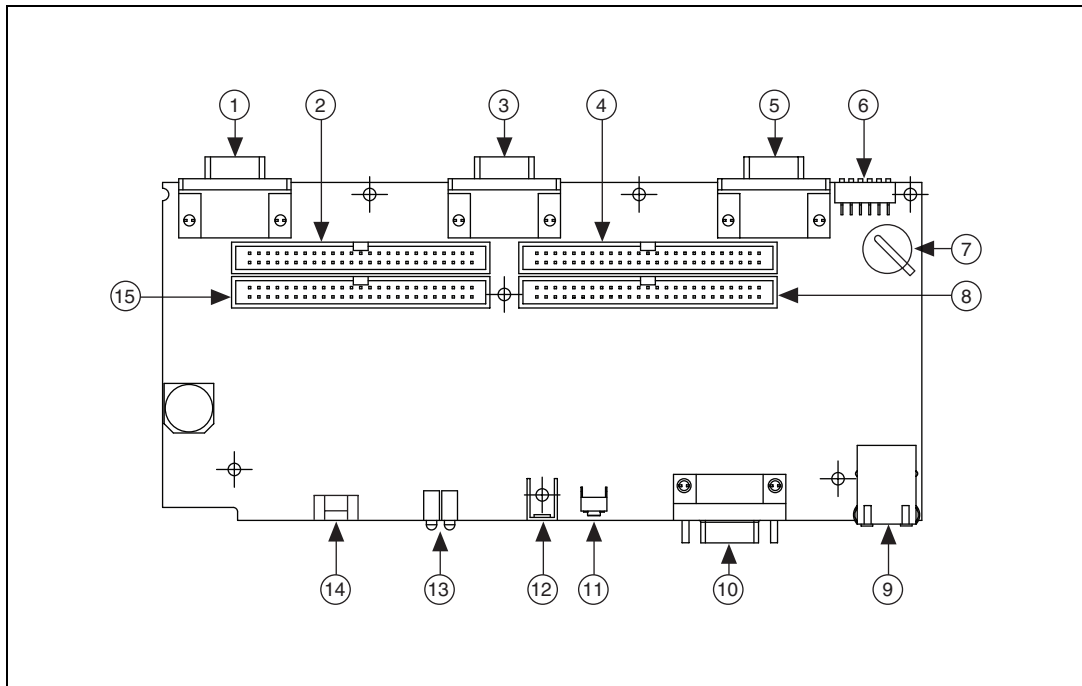
Figure 3. sbRIO-960x with C Series Modules, Dimensions in Inches (Millimeters)



Note To maintain isolation clearances on the C Series modules, do not use mounting hardware larger than 0.240 in. (6.1 mm) in diameter and maintain an air gap of at least 0.200 in. (5.0 mm) from the modules to anything else.

I/O and Other Connectors on the sbRIO Device

The following figure shows the locations of parts on the sbRIO device.



- | | | |
|--------------------------------------|---------------------------|--------------------------|
| 1 J11, Connector for C Series Module | 6 DIP Switches | 11 Reset Button |
| 2 P5, 3.3 V Digital I/O | 7 Backup Battery | 12 P1, Ground Lug |
| 3 J10, Connector for C Series Module | 8 P2, 3.3 V Digital I/O | 13 LEDs |
| 4 P4, 3.3 V Digital I/O | 9 J5, RJ-45 Ethernet Port | 14 J3, Power Connector |
| 5 J9, Connector for C Series Module | 10 J1, RS-232 Serial Port | 15 P3, 3.3 V Digital I/O |

Figure 4. sbRIO-960x Parts Locator Diagram

The following table lists and describes the connectors on sbRIO devices and lists the part number and manufacturer of each connector. Refer to the manufacturer for information about using and matching these connectors.

Table 1. sbRIO Connector Descriptions

Connector	Description	Part Number and Manufacturer
J3, Power	2-position MINI-COMBICON header and plug, 0.285 in. (7.24 mm) high	1727566 from Phoenix Contact; accepts 1714977 from Phoenix Contact (Included)
J1, RS-232 Serial Port	9-Pin DSUB plug, 0.318 in. (8.08 mm) high, with 4-40 jacksockets	5747840-6 from Amphenol
P2, P3, P4, P5	50-pin polarized header plug, 0.100 × 0.100 in. (2.54 × 2.54 mm)	N2550-6002RB from 3M

The following figures show the pinouts of the I/O connectors on the sbRIO devices.

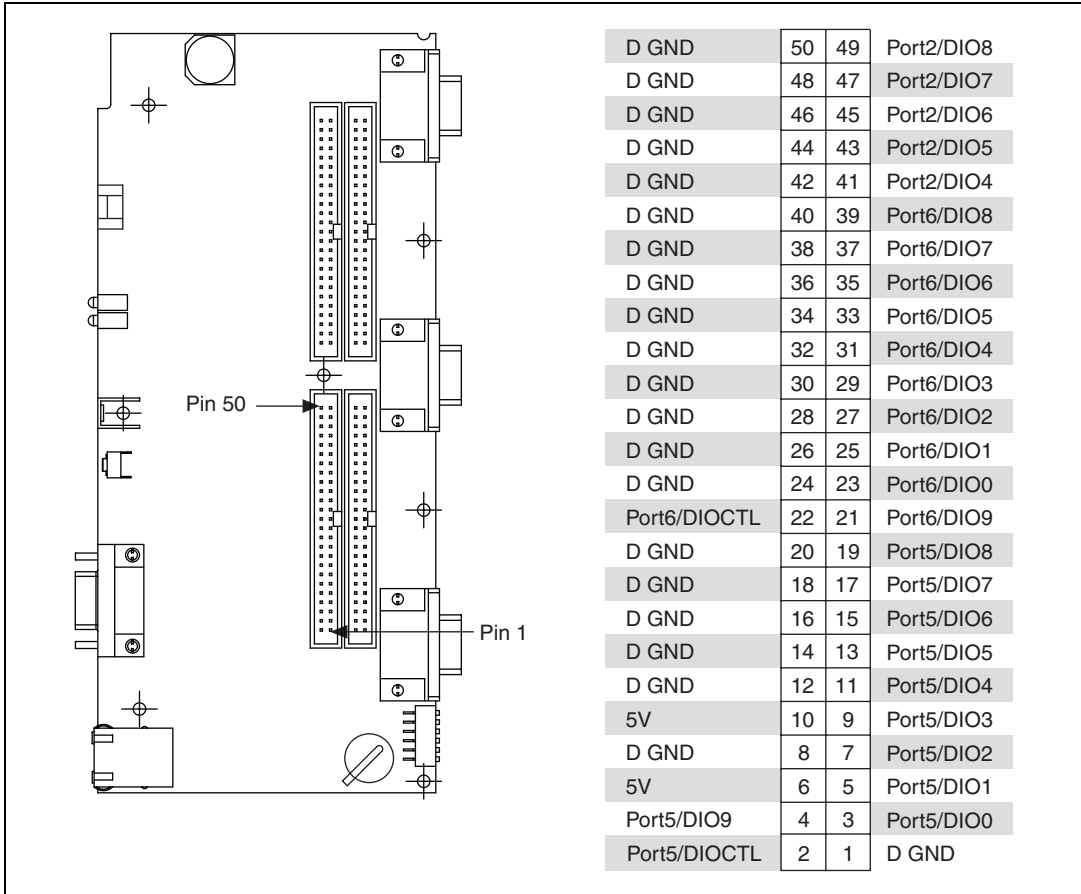


Figure 5. Pinout of I/O Connector P2, 3.3 V Digital I/O

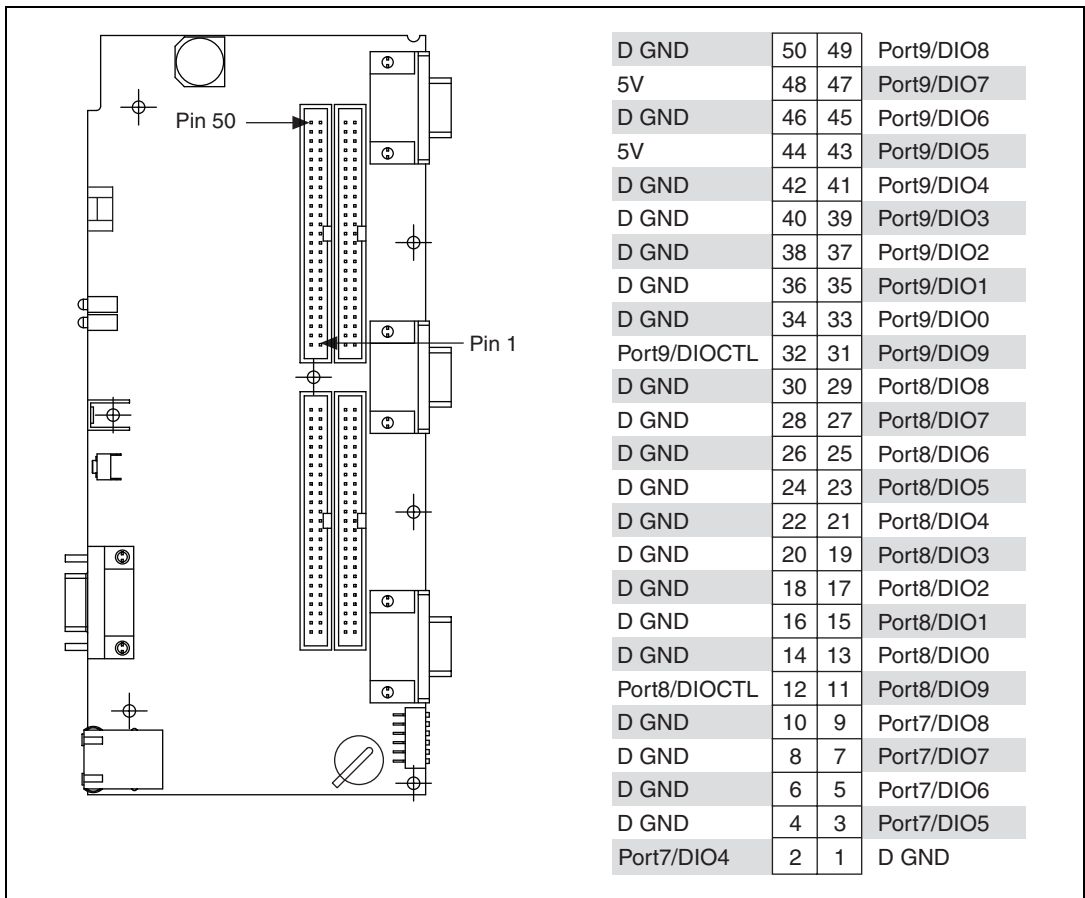


Figure 6. Pinout of I/O Connector P3, 3.3 V Digital I/O

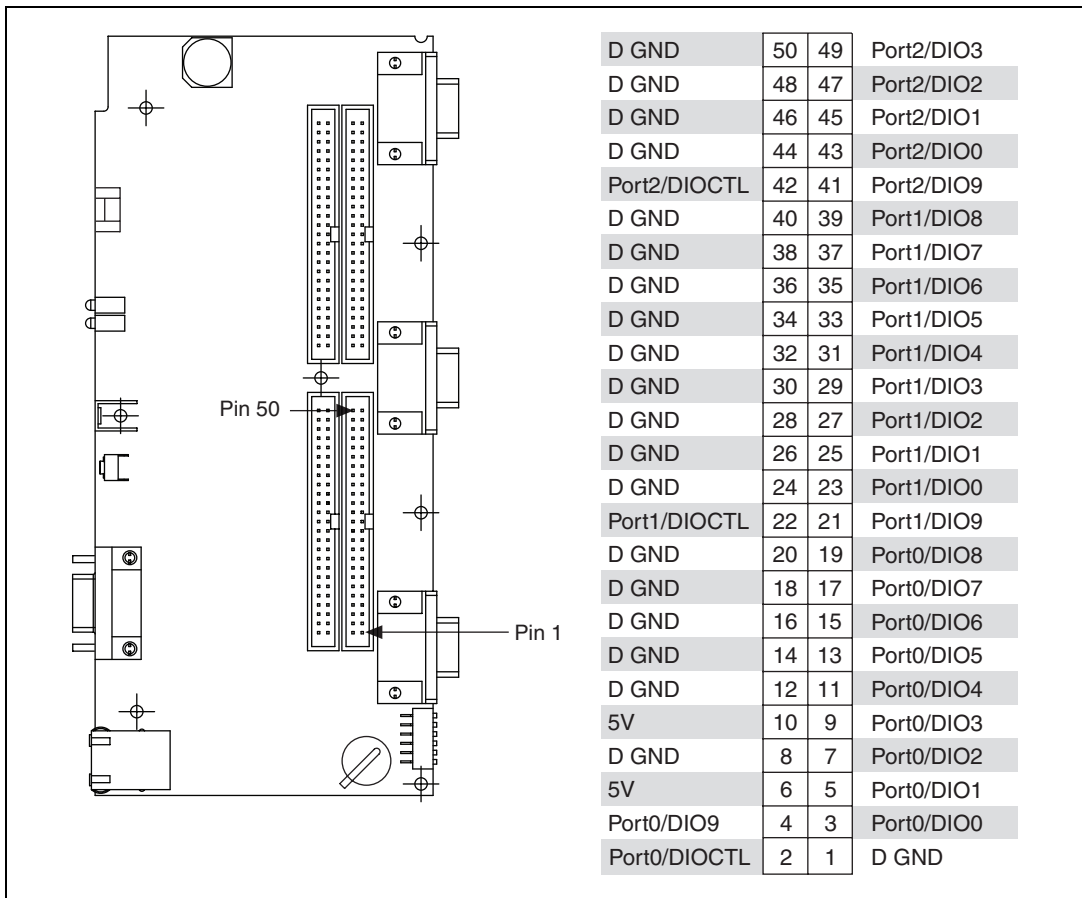


Figure 7. Pinout of I/O Connector P4, 3.3 V Digital I/O

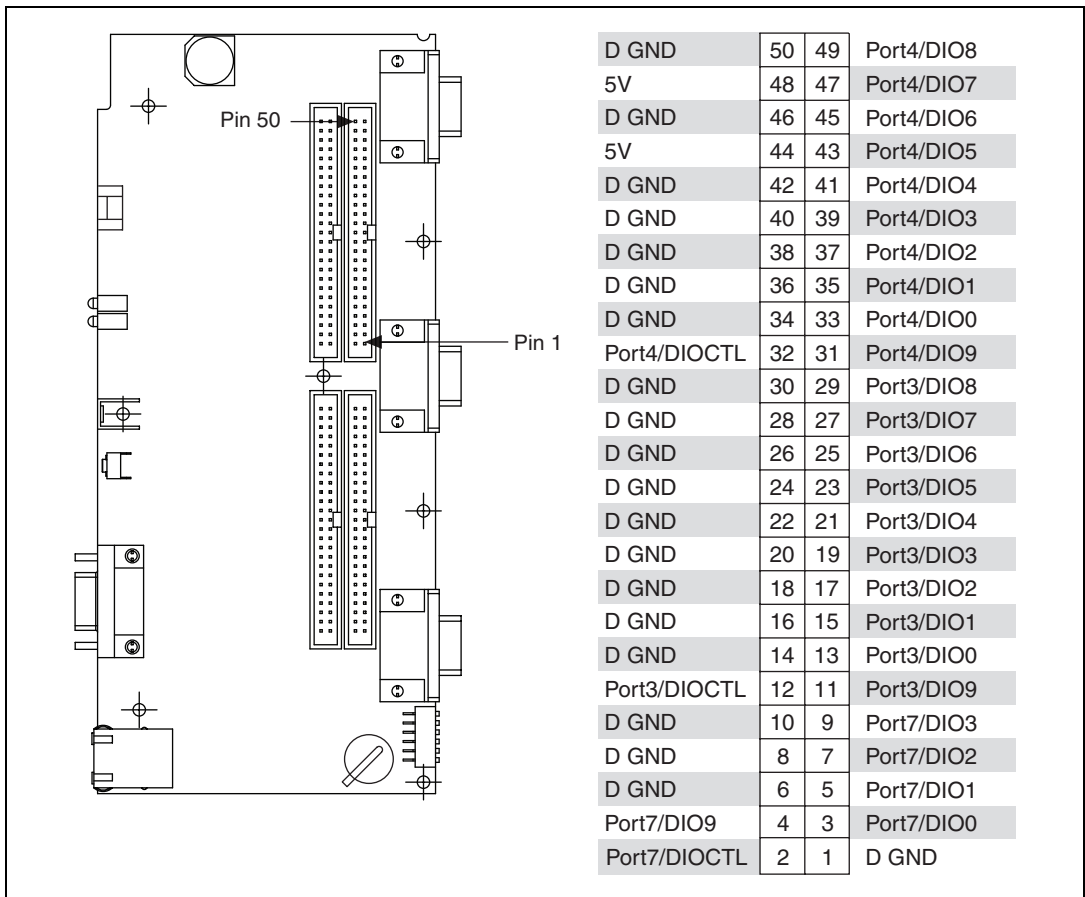


Figure 8. Pinout of I/O Connector P5, 3.3 V Digital I/O

The following figure and table show the signals on J1, the RS-232 serial port.

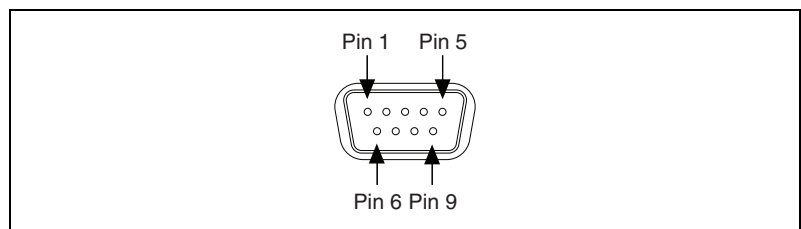


Figure 9. J1, RS-232 Serial Port

Table 2. RS-232 Serial Port Pin Descriptions

Pin	Signal
1	DCD
2	RXD
3	TXD
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

Connecting the sbRIO Device to a Network

Use a standard Category 5 (CAT-5) or better Ethernet cable to connect the RJ-45 Ethernet port to an Ethernet network.



Caution To prevent data loss and to maintain the integrity of your Ethernet installation, do *not* use a cable longer than 100 m.

If you need to build your own cable, refer to the [Cabling](#) section for more information about Ethernet cable wiring connections.

The host computer communicates with the device over a standard Ethernet connection. If the host computer is on a network, you must configure the device on the same subnet as the host computer. If neither the host computer nor the device is connected to a network, you can connect the two directly using a crossover cable.

If you want to use the device on a subnet other than the one the host computer is on, first connect the device on the same subnet as the host computer. Use DHCP to assign an IP address or reassign a static IP address for the subnet where you want it to be and physically move it to the other subnet. Refer to the *Measurement & Automation Explorer Help* for more information about configuring the device in Measurement & Automation Explorer (MAX).

Powering the sbRIO Device

The sbRIO device requires a power supply connected to J3. The supply voltage and current must meet the specifications in the [Power Requirements](#) section of this document, but the actual power requirement depends on how the device is physically configured, programmed, and used. To determine the power requirement of your application, you must measure the power consumption during execution, and add 20% to your estimates to account for transient and startup conditions.



Note Select a high-quality power supply with less than 20 mV ripple. The sbRIO device has some internal power-supply filtering on the positive side, but a low-quality power supply can inject noise into the ground path, which is unfiltered.

Four elements of the sbRIO device can require power: sbRIO internal operation; 3.3 V DIO; 5 V output; and board-only C Series modules installed on the device. Refer to the [Power Requirements](#) section for formulas and examples for calculating power requirements for different configurations and application types.

Complete the following steps to connect a power supply to the device.

1. Remove the MINI-COMBICON plug from connector J3 of the sbRIO-960x. Refer to Figure 4 for the location of J3.
2. Connect the positive lead of the power supply to the V terminal of the MINI-COMBICON plug.
3. Connect the negative lead of the power supply to the C terminal of the MINI-COMBICON plug.
4. Re-install the MINI-COMBICON connector in connector J3.

Powering On the sbRIO Device

When you apply power to the sbRIO-960x, the device runs a power-on self test (POST). During the POST, the Power and Status LEDs turn on. The Status LED turns off, indicating that the POST is complete. If the LEDs do not behave in this way when the system powers on, refer to the [Understanding LED Indications](#) section.

You can configure the device to launch an embedded stand-alone LabVIEW RT application each time it is booted. Refer to the [Running a Stand-Alone Real-Time Application \(RT Module\)](#) topic of the *LabVIEW Help* for more information.

Boot Options

Table 3 lists the reset options available on sbRIO devices. These options determine how the FPGA behaves when the device is reset in various conditions.

Table 3. sbRIO Reset Options

Reset Option	Behavior
Do Not Autoload VI	Does not load the FPGA bit stream from flash memory.
Autoload VI on Device Power-Up	Loads the FPGA bit stream from flash memory to the FPGA when the device powers on.
Autoload VI on Device Reboot	Loads the FPGA bit stream from flash to the FPGA when you reboot the device either with or without cycling power.



Note If you want a VI to run when loaded to the FPGA, complete the following steps.

1. Right-click the FPGA Target item in the **Project Explorer** window in LabVIEW.
2. Select **Properties**.
3. In the **General** category of the **FPGA Target Properties** dialog box, place a check in the **Run when loaded to FPGA** checkbox.
4. Compile the FPGA VI.

Connecting Serial Devices to the sbRIO Device

The sbRIO-960x has an RS-232 serial port to which you can connect devices such as displays or input devices. Use the Serial VIs to read from and write to the serial port from a LabVIEW RT application. For more information about using the Serial VIs, refer to the *Serial VIs and Functions* topic of the *LabVIEW Help*.

Using the Internal Real-Time Clock

The system clock of the sbRIO device gets the date and time from the internal real-time clock at startup. This synchronization provides timestamp data to the device.

Configuring DIP Switches

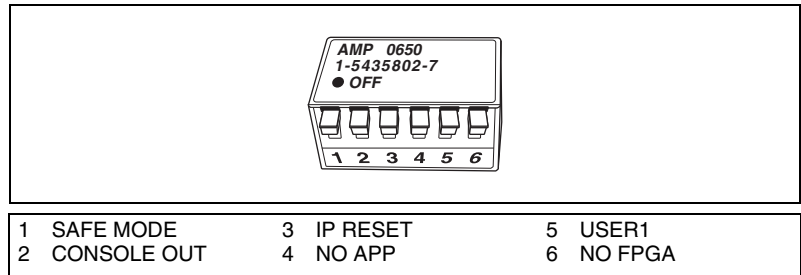


Figure 10. DIP Switches

All of the DIP switches are in the OFF (up) position when the sbRIO device is shipped from National Instruments.

SAFE MODE Switch

The position of the SAFE MODE switch determines whether the embedded LabVIEW Real-Time engine launches at startup. If the switch is in the OFF position, the LabVIEW Real-Time engine launches. Keep this switch in the OFF position during normal operation. If the switch is in the ON position at startup, the sbRIO device launches only the essential services required for updating its configuration and installing software. The LabVIEW Real-Time engine does not launch.

Push the SAFE MODE switch to the ON position if the software on the sbRIO device is corrupted. Even if the switch is not in the ON position, if there is no software installed on the device, the device automatically boots into safe mode. The SAFE MODE switch must be in the ON position to reformat the drive on the device. Refer to the *Measurement & Automation Explorer Help* for more about installing software and reformatting the drive.

CONSOLE OUT Switch

With a serial-port terminal program, you can use the serial port to read the IP address and firmware version of the sbRIO device. Use a null-modem cable to connect the serial port on the device to a computer. Push the CONSOLE OUT switch to the ON position. Make sure that the serial-port terminal program is configured to the following settings:

- 9,600 bits per second
- Eight data bits
- No parity

- One stop bit
- No flow control

Keep this switch in the OFF position during normal operation. If CONSOLE OUT is enabled, LabVIEW RT cannot communicate with the serial port.

IP RESET Switch

Push the IP RESET switch to the ON position and reboot the sbRIO device to reset the IP address to 0 . 0 . 0 . 0. If the device is on your local subnet and the IP RESET switch is in the ON position, the device appears in MAX with IP address 0 . 0 . 0 . 0. You can configure a new IP address for the device in MAX. Refer to the [Resetting the Network Configuration of the sbRIO Device](#) section for more information about resetting the IP address.

NO APP Switch

Push the NO APP switch to the ON position to prevent a LabVIEW RT startup application from running at startup. If you want to permanently disable a LabVIEW RT application from running at startup, you must disable it in LabVIEW. To run an application at startup, push the NO APP switch to the OFF position, create an application using the LabVIEW Application Builder, and configure the application in LabVIEW to launch at startup. For more information about automatically launching VIs at startup and disabling VIs from launching at startup, refer to the *Running a Stand-Alone Real-Time Application (RT Module)* topic of the *LabVIEW Help*.

USER1 Switch

You can define the USER1 switch for your application. To define the purpose of this switch in your embedded application, use the RT Read Switch VI in your LabVIEW RT embedded VI. For more information about the RT Read Switch VI, refer to the *LabVIEW Help*.

NO FPGA Switch

Push the NO FPGA switch to the ON position to prevent a LabVIEW FPGA application from loading at startup. The NO FPGA switch overrides the options described in the [Boot Options](#) section. After startup you can download bit files to flash memory from a LabVIEW project regardless of switch position. If you already have an application configured to launch at startup and you push the NO FPGA switch from ON to OFF, the startup application is automatically enabled.

Using the Reset Button

Pressing the Reset button reboots the processor. The FPGA continues to run unless you select the **Autoload VI on Device Reboot** boot option. Refer to the *Boot Options* section for more information.

Understanding LED Indications

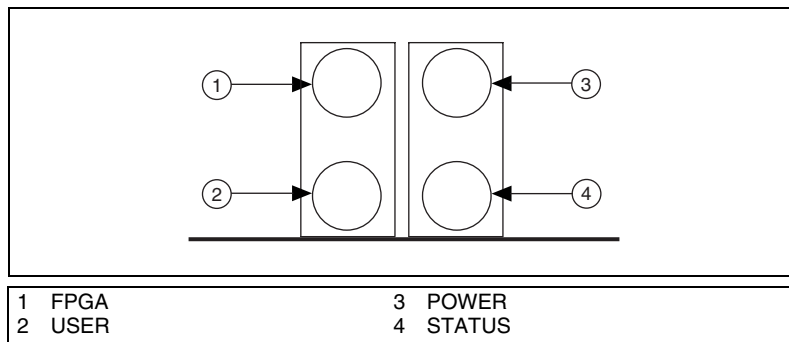


Figure 11. sbRIO-960x LEDs

FPGA LED

You can use the FPGA LED to help debug your application or easily retrieve application status. Use the LabVIEW FPGA Module and NI-RIO software to define the FPGA LED to meet the needs of your application. Refer to *LabVIEW Help* for information about programming this LED.

USER LED

You can define the USER LED to meet the needs of your application. To define the LED, use the RT LEDs VI in LabVIEW. For more information about the RT LEDs VI, refer to the *LabVIEW Help*.

POWER LED

The POWER LED is lit while the sbRIO device is powered on. This LED indicates that the 5 V and 3.3 V rails are stable.

STATUS LED

The STATUS LED is off during normal operation. The sbRIO device indicates specific error conditions by flashing the STATUS LED a certain number of times as shown in Table 4.

Table 4. Status LED Indications

Number of Flashes	Indication
1	The device is unconfigured. Use MAX to configure the device. Refer to the <i>Measurement & Automation Explorer Help</i> for information about configuring the device.
2	The device has detected an error in its software. This usually occurs when an attempt to upgrade the software is interrupted. Reinstall software on the device. Refer to the <i>Measurement & Automation Explorer Help</i> for information about installing software on the device.
3	The device is in safe mode because the Safe Mode DIP switch is in the ON position. Refer to the <i>Configuring DIP Switches</i> section for information about the Safe Mode DIP switch.
4	The software has crashed twice without rebooting or cycling power between crashes. This usually occurs when the device runs out of memory. Review your RT VI and check the memory usage. Modify the VI as necessary to solve the memory usage issue.
Continuous flashing or solid	The device may be configured for DHCP but unable to get an IP address because of a problem with the DHCP server. Check the network connection and try again. If the problem persists, contact National Instruments.

Resetting the Network Configuration of the sbRIO Device

If the sbRIO device is not able to communicate with the network, you can use the IP RESET switch to manually restore the device to the factory network settings. When you restore the device to the factory network settings, the IP address, subnet mask, DNS address, gateway, and Time Server IP are set to 0.0.0.0. Power-on defaults, watchdog settings, and VIs are unaffected.

Complete the following steps to restore the device to the factory network settings.

1. Move the IP RESET DIP switch to the ON position.
2. Press the Reset button.
3. Move the IP RESET switch to the OFF position.

The network settings are restored. You can reconfigure the settings in MAX from a computer on the same subnet. Refer to the *Measurement & Automation Explorer Help* for more information about configuring the device.



Note If the device is restored to the factory network settings, the LabVIEW run-time engine does not load. You must reconfigure the network settings and reboot the device for the LabVIEW run-time engine to load.

Integrated 3.3 V Digital I/O

The four 40-pin IDC headers, P2–P5, provide connections for 110 low-voltage DIO channels, 82 DGND, and eight +5 V voltage outputs. The following figure represents a single DIO channel.

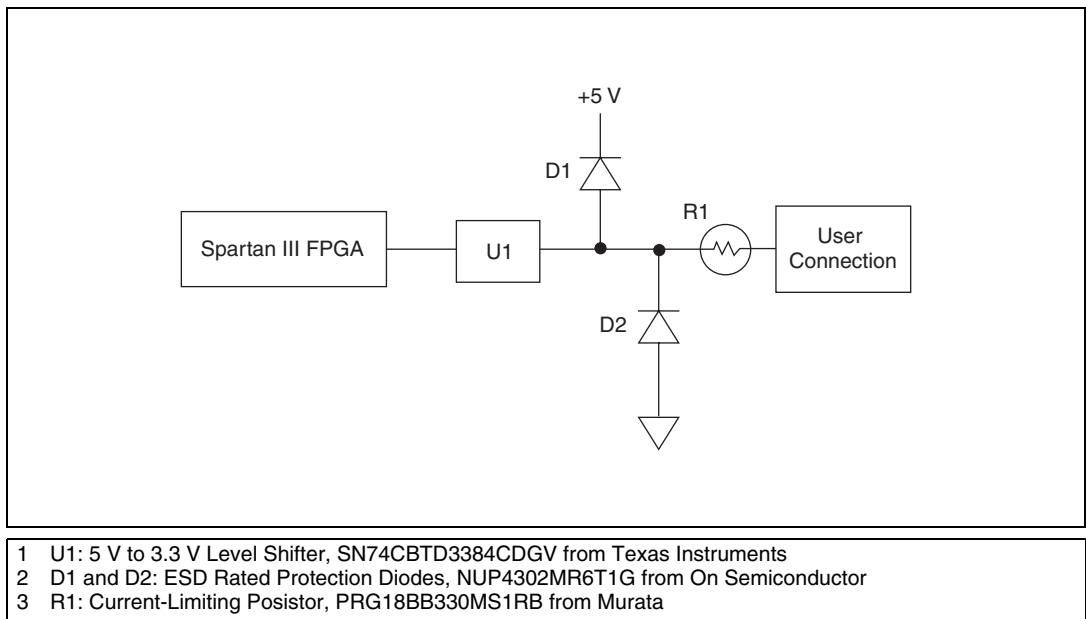


Figure 12. Circuitry of One 3.3 V DIO Channel

I/O Protection

The 33 Ω current-limiting posistor, R1, and the protection diodes, D1 and D2, protect each DIO channel against externally applied voltages of ± 20 V and ESD events. The combination of R1 and D1 protects against overvoltage, and the combination of R1 and D2 protects against undervoltage. The resistance of R1 increases rapidly with temperature.

During overvoltage conditions, high current flows through R1 and into the protection diodes. High current causes internal heating in the posistor, which increases the resistance and limits the current. Refer to the [Specifications](#) section for current-limiting and resistance values.

Drive Strength

The sbRIO devices were tested with all 110 DIO channels driving 3 mA DC loads, for a total of 330 mA sourcing from the FPGA. The FPGA uses minimum 8 mA drivers, but the devices are not characterized for loads higher than 3 mA.

Signal Integrity

The sbRIO boards were designed with 60 Ω characteristic trace impedance. The characteristic impedance of most IDC ribbon cables is 110 Ω , which is grossly mismatched from the board. However, headers P2–P5 were designed such that the signals are interwoven with ground (signal/ground/signal/ground, etc.), which greatly improves the signal integrity. This is sufficient for most applications

For the best possible signal integrity, use 3M™ ribbon cable #3353, which has a characteristic impedance of 65 Ω . This cable has a ground plane that connects to the ground plane of the board at pin 1 and pin 50. The internal ground plane of this cable also reduces noise and radiated emissions.

Using +5 V Power from 3.3 V DIO Headers P2–P5

Each of the four DIO headers has two pins to provide +5 V power for external applications. This +5 V outputs are referenced to DGND on the headers and are connected directly to the internal 5 V power plane of the sbRIO device. The +5 V source has current limiting and overvoltage clamps. Nevertheless, sudden current steps and noisy loads can inject high-frequency transients into the power planes of the device. Such transients can cause intermittent failures in the digital timing and lead to unexpected behavior. Add filters and/or additional current limiting between the external load and the +5 V output if the external load is not a quiet, slowly ramping DC load. An LC filter of 6.8 μ H and 100 μ F per 200 mA load should be sufficient, but the OEM user is responsible for final requirements and testing.

The sbRIO power supply is designed for a total of 2 A external load at 5 V. This total includes 200 mA per installed C Series module. For example, if three C Series modules are installed, only 2 A – (3 \times 0.2) = 1.4 A is available for use on headers P2–P5. Each pin on the headers is rated for 2 A, but a typical 28 AWG ribbon cable is rated for only 225 mA per conductor.

The OEM user is responsible for determining cabling requirements and ensuring that current limits are not exceeded.

Specifications

The following specifications are typical for the range –20 to 55 °C unless otherwise noted.

Network

Network interface.....	10BaseT and 100BaseTX Ethernet
Compatibility	IEEE 802.3
Communication rates	10 Mbps, 100 Mbps, auto-negotiated
Maximum cabling distance	100 m/segment

Processor Speed

sbRIO-9601	266 MHz
sbRIO-9602	400 MHz

Memory

Non-volatile memory	
sbRIO-9601	128 MB
sbRIO-9602.....	256 MB
System memory	
sbRIO-9601	64 MB
sbRIO-9602.....	128 MB

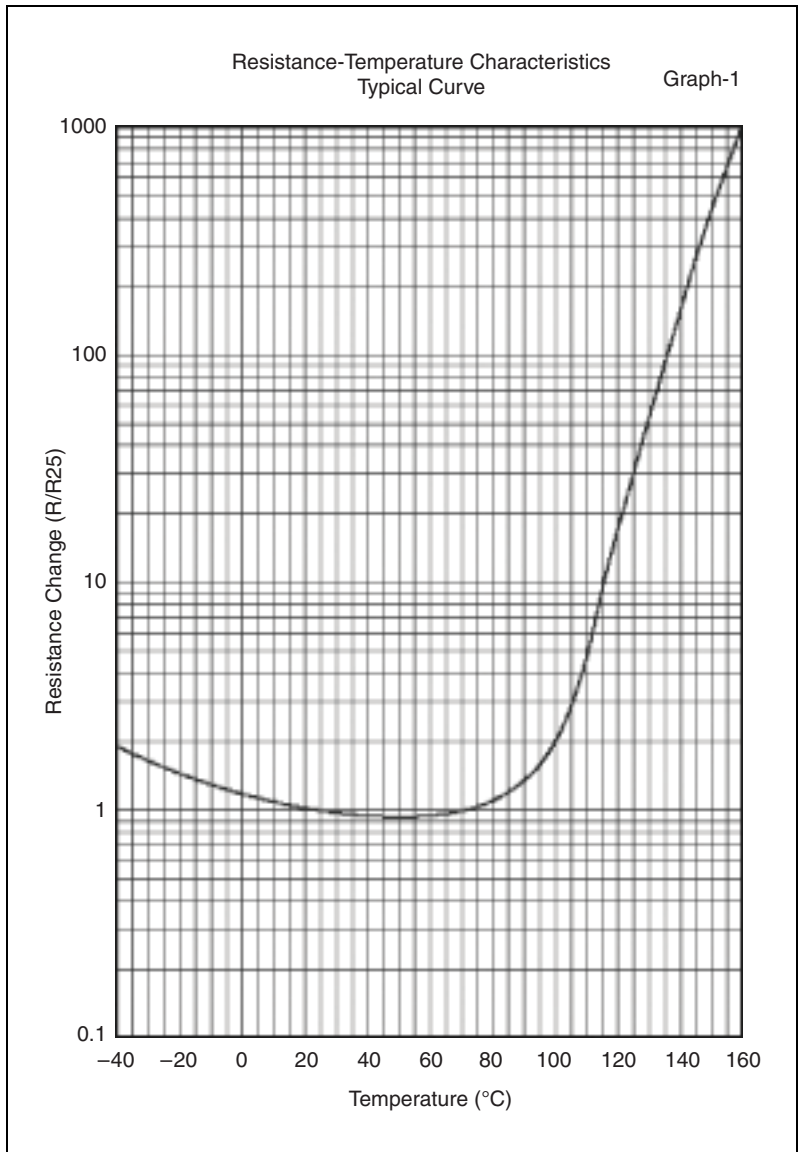
Xilinx Spartan 3 Reconfigurable FPGA

Number of logic cells	
sbRIO-9601.....	17,280
sbRIO-9602.....	46,080
Available embedded RAM	
sbRIO-9601	432 kbits
sbRIO-9602.....	720 kbits

3.3 V Digital I/O

Number of DIO channels.....	110
Maximum tested current per channel	3 mA
Maximum total current, all lines.....	330 mA
Maximum tested DIO frequency	10 MHz
Input logic levels	
Input high voltage, V_{IH}	2.0 V min; 5.25 V max
Input low voltage, V_{IL}	0 V min; 0.8 V max
Output logic levels	
Output high voltage, V_{OH} , sourcing 3 mA	2.7 V min; 3.3 V max
Output low voltage, V_{OL} , sinking 3 mA	0.07 V min; 0.54 V max
Overvoltage protection	
at -20 to 70 °C	±20 V (maximum 2 pins in overvoltage)
Posistor (PRG18BB330MS1RB from Murata)	
Maximum peak abnormal-condition current	760 mA
Maximum hold current at 25 °C.....	36 mA
Maximum hold current at 70 °C.....	20 mA
Trip current at 25 °C.....	71 mA
Resistance at 25 °C.....	33 Ω ±20%

Resistance-temperature characteristics, typical curve



Power Requirements

The sbRIO device requires a power supply connected to connector J3. Refer to Figure 4 for the location of J3. Refer to the [Powering the sbRIO Device](#) section for information about connecting the power supply.

Power supply voltage range.....19–30 VDC¹

Power supply current limit1.8 A

Power connector internal fuse2 A non-replaceable

$$\text{Total power requirement} = P_{int} + P_{DIO} + P_{5V} + P_{CSer},$$

where P_{int} is the consumption by sbRIO internal operation
 P_{DIO} is the consumption by the 3.3 V DIO
 P_{5V} is the consumption by the 5 V voltage output
 P_{CSer} is the consumption by installed board-only C Series modules.



Note You must add 20% to the calculated or measured total power requirement to account for transient and startup conditions.

Maximum P_{int} 6.0 W

Maximum P_{DIO} 1.28 W

$$P_{DIO} = \text{Total DIO Current} \times 3.3 \text{ V}/0.85$$

Maximum P_{5V} 11.1 W

$$P_{5V} = \text{Total 5 V Output Current} \times 5 \text{ V}/0.9$$

Maximum P_{CSer} 3.3 W; each installed C Series module consumes up to 1.1 W

¹ The sbRIO device is 1–2% more efficient with a 19 V supply than with a 30 V supply.

Example power requirement calculations

For an sbRIO-9602 with three installed board-only C Series modules, 20 mA total current through 3.3 V DIO pins, and 1 A of current through 5 V output, calculate the total power requirement as follows:

$$\begin{aligned}P_{int} &= 6.0 \text{ W} \\P_{CSer} &= 3.30 \text{ W} \\P_{DIO} &= 0.08 \text{ W} \\P_{5V} &= 5.55 \text{ W}\end{aligned}$$

Adding 20% for transient conditions, $14.93 \text{ W} \times 1.2 = 17.92 \text{ W}$

Total power requirement = 17.92 W

For an sbRIO-9601 with one installed board-only C Series module, 330 mA total current through 3.3 V DIO pins, and no 5 V output used, calculate the total power requirement as follows:

$$\begin{aligned}P_{int} &= 6.0 \text{ W} \\P_{CSer} &= 1.10 \text{ W} \\P_{DIO} &= 1.28 \text{ W} \\P_{5V} &= 0.00 \text{ W}\end{aligned}$$

Adding 20% for transient conditions, $8.38 \text{ W} \times 1.2 = 10.06 \text{ W}$

Total power requirement = 10.06 W

Backup battery 3 V lithium coin cell, BR2032

Working I/O Voltages

Connect only voltages that are within these limits.

V terminal to C terminal 35 VDC max,
Measurement Category I



Caution Do not connect the system to signals or use for measurements within Measurement Categories II, III, or IV.

Environmental Management

National Instruments is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial not only to the environment but also to NI customers.

For additional environmental information, refer to the *NI and the Environment* Web page at ni.com/environment. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)



EU Customers At the end of their life cycle, all products *must* be sent to a WEEE recycling center. For more information about WEEE recycling centers and National Instruments WEEE initiatives, visit ni.com/environment/weee.htm.

电子信息产品污染控制管理办法（中国 RoHS）



中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令 (RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 ni.com/environment/rohs_china。(For information about China RoHS compliance, go to ni.com/environment/rohs_china.)

Environmental

The sbRIO-960x is intended for indoor use only.

Ambient temperature in enclosure

(IEC 60068-2-1, IEC 60068-2-2).....-20 to 55 °C

Storage temperature

(IEC 60068-2-1, IEC 60068-2-2).....-40 to 85 °C

Operating humidity

(IEC 60068-2-56)10 to 90% RH, noncondensing

Storage humidity

(IEC 60068-2-56)5 to 95% RH, noncondensing

Maximum altitude.....2,000 m

Pollution Degree (IEC 60664).....2

Physical Characteristics

Torque for screw terminals on J30.5 to 0.6 N · m

(4.4 to 5.3 lb · in.)

Weight198.45 g (7.0 oz)

Cabling

Table 5 shows the standard Ethernet cable wiring connections for both normal and crossover cables.

Table 5. Ethernet Cable Wiring Connections

Pin	Connector 1	Connector 2 (Normal)	Connector 2 (Crossover)
1	white/orange	white/orange	white/green
2	orange	orange	green
3	white/green	white/green	white/orange
4	blue	blue	blue
5	white/blue	white/blue	white/blue
6	green	green	orange
7	white/brown	white/brown	white/brown
8	brown	brown	brown

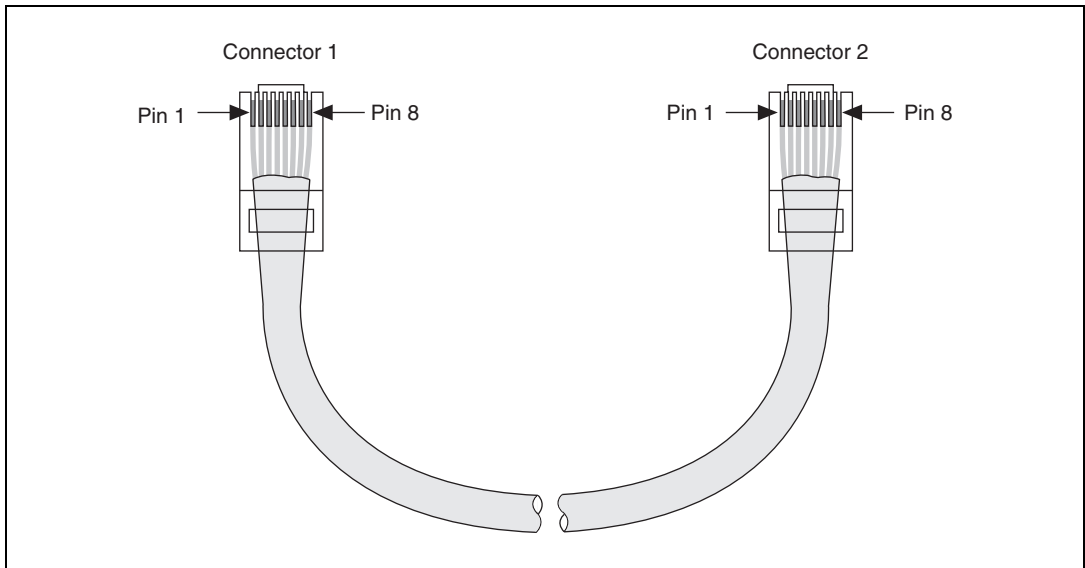


Figure 13. Ethernet Connector Pinout

Where to Go for Support

The National Instruments Web site is your complete resource for technical support. At ni.com/support you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world to help address your support needs. For telephone support in the United States, create your service request at ni.com/support and follow the calling instructions or dial 512 795 8248. For telephone support outside the United States, contact your local branch office:

Australia 1800 300 800, Austria 43 662 457990-0,
Belgium 32 (0) 2 757 0020, Brazil 55 11 3262 3599,
Canada 800 433 3488, China 86 21 5050 9800,
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