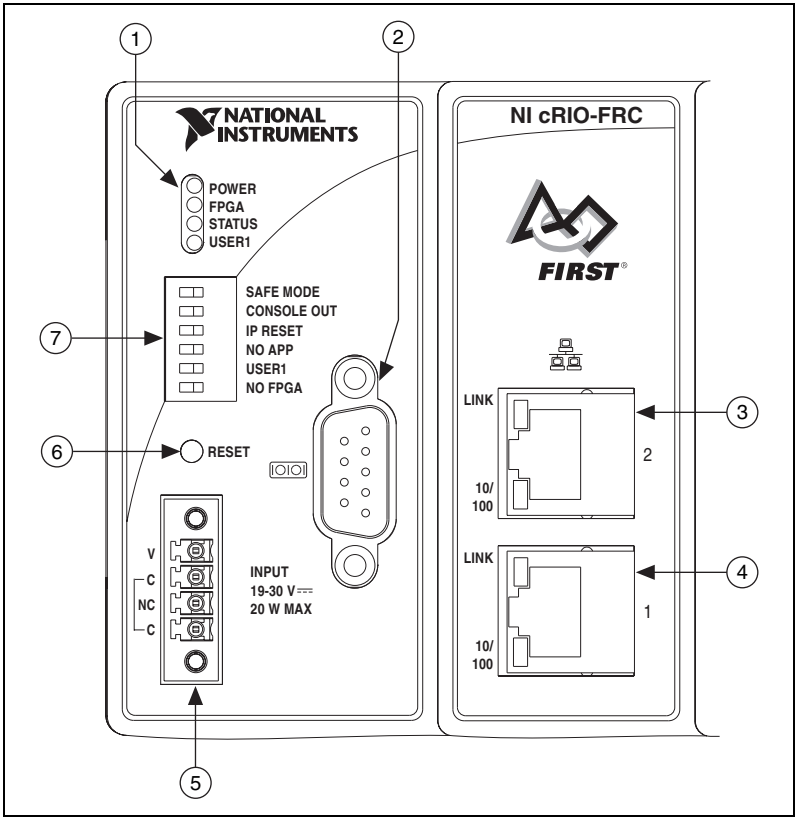
OPERATING INSTRUCTIONS AND SPECIFICATIONS

CompactRIO™ cRIO-FRC

Reconfigurable Embedded Chassis with Integrated Intelligent Real-Time Controller for *FIRST* Robotics Competition



1	LEDs	5	Power Connector
2	RS-232 Serial Port	6	Reset Button
3	RJ-45 Ethernet Port 2	7	DIP Switches
4	RJ-45 Ethernet Port 1		

Figure 1. CompactRIO cRIO-FRC

NATIONAL INSTRUMENTS™

This document describes how to connect the cRIO-FRC to a network and how to use the features of the cRIO-FRC. This document also contains specifications for the cRIO-FRC.

What You Need to Install the cRIO-FRC

- ❑ *FIRST* Robotics Competition kit, including cRIO-FRC reconfigurable embedded chassis with integrated intelligent real-time controller and the LabVIEW for FRC software
- ❑ C Series I/O modules
- ❑ DIN rail mount kit (for DIN rail mounting only)
- ❑ Two M4 or number 10 panhead screws (for panel mounting only)
- ❑ A number 2 Phillips screwdriver
- ❑ Power supply

Note The cRIO-FRC may be shipped with a clear protective film cover on the front panel. You can remove the film cover before installing the cRIO-FRC.

Related Documentation

To find the *FIRST Robotics Competition Manual* and other helpful documents mentioned in this document, go to the FRC Community Web site at `www.usfirst.org/community/frc` and select **Documents and Updates»Competition Manual and Related Documents**.

Mounting the CompactRIO Reconfigurable Embedded Chassis

You can mount the chassis in any orientation on a 35 mm DIN rail or on a panel. Use the DIN rail mounting method if you already have a DIN rail configuration or if you need to be able to quickly remove the CompactRIO chassis. Use the panel mount method for high shock and vibration applications.

Caution If the ambient operating temperature is 50 °C or higher, you must allow 25.4 mm (1 in.) on the top and bottom of the chassis and in front of the I/O modules for air circulation.

Note You must remove all I/O modules from the chassis before mounting it. Your application may require that one or more of the I/O modules be installed in specific slot locations. Record the slot location of each module before removing the modules from the chassis, and replace each module in the same slot after mounting.

Note The cRIO-FRC is shipped with slot protectors that prevent debris and contaminants from damaging the DB-15 I/O module connectors in unused slots. Do not remove slot protectors from unused slots.

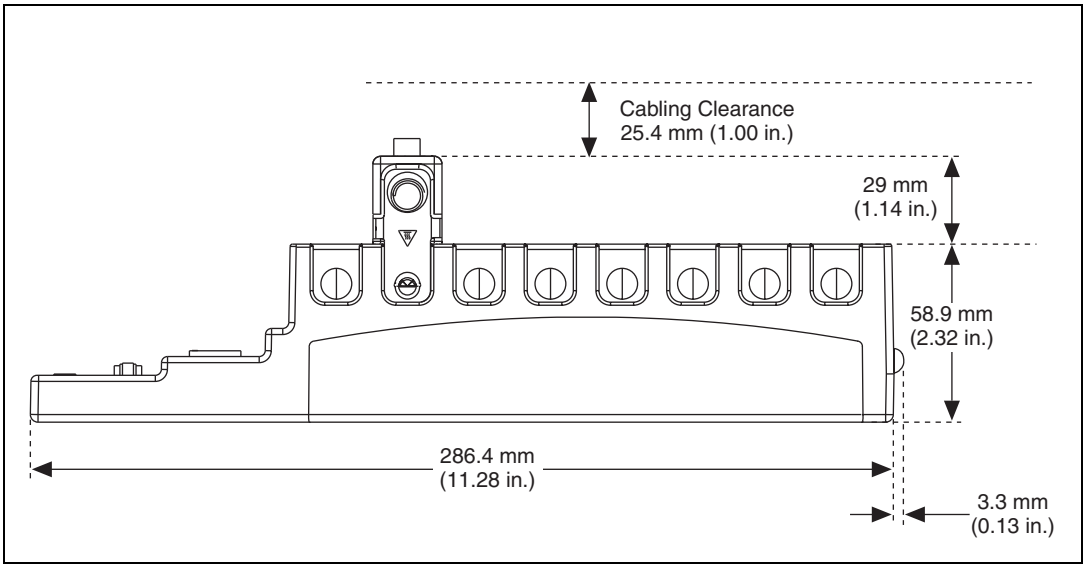


Figure 2. cRIO-FRC, Bottom View with Dimensions

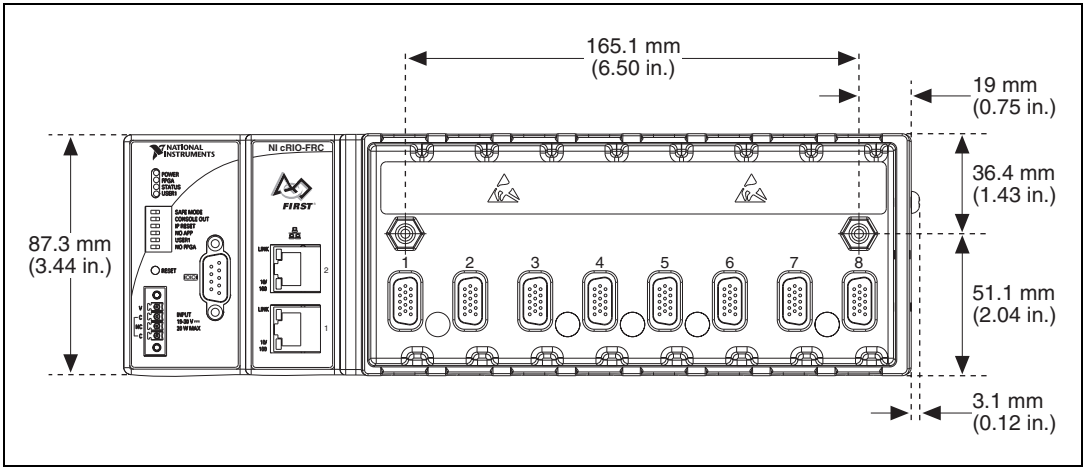


Figure 3. cRIO-FRC, Front View with Dimensions

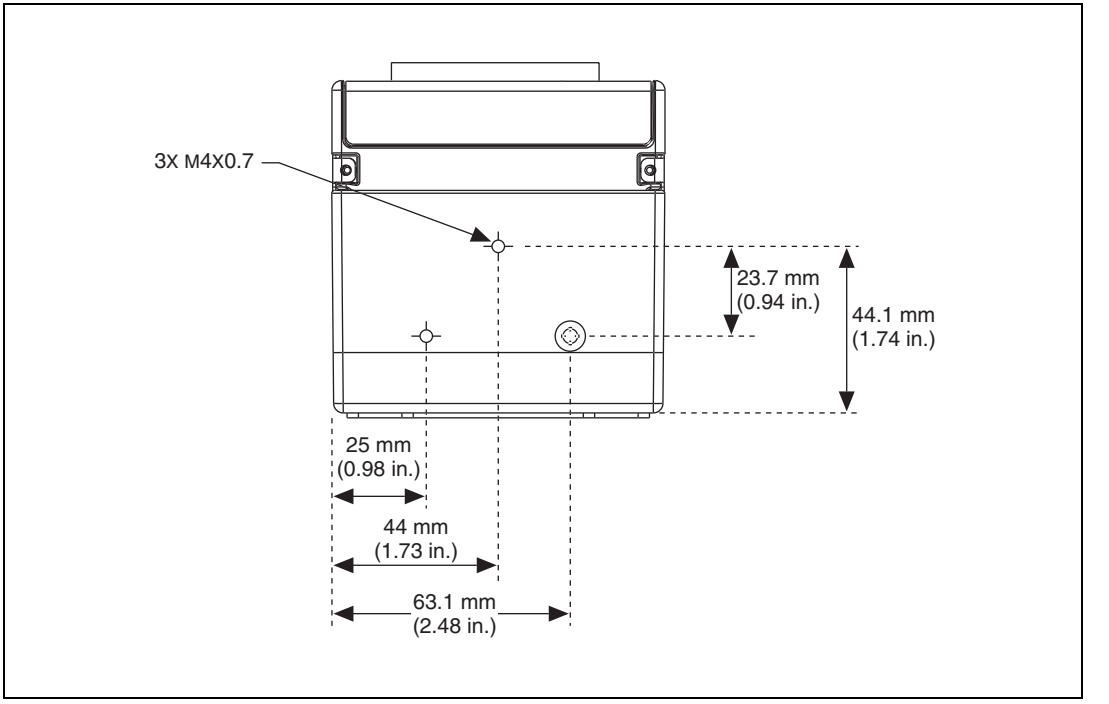


Figure 4. cRIO-FRC, Side View with Dimensions

The following sections contain instructions for the mounting methods. Before using any of these mounting methods, record the serial number from the back of the chassis. You will be unable to read the serial number after you have mounted the chassis.

Caution Make sure that no I/O modules are in the chassis before mounting it.

Mounting the Chassis on a Panel

You can use the NI 9905 panel mount kit to mount the cRIO-FRC on a flat surface. Complete the following steps.

1. Fasten the chassis to the panel mount kit using a number 2 Phillips screwdriver and two M4 × 16 screws. National Instruments provides these screws with the panel mount kit. You *must* use these screws because they are the correct depth and thread for the panel.

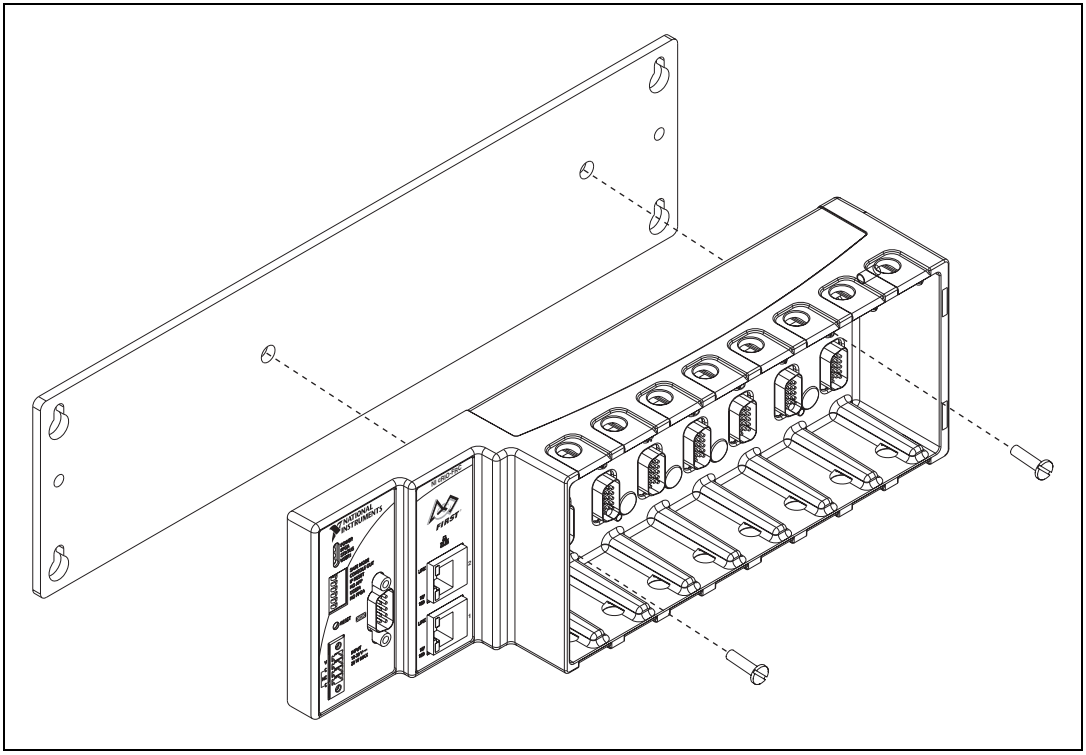


Figure 5. Installing the Panel Mount Accessory on the cRIO-FRC

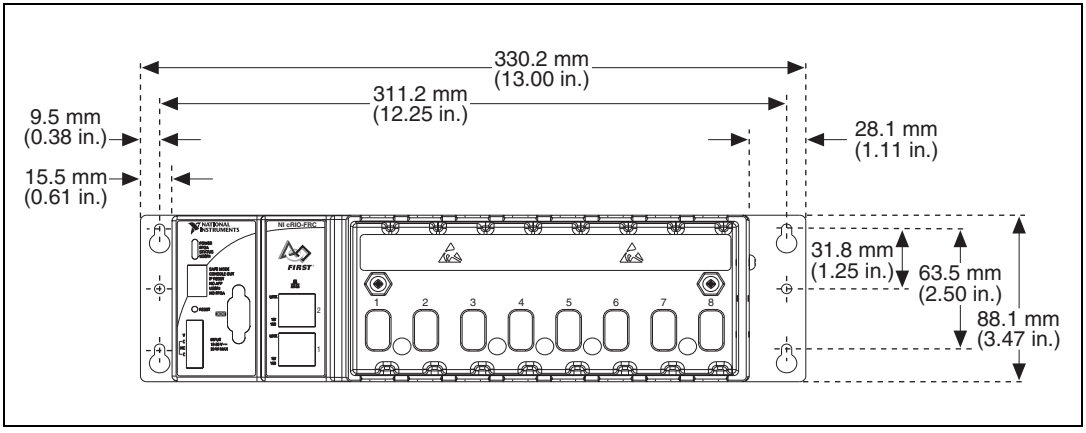


Figure 6. Dimensions of cRIO-FRC with Panel Mount Accessory Installed

2. Fasten the NI 9905 panel to the wall using the screwdriver and screws that are appropriate for the wall surface.

Caution Make sure that no I/O modules are in the chassis before removing it from the panel.

Mounting the Chassis on a DIN Rail

You can order the NI 9915 DIN rail mount kit if you want to mount the chassis on a DIN rail. You need one clip for mounting the chassis on a standard 35 mm DIN rail. Complete the following steps to mount the chassis on a DIN rail.

1. Fasten the DIN rail clip to the chassis using a number 2 Phillips screwdriver and two M4 × 16 screws. National Instruments provides these screws with the DIN rail mount kit.

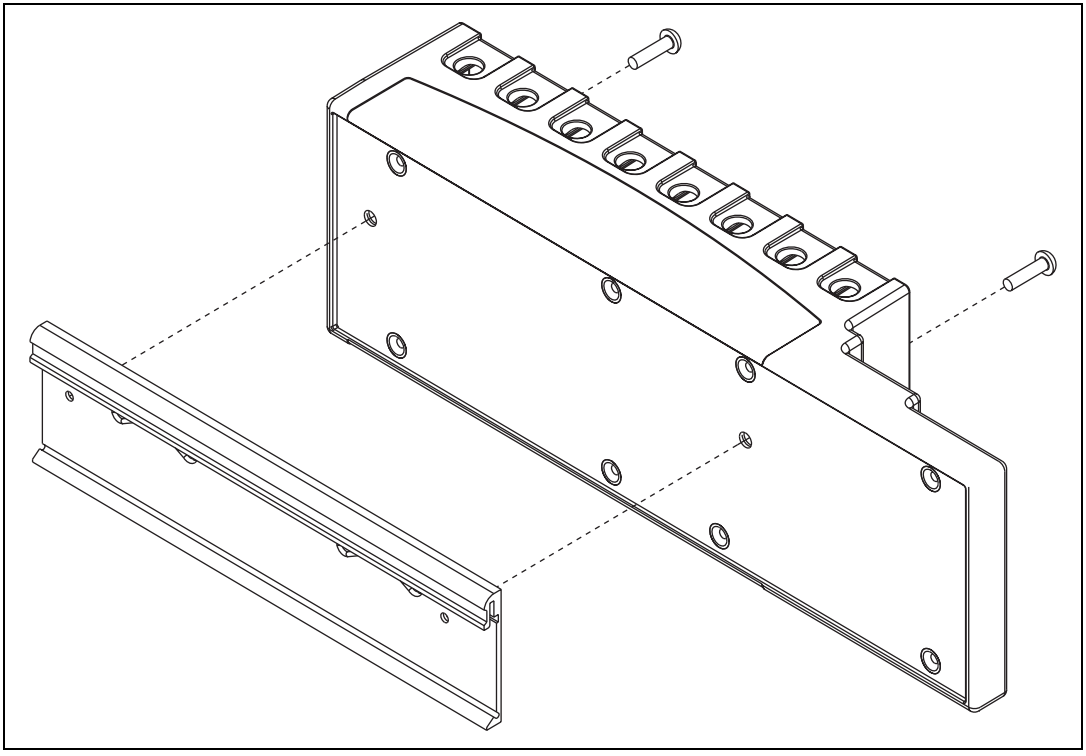
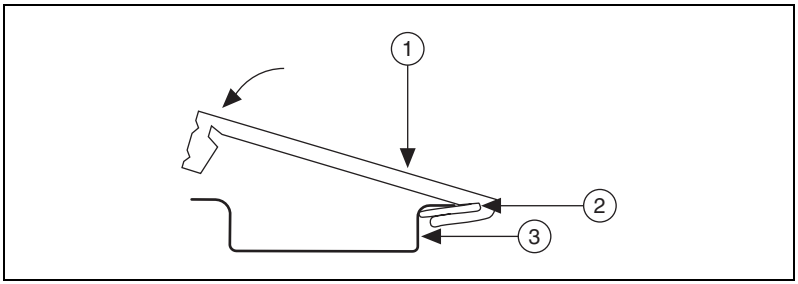


Figure 7. Installing the DIN Rail Clip on the cRIO-FRC

2. Insert one edge of the DIN rail into the deeper opening of the DIN rail clip, as shown in Figure 8.



1 DIN Rail Clip 2 DIN Rail Spring 3 DIN Rail

Figure 8. One Edge of the DIN Rail Inserted in a Clip

3. Press down firmly on the chassis to compress the spring until the clip locks in place on the DIN rail.

Caution Make sure that no I/O modules are in the chassis before removing it from the DIN rail.

Installing C Series I/O Modules in the Chassis

Figure 9 shows the mechanical dimensions of C Series I/O modules.

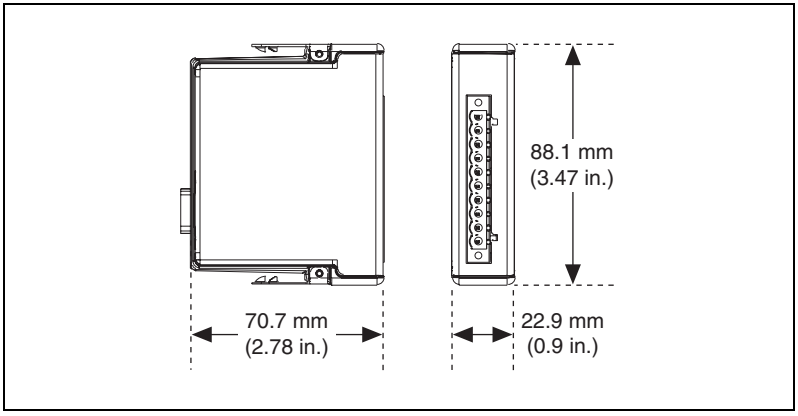
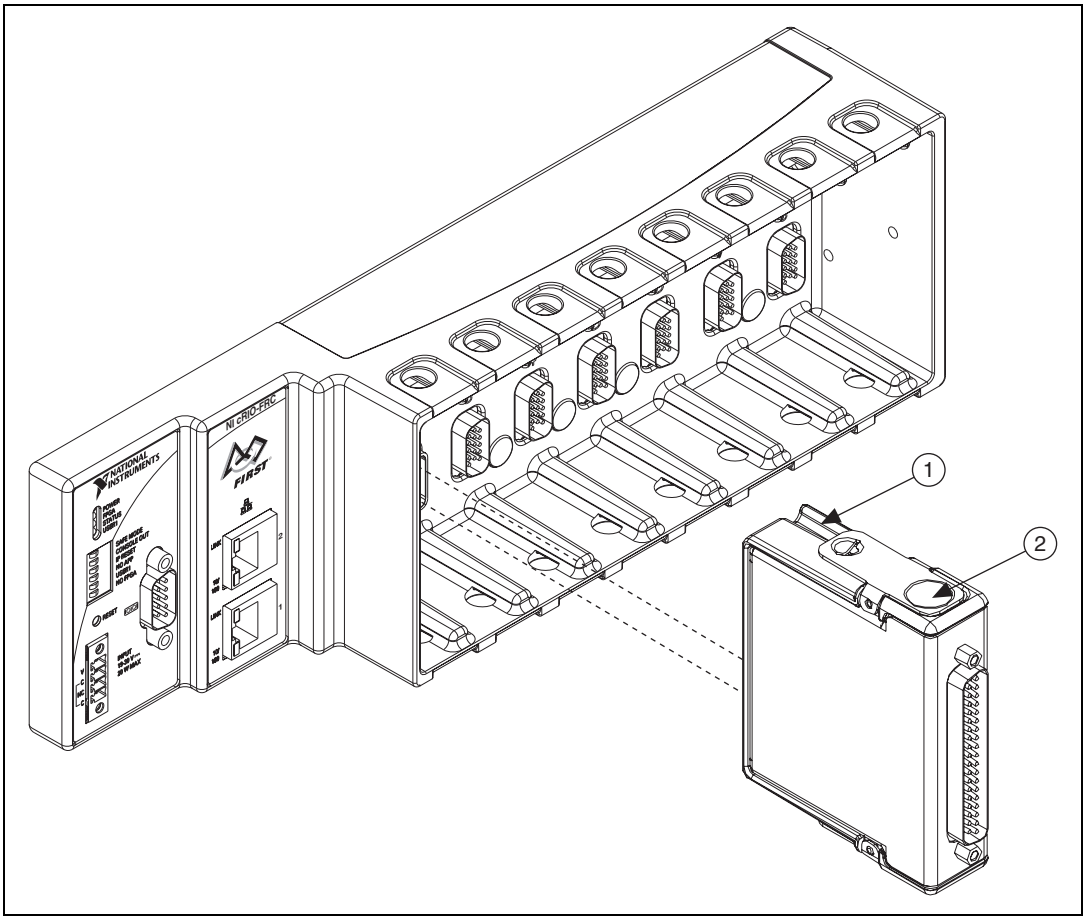


Figure 9. C Series I/O Module, Front and Side View with Dimensions

Complete the following steps to install a C Series I/O module in the chassis.

1. Make sure that no I/O-side power is connected to the I/O module. The chassis power can be on when you install I/O modules.

2. Align the I/O module with an I/O module slot in the chassis as shown in Figure 10. The module slots are labeled 1 to 8, left to right.



1	Insertion Groove	2	Latch

Figure 10. Installing an I/O Module in the Chassis

3. Squeeze the latches and insert the I/O module into the module slot.
4. Press firmly on the connector side of the I/O module until the latches lock the I/O module into place.
5. Repeat these steps to install additional I/O modules.

Removing I/O Modules from the Chassis

Complete the following steps to remove a C Series I/O module from the chassis.

1. Make sure that no I/O-side power is connected to the I/O module. The chassis power can be on when you remove I/O modules.
2. Squeeze the latches on both sides of the module and pull the module out of the chassis.

Connecting the Chassis to a Network

Connect the chassis to an Ethernet network using RJ-45 Ethernet port 1 on the controller front panel. Use a standard Category 5 (CAT-5) or better shielded, twisted-pair Ethernet cable to connect the chassis to an Ethernet hub, or use an Ethernet crossover cable to connect the chassis directly to a computer.

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

If you need to build your own cable, refer to the *Cabling* section for more information about Ethernet cable wiring connections.

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

Next you need to assign an IP address to the chassis. For information about assigning an IP address and setting up your network, refer to the *FRC Control System Manual*.

Wiring Power to the Chassis

The cRIO-FRC requires an external power supply that meets the specifications in the *Power Requirements* section. The cRIO-FRC filters and regulates the supplied power and provides power for all of the I/O modules. The cRIO-FRC has one layer of reverse-voltage protection. Complete the following steps to connect a power supply to the chassis.

1. Connect the positive lead of the power supply to the V terminal of the COMBICON connector shipped with the cRIO-FRC.
2. Connect the negative lead of the power supply to one of the C terminals of the COMBICON connector.
3. Install the COMBICON connector on the front panel of the cRIO-FRC and tighten the screws on the connector.

Caution The C terminals are internally connected to each other.

Caution Do *not* disconnect the power supply wires and connectors from the controller unless power has been switched off.

Powering On the cRIO-FRC

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

You can configure the cRIO-FRC to launch an embedded stand-alone LabVIEW RT application each time you boot the controller. Refer to the *LabVIEW Robotics Programming Guide for the FIRST Robotics Competition* document for more information.

You can also configure the cRIO-FRC to launch an embedded stand-alone C/C++ application each time you boot the controller. Refer to the *C/C++ Programming Guide for the FIRST Robotics Competition* document for more information.

Boot Options

Table 1 lists the reset options available on CompactRIO systems such as the cRIO-FRC. These options are used to determine how the FPGA behaves when the controller is reset in various conditions.

Table 1. CompactRIO Reset Options

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

Connecting Serial Devices to the cRIO-FRC

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

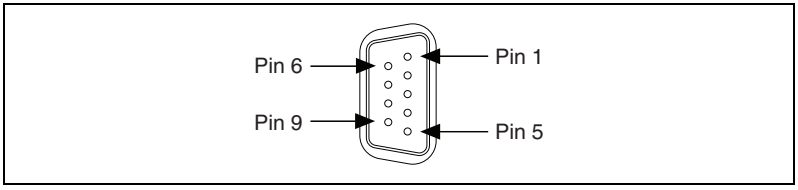


Figure 11. Controller Serial Port

Table 2. DB-9 Pin Descriptions

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

Using the Internal Real-Time Clock

The system clock of the cRIO-FRC is synchronized with the internal high-precision real-time clock at startup. This synchronization provides timestamp data to the controller. You can also use the internal real-time clock to correct drift of the system clock. Refer to the *Internal Real-Time Clock* specification in the *Specifications* section for the accuracy specifications of the real-time clock.

Configuring DIP Switches

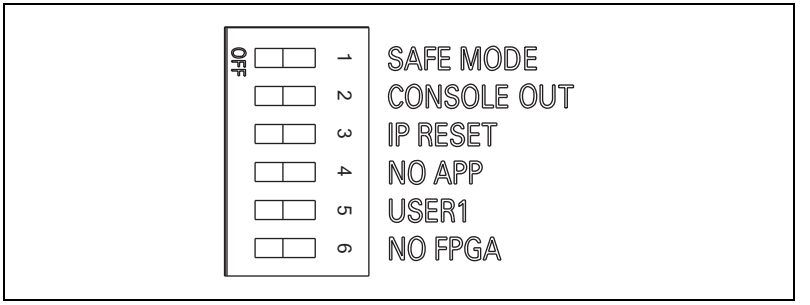


Figure 12. DIP Switches

All of the DIP switches are in the OFF position when the chassis is shipped from National Instruments.

SAFE MODE Switch

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

Push the SAFE MODE switch to the ON position if the software on the chassis is corrupted. Even if the switch is not in the ON position, if there is no software installed on the chassis, the chassis automatically boots into safe mode. The SAFE MODE switch must be in the ON position to reformat the drive on the chassis. Refer to the *FRC Control System Manual* for information about installing software and reformatting the drive.

CONSOLE OUT Switch

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

- 9,600 bits per second
- Eight data bits
- No parity
- One stop bit
- No flow control

The serial-port terminal program displays the IP address and firmware version of the chassis. Keep this switch in the OFF position during normal operation.

IP RESET Switch

If you need to reset the IP address to the default, use the FRC cRIO Imaging Utility provided with the LabVIEW for FRC software. In the event that utility fails to restore the default IP address, you can use the IP RESET switch to restore it. Push the IP RESET switch to the ON position and reboot the chassis to reset the IP address to `0.0.0.0`. If the chassis is on your local subnet and the IP RESET switch is in the ON position, the chassis appears in software with IP address `0.0.0.0`.

NO APP Switch

Push the NO APP switch to the ON position to prevent a LabVIEW RT startup application from running at startup. If you want to permanently disable a LabVIEW RT application from running at startup, you must disable it in LabVIEW. To run an application at startup, push the NO APP switch to the OFF position, build an application in LabVIEW, and configure the application in LabVIEW to launch at startup. If you already have an application configured to launch at startup and you push the NO APP switch from ON to OFF, the startup application is automatically enabled. For more information about automatically launching VIs at startup and disabling VIs from launching at startup, refer to the *LabVIEW Robotics Programming Guide for the FIRST Robotics Competition*.

The NO APP switch does not affect C/C++ startup applications. You can use the Undeploy option in Wind River Workbench to disable a C/C++ application.

USER1 Switch

You can define the USER1 switch for your application. Use the FRC ReadSwitch VI in your LabVIEW RT embedded VI to read the value of the USER1 switch. For more information about the FRC ReadSwitch VI, refer to the *LabVIEW Help*.

NO FPGA Switch

Push the NO FPGA switch to the ON position to prevent a LabVIEW FPGA application from loading at startup. The NO FPGA switch overrides the CompactRIO reset options described in the *Boot Options* section. After startup you can download to the FPGA from software regardless of switch position.

Using the RESET Button

Pressing the RESET button resets the processor in the same manner as cycling power.

Note The FPGA continues to run unless you select the **Autoload on Any Device Reset** boot option. Refer to the *Boot Options* section for more information.

Understanding LED Indications

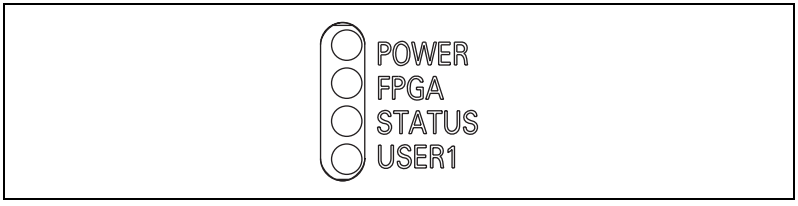


Figure 13. cRIO-FRC LEDs

POWER LED

The POWER LED is lit while the cRIO-FRC is powered on. This LED indicates that the power supply connected to the chassis is adequate.

FPGA LED

You can use use the FRC LEDs VI to set the state of the FPGA LED. Refer to the *LabVIEW Help* for more information.

STATUS LED

The STATUS LED is off during normal operation. The cRIO-FRC indicates specific error conditions by flashing the STATUS LED a certain number of times as shown in Table 3.

Table 3. Status LED Indications

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

USER1 LED

You can use the FRC LEDs VI to set the state of the USER1 LED. Refer to the *LabVIEW Help* for more information.

Resetting the Network Configuration of the cRIO-FRC

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

Complete the following steps to reset the chassis.

1. Move the IP RESET DIP switch to the ON position.
2. Push the RESET button to cycle power to the chassis. The STATUS LED flashes once, indicating that the IP address is unconfigured.

3. Move the IP RESET switch to the OFF position.

The network settings are restored. You can reconfigure the settings using the cRIO-FRC Imaging Utility from a computer on the same subnet.

Note If the chassis is restored to the factory network settings, the LabVIEW Run-Time Engine does not load. You must reconfigure the network settings and restart the chassis for the LabVIEW Run-Time Engine to load.

Specifications

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

Network

Network interface .....10BaseT and 100BaseTX Ethernet

Compatibility .....IEEE 802.3

Communication rates .....10 Mbps, 100 Mbps, auto-negotiated

imum cabling distance .....100 m/segment

RS-232 Serial Port

Maximum baud rate .....115,200 bps

Data bits 5, 6, 7, 8

Stop bits 1, 2

Parity .....Odd, Even, Mark, Space

Flow control .....RTS/CTS, XON/XOFF, DTR/DSR

Memory

Nonvolatile .....128 MB

System memory .....64 MB

Reconfigurable FPGA

FPGA type..... Spartan-3 2000

Number of logic cells..... 46,080

Number of 18 × 18 multipliers 40

Embedded block RAM..... 720 kbits

Internal Real-Time Clock

Accuracy ..... 200 ppm; 35 ppm at 25 °C

Power Requirements

Recommended power supply..... *FIRST* Power Distribution Board 24 VDC supply

Power consumption with I/O modules installed ..... 20 W maximum

Power supply input range..... 19 to 30 V

Physical Characteristics

If you need to clean the controller, wipe it with a dry towel.

Screw-terminal wiring..... 0.5 to 2.5 mm^2 (24 to 12 AWG) copper conductor wire with 10 mm (0.39 in.) of insulation stripped from the end

Torque for screw terminals ..... 0.5 to 0.6 N · m (4.4 to 5.3 lb · in.)

Weight..... 929 g (32.7 oz)

Safety Voltages

Connect only voltages that are within these limits.

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

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.

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

Safety Standards

This product is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN-61010-1
- UL 61010-1, CSA 61010-1

Note For other safety certifications, refer to the product label or visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Electromagnetic Compatibility

This product is designed to meet the requirements of the following standards of EMC for electrical equipment for measurement, control, and laboratory use:

- EN 61326 EMC requirements; Industrial Immunity
- EN 55011 Emissions; Group 1, Class A
- CE, C-Tick, ICES, and FCC Part 15 Emissions; Class A

Note For EMC compliance, operate this device according to product documentation.

CE Compliance

This product meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EEC; Electromagnetic Compatibility Directive (EMC)

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Environmental Management

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

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

Waste Electrical and Electronic Equipment (WEEE)

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

电子信息产品污染控制管理办法 （中国 RoHS）

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

Hazardous Locations

This product is not certified for use in hazardous locations.

Environmental

The cRIO-FRC is intended for indoor use only, but it may be used outdoors if mounted in a suitably rated enclosure.

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

Note To meet this operating temperature range, follow the guidelines in the installation instructions for your CompactRIO system.

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

Ingress protection .....IP 40

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

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

Maximum altitude.....2,000 m

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

Shock and Vibration

To meet these specifications, you must panel mount the CompactRIO system and affix ferrules to the ends of the power terminal wires.

Operating shock (IEC 60068-2-27) .....30 g, 11 ms half sine;
50 g, 3 ms half sine;
18 shocks at 6 orientations

Operating vibration, random
(IEC 60068-2-64) .....5 g_{rms}, 10 to 500 Hz

Operating vibration, sinusoidal
(IEC 60068-2-6) .....5 g, 10 to 500 Hz

Cabling

Table 4 shows the standard Ethernet cable wiring connections for both normal and crossover cables.

Table 4. Ethernet Cable Wiring Connections

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

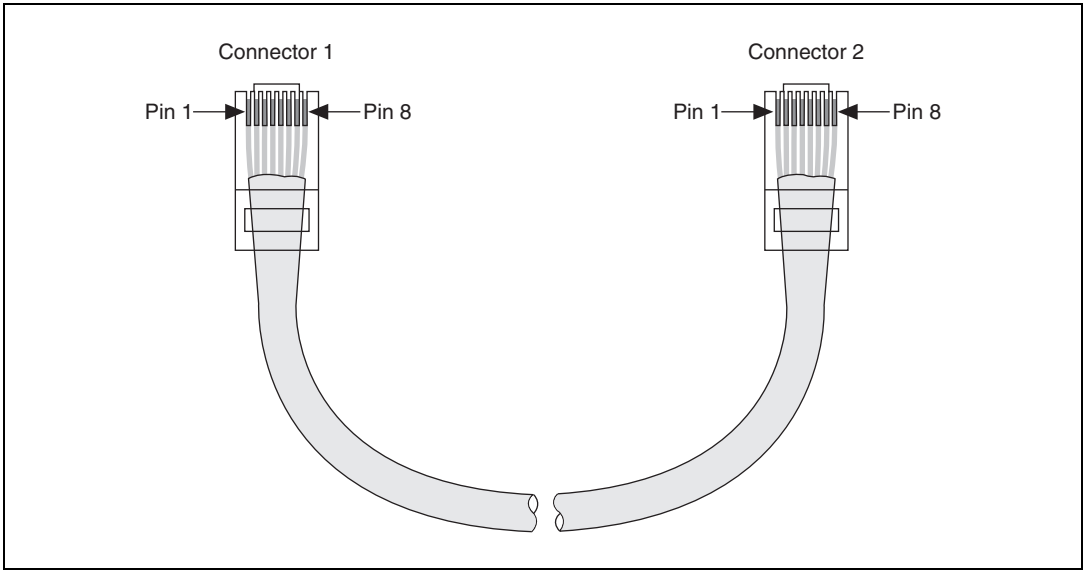


Figure 14. Ethernet Connector Pinout

Where to Go for Support

National Instruments corporate headquarters is located at
11500 North Mopac Expressway, Austin, Texas, 78759-3504.

For general support, go to the FRC Community Web site at `www.usfirst.org/community/frc`. For technical support on the cRIO-FRC, including discussion forums monitored by NI Applications Engineers, go to `ni.com/first`.

For telephone support in the United States during the build period, dial 1 866 511 6285. Before or after the build period, please use the discussion forums. Phone support will not be available before or after the build period. If you would like to purchase additional parts or need to return a part to National Instruments at any time, please dial 1 866 511 6285.

For limited telephone support outside the United States, contact your local branch office:

Australia 1800 300 800, Austria 43 662 457990-0,
Belgium 32 (0) 2 757 0020, Brazil 55 11 3262 3599,
Canada 800 433 3488, China 86 21 5050 9800,
Czech Republic 420 224 235 774, Denmark 45 45 76 26 00,
Finland 358 (0) 9 725 72511, France 01 57 66 24 24,
Germany 49 89 7413130, India 91 80 41190000, Israel 972 3 6393737,
Italy 39 02 41309277, Japan 0120-527196, Korea 82 02 3451 3400,
Lebanon 961 (0) 1 33 28 28, Malaysia 1800 887710,
Mexico 01 800 010 0793, Netherlands 31 (0) 348 433 466,
New Zealand 0800 553 322, Norway 47 (0) 66 90 76 60,
Poland 48 22 328 90 10, Portugal 351 210 311 210,
Russia 7 495 783 6851, Singapore 1800 226 5886,
Slovenia 386 3 425 42 00, South Africa 27 0 11 805 8197,
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