sbRIO-9684 User Manual

08-2023

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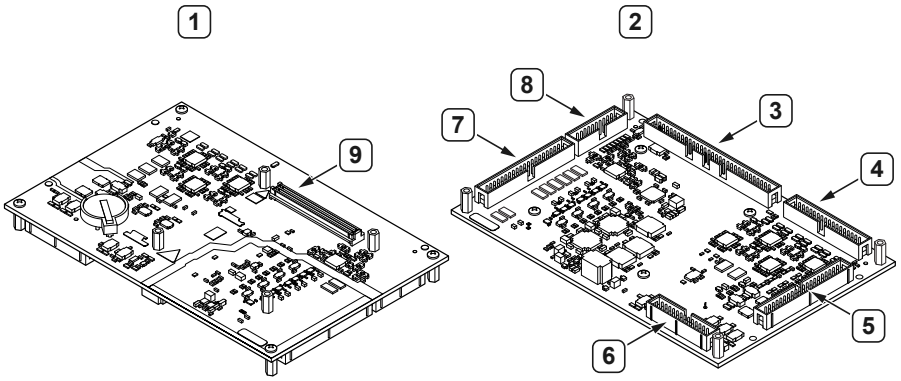
sbRIO-9684 User Manual General Purpose Inverter Controller RIO Mezzanine Card

Contents

sbRIO-9684 User Manual

This document describes the features of the sbRIO-9684 and contains mounting instructions and specifications.

Figure 1 : sbRIO-9684



1. Primary Side
2. Secondary Side
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5. Sinking DO and Relay Control DO
6. Half-bridge DO
7. Simultaneous AI
8. Scanned AI and AO
9. sbRIO Mezzanine Connector

Safety Guidelines

CAUTION

Do not operate the sbRIO-9684 in a manner not specified in this document. Product misuse can result in a hazard. You can compromise the safety protection built into the product if the product is damaged in any way. If the product is damaged, return it to NI for repair.

ATTENTION

Le sbRIO-9684 ne doit en aucun cas être utilisé d'une manière qui n'est pas spécifiée dans ce document. Une mauvaise utilisation du produit peut s'avérer dangereuse. Si le produit est endommagé de quelque manière que ce soit, la sécurité intégrée dans le produit risque d'en être compromise. Si le produit est endommagé, le renvoyer à NI pour réparation.

CAUTION
NI makes no product safety, electromagnetic compatibility (EMC), or CE marking compliance claims for the sbRIO-9684. The end-product supplier is responsible for conformity to any and all compliance requirements.

ATTENTION
NI ne fait aucune déclaration de conformité pour la sécurité des produits, la compatibilité électromagnétique (CEM) ou le marquage CE pour le sbRIO-9684. Le fournisseur du produit final est responsable du respect de toutes les exigences de conformité.

CAUTION
The sbRIO-9684 must be installed inside a suitable enclosure prior to use. Hazardous voltages may be present.

ATTENTION
Le sbRIO-9684 doit être installé dans un boîtier approprié avant d'être utilisé. Des tensions dangereuses peuvent être présentes.

CAUTION
Exercise caution when placing the sbRIO-9684 inside an enclosure. Auxiliary cooling may be necessary to keep the device under the maximum ambient temperature rating for the sbRIO-9684. Refer to the Specifications section for more information about the maximum ambient temperature rating.

ATTENTION
Faire preuve de prudence lorsque vous placez le sbRIO-9684 dans un boîtier. Un système de refroidissement auxiliaire peut être nécessaire pour maintenir l'appareil en dessous de la température nominale maximale pour le sbRIO-9684. Se reporter à la section Specifications pour en savoir plus sur la température nominale maximale.

CAUTION
The sbRIO-9684 is designed for low voltage signals. You must ensure that all signals connected to the sbRIO-9684 are not hazardous. A hazardous voltage is a voltage greater than 42.4 Vpk or 60 VDC to earth ground.

ATTENTION
Le sbRIO-9684 est conçu pour les signaux basse tension. Vous devez vous assurer qu'aucun des signaux connectés au sbRIO-9684 n'est dangereux. Une tension dangereuse est une tension supérieure à une tension de crête Vpic de 42,4 V ou à une tension par rapport à la terre de 60 V CC.

CAUTION
Do not connect the sbRIO-9684 to signals or use for measurements within Measurement Categories II, III, or IV.

ATTENTION
Ne pas connecter le sbRIO-9684 à des signaux ou l'utiliser pour effectuer des mesures dans les catégories de mesure II, III ou IV.

CAUTION
Use the sbRIO-9684 with only NI sbRIO-9603/9605/9606/9607 devices. The sbRIO-9684 is not electrically or mechanically compatible with other NI sbRIO devices.

ATTENTION
Utiliser le sbRIO-9684 uniquement avec les appareils NI sbRIO-9603/9605/9606/9607. Le sbRIO-9684 n'est pas compatible électriquement ou mécaniquement avec les autres appareils NI sbRIO.

CAUTION
The product will need to be mounted in suitable Fire and Mechanical end product enclosure; Exercise caution when placing the product inside an enclosure. Auxiliary cooling may be necessary to keep the product under the maximum ambient temperature rating for the product. Refer to the product specifications for more information about the maximum ambient temperature rating.

ATTENTION
Le produit devra être monté dans un boîtier du produit final répondant aux exigences de résistance mécanique et de protection incendie ; faites preuve de prudence lorsque vous placez le produit dans un boîtier. Un système de refroidissement auxiliaire peut être nécessaire pour maintenir le produit en dessous de sa température nominale maximale. Reportez-vous aux spécifications du produit pour obtenir plus d'informations sur la température nominale maximale.

Dimensions

The following figures show the sbRIO-9684 dimensions. For detailed dimensional drawings and 3D models, visit *ni.com/dimensions* and search for the sbRIO-9684.

Figure 2 : Primary Side Dimensions in Millimeters (Inches)

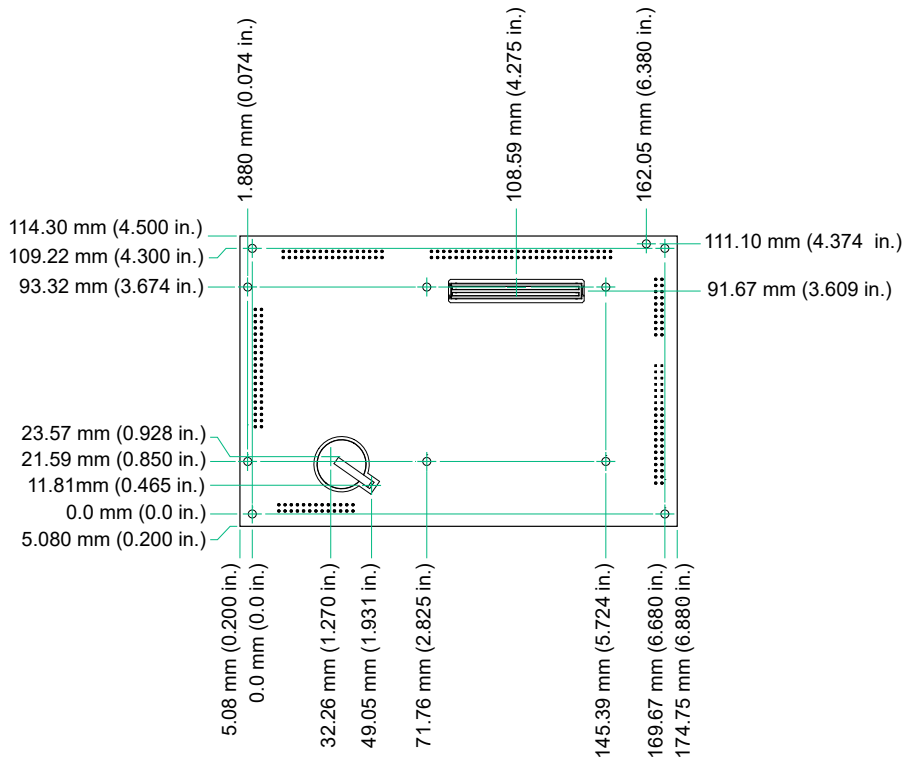


Figure 3 : Secondary Side Dimensions in Millimeters (Inches)

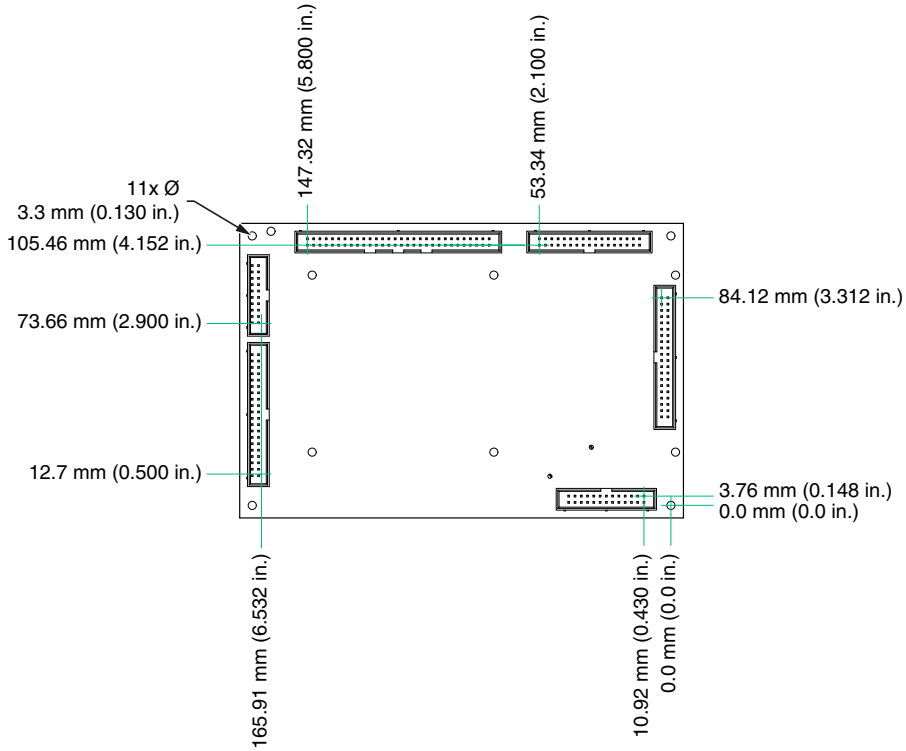
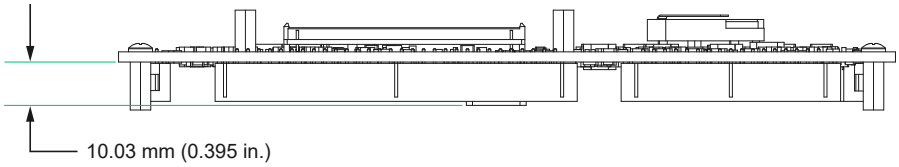


Figure 4 : Maximum Height of Components in Millimeters (Inches)



Mounting the sbRIO-9684

About this task

Mount the sbRIO-9684 to a thermally conductive surface that is at least 3 mm thick.

What to Use

- sbRIO-9684
- Mounting hardware, included with the sbRIO-9684
  - Standoff, M3 x 9.65, M-F, 4.5 HEX, SS, NYL (x4)
  - Standoff, M3 x 11.12, M-F, 4.5 HEX , SS, NYL (x4)
  - Standoff, M3 x 29.81, M-F, 4.5 HEX, SS, NYL (x4)
  - Standoff, M3 x 43.36, M-F, 4.5 HEX, SS, NYL (x4)
  - Screw, M3 x 5, Panhead, PHIL, SS, NYL (x13)

> **NOTE**
> Nine M3 nuts are also included with the sbRIO-9684 mounting hardware. The M3 nuts are provided to secure the heat spreader/sbRIO-9684/sbRIO/ interface board assembly for temporary mounting configurations where holes are not tapped into the mounting surface. To prevent possible damage to the device, use caution when installing the M3 nuts.

- NI sbRIO-9603 or sbRIO-9607 controller
- Controller-specific thermal kit
  - Heat spreader
  - Gap pad
  - Mounting hardware
- #1 Phillips screwdriver
- 4.5 mm hex nut driver
- Automatic screwdriver
- Thermal interface material

What to Do

Complete the following steps to mount the sbRIO-9684.

TIP
Tighten all standoffs and screws to a maximum torque of 0.56 N · m (5 lb · in.).

Procedure

1. Prepare the mounting surface by tapping holes according to the ***Surface Mounting Dimensions***.
2. Install the heat spreader to the mounting surface.
    a) Apply a thermal interface material, such as grease, to the flat side of the head spreader.
    b) Align the heat spreader with the tapped holes for the NI sbRIO controller.
    c) Fasten the M3 x 16, M-F standoffs through the heat spreader to the tapped holes for the NI sbRIO controller.

Figure 5 : Mounting the Heat Spreader on sbRIO-9603

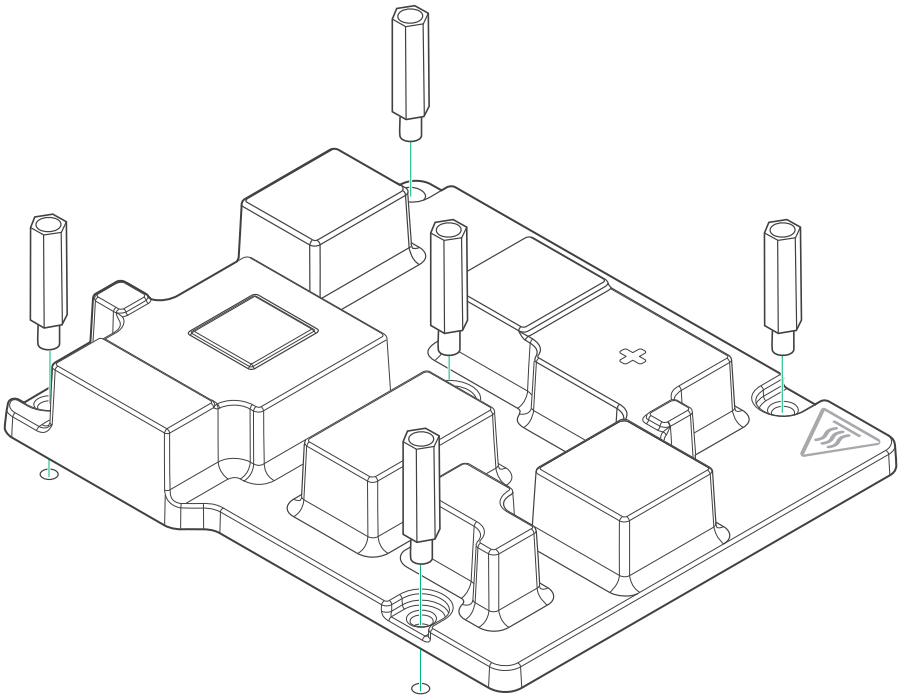
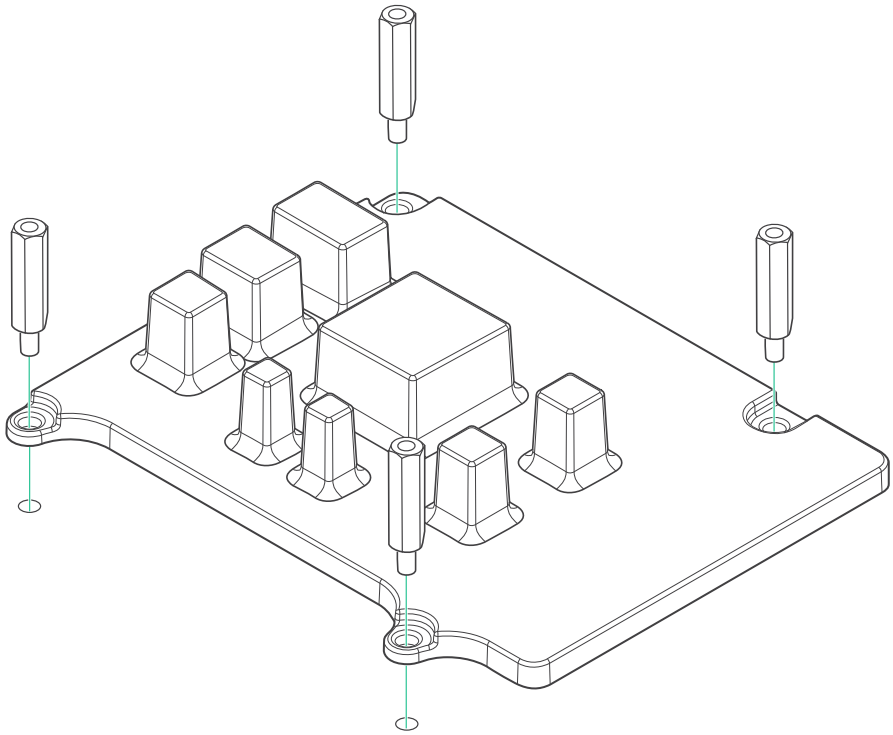


Figure 6 : Mounting the Heat Spreader on sbRIO-9607



3. Install the NI sbRIO controller.
    a) Apply the gap pad to the NI sbRIO controller. Refer to the Thermal Kit Installation Instructions for information about gap pad placement.
    b) Align the NI sbRIO controller with the heat spreader.
    c) Fasten the M3 x 9.65, M-F standoffs through the NI sbRIO controller to the M3 x 16, M-F standoffs.

Figure 7 : Installing the NI sbRIO-9603

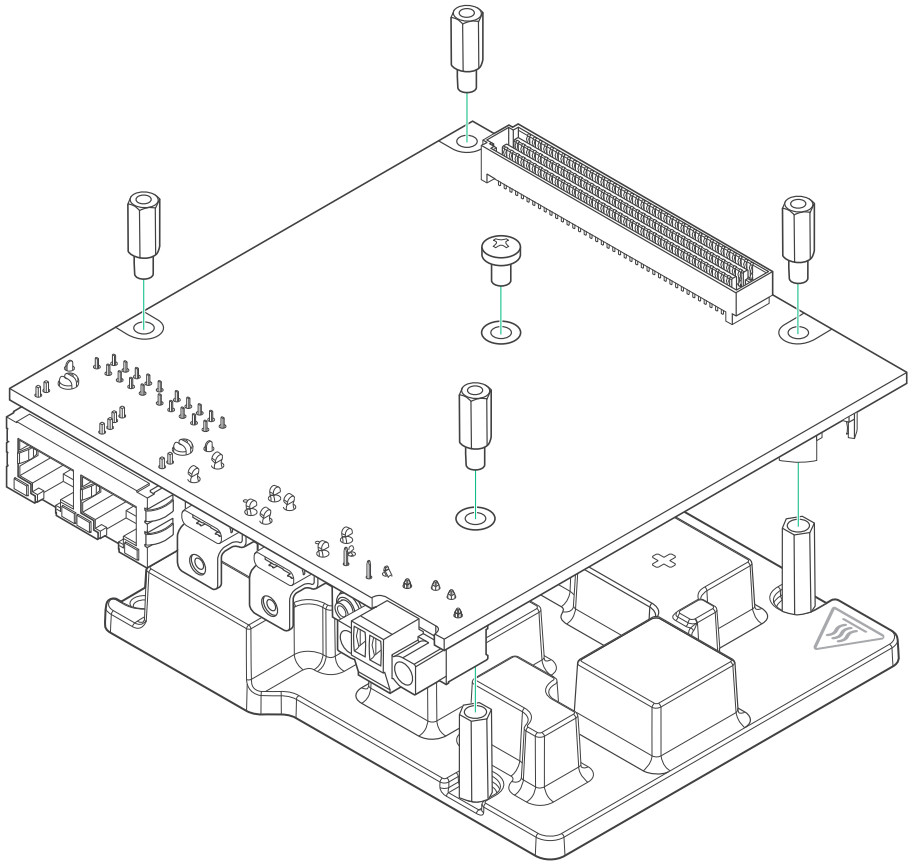
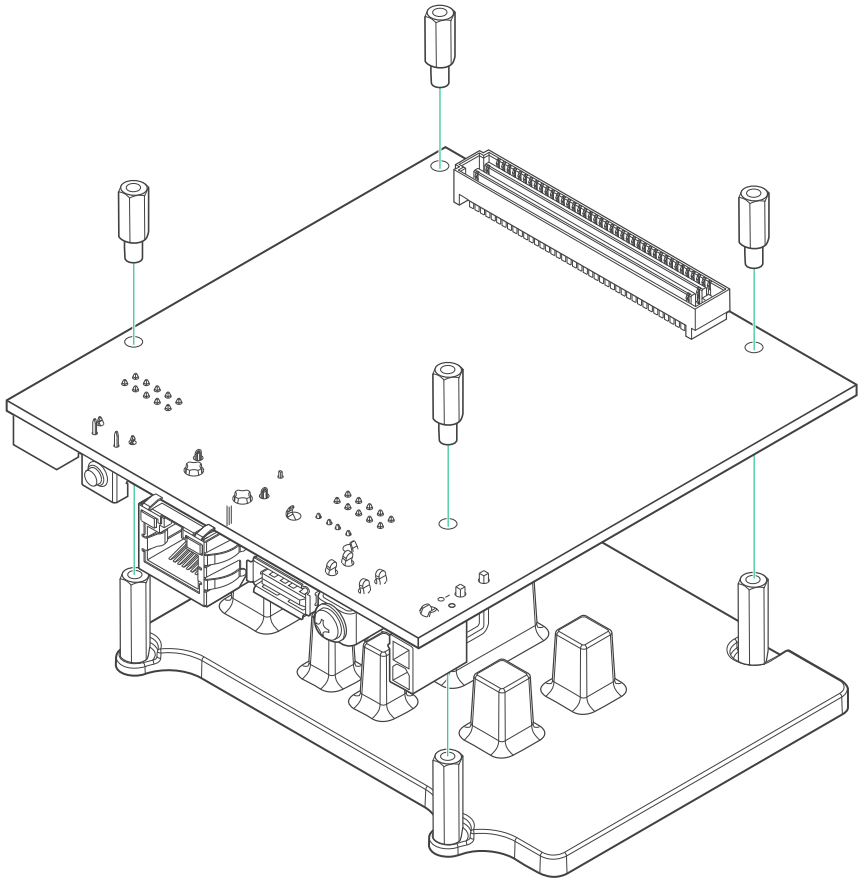


Figure 8 : Installing the NI sbRIO-9607



CAUTION

The gap pad is a viscoelastic material and compressing it too quickly places a large amount of stress on board components. If you must use an automatic screwdriver, fasten these screws at a rate less than 4.23 mm/s (10 in./min.) to prevent damage during assembly.

ATTENTION

Le tampon d'espacement est en matériau viscoélastique et sa compression trop rapide soumet les composants de la carte à une grande contrainte. Si vous devez utiliser un tournevis automatique, serrez ces vis à une vitesse inférieure à 4,23 mm/s (10 po/min) pour éviter tout dommage pendant l'assemblage.

CAUTION

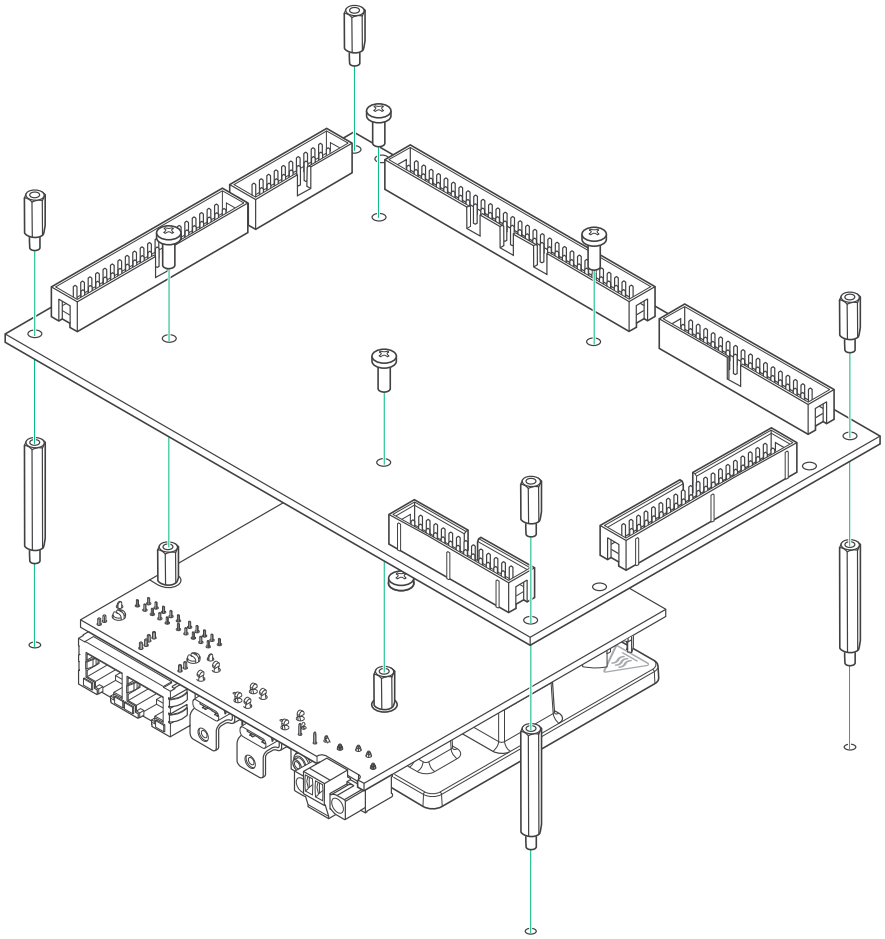
NI sbRIO-9603 has an additional mounting hole in the middle that must only be secured to the M3 x 16, M-F standoff installed to the mounting surface through the heat spreader by using an M3 x 5 panhead screw.

ATTENTION

Le NI sbRIO-9603 dispose en son milieu d'un trou de montage supplémentaire qui ne doit être fixé qu'à l'entretoise M-F M3 x 16 installée sur la surface de montage à travers le dissipateur thermique en utilisant une vis à tête cylindrique M3 x 5.

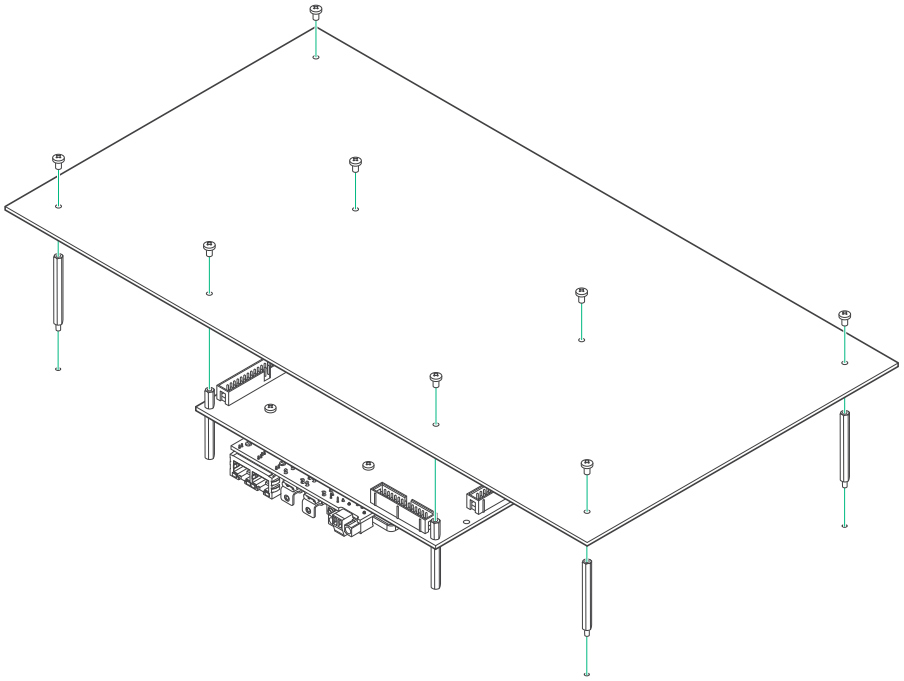
4. Install the sbRIO-9684.
   a) Install the M3 x 29.81, M-F standoffs to the tapped holes for the sbRIO-9684.
   b) Align the sbRIO-9684 with the M3 x 29.81, M-F standoffs and the NI sbRIO controller.
   c) Seat the mezzanine card connectors on the sbRIO-9684 and the NI sbRIO controller to connect the boards.
   d) Fasten the M3 x 11.12, M-F standoffs through the sbRIO-9684 to the M3 x 29.81, M-F standoffs.
   e) Insert four M3 x 5 panhead screws through the sbRIO-9684 to the installed M3 x 9.65, M-F standoffs.

Figure 9 : Mating the sbRIO-9684 to the NI sbRIO Controller



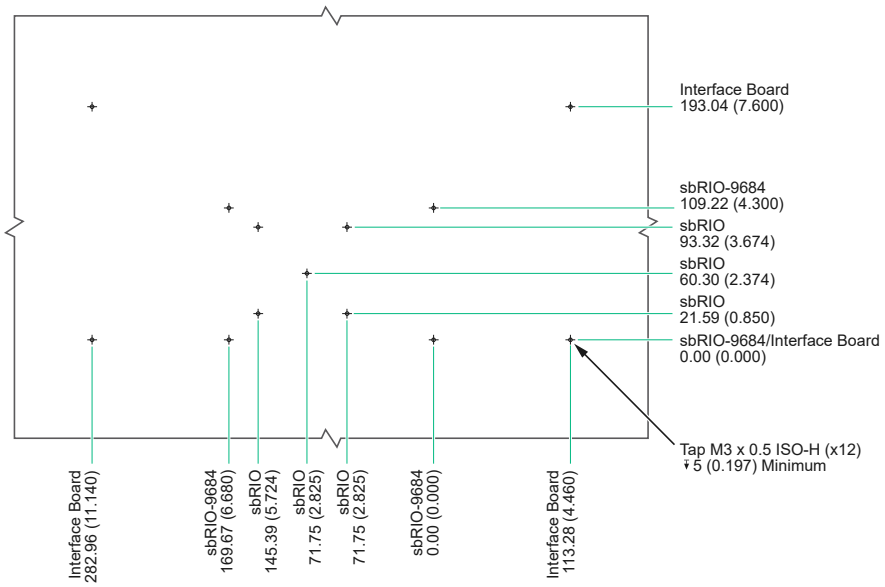
5. Install the interface board for your application.
    a) Install the M3 x 43.36, M-F standoffs in the tapped holes for the interface board.
    b) Align the interface board with the M3 x 43.36, M-F standoffs and the sbRIO-9684.
    c) Seat the connectors on the interface board and the sbRIO-9684 to connect the boards.
    d) Insert eight M3 x 5 panhead screws through the interface board to the M3 x 43.36, M-F standoffs and the M3 x 11.12, M-F standoffs.

Figure 10 : Mating the Interface Board to the sbRIO-9684



Surface Mounting Dimensions

Figure 11 : Surface Mounting Dimensions in Millimeters (Inches)



Installing Software on the Host Computer

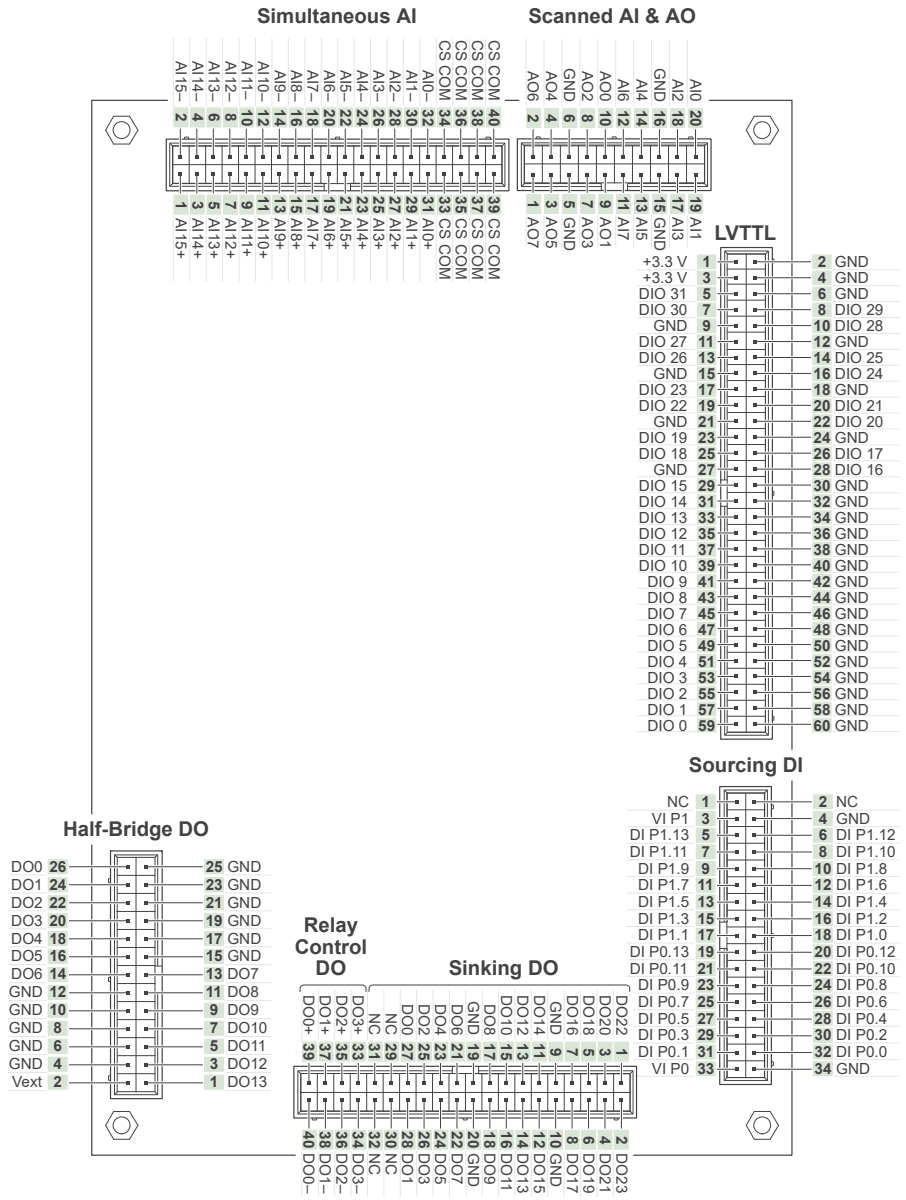
Before using the sbRIO-9684, you must install the following application software and device drivers on the host computer.

1. LabVIEW 2019 or later
2. LabVIEW Real-Time Module 2019 or later
3. LabVIEW FPGA Module 2019 or later
4. NI CompactRIO Device Driver 19.5 or later

Visit *ni.com/info* and enter the Info Code `softwareversion` for minimum software support information.

Pinout

Figure 12 : sbRIO-9684 Pinout



Connectors

The following table lists the sbRIO-9684 connectors and recommended mating connectors. Refer to the manufacturer for information about using and matching these connectors.

Table 1 : sbRIO-9684 Connectors

Connector	Description	Recommended Mating Connector
Simultaneous AI	40-position header	On-Shore Technology, Inc. (SH2-40G-PT)
Scanned AI, AO	20-position header	On-Shore Technology, Inc. (SH2-20G-PT)
Sourcing DI	34-position header	On-Shore Technology, Inc. (SH2-34G-PT)
Sinking DO, Relay Control DO	40-position header	On-Shore Technology, Inc. (SH2-40G-PT)
Half-Bridge DO	26-position header	On-Shore Technology, Inc. (SH2-26G-PT)
LVTTL DIO	60-position header	On-Shore Technology, Inc. (SH2-60G-PT)

Simultaneous Analog Input

The sbRIO-9684 provides connections for 16 pseudo-differential analog input channels.

Each channel has an AI+ and AI- pin to which you can connect a voltage signal. AI- is internally connected to the isolated ground reference through a high value resistor.

Circuitry

The incoming analog signal on each channel is buffered and conditioned by the differential amplifier and then sampled by a 16-bit ADC. The sbRIO-9684 analog channels share a common ground that is isolated from other parts of the board. The sbRIO-9684 protects each channel from overvoltages.

Each channel has an independent track-and-hold amplifier and ADC that allow you to sample and convert all 16 channel simultaneously.

Connecting Differential and Single-Ended Voltage Signals to the Simultaneous AI

You can connect differential or single-ended signal sources to the simultaneous AI on the sbRIO-9684.

Figure 13 : Connecting a Differential Voltage Signal to a Simultaneous AI Channel

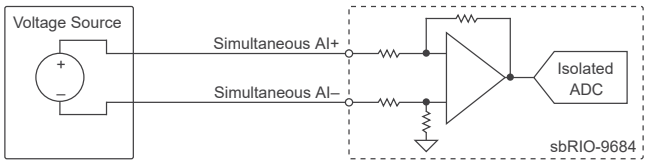
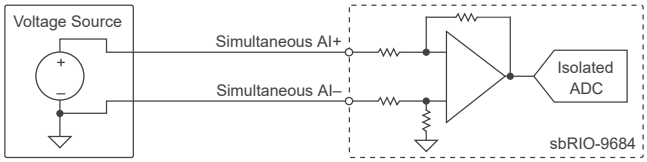


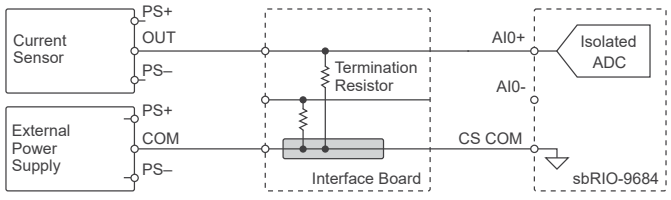
Figure 14 : Connecting a Single-Ended Voltage Signal to a Simultaneous AI Channel



Connecting Current Sensors to the Simultaneous AI

You can connect current sensors to the sbRIO-9684 using a termination resistor to convert the current measurement to a single-ended voltage measurement. Connect the current sensor output to AI+ and the external power supply COM to the current sensor common pin (CS COM) on the sbRIO-9684.

Figure 15 : Connecting a Current Sensor



To avoid the affect of common mode impedance on the measurement, connect one end of all the termination resistors to a single, small plane. Then have a single connection from the plane to the CS COM pin of the sbRIO-9684.

Termination Resistor Values

The sbRIO-9684 simultaneous analog inputs have ±10 V and ±5 V input ranges that can accommodate termination resistor values in a certain range, based on the sensor peak current. Select the highest possible termination resistor to maximize the dynamic range of the analog input.

Use the following equation to determine the maximum value for the terminal resistor based on the sensor peak current.

Figure 16 : Termination Resistor Equation

$$R_{\text{maximum}} = \frac{5\ V}{I\_peak_{\text{maximum}}}$$

For a current sensor with a peak output current of 70 mA, the maximum termination resistor that can be used with the sbRIO-9684 is as follows:

Figure 17 : Termination Resistor Example

$$R_{\text{maximum}} = \frac{5\ V}{0.07\ A} = 71\ \Omega$$

NOTE
Using the ±5 V input range can reduce the power dissipation on the termination resistor by 50% when compared to the power dissipation of the ±10 V input range.

Scanned Analog Input (Monitoring)

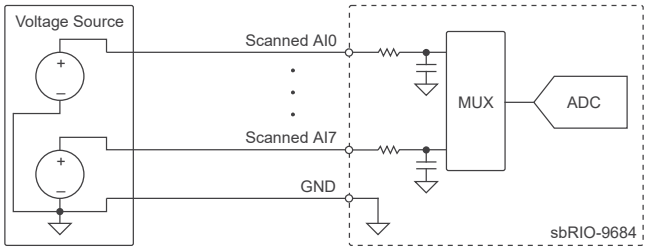
The sbRIO-9684 provides connections for eight single-ended scanned analog input channels.

Each channel has an AI pin to which you can connect a voltage signal. Scanned analog input and analog output channels share four GND pins on the dedicated 20-position connector.

Connecting Single-Ended Voltage Signals to the Scanned AI

You can connect single-ended signal sources to the scanned AI on the sbRIO-9684.

Figure 18 : Connecting Single-Ended Voltage Signals to the Scanned Analog Inputs



Scanned AI Accuracy and Bandwidth

Use signal sources with an output impedance of less than 2 kΩ to ensure specified performance. Large source impedances add to the input resistor inside the sbRIO-9684, which results in increased settling time and decreases the accuracy of the measurement. Increased input impedance also results in a decrease of the -3 dB bandwidth.

Analog Output (Set-Point)

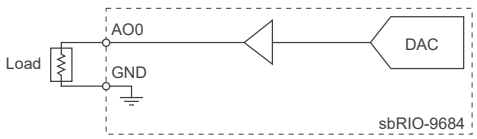
The sbRIO-9684 provides connections for eight single-ended analog output channels.

Each channel has an AO pin to which you can connect a load. Analog output and scanned analog input channels share four GND pins on the dedicated 20-position connector.

Connecting a Load to the AO

You can connect a load to the AO on the sbRIO-9684.

Figure 19 : Connecting a Load to the Analog Outputs



Half-Bridge Digital Output

The sbRIO-9684 provides connections for 14 half-bridge digital output channels.

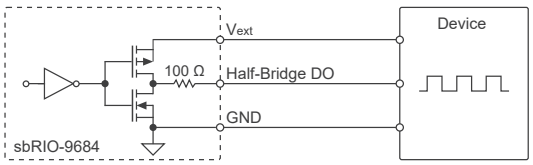
Each channel has a half-bridge DO pin to which you can connect a digital input device. An external power supply referenced to ground of the board must be connected to Vext.

The sbRIO-9684 half-bridge digital outputs are push-pull, meaning the sbRIO-9684 can sink or source current. When the channel is ON, the half-bridge DO pin is driven to the external power supply minus a voltage drop due to the sourced current. When the channel is turned OFF, the half-bridge DO pin is driven to ground plus a voltage drop due to the sinked current.

Connecting Digital Devices to the Half-Bridge DO

You can connect digital devices to the half-bridge DO.

Figure 20 : Connecting a Digital Device to a Half-Bridge DO Channel



NOTE
Make sure the devices you connect to the sbRIO-9684 are compatible with the half-bridge digital output specifications. Use connections that match the output impedance of the sbRIO-9684 half-bridge outputs.

Sinking Digital Output

The sbRIO-9684 provides connections for 24 sinking digital output channels.

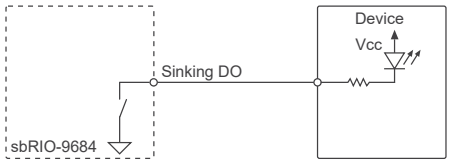
Each channel has a sinking DO pin to which you can connect a digital input device. Sinking DO pins have dedicated current return pins, GND, which are referenced to the ground of the board.

The sbRIO-9684 has current sinking digital outputs, meaning that the output pin is driven to ground (GND) when the channel is ON.

Connecting Digital Devices to the Sinking DO

You can connect digital devices to the sinking DO.

Figure 21 : Connecting a Digital Device to a Sinking DO Channel



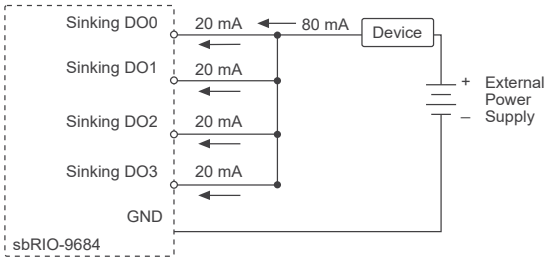
NOTE
Make sure the devices you connect to the sbRIO-9684 are compatible with the output specifications.

Increasing Current Drive

Each channel of the sbRIO-9684 has a continuous output current of 20 mA. If you want to increase the output current to a device, you can connect any number of channels together in parallel.

For example, if you want to drive 80 mA of current, connect DO<0..3> in parallel, as shown in the following figure. You must turn all parallel channels on and off simultaneously so that the current on any single channel cannot exceed the 20 mA rating.

Figure 22 : Increasing the Current to a Device Connected to the sbRIO-9684



Relay Control Digital Output

The sbRIO-9684 provides connections for four relay control digital output channels.

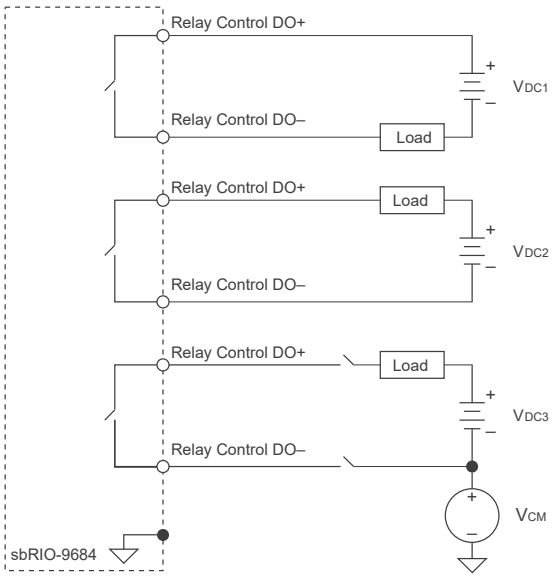
Each channel has a relay control DO+ and a current return pin, relay control DO-.

The sbRIO-9684 has current sinking outputs, meaning the relay control DO+ is driven to relay control DO- when the channel is ON.

Connecting Industrial Devices to the Relay Control DO

You can connect industrial devices such as solenoids, actuators, relays, and lamps to the relay control DO.

Figure 23 : Connecting an Industrial Device to a Relay Control DO Channel



NOTE
Ensure that all the relay control DO+/- pins are held within the safety voltage levels. A maximum common mode voltage of 30 VDC is allowed at a relay control DO+/- pin with respect to the GND of the sbRIO-9684.

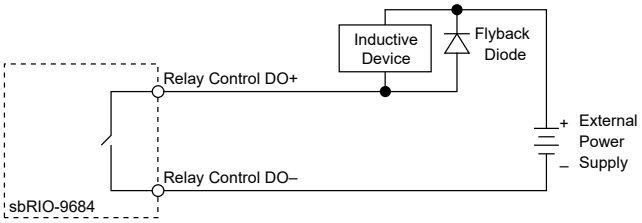
NOTE
NI recommends using the appropriate cabling for the current return pins based on the amount of current returned per each relay control DO- output.

NOTE
Make sure the devices you connect to the sbRIO-9684 are compatible with the output specifications

Protecting the Digital Outputs from Flyback Voltages

If the channel is switching an inductive or energy-storing device such as a solenoid, motor, or relay, and the device does not have flyback protection, install an external flyback diode.

Figure 24 : Connecting a Flyback Diode



Selecting a Wire Gauge for Relay Control DO

The relay control digital output is capable of sinking 8 A of inrush current for a period of 300 ms on a 60 second cycle and 500 mA of continuous current. Each channel is functionally isolated from the other channels and the rest of the board, meaning that each relay control digital output has a dedicated current return pin.

When using cables, make sure the current rating of the cable is able to handle the expected current for your application. For example, a typical 28 AWG flat ribbon cable is rated at 225 mA of continuous current per wire. In order to use the relay control digital outputs at their maximum current capability, cables within category 24 AWG or lower should be used.

Sourcing Digital Input

The sbRIO-9684 provides connections for 28 simultaneously sampled digital input channels separated in ports P0 and P1. Ports P0 and P1 are independently powered using separate power supply pins, VI P0 and VI P1. This allows you to connect the DI to multivoltage systems.

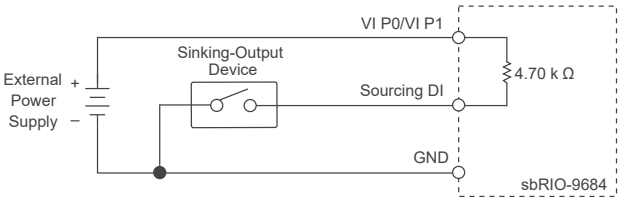
Each channel has a DI pin to which you can connect a digital input signal. The supply pins, VI P0 and VI P1, are referenced to the ground of the board. The DI operates in the low range or high range based on the VI P0 or VI P1 voltage.

The sbRIO-9684 has sourcing inputs, meaning the DI sources current from the VI P0 or VI P1 to the sinking output device. The sbRIO-9684 internally limits current signals connected to DI. The channel registers ON when the sinking-output is in the ON range. The channel registers as OFF when the sinking-output is in the OFF range. If no device is connected to the sourcing DI, the channel registers as OFF.

Connecting Digital Devices to the Sourcing DI

You can only connect 3-wire sinking-output devices to the sbRIO-9684.

Figure 25 : Connecting a Digital Device to a Sourcing DI Channel



NOTE
NI recommends that you leave sourcing DI channels that are not used in your application unconnected to lower power dissipation through the onboard pull-up resistor

LVTTL Digital Input/Output

The sbRIO-9684 provides connections for 32 LVTTL digital input/output channels.

The sbRIO-9684 LVTTL DIO channels connect directly to the FPGA DIO on the NI sbRIO-9603 or sbRIO-9607 and are unbuffered and unprotected.

CAUTION
Operating the LVTTL DIO outside the rated specifications may result in permanent damage to the FPGA on NI sbRIO-9603 or sbRIO-9607.

ATTENTION
Faire fonctionner les E/S numériques LVTTL en dehors des spécifications nominales peut entraîner des dommages permanents au FPGA sur les NI sbRIO-9603 or sbRIO-9607.

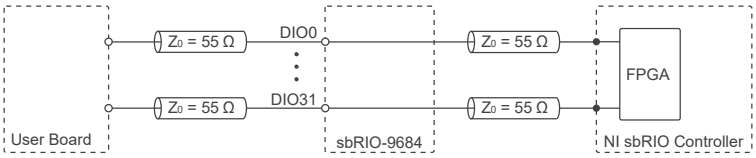
If overshoot and undershoot aberrations and signal integrity are concerns for your application, use a single load per line that does not exceed 25 pF. For edge sensitive signals, use channels DIO0 through DIO15 for better signal integrity and crosstalk performance since these channels have an individual GND pin.

The LVTTL DIO channels on the sbRIO-9684 are routed with a 55 Ω characteristic trace impedance. Route all external circuitry with a similar impedance to ensure the best signal quality.

Connecting Digital Devices to the LVTTL DIO

You can connect digital devices to the LVTTL DIO.

Figure 26 : Connecting to the LVTTL DIO Channels

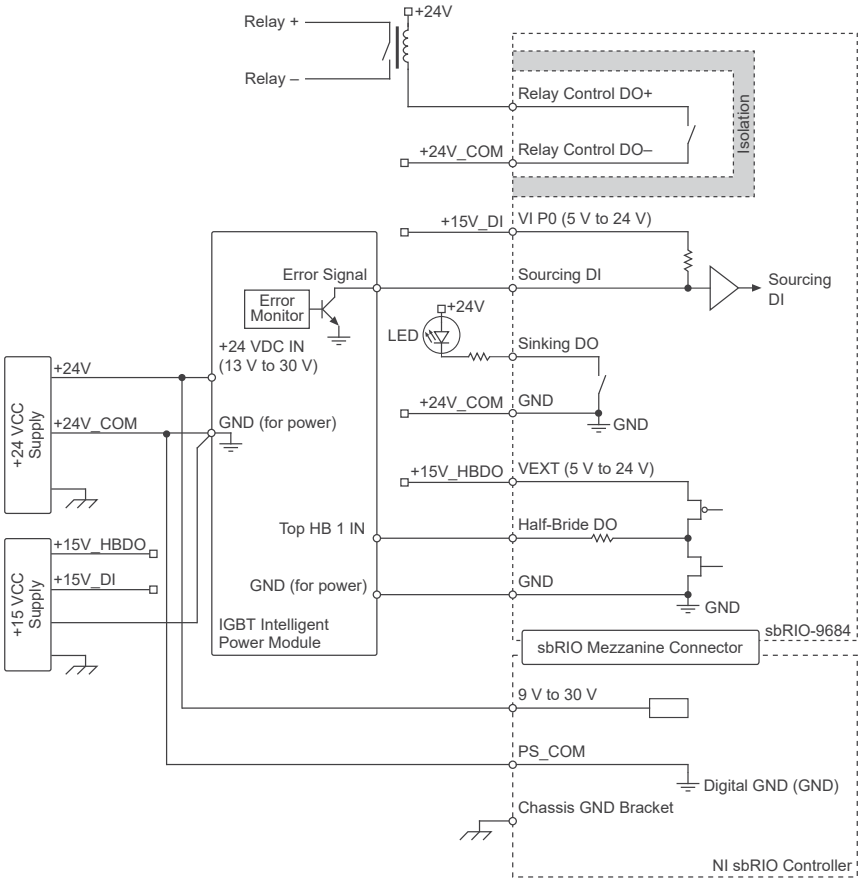


Perform signal integrity measurements to test the effect of signal routing and cable type on your application. To meet defined power-up states for outputs, use a pull-up or pull-down resistor on the line.

System Diagrams

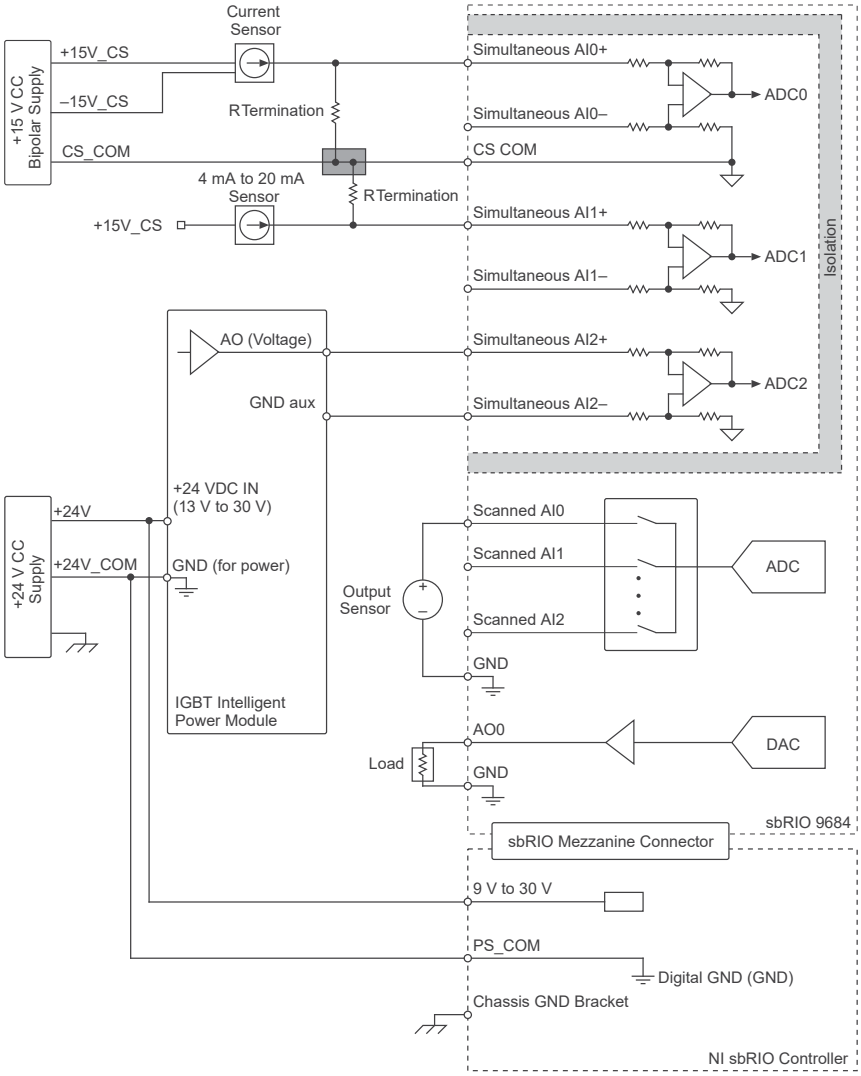
The following figure shows a diagram for interfacing digital signals with the sbRIO-9684.

Figure 27 : Interfacing Digital Signals with the sbRIO-9684



The following figure shows a diagram for interfacing analog signals with the sbRIO-9684.

Figure 28 : Interfacing Analog Signals with the sbRIO-9684



System Grounding Recommendations

NI recommends making the following connections to ground your system.

+24 VDC Power Supply Connections (Main Controller Power)

- Connect +24 V power to +24 VDC IN on the Semikron SKiiP3 26-pin connector
- Connect +24 V power to input power supply of the NI sbRIO-9603 or sbRIO-9607
- Connect +24 V GND/COM to GND input on the Semikron SKiiP3 26-pin connector
- Connect +24 V GND/COM to GND (Digital GND) input power supply of the NI sbRIO-9603 or sbRIO-9607
- Connect +24 V Earth (chassis) ground to system Earth (chassis) ground

+15 VDC Power Supply Connections (Gate Driver Control Signal Power)

- Connect +15 V power to Vext input on the sbRIO-9684
- Connect +15 V GND/COM to GND input on the Semikron SKiiP3 26-pin connector
- Connect +15 V Earth (chassis) ground to system Earth (chassis) ground

±15 VDC Sensor Power Supply Connections (Sensor/Transducer Power)

- Connect ±15 V power to system sensors/transducers
- Connect ±15 V GND/COM to CS_COM input on the sbRIO-9684

NOTE
Do not connect ±15 V sensor GND/COM to any other system ground other than CS_COM.

NOTE
Do not use the ±15 V sensor power supply as the gate driver control signal power supply.

Additional Grounding Connectivity

- Connect Semikron SKiiP3 heat sink to Earth (chassis) ground
- Connect NI sbRIO-9603 or sbRIO-9607 chassis ground metal terminal to Earth (chassis) ground
- Connect the shield of the cable interfacing the Semikron SKiiP3 to Earth (chassis) ground on your custom interface board

Specifications

The following specifications are typical for the full operating temperature range unless otherwise noted. Refer to the Environmental section for more information on operating temperatures.

Simultaneous Analog Input

Number of channels	16
ADC resolution	16 bits
Input range	
Typical	±5.2 V, ±10.4 V
Minimum	±5.1 V, ±10.2 V
Common-mode range	±10 V
Sample rate (per channel)	180 kS/s maximum

Table 2 : Accuracy

Measurement Conditions	Nominal Range (V)	Measurement Conditions†	Percent of Reading (Gain Error)	Percent of Range‡ (Offset Error)§
Calibrated	±5 V	Maximum (-40 °C to 85 °C)	0.54%	0.200%
		Typical (23 °C±5 °C)	0.13%	0.006%
	±10 V	Maximum (-40 °C to 85 °C)	0.54%	0.100%
		Typical (23 °C±5 °C)	0.13%	0.003%
Uncalibrated††	±5 V	Maximum (-40 °C to 85 °C)	1.08%	0.330%
		Typical (23 °C±5 °C)	0.48%	0.030%
	±10 V	Maximum (-40 °C to 85 °C)	1.08%	0.165%
		Typical (23 °C±5 °C)	0.48%	0.015%

† Local ambient temperature. Refer to the Environmental section for more information about operating temperatures.

‡ Range equals 5.2 V for ±5 V or 10.4 V for ±10 V.

§ Offset error includes the effect of INL.

†† Uncalibrated accuracy refers to the accuracy achieved when acquiring data in raw or unscaled modes and in which calibration constants that are stored in the module are not applied to the data.

Figure 29 : Absolute Accuracy Equation

$$\text{Absolute Accuracy} = \text{Reading} \times \text{Gain Error} + \text{Range} \times \text{Offset Error} + \text{Noise}$$

Stability	
Gain drift	26 ppm/°C
Offset drift	25 µV/°C
Noise	260 µVrms
-3 dB bandwidth	176 kHz
CMRR (f_{in} = 60 Hz)	51 dB minimum
Crosstalk (f_{in} = 10 kHz)	-69 dB

Input impedance	
Differential	250 kΩ
Single-ended	125 kΩ
Overvoltage protection	±30 V maximum

Scanned Analog Input (Monitoring)

Number of channels	8
ADC resolution	12 bits
Input range	
Typical	0 V to 5 V
Minimum	12 mV to 4.97 V
Sample rate (per channel)	1 kS/s maximum

Table 3 : Accuracy with Signal Source Impedance <2 kΩ

Measurement Conditions†	Percent of Reading (Gain Error)	Percent of Range‡ (Offset Error)§
Maximum (-40 °C to 85 °C)	0.30%	0.23%
Typical (23 °C±5 °C)	0.03%	0.02%

† Local ambient temperature. Refer to the Environmental section for more information about operating temperatures.

‡ Range equals 5 V .

§ Offset error includes the effect of INL.

NOTE
Refer to the Scanned Analog Input (Monitoring) section for more information about the influence of source impedance over accuracy.

Figure 30 : Absolute Accuracy Equation

$$\text{Absolute Accuracy} = \text{Reading} \times \text{Gain Error} + \text{Range} \times \text{Offset Error} + \text{Noise}$$

Stability	
Gain drift	5 ppm/°C
Offset drift	22 µV/°C
Noise	0.5 mVrms
-3 dB bandwidth	130 kHz

Input impedance for channel ON	10 kΩ, 120 pF low pass filter
Input current for channel OFF	10 µA maximum
Overvoltage protection	±30 V maximum

Analog Output (Set-Point)

Number of channels	8
DAC resolution	12 bits
Startup voltage[1]	0 V
Output range	
Typical	0 V to 5 V
Minimum	14 mV to 4.97 V
Current drive (per channel)	4 mA maximum
Update rate	1 kS/s maximum

Table 4 : Accuracy

Measurement Conditions†	Percent of Reading (Gain Error)	Percent of Range‡ (Offset Error)§
Maximum (-40 °C to 85 °C)	0.33%	0.28%
Typical (23 °C±5 °C)	0.05%	0.06%

† Local ambient temperature. Refer to the Environmental section for more information about operating temperatures.

‡ Range equals 5 V.

§ Offset error includes the effect of INL.

Figure 31 : Absolute Accuracy Equation

$$\text{Absolute Accuracy} = \text{Output Value} \times \text{Gain Error} + \text{Range} \times \text{Offset Error}$$

Stability	
Gain drift	6 ppm/°C
Offset drift	16 µV/°C

1 The analog outputs may generate a short pulse of up to 300 mV for 100 µs during power up.

Noise	
1 MHz bandwidth	2.5 mVrms
100 kHz bandwidth	0.3 mVrms
Protection	
Overvoltage	+15 V/-5 V maximum
Short-circuit	Indefinitely

Sourcing Digital Input

Number of channels	28
Input type	Sourcing
Input range	0 V to 24 V
External power supply voltage range (VI P0, VI P1)	
Low-range mode	3 V to 6 V
High-range mode	10 V to 24 V
Not supported	6 V to 10 V
Digital logic levels	
Low-range mode	
OFF state	≥1.8 V minimum
ON state	≤1 V maximum
High-range mode	
OFF state	≥9.6 V minimum
ON state	≤7.9 V maximum
Hold time[2]	0 s
Setup time[3]	1 µs minimum
Update/transfer time	3 µs maximum
Pull-up resistor	4.70 kΩ
Overvoltage protection (VI P0, VI P1 to channel)	±30 V maximum

Sinking Digital Output

Number of channels	24
Output type	Sinking

2 Hold time is the amount of time input signals must be stable after initiating a read from the sbRIO-9684.

3 Setup time is the amount of time input signals must be stable before reading from the sbRIO-9684.

Startup voltage	Open
Output voltage (V_O)	I_O * R_O
Continuous output current (I_O) on each channel	20 mA
Output impedance (R_O)	6 Ω maximum
External power supply voltage range	0 V to 30 V
Maximum update time	50 µs
Protection	
Reversed-voltage	None
Short-circuit	None

Half-Bridge Digital Output

Number of channels	14
Output type	Sourcing/Sinking
Startup voltage	0 V
Maximum continuous output current	10 mA
Output impedance (R_O)	105 Ω maximum
External power supply voltage range (Vext)	5 V to 30 V
Digital logic levels[4]	
High (V_{OH})	
Sourcing 0.1 mA	Vext - 0.01V
Sourcing 10 mA	Vext - 1.05 V
Low (V_{OL})	
Sinking 0.1 mA	0.01 V
Sinking 10 mA	1.05 V

[4] Digital logic levels are derived from the sinking/sourcing current multiplied by R_O.

Figure 32 : Maximum Switching Frequency Based on the Capacitive Load

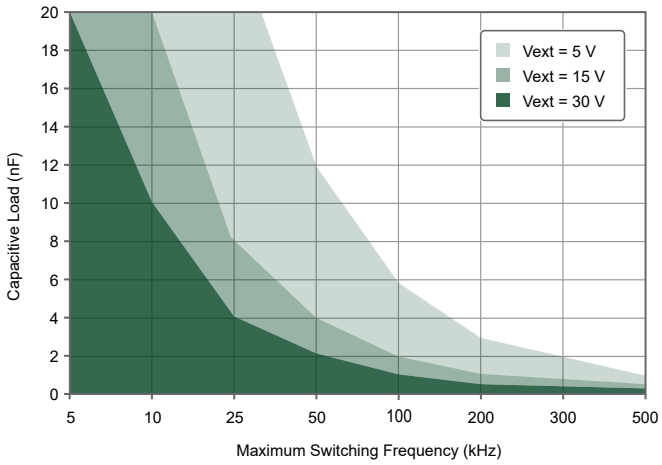
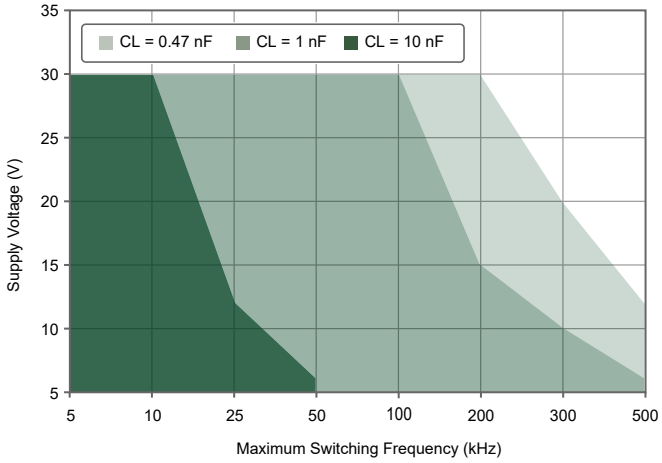


Figure 33 : Maximum Switching Frequency Based on the Supply Voltage



Propagation delay	
Vext = 5 V, CL = 50 pF	300 ns maximum
Vext > 15 V, CL = 50 pF	100 ns maximum
Protection	
Overcurrent	None
Short-circuit	None

Relay Control Digital Output

Relay control DO specifications assume the use of direct board-to-board connections to I/O connectors on the sbRIO-9684.

Number of channels	4
Output type	Sinking
Startup voltage	Open
External power supply voltage range	0 V to 30 V
Continuous current	500 mA
Maximum inrush current	8 A
Maximum inrush time	300 ms
Turn ON rate[5]	One operation per 60 s
Turn ON time	6 ms maximum
Turn OFF time	0.2 ms maximum
Protection	
Reversed-voltage	None
Short-circuit	None

LVTTL Digital Input/Output

Number of channels	32
Maximum tested current (per channel)	3 mA
Maximum total current (all lines)	96 mA

NOTE
The performance of the LVTTL DIO lines is bound by the FPGA, signal integrity, the applications timing requirements, and your design. For more information on using DIO to connect to RMCs, visit *ni.com/info* and enter the Info Code RMCDIO.

CMOS Battery

Replace the battery with the following battery or an equivalent one.

Manufacturer	Murata
Model	CR2032W
Quantity	1
Cell chemistry system	Manganese Dioxide Lithium (CR)
IEC number	CR2032

5 Turn ON rate is the minimum time between inrush current events and is based on the maximum inrush current over the maximum inrush time. You can turn OFF the relay control DO at any point during operation.

Maximum reverse charge current†	>4.2 mA

† The maximum reverse charge current of battery is specified based on application using together with NI sbRIO-9603 or sbRIO-9607. When sbRIO-9684 is not used in an application with NI sbRIO-9603 or sbRIO-9607, ensure that the protection circuit for the battery consists of two blocking components such as diodes or one blocking component and one current limiting component such as a resistor or fuse that protects the battery at not more than the maximum reverse charge current stated above.

Power Requirements

Power consumption from NI Single-Board RIO device	2 W maximum
Power-up time	0.1 s

Safety Voltages

Maximum Voltage

Connect voltages that are within the following limits.

Relay control digital output	
Relay control DO+ to Relay control DO-	0 VDC to 30 VDC
Relay control DO+/- to GND	±30 VDC
Sinking digital output	
DO-to-GND	±30 VDC
Simultaneous analog input, scanned analog input, analog output, sourcing digital input	
Pin-to-pin or pin-to-GND	±30 VDC
Half-bridge digital output	
Vext-to-GND	0 VDC to 30 VDC
LVTTL digital input/output	0 VDC to 3.465 VDC

Isolation Voltages

Simultaneous analog input	
Channel-to-channel	None
Channel-to-common	
Continuous	60 VDC, Measurement Category I
Withstand	1,000 Vrms

CAUTION

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

ATTENTION

Ne pas connecter le produit à des signaux dans les catégories de mesure II, III ou IV et ne pas l'utiliser pour effectuer des mesures dans ces catégories.

WARNING

Do not connect the product to signals or use for measurements within Measurement Categories II, III, or IV, or for measurements on MAINs circuits or on circuits derived from Overvoltage Category II, III, or IV which may have transient overvoltages above what the product can withstand. The product must not be connected to circuits that have a maximum voltage above the continuous working voltage, relative to earth or to other channels, or this could damage and defeat the insulation. The product can only withstand transients up to the transient overvoltage rating without breakdown or damage to the insulation. An analysis of the working voltages, loop impedances, temporary overvoltages, and transient overvoltages in the system must be conducted prior to making measurements.

MISE EN GARDE

Ne pas connecter le produit à des signaux dans les catégories de mesure II, III ou IV et ne pas l'utiliser pour des mesures dans ces catégories, ou des mesures sur secteur ou sur des circuits dérivés de surtensions de catégorie II, III ou IV pouvant présenter des surtensions transitoires supérieures à ce que le produit peut supporter. Le produit ne doit pas être raccordé à des circuits ayant une tension maximale supérieure à la tension de fonctionnement continu, par rapport à la terre ou à d'autres voies, sous peine d'endommager et de compromettre l'isolation. Le produit peut tomber en panne et son isolation risque d'être endommagée si les tensions transitoires dépassent la surtension transitoire nominale. Une analyse des tensions de fonctionnement, des impédances de boucle, des surtensions temporaires et des surtensions transitoires dans le système doit être effectuée avant de procéder à des mesures.

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Environmental

Operating temperature[6] (IEC 60068-2-1, IEC 60068-2-2)		
	Ambient temperature outside a 12 in. × 10 in. × 6.34 in. enclosure	-40 °C to 50 °C
	Ambient temperature with forced-air cooling in an open environment	-40 °C to 70 °C

NOTE

Visit *ni.com/info* and enter the Info Code `sbRIOcooling` for information about NI sbRIO operating temperatures.

Storage temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 85 °C
Operating humidity (IEC 60068-2-78)	10% RH to 90% RH, noncondensing
Storage humidity (IEC 60068-2-78)	5% RH to 95% RH, noncondensing
Pollution Degree	2
Maximum altitude	2,000 m

Indoor use only.

Physical Characteristics

Weight	153 g

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Engineering a Healthy Planet* 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.

6 Ensure that the local ambient temperature of the sbRIO-9684 is -40 °C to 85 °C. Measure the local ambient temperature by placing thermocouples on both sides of the PCB, 5 mm (0.2 in.) from the board surface.

EU and UK Customers

Waste Electrical and Electronic Equipment (WEEE) —At the end of the product life cycle, all NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit *ni.com/environment/weee*.

Battery Guidelines

CAUTION
Fire, explosion, and severe burn hazard. Do not open, crush, insert improperly, recharge or disassemble the battery. Do not heat the battery or the product above 100 °C. Do not incinerate the battery or the product. Do not expose the battery contents to water. Take precautions to ensure correct polarity of the battery in the product. Risk of explosion if battery is replaced by an incorrect type. Dispose of used batteries according to the instructions.

ATTENTION
Risque d'incendie, d'explosion et de brûlures graves. Ne pas ouvrir, écraser, recharger ou démonter la pile. Ne pas chauffer la pile ou le produit au-dessus de 100 °C. Ne pas incinérer la pile ou le produit. Éviter tout contact du contenu de la pile avec de l'eau. Prenez des précautions pour vous assurer que la polarité de la batterie dans le produit est correcte. Risque d'explosion si la pile est remplacée par un type de pile incorrect. Reportez-vous à la documentation de l'appareil sur ni.com/manuals pour obtenir des informations sur le remplacement, l'élimination et le recyclage de sa pile.

CAUTION
The battery must be replaced by a trained service technician. Refer to the product documentation on *ni.com/manuals* for instructions for replacing the battery.

ATTENTION
La pile doit être remplacée par un technicien de maintenance qualifié. Reportez-vous à la documentation du produit sur ni.com/manuals pour obtenir les instructions pour changer la pile.

Battery Recycling

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 product's battery, refer to the product documentation on *ni.com/manuals*. For more information about compliance with the EU Battery Directive 2006/66/EC about Batteries and Accumulators and Waste Batteries and Accumulators, visit *ni.com/environment/batterydirective*.

Battery Replacement and Disposal

Battery Directive —This product contains a long-life coin cell battery. If you need to replace it, use the Return Material Authorization (RMA) process or contact an authorized NI service representative. For more information about compliance with the EU Battery Directive 2006/66/EC about Batteries and Accumulators and Waste Batteries and Accumulators, visit *ni.com/environment/batterydirective*.

电子信息产品污染控制管理办法(中国 RoHS)

中国 RoHS — NI 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 NI 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.)

NI Services

Visit *ni.com/support* to find support resources including documentation, downloads, and troubleshooting and application development self-help such as tutorials and examples.

Visit *ni.com/services* to learn about NI service offerings such as calibration options, repair, and replacement.

Visit *ni.com/register* to register your NI product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

NI corporate headquarters is located at 11500 N Mopac Expwy, Austin, TX, 78759-3504, USA.

378017D-01 2023-08-17