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**sbRIO-9603**

# CompactRIO Single-Board Controller with NI-DAQmx

Use this document to do the following:

- Design mounting and installation solutions for the CompactRIO Single-Board Controller with DAQmx
- Ground the single-board controller
- Connect the single-board controller to power and to a host computer
- Manage and design thermal solutions for the single-board controller



**Note** For information about designing systems and fixtures using the single-board controller, programming and configuring the single-board controller, and designing a RIO mezzanine card connector, refer to the *CompactRIO Single-Board Controller with DAQmx System Development Manual* on [ni.com/manuals](http://ni.com/manuals).

**Table 1.** CompactRIO Single Board Controller with NI-DAQmx Models

Digital I/O Models	Multifunction I/O Models
sbRIO-9603	sbRIO-9628
sbRIO-9608	sbRIO-9629
sbRIO-9609	sbRIO-9638

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## CompactRIO Single-Board Controller Concepts

**Table 2.** System Development Manual Definitions

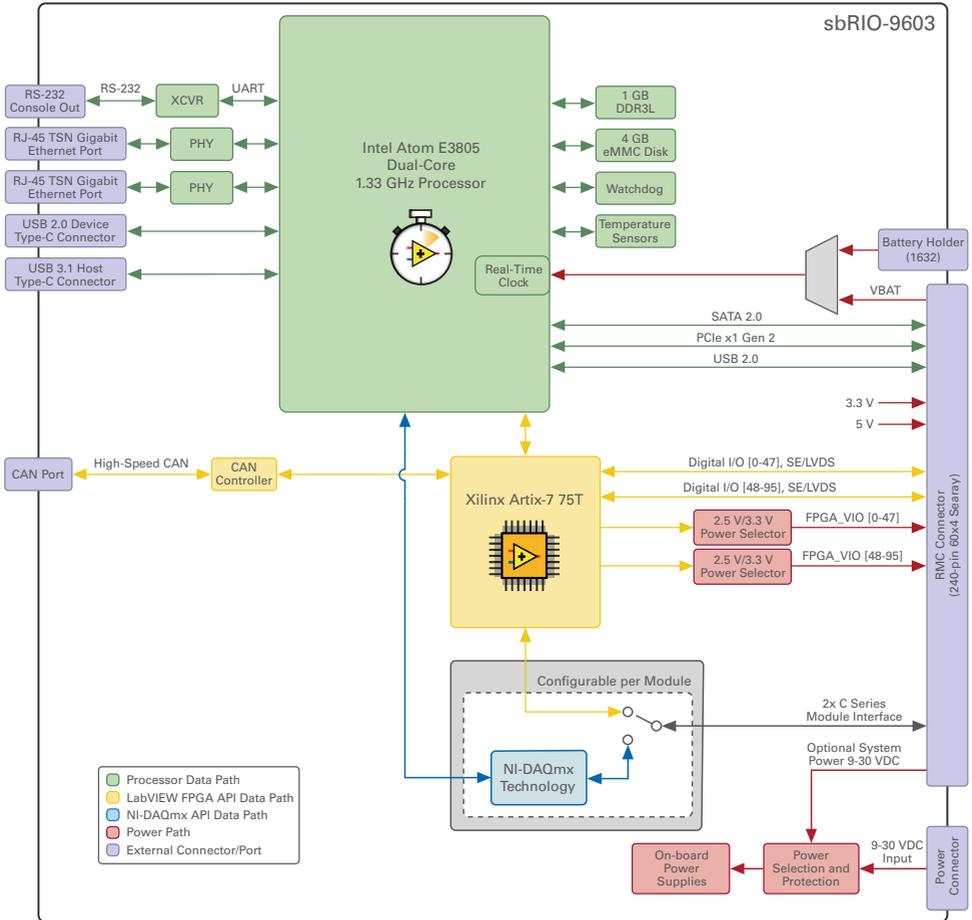
Term	Definition
<b>Connector0</b>	Connector0 refers to the MIO connector on the sbRIO-9628, sbRIO-9629, and sbRIO-9638.
<b>Connector1</b>	Connector1 refers to the DIO connector on the sbRIO-9638.

**Table 2.** System Development Manual Definitions (Continued)

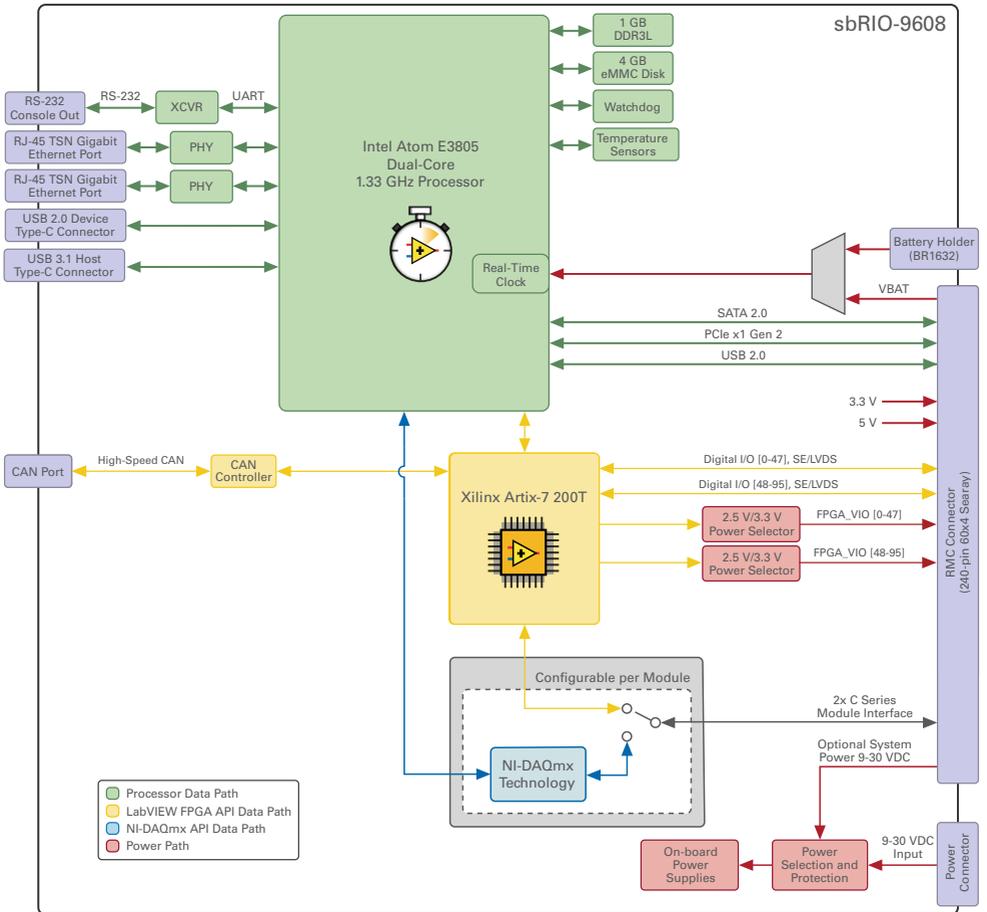
<b>Term</b>	<b>Definition</b>
<b>sbRIO-960x</b>	In this document, sbRIO-960x refers exclusively to the following CompactRIO single-board controllers with NI-DAQmx: sbRIO-9603, sbRIO-9608, and sbRIO-9609.
<b>sbRIO-962x/ sbRIO-963x</b>	In this document, sbRIO-962x/sbRIO-963x refers exclusively to the following CompactRIO single-board controllers with NI-DAQmx: sbRIO-9628, sbRIO-9629, and sbRIO-9638.
<b>sbRIO-96xx</b>	In this document, sbRIO-96xx refers exclusively to the CompactRIO single-board controllers with NI-DAQmx.
<b>C Series Module</b>	C Series Module refers to any board-only C Series module designed for implementation in an sbRIO system.
<b>Onboard I/O Module</b>	Onboard I/O Module refers to the distinct onboard modules designed into the sbRIO-96xx.
<b>sbRIO I/O Module</b>	In this document, sbRIO I/O Module refers to both onboard I/O and C Series modules.

# Block Diagrams

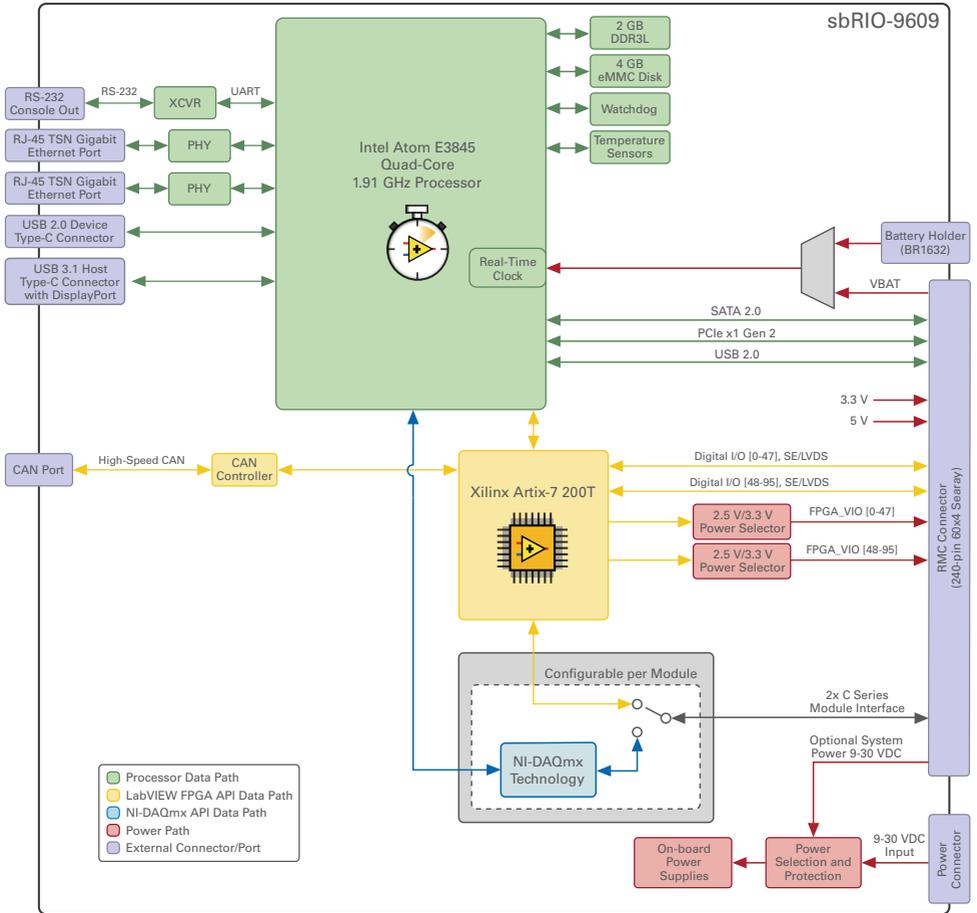
**Figure 1. sbRIO-9603 Block Diagram**



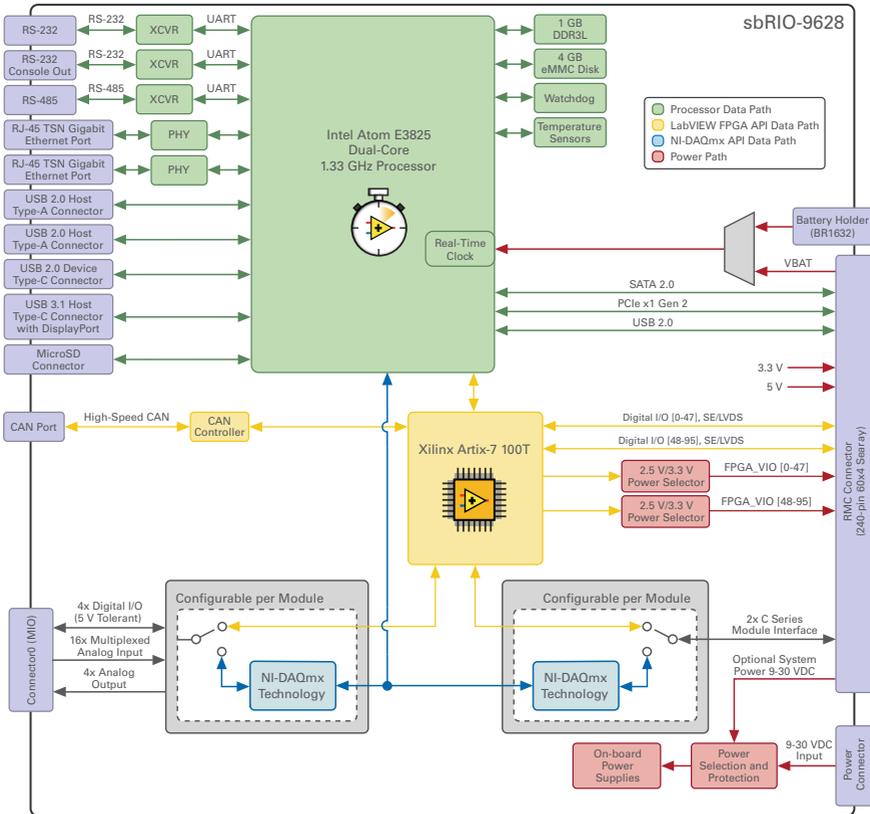
**Figure 2. sbRIO-9608 Block Diagram**



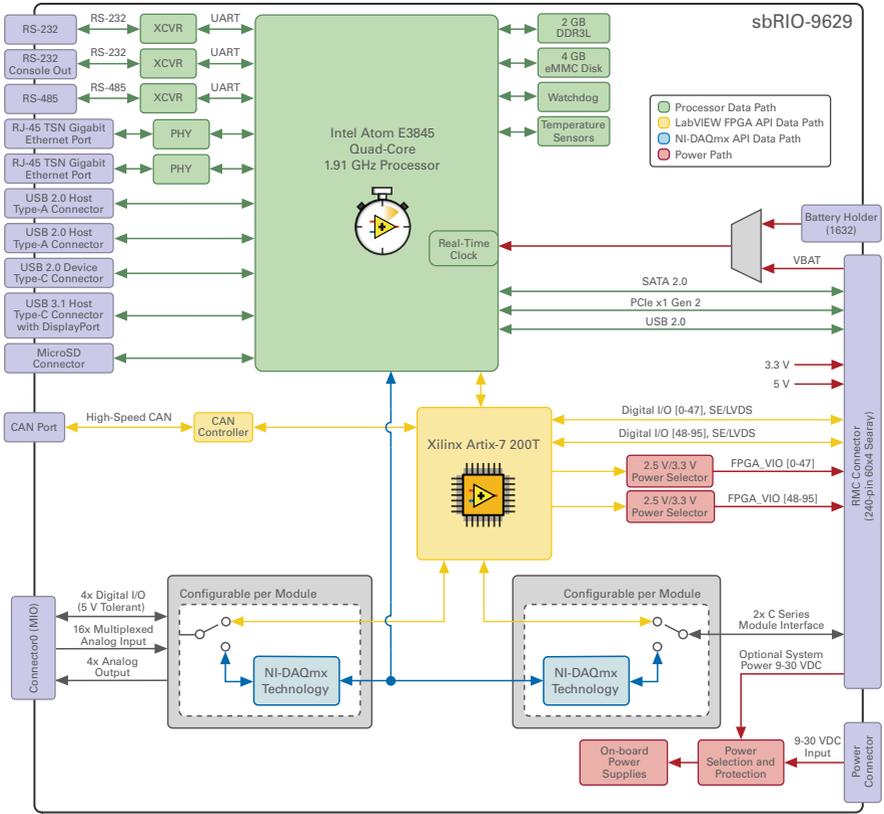
**Figure 3. sbRIO-9609 Block Diagram**



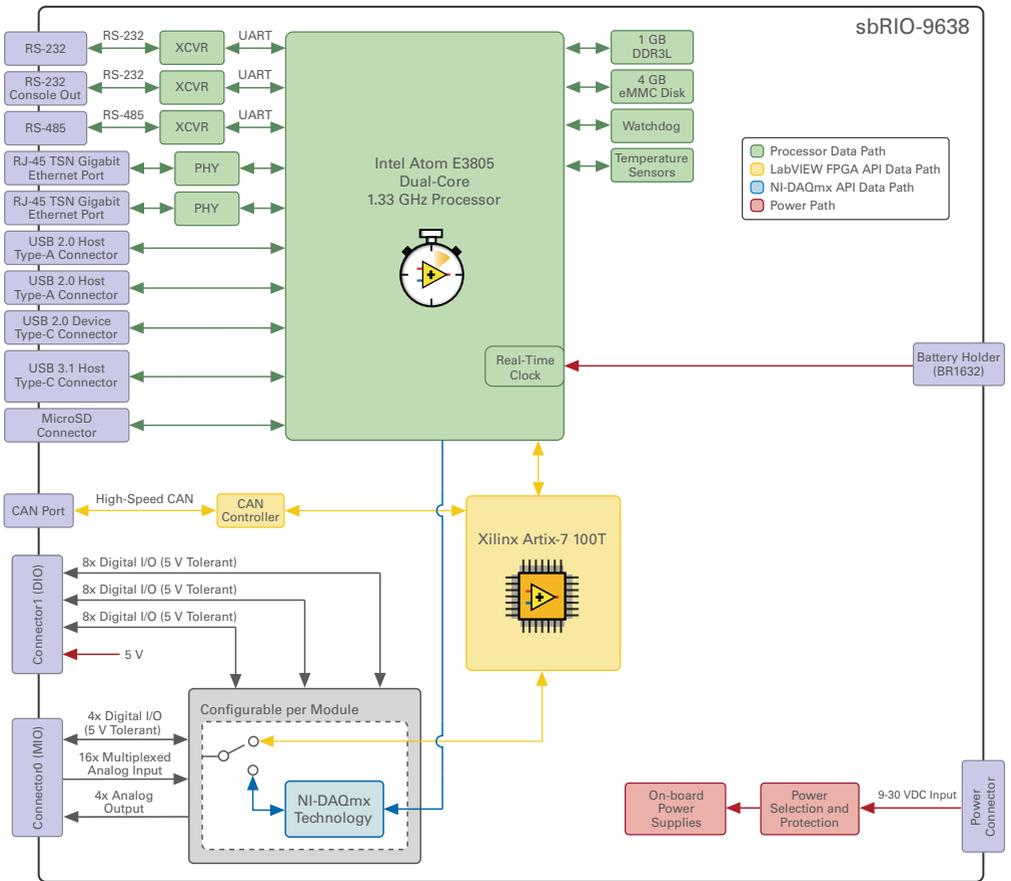
**Figure 4. sbRIO-9628 Block Diagram**



**Figure 5. sbRIO-9629 Block Diagram**



**Figure 6. sbRIO-9638 Block Diagram**



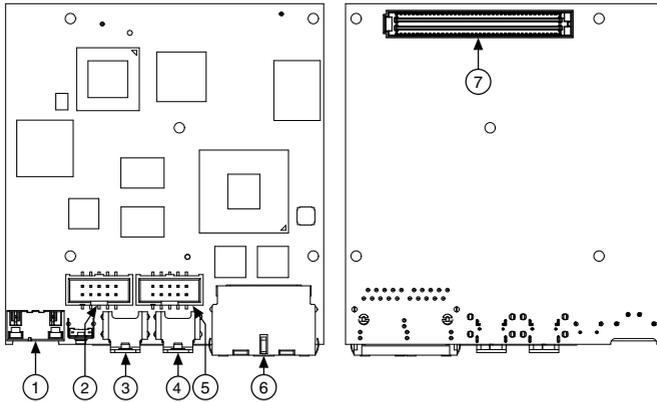
# sbRIO-96xx Features

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## Ports and Connectors

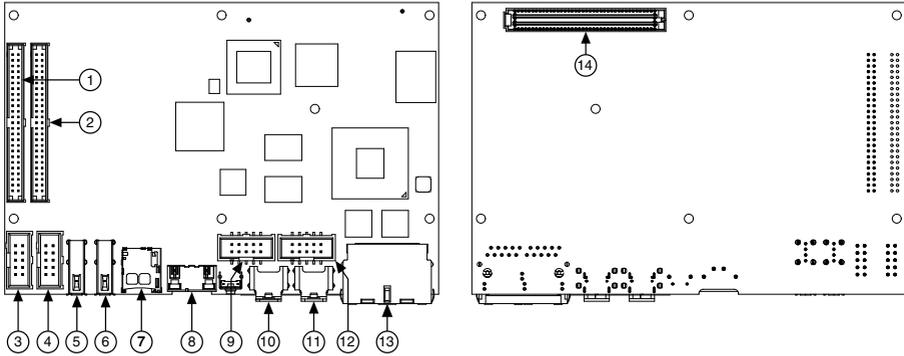
**Figure 7.** sbRIO-960x Ports and Connectors

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- 
- |  |  |
|--|--|
| 1. Power terminal  | 5. RS-232 serial port with Console Out (ASRL1) |
| 2. CAN port  | 6. RJ-45 Gigabit Ethernet ports                |
| 3. USB Type-C 2.0 device port                                    | 7. RMC connector                               |
| 4. USB Type-C 3.1 host port (with DisplayPort on the sbRIO-9609) |  |
-

**Figure 8. sbRIO-962x/sbRIO-963x Ports and Connectors**



- |   |   |
|---|---|
| <ol style="list-style-type: none"> <li>1. Connector1 (DIO port) (sbRIO-9638 only)</li> <li>2. Connector0 (MIO port)</li> <li>3. RS-485 port (ASRL3)</li> <li>4. RS-232 port (ASRL2)</li> <li>5. USB Type-A 2.0 host port</li> <li>6. USB Type-A 2.0 host port</li> <li>7. MicroSD port</li> </ol> | <ol style="list-style-type: none"> <li>8. Power terminal</li> <li>9. CAN port</li> <li>10. USB Type-C 2.0 device port</li> <li>11. USB Type-C 3.1 host port (with DisplayPort on the sbRIO-962x)</li> <li>12. RS-232 serial port with Console Out (ASRL1)</li> <li>13. RJ-45 Gigabit Ethernet ports</li> <li>14. RMC connector (sbRIO-962x only)</li> </ol> |
|---|---|

**Table 3. NI sbRIO Connector Descriptions**

Connector	Description	Manufacturer, Part Number	Recommended Mating Connector	NI Solution
Power	2-position, 3.5 mm Mini-COMBICON H = 7.3 mm (0.29 in.)	Sauro, CTMH029F8-0N0LA	Sauro, CTF02BV8-AN000A	NI, 786902-01
RS-232/485/ CAN IDC Header	10-pin, 0.100 in. CT, shrouded, H = 9.398 mm (0.370 in.)	Samtec, TST-105-01-L-D or HTST-105-01-L-DV-P-TR	TE, 1658622-1	NI, 10-pin to 9-pin D-SUB, 153158-10
50-Pin IDC Header	50-pin, 2 mm CT, Shrouded, H = 3.937 mm (0.155 in.)	3M, 957250-6002-AR	TE, 2-111623-6	NI, 50-position ribbon cable, 154041-12
RMC Connector	240-pin, 40 × 6 position, high density open pin field SEARAY	Samtec, SEAF-40-06.5-S-06-2-A-K-TR	Samtec, SEAM-40-03.0-S-06-2-A-K-TR	—

Samtec SEAM connectors come in multiple heights, indicated in millimeters by the *xx.x* portion of the SEAM-40-*xx.x*-S-06-2 example part number. You can order a mating

connector for the RMC connector from Samtec, the connector manufacturer, or from a distributor such as Arrow or Avnet.

The height of the mating connector you select to mate to the RMC connector determines the height of the standoffs you need. Samtec requires that standoffs be 0.15 mm (0.006 in.) taller than the combined height of the RMC and mating connectors. Therefore, to determine the required standoff height, you must add the heights of the connectors plus 0.15 mm (0.006 in.).

**Table 4. Example Connector Configuration and Calculated Standoff Height**

<b>Component</b>	<b>Manufacturer, Part Number</b>	<b>Height</b>
RMC connector	Samtec SEAF-40-06.5-S-06-2-A-K-TR	6.50 mm (0.256 in.)
Mating connector	Samtec SEAM-40-03.0-S-06-2-A-K-TR	3.00 mm (0.118 in.)
Required additional standoff height	—	0.15 mm (0.006 in.)
Total calculated standoff height	—	9.65 mm (0.380 in.)

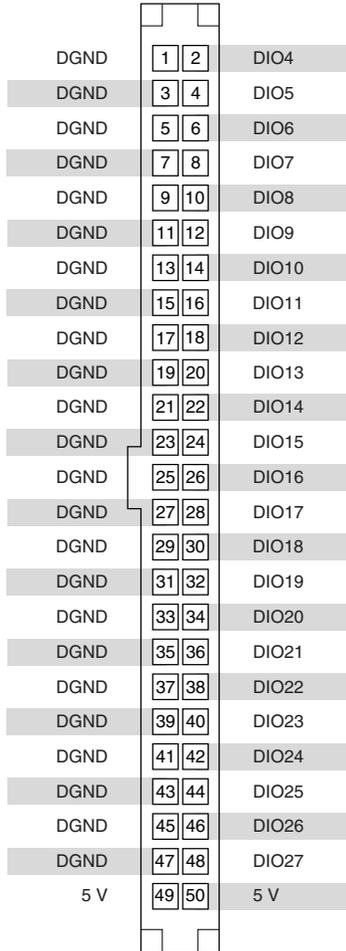
Consult Samtec for alternative heights and options. You must observe keepaways and maximum heights with all RMC and mating connector combinations.

## Connector0 (MIO Port)

Use Connector0 for analog and digital input/output configurations.



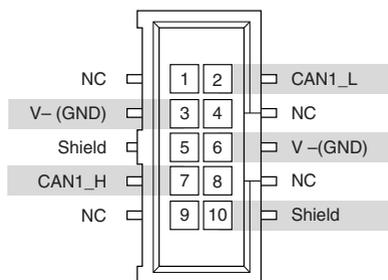
**Figure 10. Connector1 Pinout**



## CAN Port

The CAN port implements a shrouded header, 10-position modular jack to provide connections to a CAN or CAN FD bus.

**Figure 11. CAN Port Pinout**



**Table 5. CAN Port Accessories**

Accessory	Part Number
NI Single-Board RIO 10-pin header to 9-pin D-SUB	153158-10

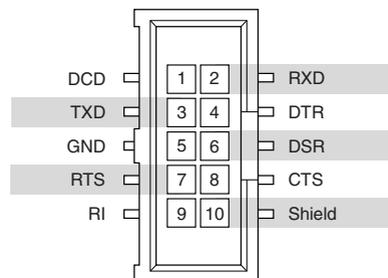
## RS-232 Serial Port

The RS-232 serial port implements a shrouded header, 10-position modular jack to connect displays or input devices. Use Serial VIs to read from and write to the serial port. Refer to the *LabVIEW Help* for information about the Serial VIs. Find examples on how to use NI-Serial or NI-VISA to perform serial communication in the NI Example Finder. Select **Help»Find Examples** in LabVIEW to launch the NI ExampleFinder.



**Note** The ASRL1 RS-232 serial port cannot be accessed by the user application when the Console Out startup option is enabled.

**Figure 12. RS-232 Serial Port Pinout**



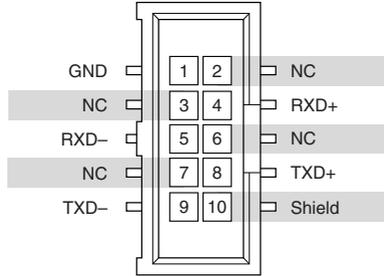
**Table 6. RS-232 Serial Port Accessories**

Accessory	Part Number
NI Single-Board RIO 10-pin header to 9-pin D-SUB	153158-10

## RS-485 Serial Port

The RS-485 serial port implements a shrouded header, 10-position modular jack to connect displays or input devices. Use Serial VIs to read from and write to the serial port. Refer to the *LabVIEW Help* for information about the Serial VIs. Find examples on how to use NI-Serial or NI-VISA to perform serial communication in the NI Example Finder. Select **Help»Find Examples** in LabVIEW to launch the NI ExampleFinder.

**Figure 13.** RS-485 Port Pinout

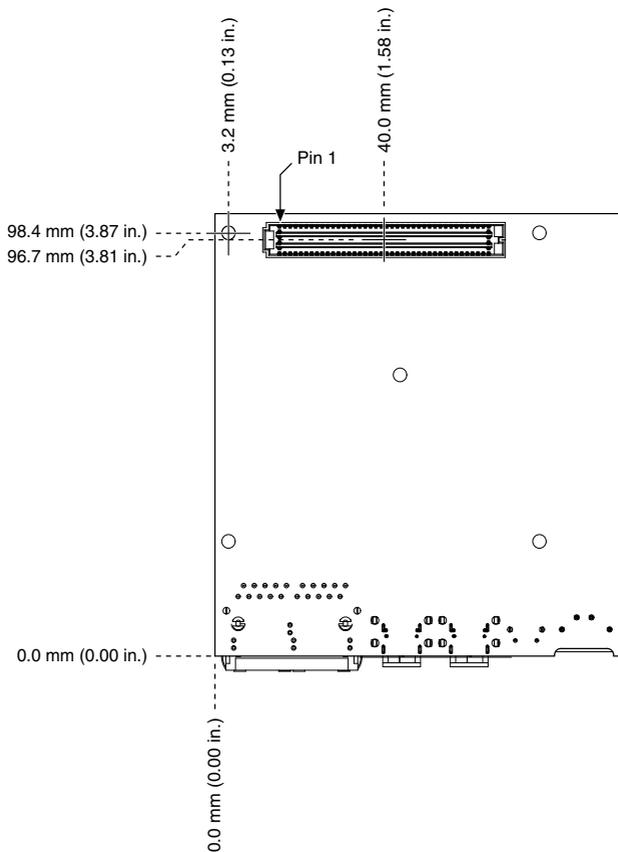


**Table 7.** RS-485 Serial Port Accessories

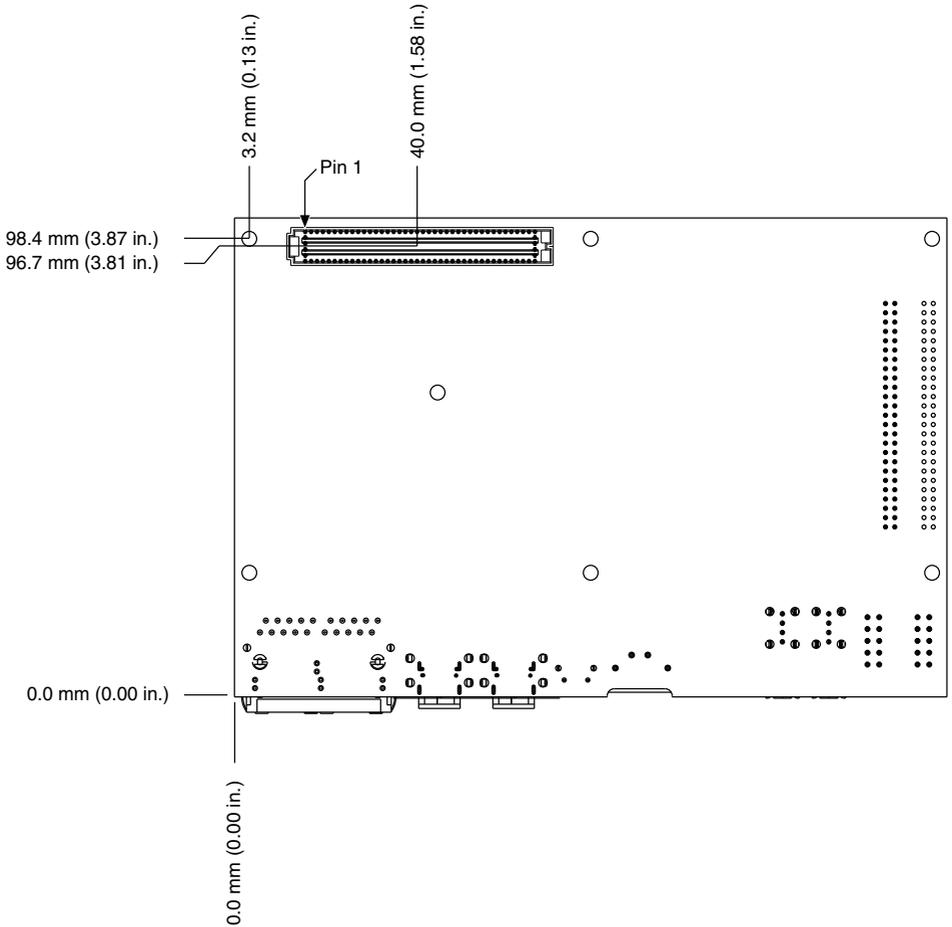
Accessory	Part Number
NI Single-Board RIO 10-pin header to 9-pin D-SUB	153158-10

# RIO Mezzanine Card Connector

**Figure 14.** sbRIO-960x RMC Connector Location and Dimensions



**Figure 15.** sbRIO-962x/sbRIO-963x RMC Connector Location and Dimensions



**Caution** RMCs are not hot-swappable. Disconnect power before mating or unmating.

# RMC Connector Pinout

**Figure 16. RMC Connector Pin Listing**

1 VIN_Filtered	2 GND	3 PCIe_Gen2 TX+	4 GND	5 SATA_TX+	6 GND
7 VIN_Filtered	8 GND	9 PCIe_Gen2 TX-	10 GND	11 SATA_TX-	12 GND
13 GND	14 VIN_Filtered	15 GND	16 PCIe_Gen2 RX+	17 GND	18 SATA_RX+
19 GND	20 VIN_Filtered	21 GND	22 PCIe_Gen2 RX-	23 GND	24 SATA_RX-
25 Reserved	26 GND	27 Reserved	28 GND	29 USB_D+	30 GND
31 PCIe_Clk-	32 PCIe_Clk+	33 USB_OPEN	34 Reserved	35 USB_D-	36 GND
37 CLK_REQ#	38 RST#	39 GND	40 ID_SELECT#[1]	41 GND	42 Reserved (3.3 V)
43 SYS_RST#	44 GND	45 SLEEP[1]	46 CVRT#_DIO3[1]	47 GND	48 3.3 V (to RMC)
49 GND	50 DONE#_DIO2[1]	51 SLEEP[2]	52 GND	53 SPIFUNC_DIO4[1]	54 5 V (to RMC)
55 SPICS#_DIO5[1]	56 MOSI_DIO7[1]	57 GND	58 OSCLK_DIO0[1]	59 PROC_LED	60 5 V (to RMC)
61 SPI_CLK[1]	62 GND	63 ID_SELECT#[2]	64 TRIG_DIO1[1]	65 GND	66 5 V (to RMC)
67 GND	68 DONE#_DIO2[2]	69 CVRT#_DIO3[2]	70 GND	71 MISO_DIO6[1]	72 5 V (to RMC)
73 SPICS#_DIO5[2]	74 MOSI_DIO7[2]	75 GND	76 OSCLK_DIO0[2]	77 SPIFUNC_DIO4[2]	78 GND
79 SPI_CLK[2]	80 GND	81 MISO_DIO6[2]	82 TRIG_DIO1[2]	83 GND	84 Reserved
85 GND	86 5V C Series	87 Reserved	88 GND	89 DIO_47 (DIO_47_P)	90 DIO_15
91 5V C Series	92 DIO_63	93 GND	94 DIO_79 (DIO_79_P)	95 DIO_46 (DIO_47_N)	96 GND
97 DIO_95	98 GND	99 DIO_31 (DIO_31_P)	100 DIO_78 (DIO_79_N)	101 GND	102 DIO_14 (DIO_14_P)
103 GND	104 DIO_62 (DIO_62_P)	105 DIO_30 (DIO_31_N)	106 GND	107 DIO_45 (DIO_45_P)	108 DIO_13 (DIO_14_N)
109 DIO_94 (DIO_94_P)	110 DIO_61 (DIO_62_N)	111 GND	112 DIO_77 (DIO_77_P)	113 DIO_44 (DIO_45_N)	114 GND
115 DIO_93 (DIO_94_N)	116 GND	117 DIO_29 (DIO_29_P)	118 DIO_76 (DIO_77_N)	119 GND	120 DIO_12 (DIO_12_P)
121 GND	122 DIO_60 (DIO_60_P)	123 DIO_28 (DIO_29_N)	124 GND	125 DIO_43 (DIO_43_P)	126 DIO_11 (DIO_12_N)
127 DIO_92 (DIO_92_P)	128 DIO_59 (DIO_60_N)	129 GND	130 DIO_75 (DIO_75_P)	131 DIO_42 (DIO_43_N)	132 GND
133 DIO_91 (DIO_92_N)	134 GND	135 DIO_27 (DIO_27_P)	136 DIO_74 (DIO_75_N)	137 GND	138 DIO_10 (DIO_10_P)
139 GND	140 DIO_58 (DIO_58_P)	141 DIO_26 (DIO_27_N)	142 GND	143 DIO_41 (DIO_41_P)	144 DIO_09 (DIO_10_N)
145 DIO_90 (DIO_90_P)	146 DIO_57 (DIO_58_N)	147 GND	148 DIO_73 (DIO_73_P)	149 DIO_40 (DIO_41_N)	150 GND
151 DIO_89 (DIO_90_N)	152 GND	153 DIO_25 (DIO_25_P)	154 DIO_72 (DIO_73_N)	155 GND	156 DIO_08 (DIO_08_P)
157 GND	158 DIO_56 (DIO_56_P)	159 DIO_24 (DIO_25_N)	160 GND	161 DIO_39 (DIO_39_P)	162 DIO_07 (DIO_08_N)
163 DIO_88 (DIO_88_P)	164 DIO_55 (DIO_56_N)	165 GND	166 DIO_71 (DIO_71_P)	167 DIO_38 (DIO_39_N)	168 GND
169 DIO_87 (DIO_88_N)	170 GND	171 DIO_23 (DIO_23_P)	172 DIO_70 (DIO_71_N)	173 GND	174 DIO_06 (DIO_06_P)
175 GND	176 DIO_54 (DIO_54_P)	177 DIO_22 (DIO_23_N)	178 GND	179 DIO_37 (DIO_37_P)	180 DIO_05 (DIO_06_N)
181 DIO_86 (DIO_86_P)	182 DIO_53 (DIO_54_N)	183 GND	184 DIO_69 (DIO_69_P)	185 DIO_36 (DIO_37_N)	186 GND
187 DIO_85 (DIO_86_N)	188 GND	189 DIO_21 (DIO_21_P)	190 DIO_68 (DIO_69_N)	191 GND	192 DIO_04 (DIO_04_P)
193 GND	194 DIO_52 (DIO_52_P)	195 DIO_20 (DIO_21_N)	196 GND	197 DIO_35 (DIO_35_P)	198 DIO_03 (DIO_04_N)
199 DIO_84 (DIO_84_P)	200 DIO_51 (DIO_52_N)	201 GND	202 DIO_67 (DIO_67_P)	203 DIO_34 (DIO_35_N)	204 GND
205 DIO_83 (DIO_84_N)	206 GND	207 DIO_19 (DIO_19_P)	208 DIO_66 (DIO_67_N)	209 GND	210 DIO_02 (DIO_02_P)
211 GND	212 DIO_50 (DIO_50_P)	213 DIO_18 (DIO_19_N)	214 GND	215 DIO_33 (DIO_33_P)	216 DIO_01 (DIO_02_N)
217 DIO_82 (DIO_82_P)	218 DIO_49 (DIO_50_N)	219 GND	220 DIO_65 (DIO_65_P)	221 DIO_32 (DIO_33_N)	222 GND
223 DIO_81 (DIO_82_N)	224 GND	225 DIO_17 (DIO_17_P)	226 DIO_64 (DIO_65_N)	227 GND	228 DIO_00
229 GND	230 DIO_48	231 DIO_16 (DIO_17_N)	232 GND	233 Reserved	234 FPGA_VIO 47..0
235 DIO_80	236 VBAT	237 GND	238 Reserved	239 FPGA_CONF	240 FPGA_VIO 95..48

GND	C Series	FPGA I/O	FPGA Clock Optimized	Processor I/O	Power	Reserved
-----	----------	----------	----------------------	---------------	-------	----------

Use the RMC Connector Feature Set Compatibility table to determine if a previously designed RMC is compatible with the new RMC pinout and as guidance on how to design an RMC for compatibility with future generations of the RMC.

**Table 8. RMC Connector Feature Set Compatibility**

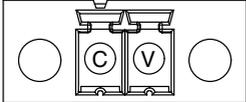
Feature Set		sbRIO-96x7 (Previous Generation)	sbRIO-96xx (CompactRIO Single-Board Controllers with NI- DAQmx)	Future Design Compatibility
DIO[0..63]		Yes	Yes	Yes
DIO[64..95]		Yes	Yes	Not guaranteed
FPGA_CONF		Yes	Yes	Yes
USB_D+/-		Yes	Yes	Yes
RST#		Yes	Yes	Yes
SYS_RST#		Yes	Yes	Yes
5V		Yes	Yes	Yes
3.3V		Yes	Yes	Yes
FPGA_VIO <sup>1</sup>		Yes	Yes	Yes
VBAT		Yes	Yes	Yes
Processor I/O via DIO[0..95]	CAN	Yes	No	Not guaranteed
	RS-232	Yes	Visit <a href="http://ni.com/r/sbrio">ni.com/r/sbrio</a> for more information	Not guaranteed
	RS-485	Yes		Not guaranteed
	SDHC	Yes	No	Not guaranteed
GBE_MDI[0..3+/-]		Yes	No	Not guaranteed
USB_MODE, USB_VBUS		Yes	No	Not guaranteed
USB_CPEN		Yes	Yes	Not guaranteed
Dedicated C Series DIO		Yes	Yes	Not guaranteed
VIN_FILTERED		Yes	Yes	Yes
PCIe		No	Yes	No
SATA		No	Yes	No

<sup>1</sup> FPGA\_VIO present when the FPGA is programmed.

## Power Connector

The sbRIO-96xx has reverse-voltage protection.

**Table 9.** Power Connector Pinout

Pinout	Pin	Description
	C	Common
	V	Power input

## MicroSD Card Removable Storage

The microSD card slot supports microSD card interface speeds up to UHS-I DDR50.



**Notice** Using microSD cards that are not approved by NI might invalidate specifications and result in unreliable performance.

**Table 10.** MicroSD Storage Accessories

Accessory	Capacity	Part Number
Industrial microSD card, -40 °C to 85 °C, UHS-I	16 GB	786913-01
	32 GB	786989-01

## USB 2.0 Type-C Device Port

The USB device functionality provides an alternate method to connect the controller to a host PC for configuration, application deployment, debugging, and maintenance.

## USB 3.1 Type-C Host Port with DisplayPort Alt Mode



**Note** The sbRIO-9609, sbRIO-9628, and sbRIO-9629 support DisplayPort Alt Mode.

The USB host port supports common USB mass-storage devices such as USB Flash drives, USB-to-IDE adapters, keyboards, mice, and USB cameras.



**Note** To use DisplayPort Alt Mode and USB at the same time, use an appropriate adapter that breaks out into both ports.

**Table 11.** NI USB Type-C Adapters for sbRIO-96xx

Adapter	Length	Part Number
USB to DVI Adapter with Retention, USB Type-C Male to DVI-D Female	0.5 m	143558-0R5
USB to VGA Adapter with Retention, USB Type-C Male to VGA Female	0.5 m	143557-0R5
USB Cable with Retention, Type-C Male to Type-A Female, USB 3.1, 3A	0.5 m	143555-0R5

**Table 12.** NI USB Cables with Retention

Cable	Length	Part Number
USB Cable with Retention, Type-C Male to Type-C Male, USB 3.1, 3A	0.3 m	143556-0R3
	1 m	143556-01
	2 m	143556-02

## RJ-45 Gigabit Ethernet Port

Use the tri-speed RJ-45 Gigabit Ethernet port to connect to a network or a host computer. By default, the Ethernet port is enabled and configured to obtain an IP address automatically. The Ethernet port can be configured in MAX.



**Note** Both Ethernet ports perform automatic crossover configuration so you do not need to use a crossover cable to connect to a host computer.

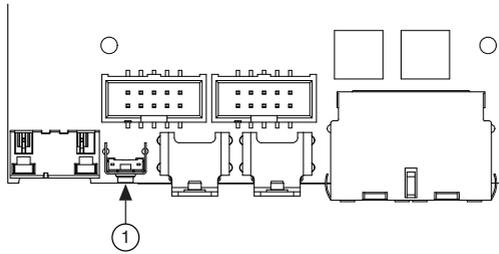
**Table 13.** RJ-45 Gigabit Ethernet Cables

Cables	Length	Part Number
CAT-5E Ethernet Cable, shielded	2 m	151733-02
	5 m	151733-05
	10 m	151733-10

## RESET Button

Press the RESET button to reset the processor in a similar manner as cycling power.

**Figure 17. DIO RESET button**



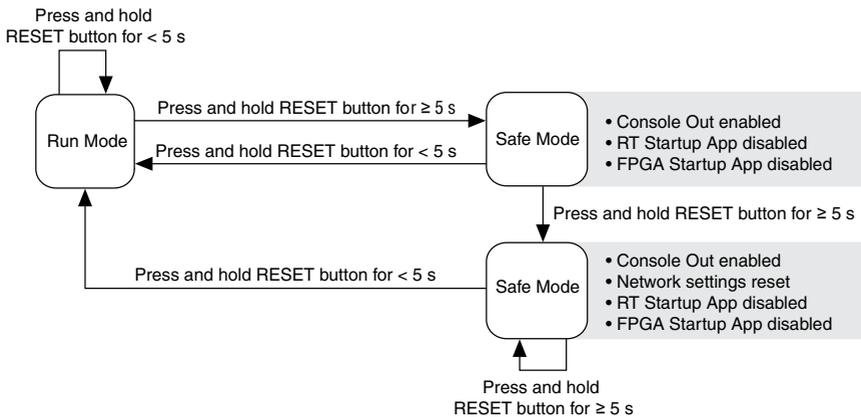
1. RESET button

## System Reset



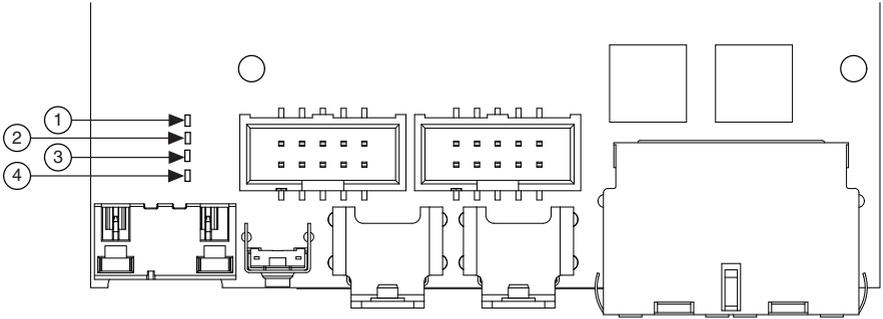
**Note** Resetting the model through the RMC connection implements the same behavior as using the reset button on the model.

**Figure 18. Reset Button Behavior**



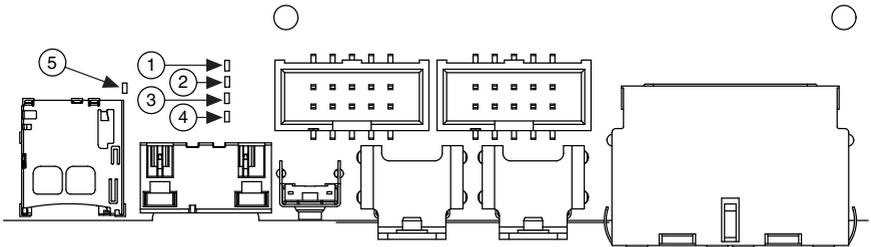
# LEDs

**Figure 19. sbRIO-960x LEDs**



- 1. Power LED
- 2. Status LED
- 3. User1 LED
- 4. User FPGA1 LED

**Figure 20. sbRIO-962x/sbRIO-963x LEDs**



- 1. Power LED
- 2. Status LED
- 3. User1 LED
- 4. User FPGA1 LED
- 5. SD In USE LED

## POWER LED Indicators

**Table 14. POWER LED Indicators**

LED Color	LED Pattern	Indication
Green	Solid	The sbRIO-96xx is powered ON or powered through the RMC connector.
—	Off	The sbRIO-96xx is powered OFF.

## STATUS LED Indicators

**Table 15.** STATUS LED Indicators

LED Pattern	Indication
Blinks twice and pauses	<p>The sbRIO-96xx is in safe mode. Software is not installed, which is the factory default state, or software has been improperly installed on the sbRIO-96xx.</p> <p>An error can occur when an attempt to upgrade the software is interrupted. Reinstall software on the sbRIO-96xx. Refer to the <i>Measurement &amp; Automation Explorer (MAX) Help</i> for information about installing software on the sbRIO-96xx.</p>
Blinks three times and pauses	<p>The sbRIO-96xx is in user-directed safe mode, or the sbRIO-96xx is in install mode to indicate that software is currently being installed.</p> <p>This pattern may also indicate that the user has forced the sbRIO-96xx to boot into safe mode by pressing the reset button for longer than five seconds or by enabling safe mode in MAX. Refer to the <i>Measurement &amp; Automation Explorer (MAX) Help</i> for information about safe mode.</p>
Blinks four times and pauses	<p>The sbRIO-96xx is in safe mode. The software has crashed twice without rebooting or cycling power between crashes.</p>
Continuously blinks	<p>The sbRIO-96xx has not booted into NI Linux Real-Time. The sbRIO-96xx either booted into an unsupported operating system, was interrupted during the boot process, or detected an unrecoverable software error.</p>
On momentarily	<p>The sbRIO-96xx is booting. No action required.</p>
Off	<p>The sbRIO-96xx is in run mode. Software is installed and the operating system is running.</p>

### User LEDs



**Note** You can define the USER1 and USER FPGA1 LEDs to meet the needs of your application.

**Table 16. User LEDs**

LED	LED Color	Description
USER1	Green	Use LabVIEW Real-Time to define the USER1 LED with the RT LEDs VI. For more information about the RT LEDs VI, refer to the <i>LabVIEW Help</i> .
USER FPGA1	Green	Use the LabVIEW FPGA Module and NI-RIO Device Drivers software to define the USER FPGA1 LED. Use the USER FPGA1 LED to help debug your application or retrieve application status. Refer to the <i>LabVIEW Help</i> for information about programming this LED.

## Ethernet LED Indicators

**Table 17. Ethernet LED Indicators**

LED	LED Color	LED Pattern	Indication
ACT/LINK	—	Off	LAN link not established
	Green	Solid	LAN link established
		Flashing	Activity on LAN
10/100/1000	Yellow	Solid	1,000 Mbit/s data rate selected
	Green	Solid	100 Mbit/s data rate selected
	—	Off	10 Mbit/s data rate selected

## Internal Real-Time Clock (RTC)

The system clock of the NI sbRIO-96xx gets the date and time from the internal RTC at startup. This synchronization provides timestamp data to the device.

## Real-Time Clock (RTC) Battery

The sbRIO-96xx contains an RTC battery, which is a lithium cell battery that stores the system clock information when the sbRIO-96xx is powered off. Only a slight drain on the RTC battery occurs when power is applied to the sbRIO-96xx power connector. The rate at which the RTC battery drains when power is disconnected depends on the ambient storage temperature. For longer battery life, store the sbRIO-96xx at a cooler temperature and apply power to the power connector. Refer to the device specifications on [ni.com/manuals](http://ni.com/manuals) for the expected battery lifetime.

The battery is user-replaceable. The sbRIO-96xx ships with an industrial-rated BR1632 battery from RAYOVAC.

# Replacing the Battery

## What To Use

- Replacement battery (Rayovac BR1632)

## What To Do

1. Power off the sbRIO-96xx.
2. Remove the battery.
3. Align and insert the new battery into the space on the board.

## Battery Recycling

The model contains a replaceable battery. Products containing lithium must be disposed of or recycled in accordance with all local laws and site regulations. For more information about disposing of or recycling this device's battery, refer to <https://www.rayovac.com/>.

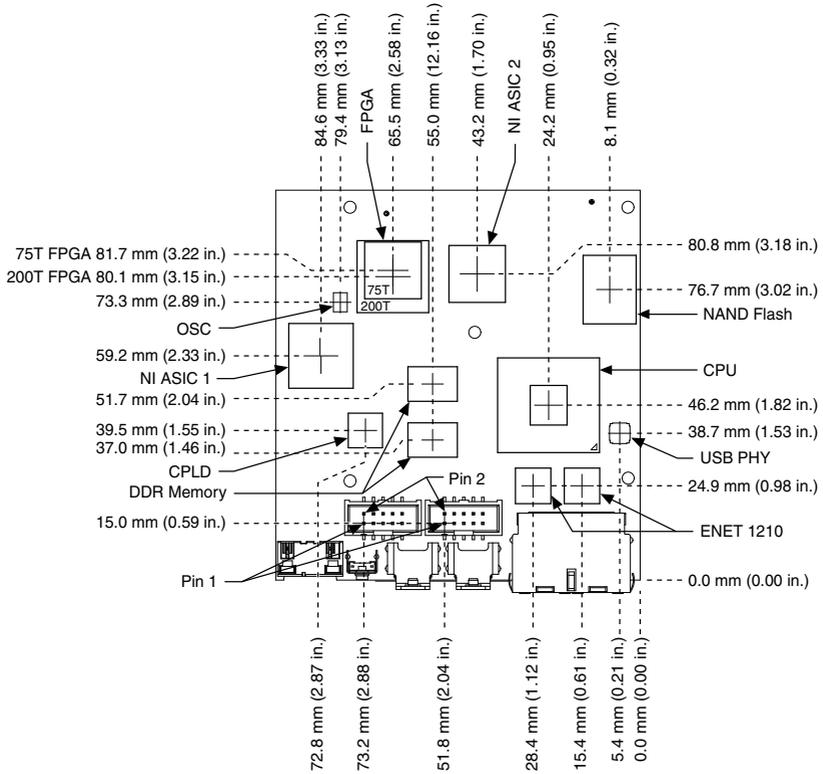
## Mounting a sbRIO-960x Model

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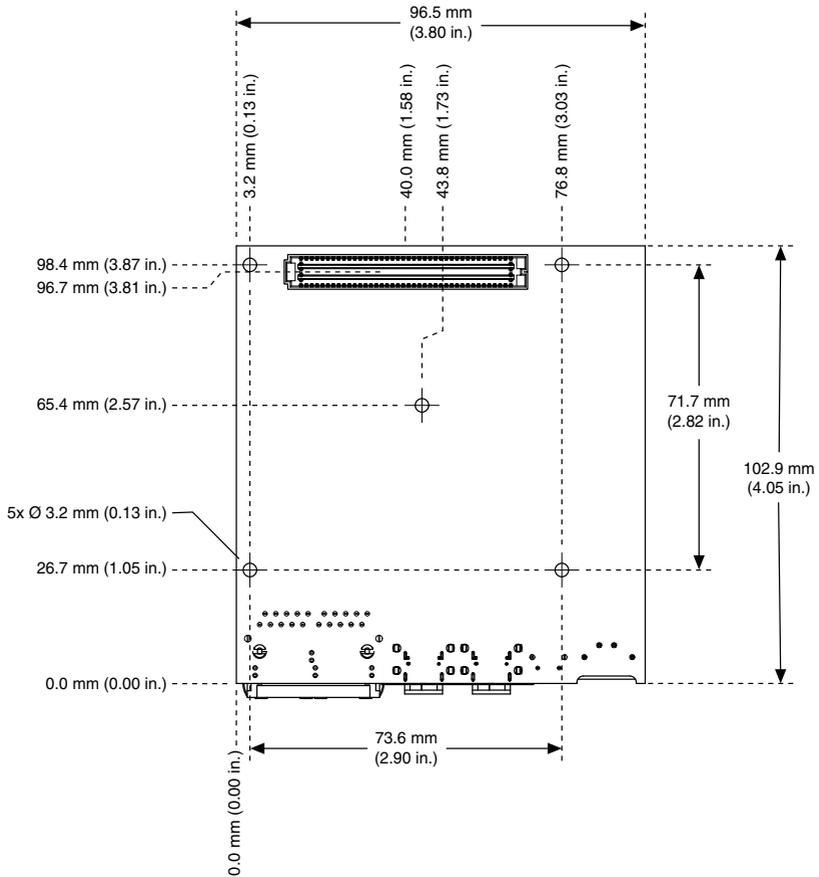
You can mount the NI sbRIO device in a variety of ways in order to maximize system performance. Some mounting methods might require custom fasteners or unique assembly techniques to maintain required connector stack heights and enable improved thermal and structural design for rugged environments.

# sbRIO-960x Dimensions

**Figure 21. Primary-Side Dimensions**

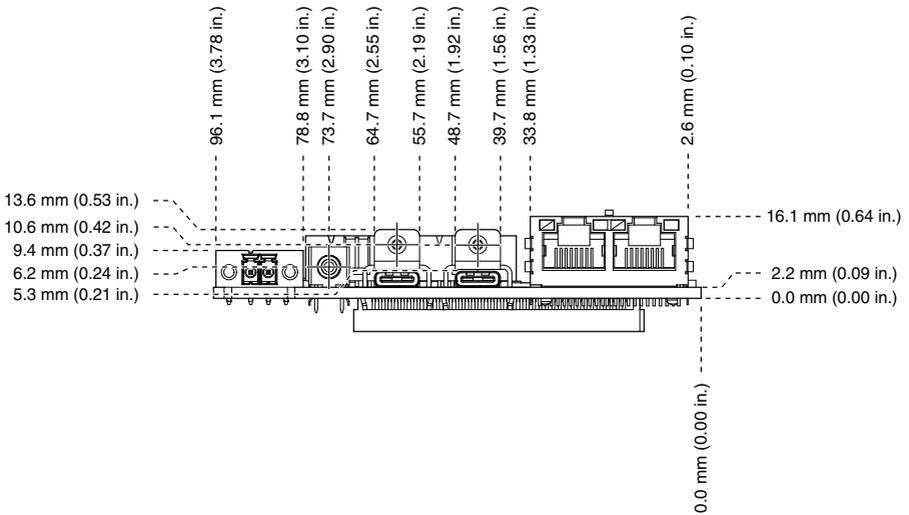


**Figure 22. Secondary-Side Dimensions**



**Note** Holes and keepouts are sized for M3 standoff (4.5 mm Hex) or 4-40 standoff (3/16-in. Hex).

**Figure 23. Front Dimensions**



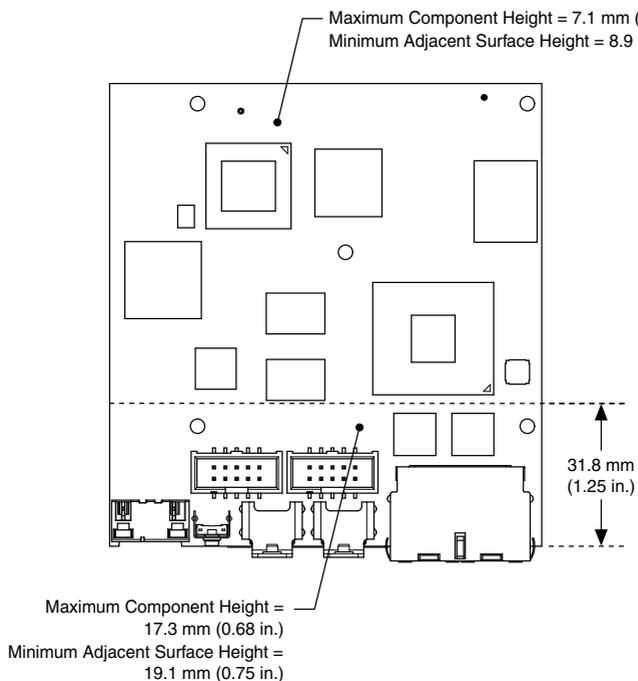
**Tip** For two-dimensional drawings and three-dimensional models of the sbRIO-960x, visit [ni.com/dimensions](https://ni.com/dimensions) and search by model number.

## sbRIO-960x Maximum Component Heights

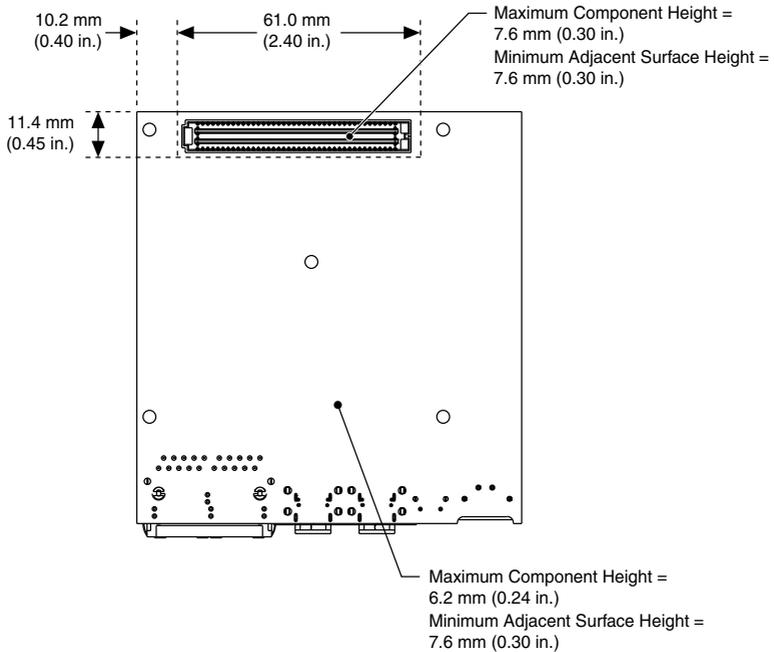


**Note** In addition to the maximum component heights, you must also observe minimum keepaway distances for adjacent PCBs and surfaces.

**Figure 24. Maximum Component Height of Primary Side**



**Figure 25. Maximum Component Height of Secondary Side**



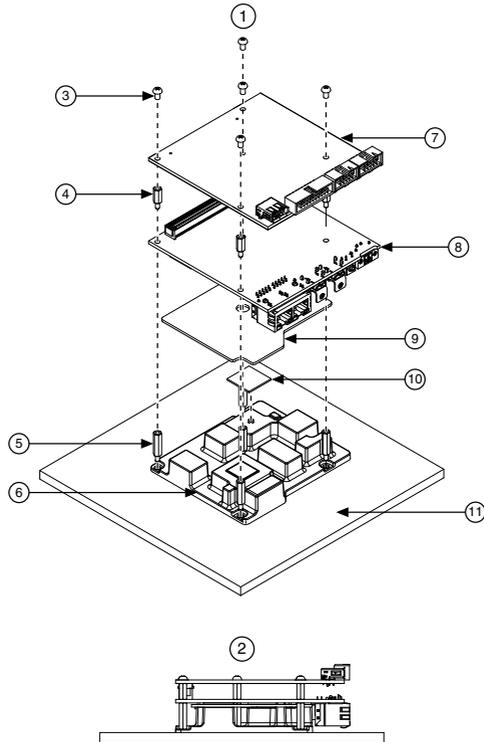
## sbRIO-960x Mounting Direction Options

The Thermal Kit for CompactRIO Single Board Controller with NI-DAQmx (787331-01) and certain RMC accessories are designed to allow traditional M-F standoff threads to pass through and stack in either direction.

# Mounting a sbRIO-960x Model with a Thermal Conduction Path

If possible, NI recommends that you mount the sbRIO-960x on a panel or plate, such that a thermal solution provides a conduction path from the primary side components and is secured to or made from the panel or plate.

**Figure 26.** Thermal Conduction Mounting

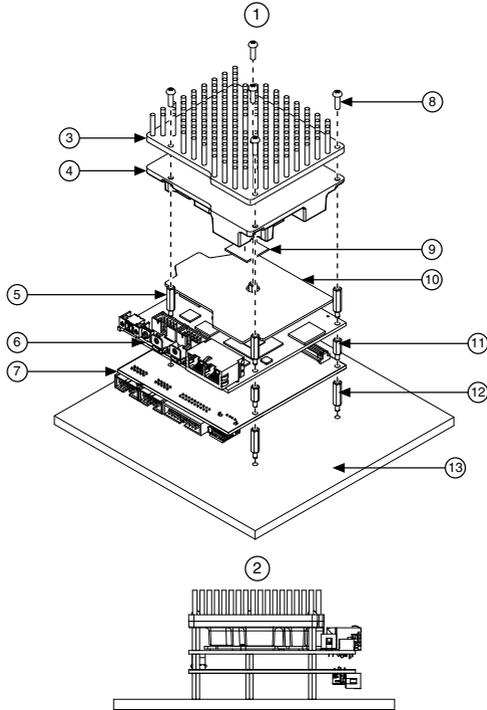


- |  |  |
|--|--|
| 1. Exploded view of all mounting components  | 7. RMC board   |
| 2. Complete assembled and mounted view   | 8. NI sbRIO-9603/9608/9609   |
| 3. Mounting screws   | 9. Thermal pad, main (Included with the Thermal Kit)                               |
| 4. Standoff, 9.65 mm (0.38 in.)  | 10. Thermal pad, supplemental (sbRIO-9603 only)<br>(Included with the Thermal Kit) |
| 5. Standoff, 16.0 mm (0.63 in.)  | 11. Mounting Surface   |
| 6. Thermal Kit for CompactRIO Single Board<br>Controller with NI-DAQmx (787331-01) |  |

# Mounting the sbRIO-960x Model with a Thermal Convection Path

Alternatively, the thermal solution can be used for convection to natural or forced air flow or used in conjunction with a heat sink optimized for the environment.

**Figure 27.** Thermal Convection Mounting



- |   |  |
|---|--|
| 1. Exploded view of all mounting components                                     | 8. Mounting screws   |
| 2. Complete assembled and mounted view  | 9. Thermal pad, supplemental (sbRIO-9603 only) (Included with the Thermal Kit) |
| 3. Heatsink   | 10. Thermal pad, main (Included with the Thermal Kit)                          |
| 4. Thermal Kit for CompactRIO Single Board Controller with NI-DAQmx (787331-01) | 11. Standoff, 9.65 mm (0.38 in.)   |
| 5. Standoff, 16.0 mm (0.63 in.)   | 12. Standoff   |
| 6. NI sbRIO-9603/9608/9609  | 13. Mounting surface   |
| 7. RMC board  |  |

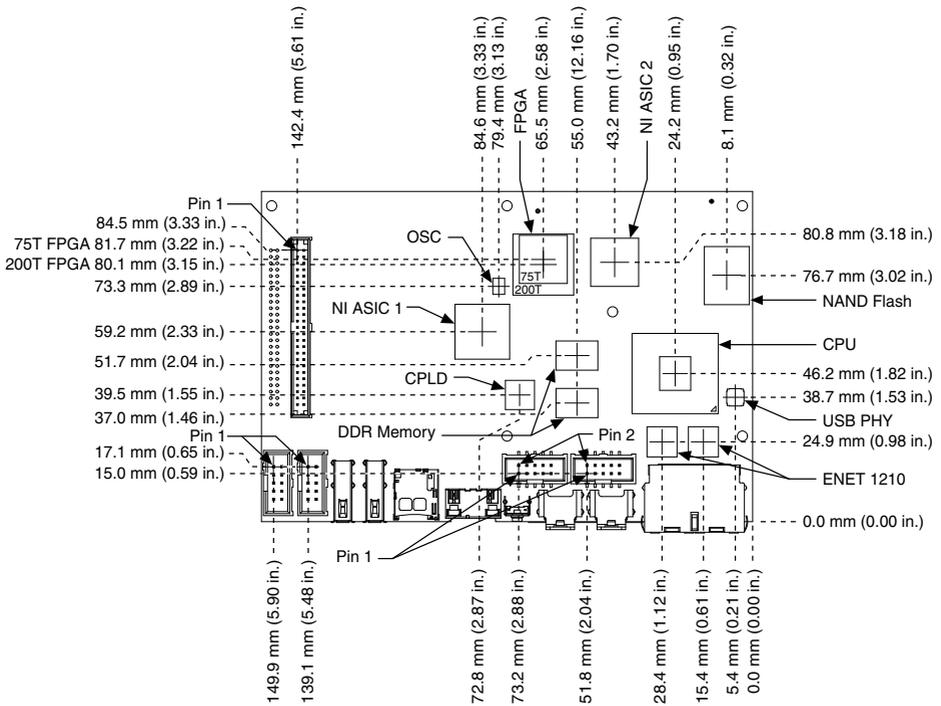
# Mounting a sbRIO-962x/sbRIO-963x Model

You can mount the NI sbRIO device in a variety of ways in order to maximize system performance. Some mounting methods might require custom fasteners or unique assembly

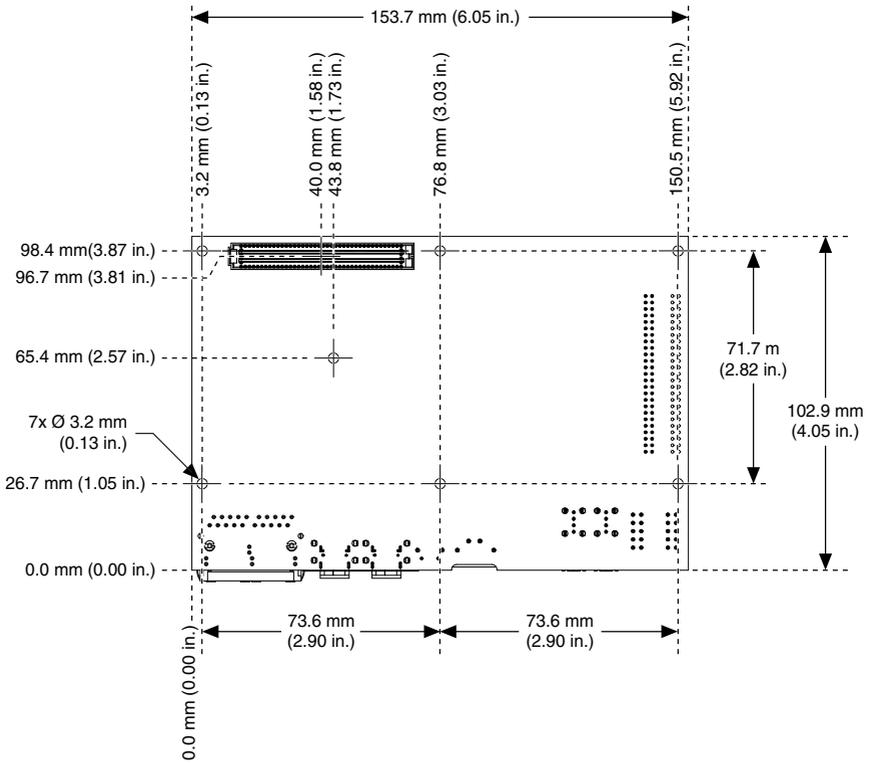
techniques to maintain required connector stack heights and enable improved thermal and structural design for rugged environments.

## sbRIO-962x/sbRIO-963x Dimensions

**Figure 28.** Primary-Side Dimensions

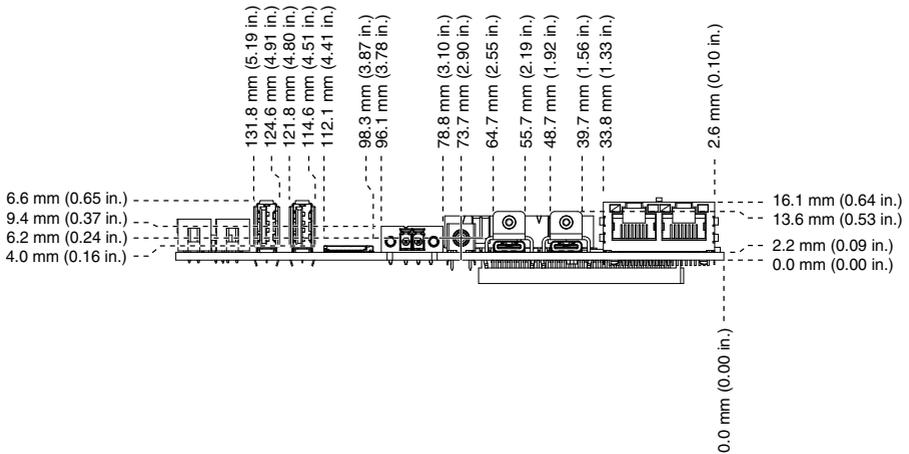


**Figure 29. Secondary-Side Dimensions**



**Note** Holes and keepouts are sized for M3 standoff (4.5 mm Hex) or 4-40 standoff (3/16-in. Hex).

**Figure 30. Front Dimensions**



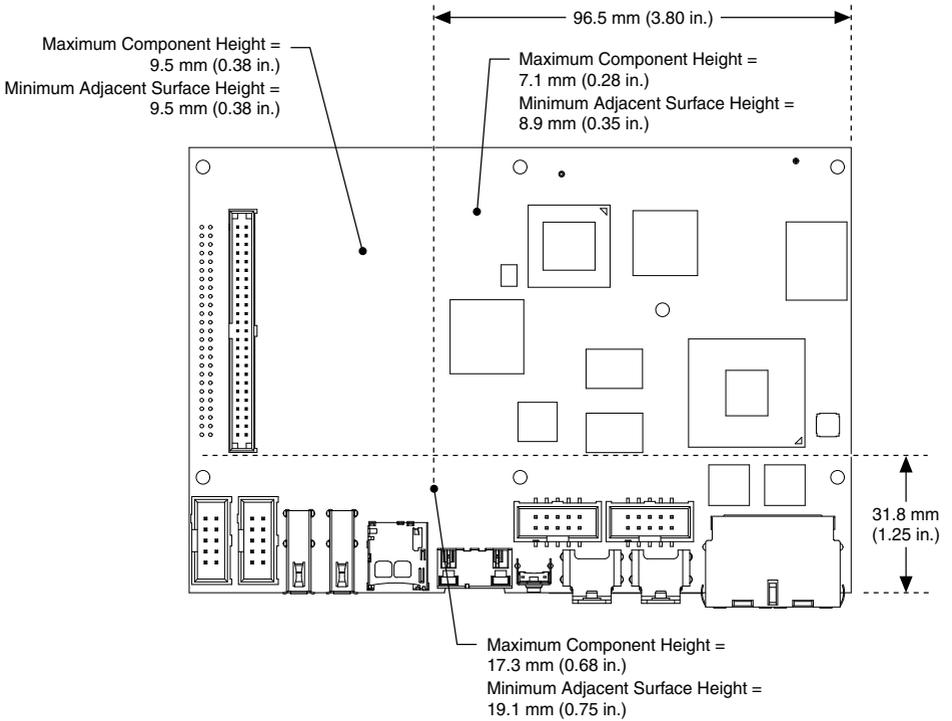
**Tip** For two-dimensional drawings and three-dimensional models of the sbRIO-962x/sbRIO-963x, visit [ni.com/dimensions](https://ni.com/dimensions) and search by model number.

## sbRIO-962x/sbRIO-963x Maximum Component Heights

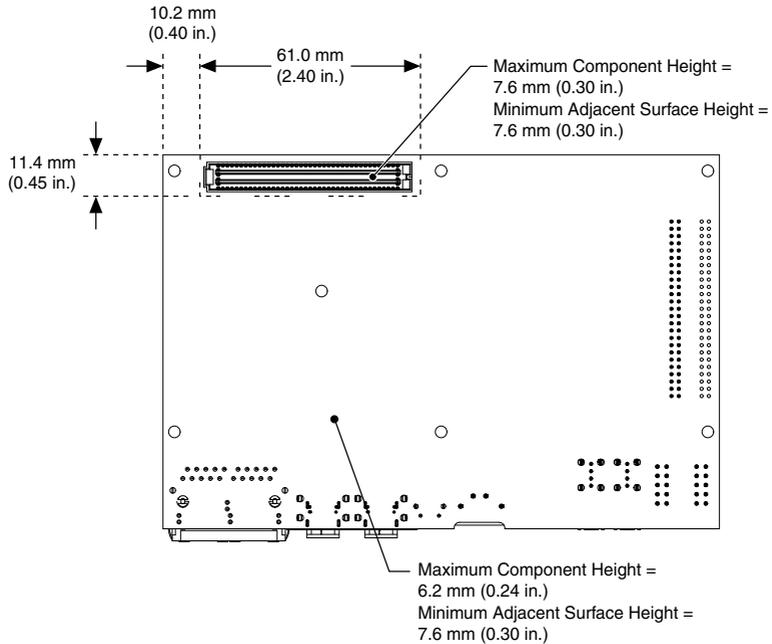


**Note** In addition to the maximum component heights, you must also observe minimum keepaway distances for adjacent PCBs and surfaces.

**Figure 31. Maximum Component Height of Primary Side**



**Figure 32. Maximum Component Height of Secondary Side**



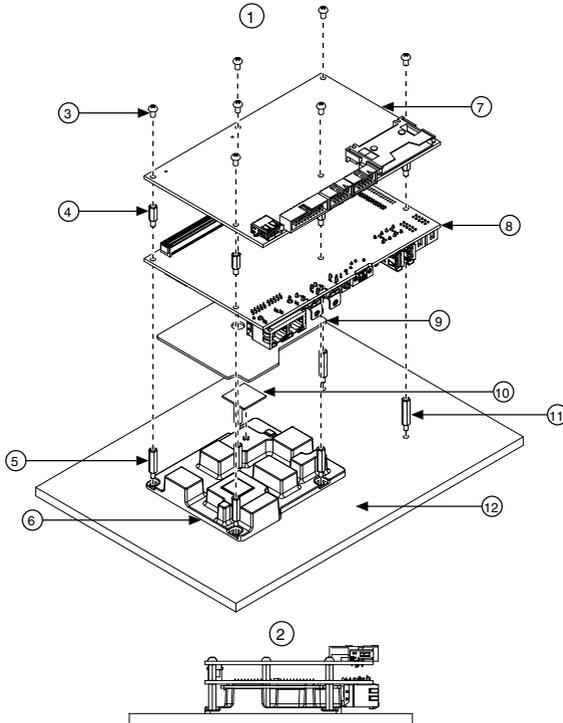
## sbRIO-962x/sbRIO-963x Mounting Direction Options

The Thermal Kit for CompactRIO Single Board Controller with NI-DAQmx (787331-01) and certain RMC accessories are designed to allow traditional M-F standoff threads to pass through and stack in either direction.

# Mounting a sbRIO-962x/sbRIO-963x Model with a Thermal Conduction Path

If possible, NI recommends that you mount the sbRIO-962x/sbRIO-963x on a panel or plate, such that a thermal solution provides a conduction path from the primary side components and is secured to or made from the panel or plate.

**Figure 33. Thermal Conduction Mounting**

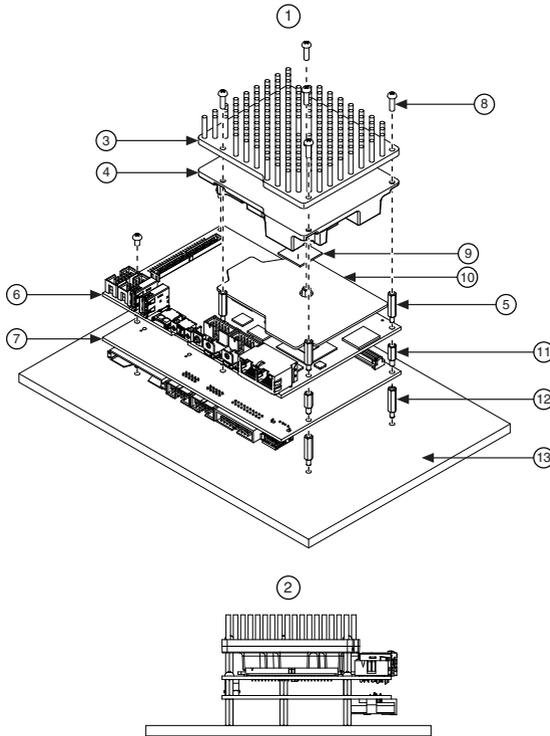


- |   |  |
|---|--|
| 1. Exploded view of all mounting components                                     | 7. RMC board   |
| 2. Complete assembled and mounted view  | 8. NI sbRIO-9628/9629/9638   |
| 3. Mounting screws  | 9. Thermal pad, main (Included with the Thermal Kit)                                 |
| 4. Standoff, 9.65 mm (0.38 in.)   | 10. Thermal pad, supplemental (sbRIO-9628/9638 only) (Included with the Thermal Kit) |
| 5. Standoff, 16.0 mm (0.63 in.)   | 11. Standoff, 18.0 mm (0.71 in.)   |
| 6. Thermal Kit for CompactRIO Single Board Controller with NI-DAQmx (787331-01) | 12. Mounting Surface   |

# Mounting the sbRIO-962x/sbRIO-963x Model with a Thermal Convection Path

Alternatively, the thermal solution can be used for convection to natural or forced air flow or used in conjunction with a heat sink optimized for the environment.

**Figure 34.** Thermal Convection Mounting

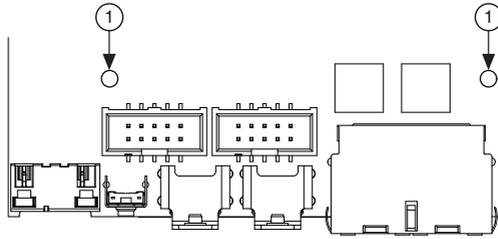


- |   |   |
|---|---|
| 1. Exploded view of all mounting components                                     | 8. Mounting screws  |
| 2. Complete assembled and mounted view  | 9. Thermal pad, supplemental (sbRIO-9628/9638 only) (Included with the Thermal Kit) |
| 3. Heatsink   | 10. Thermal pad, main (Included with the Thermal Kit)                               |
| 4. Thermal Kit for CompactRIO Single Board Controller with NI-DAQmx (787331-01) | 11. Standoff, 9.65 mm (0.38 in.)  |
| 5. Standoff, 16.0 mm (0.63 in.)   | 12. Standoff  |
| 6. NI sbRIO-9628/9629/9638  | 13. Mounting surface  |
| 7. RMC board  |   |

## Grounding the Model

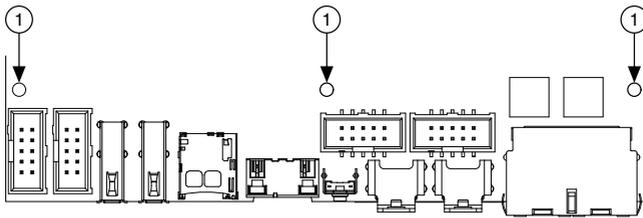
You can terminate a ground wire by attaching a copper ring to one of the front mounting holes on the model.

**Figure 35.** sbRIO-960x Front Mounting Holes



1. Front Mounting Holes

**Figure 36.** sbRIO-962x/sbRIO-963x Front Mounting Holes



1. Front Mounting Holes

The front I/O connector shields, chassis ground bracket, and mounting holes near the front I/O are connected together internally to form chassis ground. Chassis ground is capacitively coupled to digital ground near each of the IO connectors. For the best possible ESD protection, connect chassis ground at the mounting holes to a low-inductance earth ground.

When connecting the NI sbRIO-96xx to external devices, ensure that stray ground currents are not using the device as a return path. Significant stray currents traversing through the NI sbRIO-96xx can result in device failure.

To verify correct grounding of the NI sbRIO-96xx, make sure the current flowing into the power connector equals the current flowing out of the power connector. These currents should be measured with a current probe after final assembly of the end system. Investigate and remove any current differences.

## Connecting the sbRIO-96xx to Power

The NI sbRIO-96xx requires a 9 V DC to 30 V DC external power supply. The NI sbRIO-96xx filters and regulates the supplied power and provides power for RMCs.



**Note** Refer to the device specifications for the power requirements, formulas and examples for calculating power requirements for different configurations and application types, and proper wiring of the power cable assembly.



**Caution** Do not mate or unmate the power supply connectors while power is applied.

### What to Use

- Screwdriver, 2.54 mm (0.10 in.) flathead
- Primary power supply, 9 V to 30 V, 55 W minimum

NI recommends the following power supplies for the sbRIO-96xx.

**Table 18.** NI Power Supplies

Power Supply	Part Number
NI PS-15 Industrial Power Supply (24 VDC, 5 A, 100 VAC to 120 VAC/200 VAC to 240 VAC input)	781093-01
NI PS-10 Desktop Power Supply (24 VDC, 5 A, 100 VAC to 120 VAC/200 VAC to 240 VAC input)	782698-01

### What to Do

1. Ensure that your power supply is powered off.
2. Insert the power connector plug into the power connector receptacle of the NI sbRIO-96xx until the connector latches into place.
3. Turn on the power supply.

## Installing a Ferrite

### What to Use

- Ferrite, NI part number 711849-01 (included in kit)
- Screwdriver, 2.54 mm (0.10 in.) flathead
- Primary power supply, 9 V to 30 V, 55 W minimum

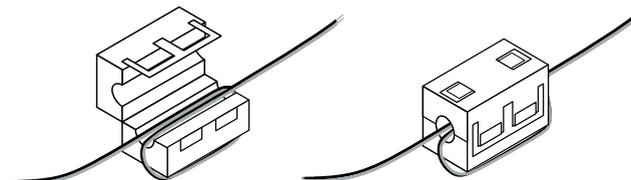
### What to Do

Complete the following steps to install a ferrite on the sbRIO-96xx.



**Note** If your kit contains an NI PS-10, you do not need to install a ferrite. The NI PS-10 has a ferrite installed on the power leads.

**Figure 37.** Installing a Ferrite on the Power Leads



1. Power off the power supply.
2. Install the ferrite on the negative and positive leads of the power supply.
3. Pass the leads through the ferrite twice.



**Note** Leave 50 mm to 75 mm (2 in. to 3 in.) between the ferrite and the end of the leads.

4. Close the ferrite around the leads.

## Calculating the Power Requirement



**Notice** Exceeding the power limits may cause unpredictable device behavior.

$$\text{Total power requirement} = P_{\text{int}} + P_{DIO} + P_{5V} + P_{3.3V} + P_{USB\text{TypeC}} + P_{USB2.0} + P_{\mu SD}$$

where

$P_{\text{int max}}$  is the power consumption by the NI sbRIO-96xx internal operation, including integrated I/O functions

$P_{DIO}$  is the power consumption by the 3.3 V DIO pins across the RMC or DIO connectors

$P_{5V}$  is the power consumption by the 5 V voltage output across the RMC or DIO connectors

$P_{3.3V}$  is the power consumption by the 3.3 V voltage output across the RMC connector

$P_{\mu SD}$  is the power consumption of a MicroSD card installed in the MicroSD port

$P_{USB\text{Type-C}}$  is the power consumption of a device plugged into the USB Type-C port

$P_{USB\ 2.0}$  is the power consumption of a device plugged into the USB 2.0 port

$P_{ETH}$  is 0.4 W, typical per port (included in  $P_{\text{int max}}$  for the calculation)

$P_{SERIAL}$  is 0.4 W, typical per port (included in  $P_{\text{int max}}$  for the calculation)

When calculating each component of the maximum power consumption the following efficiency factors must be used:

$$\eta_{3.3V} \text{ and } \eta_{DIO} = 80\%$$

$$\eta_{5V} \text{ and } \eta_{USB} = 90\%$$



**Note** You must add 10% to the calculated or measured total power requirement to account for transient and startup conditions.

**Table 19. Approximate Power Requirement**

<b>Power</b>	<b>Model</b>	<b>Values and Calculations</b>
$P_{\text{int typ}}$	sbRIO-9603	7.1 W
	sbRIO-9608	7.6 W
	sbRIO-9609	8.0 W
	sbRIO-9628	8.5 W
	sbRIO-9629	9.5 W
	sbRIO-9638	8.5 W
$P_{\text{int max}}$	sbRIO-9603	19.1 W
	sbRIO-9608	21.3 W
	sbRIO-9609	24.8 W
	sbRIO-9628	22.5 W
	sbRIO-9629	26.5 W
	sbRIO-9638	22.5 W
$P_{\text{LVDS}}$	sbRIO-960x and sbRIO-962x	Number of RMC LVDS outputs $\times$ 0.0395 W (maximum of 45 outputs)
$P_{\mu\text{SD}}$	sbRIO-962x and sbRIO-963x	Total $\mu\text{SD}$ current $\times$ 3.3 V/0.8 1.4 A, maximum 0.5 A, typical
$P_{\text{USB Type-C}}$	All sbRIO-96xx	Total USB current $\times$ 5 V/0.9 0.9 A, maximum 0.25 A, typical for flash drive 0.5 A, typical for display
$P_{\text{USB 2.0}}$	sbRIO-962x and sbRIO-963x	Total USB current $\times$ 5 V/0.9 1.4 A, maximum 0.25 A, typical for flash drive

**Table 19. Approximate Power Requirement (Continued)**

Power	Model	Values and Calculations
$P_{DIO}$	All sbRIO-96xx	Total DIO current $\times 3.3 V/0.8$
$P_{5V}$	All sbRIO-96xx	Total 5 V current $\times 5 V/0.9$ 1.5 A, maximum
$P_{3.3V}$	All sbRIO-96xx	Total 3.3 V current $\times 3.3 V/0.8$ 0.33 A, maximum



**Note** Actual  $P_{int}$  will measure between typical and maximum  $P_{int}$ .



**Note** Approximate typical  $P_{int}$  assumes a Real-Time application connected over Ethernet that loads an FPGA application that blinks the User FPGA1 LED.



**Note** Approximate maximum  $P_{int}$  approximates the maximum power requirements for an NI sbRIO system. Assumptions include 85% LUT, Flip Flop, DSP, BRAM utilization of the FPGA running at 80 MHz, and 100% processor utilization.

## Power-On Self Test

The NI sbRIO-96xx runs a power-on self test (POST) when you apply power to the device. The Power and Status LEDs turn on when the POST begins. The Status LED turns off when the POST completes.



**Note** Refer to the [STATUS LED Indicators](#) section to troubleshoot Status LED behavior.

## Installing Software on the Host Computer

Before using the sbRIO-96xx, install the following application software and device drivers on the host computer.

### Application Software

- [LabVIEW 2019 SP1 or later](#)
- [LabVIEW Real-Time Module 2019 SP1 or later](#)
- [LabVIEW FPGA Module 2019 SP1 or later](#)

## Required Drivers

- [NI CompactRIO Drivers 19.5 or later](#)



**Note** For minimum software support information, visit [ni.com/r/softwareversion](https://ni.com/r/softwareversion).

# Connecting the sbRIO-96xx to the Host Computer

---

Complete the following steps to connect the sbRIO-96xx to the host computer using the RJ-45 Ethernet port.



**Note** You can also connect the sbRIO-96xx to the host computer using a Type-C to Type-A USB cable through the USB device port.

1. Power on the host computer.
2. Connect the sbRIO-96xx to the host computer using a standard Category 5 (CAT-5) or better shielded, twisted-pair Ethernet cable.



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

The first time you power up the device, it attempts to initiate a DHCP network connection. If the device is unable to initiate a DHCP connection, it connects to the network with a link-local IP address with the form 169.254.x.x. After the device has powered up, you must install software on the device and configure the network settings in MAX.



**Note** Installing software may change the network behavior of the device. For information about network behavior by installed software version, visit [ni.com/r/ipconfigrio](https://ni.com/r/ipconfigrio).

# Finding the sbRIO-96xx on the Network (DHCP)

---

Complete the following steps to find the sbRIO-96xx on a network using DHCP.

1. Disable secondary network interfaces on the host computer, such as a wireless access card on a laptop.
2. Ensure that any anti-virus and firewall software running on the host computer allows connections to the host computer.



**Note** MAX uses UDP 44525. Refer to the documentation of your firewall software for information about configuring the firewall to allow communication through the UDP 44525.

3. Launch MAX on the host computer.

4. Expand **Remote Systems** in the configuration tree and locate your system.



**Note** MAX lists the system under the model number followed by the serial number, such as NI-sbRIO-96xx-1856AAA

## Finding the sbRIO-96xx on the Network (Static IP)

---

Complete the following steps to find the sbRIO-96xx on the network if the host computer is using a static IP address. The following instructions are for host computers running Microsoft Windows 7. For more information about performing the network configuration steps in this section, visit [www.microsoft.com](http://www.microsoft.com) and search for `change tcp/ip settings`.

1. Obtain IP settings from the host computer.
  - a) Click **Start**»**Control Panel**»**Network and Sharing Center**.
  - b) Select the primary network connection, which may appear as **Local Area Connection** or something similar.
  - c) In the dialog box that appears, click **Properties**.
  - d) Select **Internet Protocol Version 4 (TCP/IPv4)**.
  - e) Click **Properties**.
  - f) Record the **IP address**, **Subnet mask**, and **Default gateway** address. You need these settings to configure the network settings of the sbRIO-96xx and to restore the network settings of the host computer.



**Tip** You can also access these settings by opening the Start menu, entering `cmd.exe`, and entering `ipconfig` in the command window that launches.

- g) Wait at least one minute.
2. Configure IP Settings on the controller in MAX.

- a) Launch MAX on the host computer.
- b) Expand **Remote Systems** in the configuration tree and locate your system.



**Note** MAX lists the system under the model number followed by the serial number, such as NI-sbRIO-96xx-1856AAA

- c) Select the **Network Settings** tab near the bottom of the window.
- d) Select **Static** on the **Configure IPv4 Address** control.
- e) Enter values for **IPv4 Address**, **Subnet Mask**, **Gateway**, and **DNS Server** based on the information you recorded. Be sure to enter a value for **IPv4 Address** that is not used by another device on the network. For example, do not use the IP address usually assigned to the host computer.
- f) Click **Save** and let MAX restart the sbRIO-96xx. The sbRIO-96xx disappears from under **Remote Systems** and does not reappear until you restore the original network settings to the host computer.
- g) Restore the original network settings to the host computer.
- h) Return to MAX and refresh **Remote Systems**.

# Connecting CAN Networks

The sbRIO-96xx is populated with one IDC header to provide connections to a CAN bus. This connector has pins for CAN\_H and CAN\_L, which can connect to the CAN bus signals. The CAN port uses an TI TCAN4550 high-speed CAN transceiver that is fully compatible with the ISO 11898 standard and supports baud rates up to 1 Mb/s and up to 5 Mb/s for CAN FD.

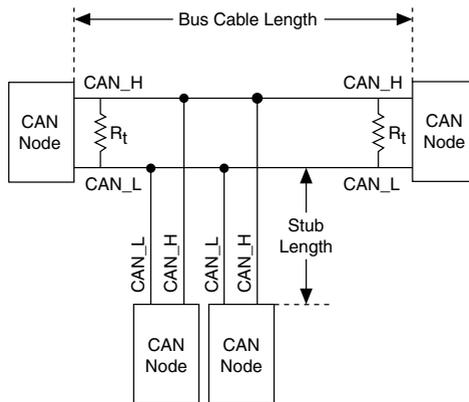
The port has two common pins (GND) that serve as the reference ground for CAN\_H and CAN\_L. You can connect the CAN bus reference ground (sometimes referred to as CAN\_V-) to one or both COM pins. The port also has an optional shield pin (SHLD) that can connect to a shielded CAN cable. Connecting SHLD may improve signal integrity and EMC performance.

## CAN Bus Topology and Termination

A CAN bus consists of two or more CAN nodes cabled together. The CAN\_H and CAN\_L pins of each node are connected to the main CAN bus cable through a short connection called a stub. The pair of signal wires, CAN\_H and CAN\_L, constitutes a transmission line. If the transmission line is not terminated, signal changes on the bus cause reflections that can cause communication errors. The CAN bus is bidirectional, and both ends of the cable must be terminated. However, only the two nodes at the far end of the cable, not every node on the bus, require termination resistors.

The following figure shows a simplified diagram of a CAN bus with multiple CAN nodes and proper termination resistor ( $R_t$ ) locations.

**Figure 38.** CAN Bus Topology and Termination Resistor Locations



## Cable Specifications

Cables must meet the physical medium requirements specified in ISO 11898, shown in the following table. Belden cable (3084A) meets all these requirements and is suitable for most applications.

**Table 20.** ISO 11898 Specifications for Characteristics of a CAN\_H and CAN\_L Pair of Wires

Characteristic	Value
Impedance	95 $\Omega$ minimum, 120 $\Omega$ nominal, 140 $\Omega$ maximum
Length-related resistance	70 m $\Omega$ /m nominal
Specific line delay	5 ns/m nominal

## Termination Resistors

The termination resistors ( $R_t$ ) must match the nominal impedance of the CAN cable and therefore comply with the values in the following table.

**Table 21.** Termination Resistor Specification

Characteristic	Value	Condition
Termination resistor, $R_t$	100 $\Omega$ min, 120 $\Omega$ nominal, 130 $\Omega$ max	Minimum power dissipation: 220 mW

## Cable Lengths

The cabling characteristics and desired bit transmission rates affect the allowable cable length. You can find detailed cable length recommendations in the ISO 11898, CiA DS 102, and DeviceNet specifications.

ISO 11898 specifies 40 m total cable length with a maximum stub length of 0.3 m for a bit rate of 1 Mb/s. The ISO 11898 specification allows for significantly longer cable lengths at lower bit rates, but NI recommends that you analyze each node for signal integrity problems.

## Number of CAN Nodes

The maximum number of nodes depends on the electrical characteristics of the nodes on the network. If all nodes meet the ISO 11898 requirements, you can connect at least 30 nodes to the bus. You can connect higher numbers of nodes if the electrical characteristics of the node do not degrade signal quality below ISO 11898 signal level specifications.

## Environmental

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### Managing Thermal Conditions

Due to the small size of the sbRIO-96xx, it is very important to appropriately dissipate the heat generated during operation. You must plan for the thermal conditions of your application throughout development and validation. This section provides design recommendations and validation tools and methods for maximizing the thermal performance of the system.

## Designing a Suitable Enclosure

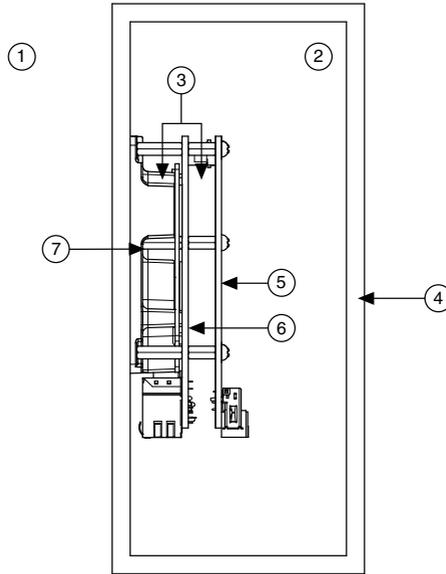
NI sbRIO-96xx operate as components in a higher-level system and may require an enclosure to protect the internal circuit card assemblies and dissipate heat. For the sbRIO-96xx, the system integrator is responsible for designing an enclosure that meets the thermal requirements of your specific application.

NI sbRIO-96xx integrated into an enclosure or system with proper thermal dissipation can be deployed in high- and low-temperature environments. However, the 85 °C local ambient operating temperature rating of the sbRIO-96xx does not mean that the external temperature of the natural convection environment such as a room or larger enclosure can be 85 °C. In this way, properly designed NI sbRIO-96xx may still require an external ambient temperature of 70 °C or less and may still require specific mounting requirements to ensure that the local ambient and thermally-relevant component maximum operating temperatures are within specification.

## Understanding Thermal Specifications

A deployed system has several temperature measurement locations that indicate the thermal performance of the system and the devices the system contains. For example, in a natural convection system, the temperature of a critical component will be higher than the temperature of the air in the immediate vicinity of the component. This local air temperature will also be higher inside an enclosure than in the room ambient that surrounds the enclosure.

**Figure 39. Ambient Temperatures**



- |   |   |
|---|---|
| 1. External ambient temperature           | 5. RMC board  |
| 2. Internal/enclosure ambient temperature | 6. NI sbRIO-96xx  |
| 3. Local ambient temperature              | 7. Thermal Kit for CompactRIO Single Board Controller with NI-DAQmx (787331-01) |
| 4. Enclosure                              |   |

- External ambient—The maximum air temperature of the room or installation location that surrounds the system.
- Internal/enclosure ambient—The maximum air temperature inside the enclosure. This can be measured at various locations within the enclosure and is highly influenced by the proximity and dissipation of devices inside the enclosure.
- Local ambient—The maximum air temperature as specified directly adjacent to the sbRIO-96xx. This is measured on all sides of a device that has exposed circuitry.

Because the system integrator may use any number of enclosure sizes, materials, thermal solutions, and room conditions when designing an enclosure for a specific application, sbRIO-96xx are specified in a manner that removes most of these external variables. Therefore, the sbRIO-96xx thermal performance is not determined by measuring the external ambient or internal/enclosure ambient temperatures, but by measuring the local ambient and specific component temperatures. NI provides digitally reported temperatures to help you accurately measure these critical temperatures.

## Shock and Vibration

The mounting method you use, components you select, and assembly techniques you use influence the ability of the system to resist fretting corrosion and other damage caused by exposure to shock and vibration. Consider the following factors when designing your sbRIO-96xx system to account for shock and vibration:

- In general, shorter SEARAY stack heights perform better than taller stack heights.
- Directly mounting the thermal solution to a rigid surface provides the best performance. If this method is not feasible for your design, minimize the amount of extra mass that only the sbRIO-96xx supports, such as a heat sink or other thermal solution, that is fastened to the standoffs. If you require substantial thermal solutions, provide additional structural support.
- NI recommends that you use connectors that provide the following benefits:
  - Positive locking
  - Provisions for strain relief
  - Substantial gold plating on pins
- The sbRIO-96xx has been tested to industry specifications for rugged environments.
- NI offers a variety of cable assemblies and other connectivity accessories to complete your system design. Typically, these accessories include the best available designs, materials, and plating to maximize performance and longevity in rugged environments.

## Validating the System

NI recommends that you use a validation system for an extended period of time in a test environment with the same thermal, environmental, and functional utilization characteristics as the target deployment environment. You are responsible for final validation of your application.

### Temperature Validation Guidelines

The sbRIO-96xx includes four onboard temperature monitoring sensors to simplify validation of a thermal solution by indicating thermal performance during validation and deployment.

The sensors measure the CPU/FPGA junction temperature and printed circuit board temperatures that can be used to approximate the primary and secondary side local ambient temperatures. This approach is called digital validation. Alternatively, the traditional analog approach using thermocouples can be used to validate thermal performance. The digital approach is more accurate for determining the performance of the CPU/FPGA but is more conservative for determining the local ambient temperatures. NI recommends using digital validation.

For digital validation, ensure that the reported CPU/FPGA, reported Primary System, and reported Secondary System temperatures do not exceed any of the maximum temperatures listed in this document. Thermal validation is complete if the reported temperatures are within specifications. For more information about how to access the onboard sensors, visit [ni.com/info](http://ni.com/info) and enter the Info Code `sbriosensors`. If the reported Primary System temperature or reported Secondary System temperature exceed the maximum temperatures listed in this document then analog validation may be used for further verification.

For analog validation, measure the local ambient temperature by placing thermocouples on both sides of the PCB, 5 mm (0.2 in.) from the board surface. Avoid placing thermocouples next to hot components such as the CPU/FPGA or near board edges, which can cause inaccurate temperature measurements. In addition to the local ambient temperature, the case

temperature of the components should not exceed the recommended maximum case temperature.

## Managing Power and Feature Utilization

An sbRIO-96xx that heavily utilizes all of its performance and features consumes and dissipates substantially more power than an idle device.

Consider the following options for reducing the die junction temperature.

- Design for additional thermal cooling that can appropriately dissipate power
- Reduce device feature utilization



**Note** Your final validation must consider software and hardware utilization that is representative of the final deployment conditions.



**Note** Refer to the device specifications on [ni.com/manuals](https://ni.com/manuals) for specifications that approximate the maximum power requirement for each input rail on the sbRIO-96xx with worst-case silicon manufacturing process and maximum junction temperatures. For a more accurate estimate of the power consumption for a specific application, NI recommends that you directly measure the power the sbRIO-96xx consumes when running your application in an environment that is representative of the intended use case.

## Mounting Recommendations for Maximizing Thermal Performance

Thermal performance of the sbRIO-96xx can be maximized by implementing the following recommendations.

- Directly mount a thermal solution such as the Thermal Kit for CompactRIO Single Board Controller with NI-DAQmx (787331-01) to a thermally conductive surface such as a metal enclosure wall or plate. An interface material such as thermal grease should be used to maximize the heat transfer from the heat spreader to the enclosure or plate.

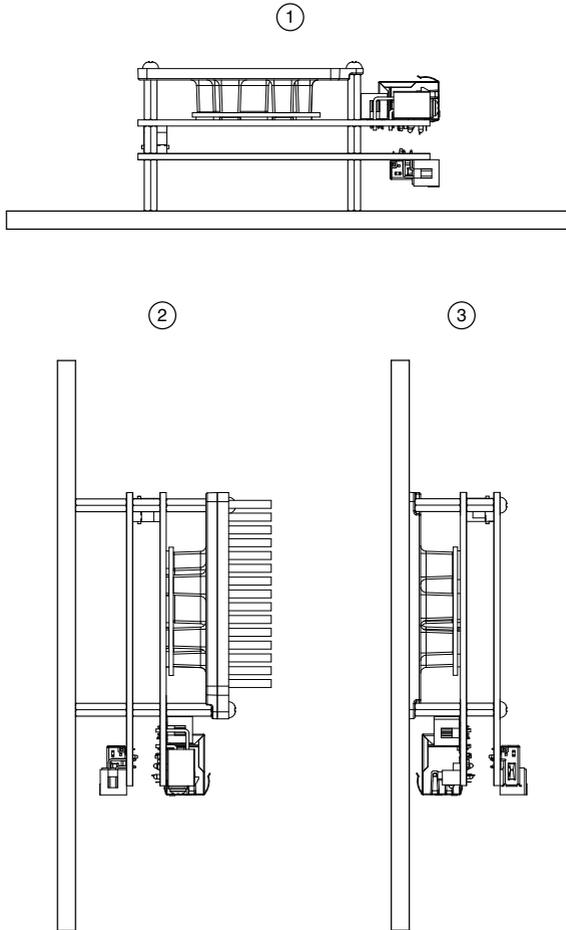
If design limitations prevent this solution, you can alternatively attach a heat sink or other thermal solution. This solution takes advantage of natural convection or forced cooling provided by a fan.

- Mount the sbRIO-96xx vertically with respect to gravity to take advantage of natural convection cooling.
- Mount the sbRIO-96xx below and away from other heat-dissipating components.



**Note** Placing the sbRIO-96xx within a system or enclosure will also influence thermal performance.

**Figure 40. Thermal Mounting Solutions Comparison**

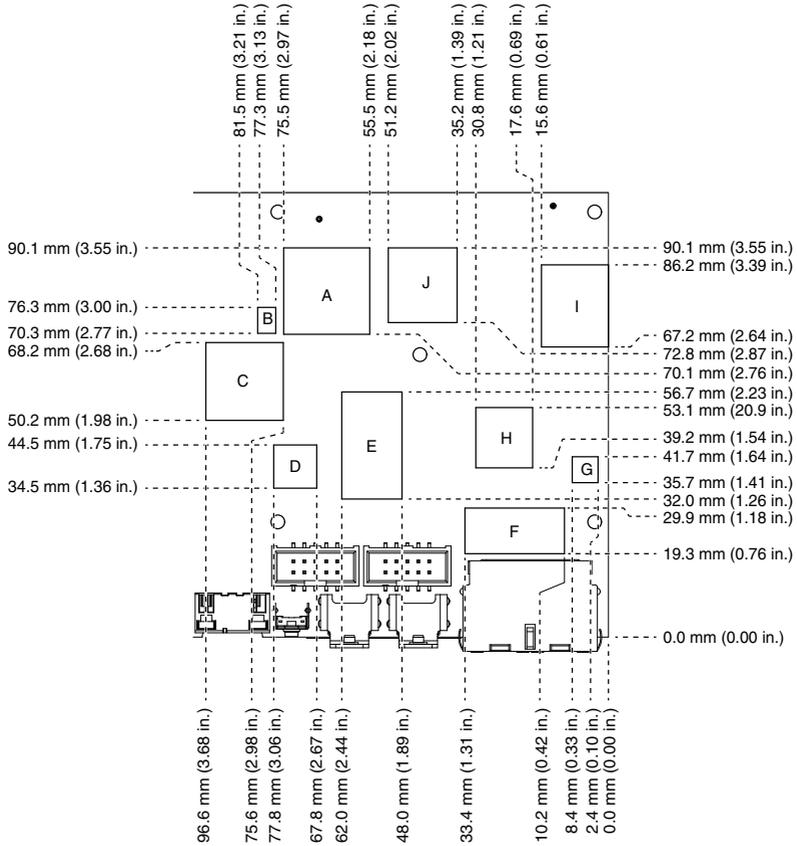


1. Good—Horizontal mounting with no additional thermal provisions
2. Better—Vertical mounting with an attached heat sink
3. Best—Vertical mounting directly to a thermally-conductive wall or plate

## Designing A Thermal Solution

If the Thermal Kit for CompactRIO Single Board Controller with NI-DAQmx (787331-01) does not satisfy your design requirements, NI recommends replicating the features of the heat spreader into your own thermal solution. Use the specified pedestal dimensions and a Laird HD700 0.060 in. thermal gap pad with a fastener assembly rate of 4.23 mm/s (10 in./min.) to prevent damage to the critical components during assembly. NI recommends that you replicate each of the pedestals and not just the pedestal for the CPU/FPGA.

**Figure 41. sbRIO-96xx Pedestal Dimensions**



**Table 22. Pedestal Height from Board Surface**

Designation	Pedestal Corresponding Component	Pedestal Height from Board Surface <sup>2</sup>
A	FPGA (75T)	2.4 mm (0.094 in.)
	FPGA (100T)	2.4 mm (0.094 in.)
	FPGA (200T)	3.3 mm (0.130 in.)
B	OSC	2.4 mm (0.094 in.)
C	NI ASIC 1	2.6 mm (0.102 in.)

<sup>2</sup> Using a 1.5 mm (0.06 in.) thick thermal gap-filler.

**Table 22. Pedestal Height from Board Surface (Continued)**

Designation	Pedestal Corresponding Component	Pedestal Height from Board Surface <sup>2</sup>
D	CPLD	2.2 mm (0.087 in.)
E	DDR Memory	2.4 mm (0.094 in.)
F	ENET 1210	2.2 mm (0.087 in.)
G	USB PHY	2.2 mm (0.087 in.)
H	CPU	2.5 mm (0.098 in.)
I	NAND Flash	2.6 mm (0.102 in.)
J	NI ASIC 2	2.4 mm (0.094 in.)



**Note** Pedestals of the same dimensions are allowed to violate the primary side maximum component height keepaway restrictions.



**Note** Gap-filling thermal interface materials between the components and pedestals confined to within the indicated region are allowed to violate the primary side maximum component height keepaway restrictions.



**Note** Pedestals of the same dimensions are allowed to have 0.5 mm (0.02 in.) rounds and 2° draft angles.

## Additional Resources for Managing Thermal Conditions

Visit [ni.com/r/sbriocooling](https://ni.com/r/sbriocooling) for the following additional information to help you manage thermal conditions:

- Examples regarding the effect of the design factors discussed in this chapter
- Case study examples to help you estimate the achievable external ambient temperature for a representative system

<sup>2</sup> Using a 1.5 mm (0.06 in.) thick thermal gap-filler.

# Troubleshooting the Controller

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## The sbRIO-96xx is Not Communicating with the Network

- Verify that all network connections are secure.
  - The USB connection between the sbRIO-96xx and the host computer
  - The Ethernet connection between the sbRIO-96xx and the ethernet switch
  - The Ethernet connection between the host computer and the ethernet switch
- Configure the IP and other network settings by completing the following steps.
  1. Use a USB-Type-C-to-USB-Type-A cable (included in the kit) to connect the sbRIO-96xx USB Type-C Device Port to a host computer. The USB driver creates a virtual network interface card and assigns an IP address to the sbRIO-96xx in the format of 172.22.11.x.
  2. In MAX, expand your system under **Remote Systems**.
    -  **Tip** If you do not see the sbRIO-96xx under **Remote Systems**, use the **Troubleshoot Remote System Discovery** utility to walk through troubleshooting steps.
  3. Select the **Network Settings** tab to configure the IP and other network settings.
  4. (Optional) Use the RJ-45 Ethernet port 0 or port 1 to reconnect the sbRIO-96xx to the host computer. The sbRIO-96xx attempts to initiate a DHCP network connection at power up.
    -  **Note** If the sbRIO-96xx 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 sbRIO-96xx over a standard Ethernet connection.
- Ensure that you have the correct version of NI CompactRIO Device Drivers installed on the host computer. Visit [ni.com/r/swsupport](https://ni.com/r/swsupport) for the minimum supported versions of LabVIEW and NI CompactRIO Device Drivers.
  -  **Tip** If you have recently upgraded LabVIEW, you must reinstall NI CompactRIO Device Drivers.
- Ensure that the NI USBLAN adapter is recognized in the Device Manager. Select **Start»Control Panel»Device Manager»Network adapters»National Instruments»USBLAN adapter**. If the USBLAN adapter is not recognized, you must reinstall NI CompactRIO Device Drivers.
  -  **Note** For Windows 10, you may need to search for the Control Panel as it not always available from the Start Menu.
- Temporarily disable any network firewalls or other security software.

## Verify or Reset the System IP Configuration

Complete the following steps to verify or reset the system IP configuration of your sbRIO-96xx

1. Put the sbRIO-96xx in safe mode by holding the RESET button down for 5 seconds.  
The STATUS LED starts blinking three times every few seconds.
2. Connect the 10-pin IDC to DSUB accessory (Serial/CAN cable) to the RS-232 to read the IP address via Console Out.
3. Set a new DHCP connection by holding the RESET button down for 5 seconds. The STATUS LED repeats the same behavior from Step 1.  
If the sbRIO-96xx 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 sbRIO-96xx by pressing the RESET button.

## Configure the Windows Firewall

Use this topic to configure the firewall in Windows to ensure you sbRIO-96xx can communicate with the network.

- Use the **Troubleshoot Remote System Discovery** tool to configure the firewall.
  1. In MAX, right click **Remote Systems** and select **Troubleshoot Remote System Discovery**.
  2. Follow the steps in the tool.
- Add an exception for MAX to your network firewall or other security software by completing the following steps:
  1. Select **Start»Control Panel»Windows Firewall»Allow a program through Windows Firewall**.



**Note** For Windows 10, you may need to search for the Control Panel as it not always available from the Start Menu.

2. Click **Allow another program**.
  3. Select **Measurement & Automation**.
  4. Click **Add**.
  5. Click **OK**.
- Ensure that UDP port 44525 is open to communication on the host computer. If you are using an intelligent switch on the network, ensure that it is not disabling UDP port 44525.

## Worldwide Support and Services

The NI website is your complete resource for technical support. At [ni.com/support](https://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.

Visit [ni.com/services](https://ni.com/services) for information about the services NI offers.

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377904A-01 October 22, 2019