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NI cDAQ™-9138/9139

User Manual

NI CompactDAQ Eight-Slot Controller

March 2016
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1

Getting Started with the cDAQ Controller

The National Instruments CompactDAQ cDAQ-9138 controller features the 1.06 GHz Celeron processor. The National Instruments CompactDAQ cDAQ-9139 controller features the 1.33 GHz Intel Core i7 processor. The NI cDAQ-9138 and NI cDAQ-9139 are available as a Windows Embedded Standard 7 (WES7) or a LabVIEW Real-Time system.

This chapter contains information about getting started with the cDAQ controller with Windows and with LabVIEW Real-Time:

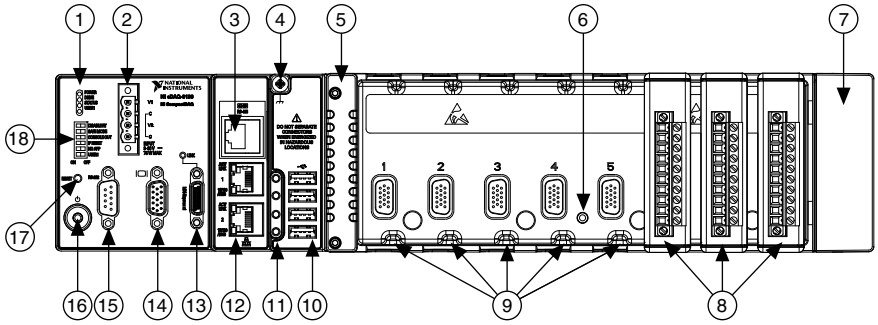
- For NI cDAQ-9138/9139 for Windows, refer to the *Installing the NI cDAQ-9138/9139 for Windows* section
- For NI cDAQ-9138/9139 for LabVIEW Real-Time, refer to the *Installing the NI cDAQ-9138/9139 for LabVIEW Real-Time* section

The eight-slot cDAQ controller has a number of standard interfaces and combines with C Series modules to measure a broad range of analog and digital I/O signals that can be logged to the local hard drive. For specifications, refer to the specifications document for your cDAQ controller. For module specifications, refer to the documentation included with your C Series module(s) or go to `ni.com/manuals`.

Note Go to `ni.com/info` and enter Info Code `exswh5` for up-to-date information about supported NI devices for the cDAQ controller.

Figure 1-1 shows the NI cDAQ-9138/9139 controller.

Figure 1-1. NI cDAQ-9138/9139 Controller



1 POWER, DRIVE, STATUS, and USER1 LEDs
2 Power Connector
3 RS-485/422 Serial Port
4 Chassis Grounding Screw
5 CFast SSD Module Housing
6 CMOS Reset Button
7 CPU eXpansion Module (CXM) Connector
8 Installed C Series Modules
9 Module Slots
10 USB Ports
11 USB Retention Standoff
12 Ethernet Ports, ACT/LINK and 10/100/1000 Ethernet LEDs
13 MXI-Express Port and LINK LED
14 Video (VGA) Port
15 RS-232 Serial Port
16 Power Button
17 RESET Button
18 DISABLE RT, SAFE MODE, CONSOLE OUT, IP RESET, NO APP, and USER1 DIP Switches

Safety Guidelines

Caution Do *not* operate the NI cDAQ-9138/9139 controller in a manner not specified in these operating instructions. 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 National Instruments for repair.

Note Because some C Series modules may have more stringent certification standards than the NI cDAQ-9138/9139 controller, the combined system may be limited by individual component restrictions. Refer to the specifications document for your cDAQ controller for more details.

Hot Surface This icon denotes that the component may be hot. Touching this component may result in bodily injury.

Electromagnetic Compatibility Guidelines

This product was tested and complies with the regulatory requirements and limits for electromagnetic compatibility (EMC) stated in the product specifications. These requirements and limits provide reasonable protection against harmful interference when the product is operated in the intended operational electromagnetic environment.

This product is intended for use in residential, commercial and industrial locations. However, harmful interference may occur in some installations or when the product is connected to a peripheral device or a test object. To minimize interference with radio and television reception and prevent unacceptable performance degradation, install and use this product in strict accordance with the instructions in the product documentation.

Furthermore, any modifications to the product not expressly approved by National Instruments could void your authority to operate it under your local regulatory rules.

Caution To ensure the specified EMC performance, operate this product only with shielded cables and accessories. Note that the input DC power cables may be unshielded.

Caution To ensure the specified EMC performance, do not connect the power input to a DC mains supply or to any supply requiring a connecting cable longer than 3 m (10 ft). A DC mains supply is a local DC electricity supply network in the infrastructure of a site or building.

Caution To ensure the specified EMC performance, the length of any cable connected to the video port must be no longer than 3 m (10 ft). The length of any cable connected to the RS-232, USB, and MXI-Express ports must be no longer than 30 m (100 ft).

Caution To ensure the specified EMC performance, install snap-on, ferrite bead (National Instruments part number 711849-01, included in the shipping kit) in accordance with the product installation instructions.

Hardware Symbol Definitions

The following symbols are marked on your cDAQ controller.

Caution When this symbol is marked on a product, refer to the *Safety Guidelines* section for information about precautions to take.



ESD When this symbol is marked on a product, the product could be damaged if subjected to Electrostatic Discharge (ESD) on the connector pins of any I/O port. To prevent damage, industry-standard ESD prevention measures must be employed during installation, maintenance, and operation.



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Unpacking

The cDAQ controller ships in an antistatic package to prevent electrostatic discharge (ESD). ESD can damage several components on the device.



Caution *Never* touch the exposed pins of connectors.

To avoid ESD damage in handling the device, take the following precautions:

- Ground yourself with a grounding strap or by touching a grounded object.
- Touch the antistatic package to a metal part of your computer controller before removing the device from the package.

Remove the device from the package and inspect it for loose components or any other signs of damage. Notify NI if the device appears damaged in any way. Do not install a damaged device in your computer or controller.

Store the device in the antistatic package when the device is not in use.

Installing the NI cDAQ-9138/9139 for Windows

(NI cDAQ-9138/9139 for Windows) The NI cDAQ-9138/9139 for Windows is shipped with preloaded Windows Embedded Standard 7 (WES7), LabVIEW (evaluation version), and NI-DAQmx driver software. The cDAQ controller and C Series module(s) are packaged separately. You will require a monitor, VGA cable, and computer mouse and keyboard to complete this installation process. You will also require number 1 and number 2 Phillips screwdrivers to install and set up the cDAQ controller.

You will need the following items to set up the NI cDAQ-9138/9139 for Windows controller:

- Power connector (packaged with the cDAQ controller)
- Ferrites (packaged with the cDAQ controller)
- Screwdriver (packaged with the cDAQ controller)
- Power supply
- Monitor
- Compatible VGA cable
- Computer mouse and keyboard
- Number 1 and number 2 Phillips screwdrivers
- C Series module(s)

Note Table 1-1 lists the earliest supported driver version for each cDAQ controller for Windows.

Table 1-1. cDAQ Controller NI-DAQmx Software Support

cDAQ Controller	Earliest NI-DAQmx Support
NI cDAQ-9138 for Windows	NI-DAQmx 9.5.1
NI cDAQ-9139 for Windows	NI-DAQmx 9.5.1

The NI-DAQmx driver software preloaded onto your cDAQ controller is available for download at `ni.com/support`. The documentation for NI-DAQmx is available from **Start»All Programs»National Instruments»NI-DAQ**. Other NI documentation is available from `ni.com/manuals`.

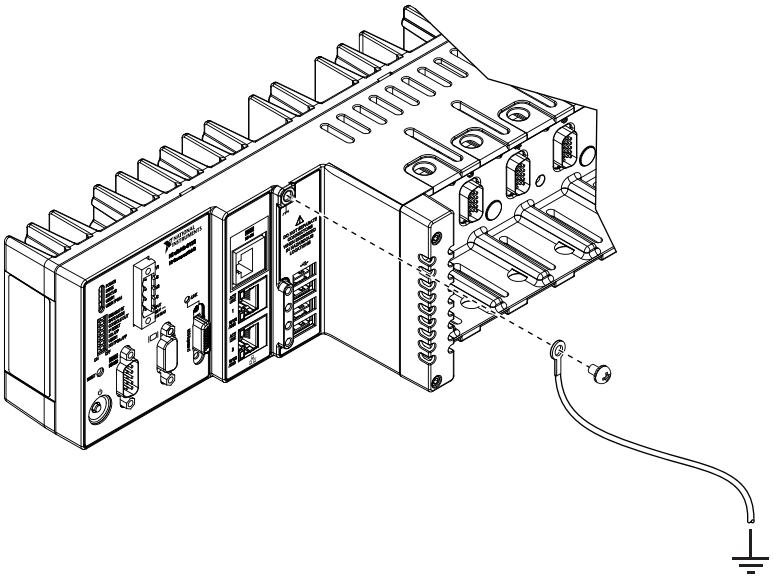
Refer to Figure 1-1 while completing the following assembly steps.

1. Mount the cDAQ controller to a panel, wall, or DIN rail, or attach the desktop mounting kit, as described in the *Mounting the cDAQ Controller* section.
2. Connect a monitor to the cDAQ controller video port with a compatible VGA cable. Refer to the *Video (VGA) Port* section for more information about this connector.
3. Power on the monitor.

4. Connect a computer keyboard and mouse to the bottom two USB ports on the cDAQ controller.
5. Attach a ring lug to a 1.31 mm^2 (16 AWG) or larger wire. Remove the ground screw from the ground terminal on the front panel. Attach the ring lug to the ground terminal and tighten the grounding screw to 0.5 N · m (4.4 lb · in.) of torque. Attach the other end of the wire to chassis safety ground using a method appropriate for the application, as shown in Figure 1-2. Refer to the *Chassis Grounding Screw* section for more information about earth ground.

Note If you use shielded cabling to connect to a C Series module with a plastic connector, you must attach the cable shield to the chassis grounding terminal using 1.31 mm^2 (16 AWG) or larger wire. Use shorter wire for better EMC performance.

Figure 1-2. Ring Lug Attached to Ground Terminal



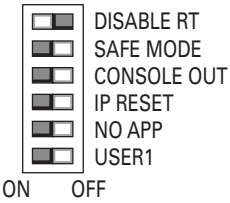
Note Make sure that no I/O-side power is connected to the module. If the controller is in a nonhazardous location, the controller power can be on when you install modules.

6. Align the module with a cDAQ controller slot. The module slots are labeled 1 to 8, left to right.
7. Squeeze the latches and insert the module into the module slot, and press firmly on the connector side of the module until the latches lock the module into place.

   Repeat these steps to install additional modules.

8. Verify that the DISABLE RT DIP switch is in the ON position so that the controller boots into the Windows operating system. Refer to the *DIP Switches* section for more information about the DISABLE RT DIP switch.

Figure 1-3. DISABLE RT DIP Switch in ON Position



9. Wire your external power source as outlined in the *Wiring Power to the cDAQ Controller* section. The cDAQ controller requires an external power supply that meets the specifications listed in the specifications document for your cDAQ controller.
10. Turn on the external power supply.
11. Press the power button on the front panel of the cDAQ controller.

    When the cDAQ controller powers on, the Power LED lights and the controller runs a power-on self test (POST). When the POST is complete, the operating system is loaded.
12. Go through the steps on the Set Up Windows screen that opens on your monitor. Windows prepares your desktop.
13. Wire the C Series module as indicated in the C Series module documentation, available from `ni.com/manuals`.
14. Self-test your controller in Measurement & Automation Explorer (MAX) by double-clicking the MAX icon on the desktop to open MAX. Expand **Devices and Interfaces**, right-click **NI cDAQ-<*model number*>**, and select **Self-Test**. Self-test performs a brief test to determine successful controller installation.
15. Run a Test Panel in MAX by expanding **Devices and Interfaces»NI cDAQ-<*model number*>**, right-clicking your C Series module, and selecting **Test Panels** to open a test panel for the selected module.

    If the test panel displays an error message, refer to `ni.com/support`.

New users can view and use the Voltage - Continuous Input VI, available in the LabVIEW Example Finder. Experienced users can use the LabVIEW Sample Projects, Finite Measurement (NI-DAQmx) and Continuous Measurement and Logging (NI-DAQmx).

Note When in use, the cDAQ controller may become warm to the touch. This is normal.

Note The network behavior is determined by the Windows network drivers. Refer to the Windows documentation for information about configuring IP settings.

Note You can use the cDAQ controller BIOS setup utility to configure the cDAQ controller to start immediately when power is applied or to respond to the front-panel power button. Refer to the *Power/Wake Configuration Submenu* section of Appendix A, *Controller Operating System and Configuration*, for information about the different powerup behaviors you can configure. The power button is enabled by default so that the cDAQ controller does not power on until the power button is pressed.

Installing the NI cDAQ-9138/9139 for LabVIEW Real-Time

The NI cDAQ-9138/9139 for LabVIEW Real-Time features a hard drive formatted for LabVIEW Real-Time. The cDAQ controller and C Series module(s) are packaged separately. You will need a host computer running Windows 10/8.1/8/7/Vista/XP (check your driver and ADE readme files for specific version compatibility). You will also require number 1 and number 2 Phillips screwdrivers to install and set up the cDAQ controller.

You will need the following items to set up the NI cDAQ-9138/9139 for LabVIEW Real-Time controller:

- Power connector (packaged with the cDAQ controller)
- USB cable (packaged with the cDAQ controller)
- Ferrites (packaged with the cDAQ controller)
- Screwdriver (packaged with the cDAQ controller)
- Host computer running Windows (check your driver and ADE readme files for specific version compatibility)
- LabVIEW software
- LabVIEW Real-Time software
- NI-DAQmx driver (packaged with the cDAQ controller)
- Power supply
- Number 1 and number 2 Phillips screwdrivers
- C Series module(s)

Refer to Figure 1-1 while completing the following assembly steps.

1. Install LabVIEW on your host computer, as described in the *LabVIEW Installation Guide*.
2. Install LabVIEW Real-Time on your host computer, as described in the *LabVIEW Real-Time Module Release and Upgrade Notes*.
3. Install NI-DAQmx on your host computer, as described in the *Read Me First: NI-DAQmx and DAQ Device Installation Guide*.

Note Table 1-2 lists the earliest supported driver version for each cDAQ controller for LabVIEW for Real-Time.

Table 1-2. cDAQ Controller NI-DAQmx Software Support

cDAQ Controller	Earliest NI-DAQmx Support
NI cDAQ-9138 for LabVIEW Real-Time	NI-DAQmx 9.6
NI cDAQ-9139 for LabVIEW Real-Time	NI-DAQmx 9.6

The NI-DAQmx driver software is included on the disk shipped with your kit and is available for download at ni.com/support. The documentation for NI-DAQmx is available after installation from **Start»All Programs»National Instruments»NI-DAQ**. Other NI documentation is available from ni.com/manuals.

4. Power on the host computer and connect it to an Ethernet network.
5. Mount the cDAQ controller to a panel, wall, or DIN rail, or attach the desktop mounting kit, as described in the *Mounting the cDAQ Controller* section.
6. Attach a ring lug to a 1.31 mm^2 (16 AWG) or larger wire. Remove the ground screw from the ground terminal on the front panel. Attach the ring lug to the ground terminal and tighten the grounding screw to 0.5 N · m (4.4 lb · in.) of torque. Attach the other end of the wire to chassis safety ground using a method appropriate for the application, as shown in Figure 1-2. Refer to the *Chassis Grounding Screw* section for more information about earth ground.

Note If you use shielded cabling to connect to a C Series module with a plastic connector, you must attach the cable shield to the chassis grounding terminal using 1.31 mm^2 (16 AWG) or larger wire. Use shorter wire for better EMC performance.

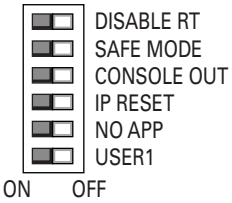
Note Make sure that no I/O-side power is connected to the module. If the controller is in a nonhazardous location, the controller power can be on when you install modules.

7. Align the module with a cDAQ controller slot. The module slots are labeled 1 to 8, left to right.
8. Squeeze the latches and insert the module into the module slot, and press firmly on the connector side of the module until the latches lock the module into place.

   Repeat these steps to install additional modules.

9. Verify that the DISABLE RT DIP switch is in the OFF position so that the controller will boot into LabVIEW Real-Time. Refer to the *DIP Switches* section for more information about the DISABLE RT DIP switch.

Figure 1-4. DISABLE RT DIP Switch in OFF Position



10. Wire your external power source as outlined in the *Wiring Power to the cDAQ Controller* section. The cDAQ controller requires an external power supply that meets the specifications listed in the specifications document for your cDAQ controller.
11. Turn on the external power supply.
12. Connect RJ-45 Ethernet port 1 on the cDAQ controller to the same Ethernet network as the host computer with a shielded straight through Category 5 (CAT-5) or better shielded, twisted-pair Ethernet cable.

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 *Ethernet Cabling* section for information about Ethernet cable wiring connections.

13. Press the power button on the front panel of the cDAQ controller.

    When the cDAQ controller powers on, the Power LED lights and the controller runs a power-on self test (POST). When the POST is complete, the operating system is loaded.

    The cDAQ controller attempts to initiate a DHCP network connection at powerup. If the cDAQ controller is unable to 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 cDAQ controller over a standard Ethernet connection.

Note You can use the cDAQ controller BIOS setup utility to configure the cDAQ controller to start immediately when power is applied or to respond to the front-panel power button. Refer to the *Power/Wake Configuration Submenu* section of Appendix A, *Controller Operating System and Configuration*, for information about the different powerup behaviors you can configure. The power button is enabled by default so that the cDAQ controller does not power on until the power button is pressed.

Note You can configure the cDAQ controller to launch an embedded stand-alone LabVIEW RT application each time you boot the controller. Refer to the *Running a*

Stand-Alone Real-Time Application (RT Module) topic of the *LabVIEW Help* for more information about startup applications.

Note After powerup, you can install software on the cDAQ controller. For RT systems, you can also change the network settings using Measurement & Automation Explorer (MAX) on a host computer.

14. Wire the C Series module as indicated in the C Series module documentation.
15. Launch Measurement & Automation Explorer (MAX) by double-clicking the MAX icon on the host computer desktop. Expand **Remote Systems** and select **NI-cDAQ<*model number*>-<*serial number*>**[1]. Click the **System Settings** tab and verify that the controller has an Ethernet IP address and that System State reads **`Connected - No software installed`**.
16. Expand **NI-cDAQ<*model number*>-<*serial number*>**. Right-click **Software** and select **Add/Remove Software**.
17. In the window that opens, select **NI-DAQmx**, and then select **Install the feature**. Other required dependencies will be selected automatically.
18. Click **Next** to confirm the requested software features.
19. Click **Next** to install the software. After the installation completes, the cDAQ controller reboots.
20. Click **Finish**.
21. In MAX, expand **Remote Systems** and select **NI-cDAQ<*model number*>-<*serial number*>**. Click the **System Settings** tab and verify that the System State reads **`Connected - Running`**.
22. Self-test your controller in MAX by expanding **NI-cDAQ<*model number*>-<*serial number*>»Devices and Interfaces**. Right-click **NI cDAQ-<*model number*>** and select **Self-Test**. Self-test performs a brief test to determine successful controller installation.
23. Run a Test Panel in MAX by expanding **NI-cDAQ<*model number*>-<*serial number*>» Devices and Interfaces»NI cDAQ-<*model number*>**, right-clicking your C Series module, and selecting **Test Panels** to open a test panel for the selected module.

    If the test panel displays an error message, refer to `ni.com/support`.

New users can view and use the Voltage - Continuous Input VI, available in the LabVIEW Example Finder. Experienced users can use the LabVIEW Sample Projects, LabVIEW Real-Time Control (NI-DAQmx) and LabVIEW Waveform Acquisition and Logging (NI-DAQmx).

Note For information about configuring network settings, refer to the *Configure Network Settings* book of the *MAX Remote Systems Help*. In MAX, click **Help»Help**

[1] The serial number listed in MAX is the last eight digits of the cDAQ controller primary MAC address.

Topics»Remote Systems. On the **Contents** tab, browse to **LabVIEW Real-Time Target Configuration»Configure Network Settings**.

For information about configuring the controller to launch an embedded stand-alone application at startup, refer to the *LabVIEW Help*. For more information about setting up the controller as an RT target, refer to the *LabVIEW Help*. For more information about configuring the controller in MAX, refer to the *MAX Help*.

You can also change the network settings using Measurement & Automation Explorer (MAX) on a host computer.

Troubleshooting Network Communication in NI cDAQ-9138/9139 for LabVIEW Real-Time Controller

If the controller cannot communicate with the network, you can use the IP RESET DIP switch to manually restore the controller to the default network settings. When you reboot the controller with the IP RESET DIP switch in the ON position, the controller attempts to connect to the network using DHCP. If the controller is unable to obtain an IP address, it connects to the network with a link-local IP address with the form `169.254.x.x`.

Complete the following steps to restore the controller to the default network settings.

1. Move the IP RESET DIP switch to the ON position.

Figure 1-5. IP RESET DIP Switch in ON Position



2. Push the RESET button to cycle power to the cDAQ controller.
3. Configure the IP and other network settings in MAX from the host computer.
4. Move the IP RESET DIP switch to the OFF position.

Figure 1-6. IP RESET DIP Switch in OFF Position



For more information about troubleshooting network communication, refer to the *MAX Remote Systems Help* topic in the *Measurement & Automation Explorer Help*.

Wiring Power to the cDAQ Controller

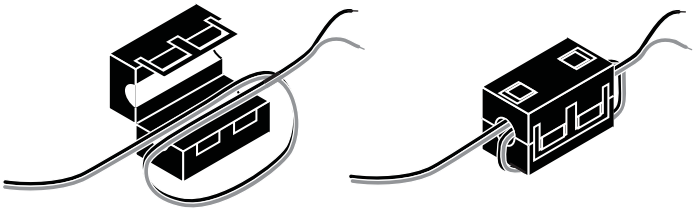
The cDAQ controller requires an external power source as described in the *Power Requirements* section of the specifications document for your cDAQ controller. Some suggested NI power supplies are listed in Table 1-10. The cDAQ controller filters and regulates the supplied power and provides power to all of the modules. The cDAQ controller has a primary power input, V1, and a secondary power input, V2. The POWER LED on the front panel identifies the power input in use. When the LED is lit green, V1 is in use; when the LED is lit yellow, V2 is in use.

Caution Do *not* connect V2 to a DC mains supply or to any supply requiring a connecting cable longer than 3 m (10 ft). A DC mains supply is a local DC electricity supply network in the infrastructure of a site or building.

Complete the following steps to connect a power source to the cDAQ controller.

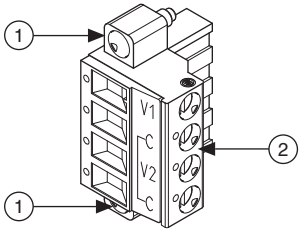
1. Make sure the power source is turned off.
2. Install the ferrite shipped with the cDAQ controller across the negative and positive leads of the power source, approximately 50 to 75 mm (2 to 3 in.) from the ends of the leads near the cDAQ controller, as shown in Figure 1-7.

Figure 1-7. Installing the Ferrite on the Power Leads



3. Loosen the connector screw flanges and remove the power screw terminal connector plug from the cDAQ controller. Figure 1-8 shows the terminal screws, which secure the wires in the screw terminals, and the connector screw flanges, which secure the connector plug on the front panel.

Figure 1-8. Power Screw Terminal Connector Plug



1 Terminal Screw 2 Connector Screw Flanges

Caution Do *not* tighten or loosen the terminal screws on the power connector while the power is on.

4. Connect the positive lead of the primary power source to the V1 terminal of the power connector plug and tighten the terminal screw.
5. Connect the negative lead of the primary power source to one of the C terminals of the power screw terminal connector plug and tighten the terminal screw.
6. Optionally, you can connect the positive lead of a secondary power source to the V2 terminal and the negative lead to the other C terminal.

7. Install the power connector plug on the front panel of the cDAQ controller and tighten the connector screw flanges.
8. Turn on the external power source(s).

The cDAQ controller uses V1 if the voltage across V1 and C is 9 V or greater. If the V1-to-C voltage drops below 9 V, the cDAQ controller switches to V2. If the V2-to-C voltage is less than 9 V, operation may be interrupted.

Note If the cDAQ controller is using V1 and a secondary power source is connected to V2, there is a small leakage current on V2. The leakage current depends on the V2-to-C voltage. Refer to the *Power Requirements* section of the specifications document for your cDAQ controller for nominal values of this leakage current.

If the power source is connected to the power connector using long wiring with high DC resistance, the voltage at the power connector may be significantly lower than the specified voltage of the power source.

The C terminals are internally connected to each other but are not connected to chassis ground. You can connect the C terminals to chassis ground externally. Refer to the *Power Requirements* section of the specifications document for your cDAQ controller for information about the power supply input range. Refer to the *Safety Voltages* section of the specifications document for your cDAQ controller for information about the maximum voltage from terminal to chassis ground.

Mounting the cDAQ Controller

You can use the cDAQ controller on a desktop or mount it to a panel, wall, DIN rail, or rack. For accessory ordering information, refer to the pricing section of the NI cDAQ-9138/9139 product page at `ni.com`.

Note The cDAQ controller was designed and tested in multiple mounting configurations. The varied mounting orientations or configurations can reduce the maximum allowable ambient temperature and can affect the accuracy of C Series modules in the controller. Visit `ni.com/info` and enter the Info Code `cdaqmounting` for more information about mounting and accuracy.

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

Caution You must mount the controller horizontally on a flat, vertical, metallic surface using the NI panel mount kit, part number 781919-01, to achieve an allowable operating ambient temperature of 45 to 55 °C. Mounting the controller in a different orientation or on a nonmetallic surface reduces the maximum allowable ambient

temperature and can affect the measurement accuracy of modules in the controller. Figure 1-9 shows the controller mounted horizontally. Refer to the *Mounting the cDAQ Controller on a Panel* section for complete panel mounting instructions.

Measure the ambient temperature at each side of the controller, 63.5 mm (2.5 in.) from the side and 50.8 mm (2 in.) forward from the rear of the controller, as shown in Figure 1-10.

For more information about how different mounting configurations can cause temperature derating, go to `ni.com/info` and enter the Info Code `cdaqmounting`.

Figure 1-9. NI cDAQ-9138/9139 Mounted Horizontally with Panel Mount Kit

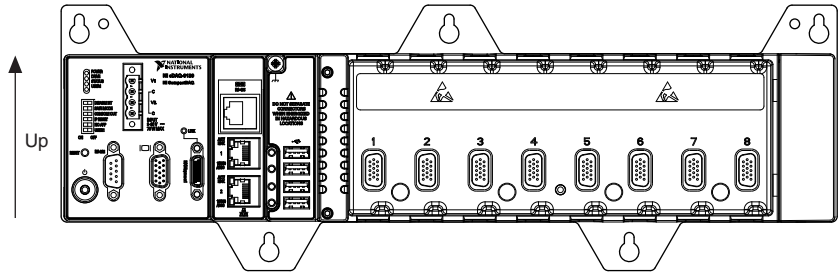
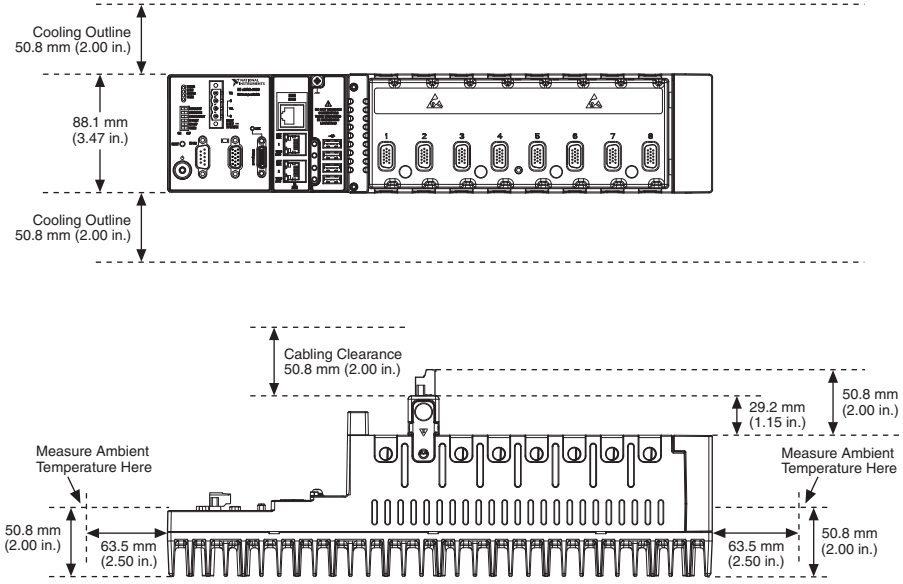


Figure 1-10. NI cDAQ-9138/9139 Temperature, Cooling, and Cabling Dimensions



Caution Your installation must meet the following requirements for space and cabling clearance, as shown in Figure 1-10:

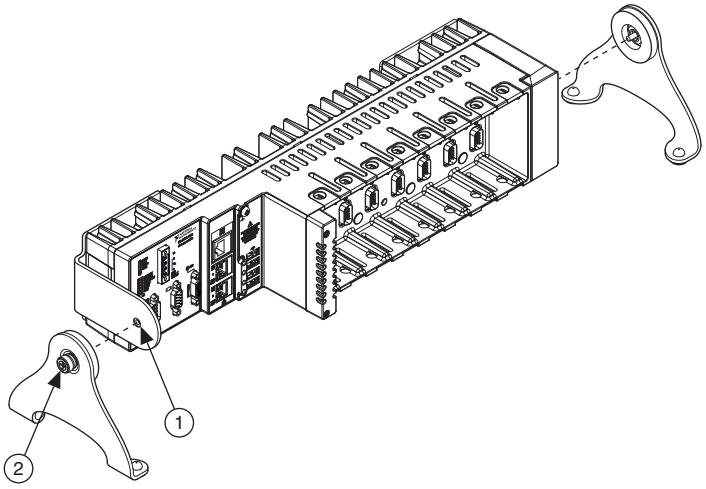
- Allow 50.8 mm (2 in.) on the top and the bottom of the controller for air circulation.
- Allow 50.8 mm (2 in.) in front of modules for cabling clearance for common connectors, such as the 10-terminal, detachable screw terminal connector.

Using the cDAQ Controller on a Desktop

Complete the following steps to install the NI desktop mount kit, part number 781988-01, on the cDAQ controller.

9. Align one of the end brackets with the mounting hole at one of the ends of the controller, as shown in Figure 1-11.

Figure 1-11. Connecting the End Brackets to the Controller



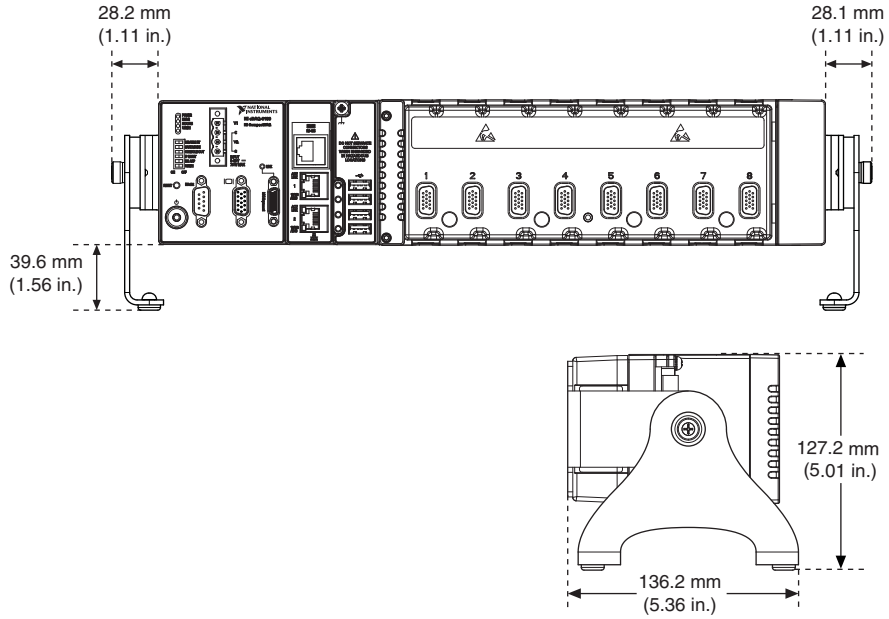
1	Mounting Holes	2	Captive Screw

10. Use a number 2 Phillips screwdriver to tighten the captive screw on the end bracket.
11. Repeat steps 9 and 10 to attach the other end bracket to the other end of the controller.

Note To achieve the highest accuracy when mounting the controller in the desktop kit, NI recommends that you operate the controller with the modules rotated forward, as shown in Figure 1-11. Visit `ni.com/info` and enter the Info Code `cdaqmounting` for more information about mounting and accuracy.

Figure 1-12 shows the dimensions of a controller after the desktop mounting kit is installed.

Figure 1-12. Dimensions of the cDAQ Controller with Desktop Mounting Kit Installed



Mounting the cDAQ Controller on a Panel

Panel or wall mounting is the best method for applications that are subject to high shock and vibration. You can use the NI panel mount kit, part number 781919-01, to mount the cDAQ controller on a flat surface. Complete the following steps.

1. Fasten the mounting plate to the controller using a number 2 Phillips screwdriver and six M4 × 10 screws. National Instruments provides these screws with the panel mount kit. Tighten the screws to a maximum torque of 1.3 N · m (11.5 lb · in.).

Figure 1-13. Installing the Mounting Plate on the cDAQ Controller

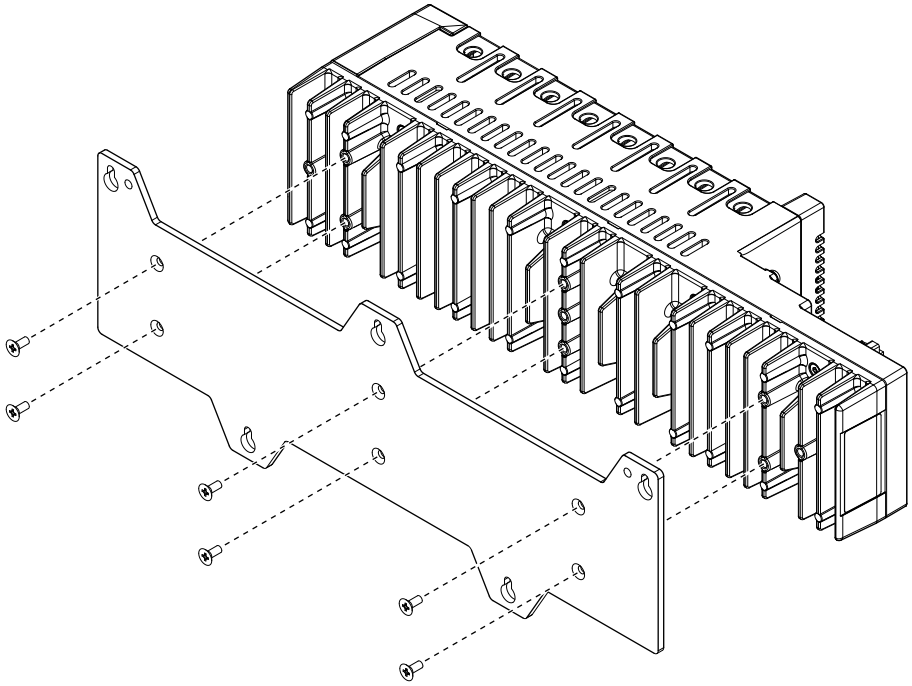
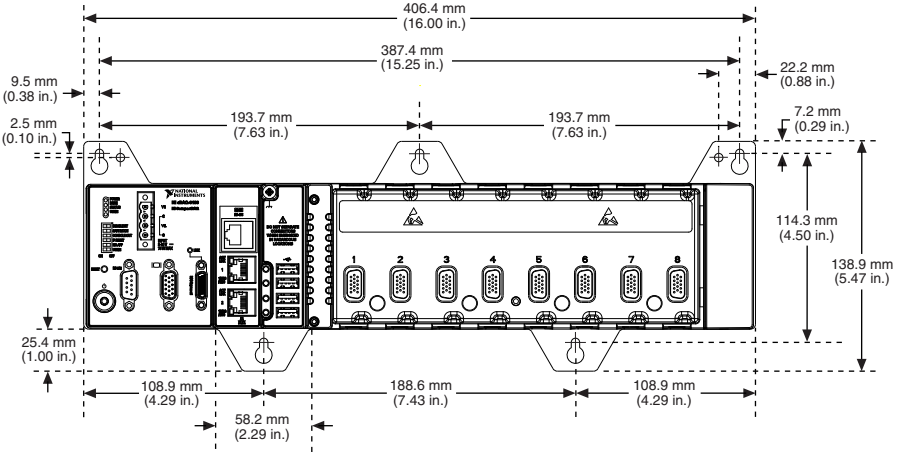
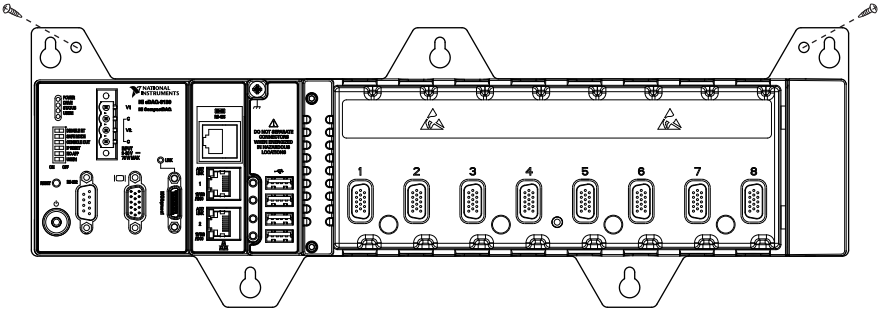


Figure 1-14. Dimensions of the cDAQ Controller with Mounting Plate Installed



2. Fasten the mounting plate to the surface using the screwdriver and screws that are appropriate for the surface. The maximum screw size is M4 or number 8.
3. Optionally, you can use two additional screws to attach the mounting plate to the panel or wall permanently, preventing the controller from being removed.

Figure 1-15. Permanently Attaching the Mounting Plate to the Panel or Wall

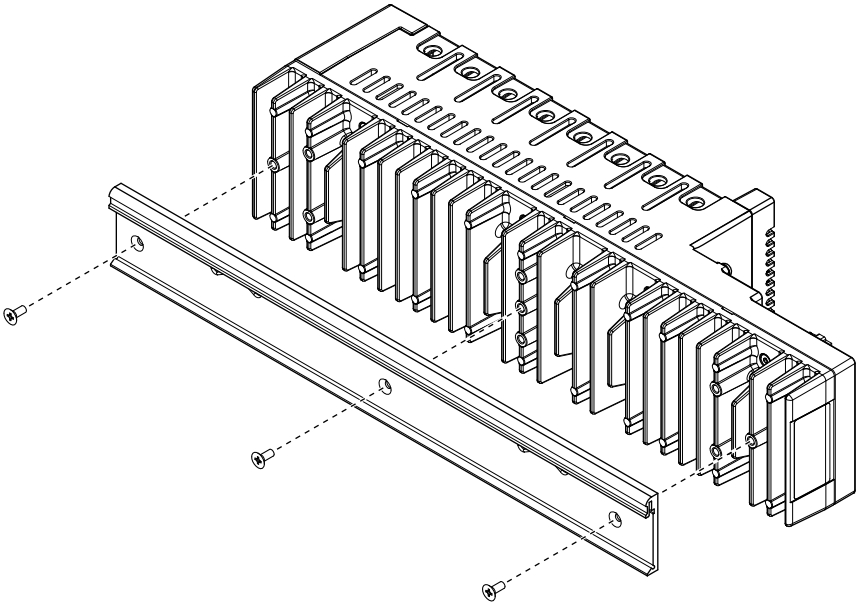


Mounting the cDAQ Controller on a DIN Rail

Use the DIN rail mounting method if you already have a DIN rail configuration or if you need to be able to remove the controller quickly. You can order the NI DIN rail mount kit, part number 781987-01, to mount the controller on a DIN rail. You need one clip for mounting the controller on a standard 35 mm DIN rail. Complete the following steps to mount the controller on a DIN rail.

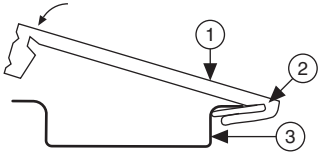
1. Fasten the DIN rail clip to the controller using a number 2 Phillips screwdriver and three M4 × 10 screws. National Instruments provides these screws with the DIN rail mount kit. Tighten the screws to a maximum torque of 1.3 N · m (11.5 lb · in.). Make sure the DIN rail kit is installed as shown in Figure 1-16, with the larger lip of the DIN clip positioned up. When the DIN rail kit is properly installed, the cDAQ controller is centered on the DIN rail.

Figure 1-16. Installing the DIN Rail Clip on the cDAQ Controller



2. Insert one edge of the DIN rail into the deeper opening of the DIN rail clip, as shown in Figure 1-17, and press down firmly on the controller to compress the spring until the clip locks in place on the DIN rail.

Figure 1-17. DIN Rail Clip Parts Locator Diagram



1	DIN Rail Clip	2	DIN Rail Spring	3	DIN Rail

Caution Remove the modules before removing the controller from the DIN rail.

Mounting the cDAQ Controller on a Rack

NI offers two rack mount kits, part numbers 779102-01 and 781989-01, that you can use to mount the cDAQ controller and other DIN rail–mountable equipment on a standard 19-inch rack. You must order the NI DIN rail mount kit, part number 781987-01, in addition to these kits.

Removing Modules from the cDAQ Controller

Complete the following steps to remove a C Series module from the cDAQ controller.

1. Make sure that no I/O-side power is connected to the module. If the controller is in a nonhazardous location, the controller power can be on when you remove modules.
2. Squeeze the latches on both sides of the module and pull the module out of the controller.

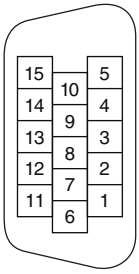
cDAQ Controller Features

The cDAQ controller features many ports, DIP switches, LEDs, a RESET button, and a power button. Refer to Figure 1-1 for the locations of these features on the cDAQ controller.

Video (VGA) Port

The cDAQ controller video (VGA) port, shown in Figure 1-1, outputs graphics using VESA standard VGA analog signaling. Use this port to connect a monitor to program the NI cDAQ-9138/9139 for Windows. Table 1-3 lists the video port pin locations and VGA signals.

Table 1-3. Video Port Pin Locations

Pinout	Pin	Signal Name	Signal Description
	1	RED	Red analog video signal
	2	GREEN	Green analog video signal
	3	BLUE	Blue analog video signal
	4	No Connect	—
	5	GND	Ground reference
	6	RED RETURN	Ground reference
	7	GREEN RETURN	Ground reference
	8	BLUE RETURN	Ground reference
	9	PWR	5 V power for DDC
	10	GND	Ground return for power
	11	No Connect	—
	12	DDC_D	Data signal of serial communication
	13	HSYNC	Horizontal synchronization signal
	14	VSYNC	Vertical synchronization signal
	15	DDC_C	Clock signal of serial communication

Caution Do *not* hot-swap VGA devices while the cDAQ controller is in a hazardous location or connected to high voltages.

USB Ports

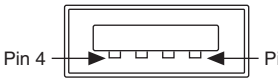
The cDAQ controller supports common USB mass-storage devices such as USB Flash drives and USB-to-IDE adapters formatted with FAT16 and FAT32 file systems. LabVIEW usually maps USB devices to the `U:`, `V:`, `W:`, or `X:` drive, starting with the `U:` drive if it is available. You can also use these ports to connect a computer keyboard and mouse for cDAQ-9138/9139 for Windows programming. Go to `ni.com/info` and enter Info Code `exswh5` for up-to-date information about supported NI devices for the cDAQ controller.

Note For optimal performance, NI recommends that you use the upper two USB ports for high-throughput USB peripherals, such as mass storage devices or expansion I/O controller.

Go to `ni.com/info` and enter Info Code `exyerk` for information about best practices for data logging performance with the NI cDAQ-9138/9139.

Refer to Figure 1-1 for the location of the four USB ports on the cDAQ controller. Refer to Table 1-4 for USB pin locations and signal descriptions.

Table 1-4. USB Port Pin Locations

Pinout	Pin	Signal Name	Signal Description
	1	VCC	Cable power (+5 V)
	2	D-	USB data-
	3	D+	USB data+
	4	GND	Ground

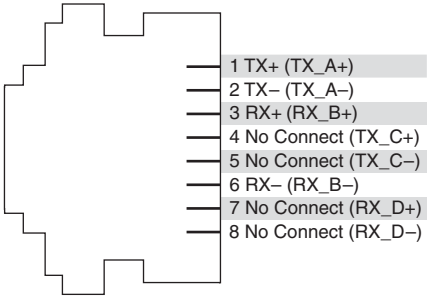
Caution Do *not* hot-swap USB devices while the cDAQ controller is in a hazardous location or connected to high voltages.

Ethernet Ports

The cDAQ controller has two tri-speed RJ-45 Ethernet ports, shown in Figure 1-1.

Refer to Figure 1-18 for Ethernet pin locations and signal descriptions. The Ethernet signal names are listed as Fast Ethernet signal name, RX/TX +/-, and then Gigabit Ethernet signal name, (RX/TX_*x*+/-).

Figure 1-18. Ethernet Port Pin Locations: Fast Ethernet Signals (Gigabit Ethernet Signals)



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

(NI cDAQ-9138/9139 for Windows) Both Ethernet ports are enabled and configured as DHCP, to "obtain an IP address automatically," by default. The Ethernet ports can be configured in the Windows Control Panel, under the Network and Internet category.

Ethernet port 1 provides Wake-on-LAN functionality and AMT support. Ethernet port 1 remains powered when the controller is in sleep mode.

(NI cDAQ-9138/9139 for LabVIEW Real-Time) You must use Ethernet port 1 to configure the NI cDAQ-9138/9139 for LabVIEW Real-Time; you cannot configure the controller through Ethernet port 2. To use Ethernet port 2, you must assign a static IP address to the port using MAX. The IP address must be on a different subnet than the IP address of Ethernet port 1. You cannot use DHCP with Ethernet port 2. For more information about using Ethernet port 2, go to `ni.com/info` and enter the Info Code `dualenet`.

Ethernet LEDs

Each Ethernet port has two LEDs—ACT/LINK and 10/100/1000. Refer to Table 1-5 for information about the Ethernet ACT/LINK and 10/100/1000 LAN connector LEDs.

Table 1-5. Ethernet LED Indications

LED	LED Color	LED State	Indication
ACT/ LINK	—	Off	LAN link not established
	Green	Solid	LAN link established
		Flashing	Activity on LAN

Table 1-5. Ethernet LED Indications (Continued)

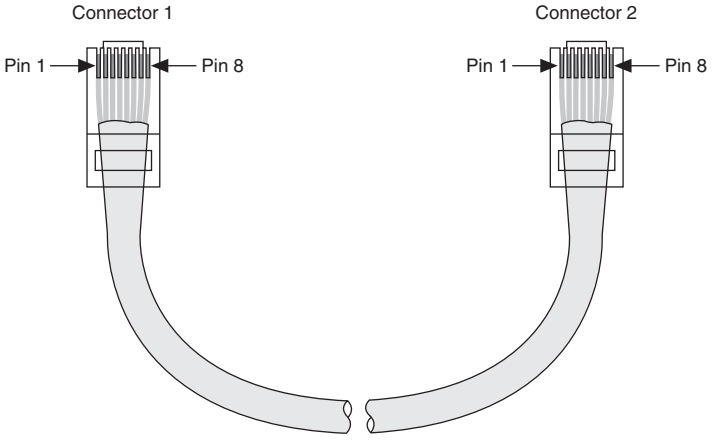
LED	LED Color	LED State	Indication
10/100/ 1000	Yellow	Solid	1,000 Mbit/s data rate selected
	Green	Solid	100 Mbit/s data rate selected
	—	Off	10 Mbit/s data rate selected

Ethernet Cabling

Table 1-6 shows the shielded Ethernet cable wiring connections for both straight through and crossover cables.

Table 1-6. Ethernet Cable Wiring Connections

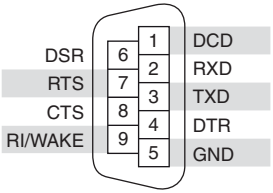
Pin	Connector 1	Connector 2	
		Straight Through	Crossover
1	white/orange	white/orange	white/green
2	orange	orange	green
3	white/green	white/green	white/orange
4	blue	blue	blue
5	white/blue	white/blue	white/blue
6	green	green	orange
7	white/brown	white/brown	white/brown
8	brown	brown	brown



RS-232 Serial Port

The cDAQ controller has an RS-232 serial port, shown in Figure 1-1, 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. Refer to the *LabVIEW Help* for information about the Serial VIs. Refer to Figure 1-19 for pin locations and signal descriptions.

Figure 1-19. RS-232 Serial Port Pin Locations

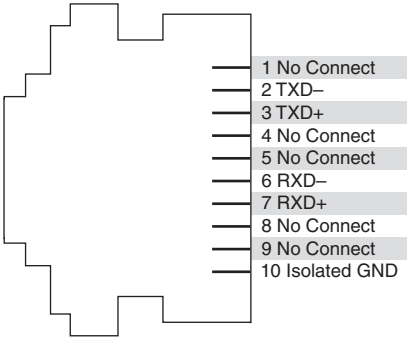


You can use the Ring Indicator (RI/WAKE) on pin 9 to wake the controller from a low power state. You can drive RI/WAKE with logic-level signals where a high level greater than 2.4 V signals a wake event.

RS-485/422 Serial Port

The cDAQ controller has an RS-485/422 serial port, COM 2, accessible through a 10-position RJ-50 modular jack. The shield of the RJ-50 connector is isolated from the controller, enabling you to use shielded cables while maintaining isolation. The RS-485/422 serial port is shown in Figure 1-1. Refer to Figure 1-20 for pin locations and signal descriptions.

Figure 1-20. RS-485/422 Serial Port Pin Locations



COM 2 is designed to operate in four-wire (RS-422) or two-wire mode.

NI offers a DIN rail-mountable screw terminal adapter (NI part number 778674-01) that you can use to connect termination resistors to COM 2.

Cable adapters for the 10-position modular jacks are available from NI. Part numbers 182845-01, -02, and -03 are 1, 2, and 3 m cable adapters for connecting the 10-position modular jack to a 9-position D-SUB plug.

Go to ni.com/info and enter Info Code exswh5 for up-to-date information about supported NI devices for the NI cDAQ-9138/9139 controller.

MXI-Express Port

You can use the cDAQ controller MXI-Express port, shown in Figure 1-1, to connect to a MXI-Express controller. The NI cDAQ-9138/9139 for Windows controller support all NI MXI-Express controller. Currently, the NI cDAQ-9138/9139 for LabVIEW Real-Time controller support the RIO expansion controller. Go to ni.com/info and enter Info Code exswh5 for up-to-date information about supported NI devices for the NI cDAQ-9138/9139 controller.

Complete the following steps to connect one or more cDAQ controller to a MXI-Express device.

1. Make sure the MXI-Express device is configured and powered off.
2. Make sure the cDAQ controller is powered off.
3. Connect the cDAQ controller to the MXI-Express device using a x1 cable. Refer to Table 1-10 for MXI-Express cable lengths and part numbers.
4. Power on the MXI-Express device.
5. Power on the cDAQ controller.

The MXI-Express port has one LINK LED. Refer to Table 1-8 for information about the MXI-Express LINK LED behavior.

Note Do *not* connect MXI-Express devices to the cDAQ controller while the controller is powered on. The MXI-Express device may not be detected by the cDAQ controller.

DIP Switches

The cDAQ controller features six DIP switches, shown in Figure 1-1.

Table 1-7. DIP Switches

Switch	Description
DISABLE RT	**(NI cDAQ-9138/9139 for LabVIEW Real-Time)** The position of the DISABLE RT determines the operating system the cDAQ controller boots into. If the switch is in the OFF position, the controller boots into LabVIEW RT. Move the switch to the ON position to boot the cDAQ controller from an external drive.
	(NI cDAQ-9138/9139 for Windows) The position of the DISABLE RT determines the operating system the cDAQ controller boots into. If the switch is the ON position, the controller boots into Windows Embedded Standard 7 (WES7). If the switch is in the OFF position, the controller does not boot into Windows.
SAFE MODE	**(NI cDAQ-9138/9139 for LabVIEW Real-Time)** 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. If the switch is in the ON position at startup, the cDAQ controller launches only the essential services required for updating its configuration and installing software. The LabVIEW Real-Time engine does not launch. If the software on the controller is corrupted, you must put the controller into safe mode and reformat the controller drive. You can put the controller into safe mode by powering it up either with the SAFE MODE switch in the ON position or with no software installed on the drive. Refer to the *Measurement & Automation Explorer Help* for more information about installing software on the controller and reformatting the drive on the controller. Keep the SAFE MODE switch in the OFF position during normal operation.
	(NI cDAQ-9138/9139 for Windows) NI recommends that you keep the SAFE MODE switch in the OFF position at all times.

Table 1-7. DIP Switches (Continued)

Switch	Description
CONSOLE OUT	**(NI cDAQ-9138/9139 for LabVIEW Real-Time)** The position of the CONSOLE OUT switch determines whether console input and output are redirected to the RS-232 serial port. If the switch is in the ON position, console input and output are redirected to the RS-232 serial port. If the switch is in the OFF position, the RS-232 serial port functions normally. With a serial-port terminal program, you can use console output to read the POST results, BIOS revision, IP addresses, and software installed on the cDAQ controller. Use a null-modem cable to connect the RS-232 serial port on the controller to a computer. Push the CONSOLE OUT switch to the ON position. Make sure that the serial-port terminal program is configured with the same settings as the RS-232 serial port. The RS-232 serial port in CONSOLE OUT mode has the following default configuration settings: 9,600 bits per second Eight data bits No parity One stop bit No flow control You can use the BIOS setup menu to modify the CONSOLE OUT configuration settings for the RS-232 serial port. Keep the CONSOLE OUT switch in the OFF position during normal operation.
	(NI cDAQ-9138/9139 for Windows) NI recommends that you keep the CONSOLE OUT switch in the OFF position at all times.
IP RESET	**(NI cDAQ-9138/9139 for LabVIEW Real-Time)** Push the IP RESET switch to the ON position and reboot the controller to reset the IP address and other TCP/IP settings of the controller to the factory defaults. Refer to the *Using the BIOS Setup Utility to Change Configuration Settings* section of Appendix A, *Controller Operating System and Configuration*, for more information about resetting the IP address. You can also push this switch to the ON position to unlock a controller that was previously locked in MAX.
	(NI cDAQ-9138/9139 for Windows) NI recommends that you keep the IP RESET switch in the OFF position at all times.

Table 1-7. DIP Switches (Continued)

Switch	Description
NO APP	**(NI cDAQ-9138/9139 for LabVIEW Real-Time)** Push the NO APP switch to the ON position to prevent a LabVIEW RT startup application from running at startup. If you want to permanently disable a LabVIEW RT application from running at startup, you must disable it in LabVIEW. To run an application at startup, push the NO APP switch to the OFF position, create an application using the LabVIEW Application Builder, and configure the application in LabVIEW to launch at startup. 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 *Running a Stand-Alone Real-Time Application (RT Module)* topic of the *LabVIEW Help*.
	(NI cDAQ-9138/9139 for Windows) NI recommends that you keep the NO APP switch in the OFF position at all times.
USER1	**(NI cDAQ-9138/9139 for LabVIEW Real-Time)** You can define the USER1 switch for your application. To define the purpose of this switch in your embedded application, use the RT Read Switch VI in your LabVIEW RT embedded VI. For more information about the RT Read Switch VI, refer to the *LabVIEW Help*.
	(NI cDAQ-9138/9139 for Windows) NI recommends that you keep the USER1 switch in the OFF position at all times.

Power Connector

Refer to the *Wiring Power to the cDAQ Controller* section and the specifications document for your cDAQ controller for more information about the power connector

RESET Button

Pressing the RESET button, shown in Figure 1-1, resets the processor in the same manner as cycling power.

Power Button

Pressing the power button, shown in Figure 1-1, powers the cDAQ controller on and off. If the cDAQ controller becomes unresponsive, you can power it off by holding the power button down for 4 seconds. Refer to the *Power/Wake Configuration Submenu* section of Appendix A, *Controller Operating System and Configuration*, for information about configuring how the controller responds to the power button.

LEDs

The cDAQ controller features four LEDs—POWER, DRIVE, STATUS, and USER1—on its front panel, two LEDs—ACT/LINK and 10/100/1000—near each Ethernet connector, and one LINK LED near the MXI-Express port. Refer to Figure 1-1 for the locations of the LEDs. Table 1-8 lists the LEDs and status indications.

Table 1-8. LED Indications

LED	LED Color	LED State	Indication
LINK	Green	Solid	MXI-Express communication established
	Yellow	Solid	MXI-Express communication broken or no cable is connected
POWER	Green	Solid	The cDAQ controller is powered from the V1 input
	Yellow	Solid	The cDAQ controller is powered from the V2 input
	—	Off	The controller is not powered.
DRIVE	Yellow	Solid	An internal drive is being accessed.

Table 1-8. LED Indications (Continued)

LED	LED Color	LED State	Indication
STATUS	Yellow	1 flash every few seconds	Software error—The controller is unconfigured. Use MAX to configure the controller. Refer to the *Measurement & Automation Explorer Help* for information about configuring the controller.
		2 flashes every few seconds	Software error—The controller has detected an error in its software. This usually occurs when an attempt to upgrade the software is interrupted. Reinstall software on the controller. Refer to the *Measurement & Automation Explorer Help* for information about installing software on the controller.
		3 flashes every few seconds	Software error—The controller is in safe mode because the SAFE MODE DIP switch is in the ON position or there is no software installed on the controller. Refer to the *DIP Switches* section for information about the SAFE MODE DIP switch.
		4 flashes every few seconds	Software error—The software has crashed twice without rebooting or cycling power between crashes. This usually occurs when the controller runs out of memory. Review your RT VI and check the memory usage. Modify the VI as necessary to solve the memory usage issue.
		Continuously flashing	Software error—The controller has detected an unrecoverable error. Contact National Instruments.
		Continuously flashing or solid	Software error—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.

Table 1-8. LED Indications (Continued)

LED	LED Color	LED State	Indication
STATUS	Red	Continuously flashing	Hardware error—An internal power supply has failed. Check front-panel I/O, CXM, and C Series module connections for shorts. Remove any shorts and power cycle the controller. If the problem persists, contact National Instruments.
		Solid	Hardware error—The cDAQ controller internal temperature has exceeded a critical threshold. Ensure that the ambient operating temperature does not exceed the range specified in the *Environmental* section of the specifications document for your cDAQ controller. If the problem persists, contact National Instruments.
	—	Off	Normal operation.
USER1	Green/ yellow	—	This LED is controlled directly from your LabVIEW RT application You can define the USER1 LED to meet the needs of your application. To define the LED, use the RT LEDs VI in LabVIEW. For more information about the RT LEDs VI, refer to the *LabVIEW Help*.

CMOS Battery and CMOS Reset Button

The cDAQ controller contains a CMOS battery, a lithium cell battery that stores the system clock information when the controller is powered off. There is only a slight drain on the CMOS battery when power is applied to the cDAQ controller power connector. The rate at which the CMOS battery drains when power is disconnected depends on the ambient storage temperature. For longer battery life, store the cDAQ controller at a cooler temperature. Refer to the *CMOS Battery* section of the specifications document for your cDAQ controller for the expected battery lifetime.

The `CMOS Battery Is Dead` warning appears onscreen during the power-on self test if the battery is dead. The controller still starts, but the system clock is reset to the date and time of the BIOS release. The battery is not user replaceable. If you need to replace the CMOS battery, contact National Instruments.

Resetting the System CMOS and BIOS Settings

The cDAQ controller BIOS configuration information is stored in a nonvolatile memory location that does not require a battery to preserve the settings. Additionally, the BIOS optimizes boot time by saving specific system information to memory backed up by a battery (CMOS).

Complete the following steps to reset the CMOS and reset the BIOS settings to factory default values:

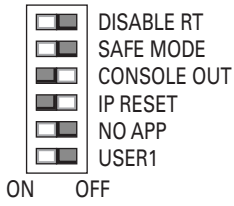
1. Disconnect power from the cDAQ controller.
2. Press the CMOS reset button, shown in Figure 1-1, *NI cDAQ-9138/9139 Controller*, and hold it for 1 second.
3. Reconnect power to the cDAQ controller.

The `BIOS Reset Detected` warning message appears onscreen.

If the CMOS battery is dead, the CMOS reset button does not work. You must complete the following alternative steps to reset the CMOS and reset the BIOS settings to factory default values:

1. Disconnect power from the cDAQ controller.
2. Configure the front-panel DIP switches as shown in Table 1-9.

Table 1-9. DIP Switch Settings to Reset CMOS and BIOS Settings

Configuration	Switch	Position
	DISABLE RT	ON
	SAFE MODE	ON
	CONSOLE OUT	OFF
	IP RESET	OFF
	NO APP	ON
	USER1	ON

Note These DIP switch settings are only applicable when the CMOS battery is dead.

3. Reconnect power to the cDAQ controller. The `BIOS Reset Detected` warning message appears onscreen.
4. Reset the DIP switches to their normal positions.

Chassis Grounding Screw

For EMC compliance, the cDAQ controller *must* be connected to earth ground through the controller ground, shown in Figure 1-1.

The wire should be 1.31 mm^2 (16 AWG) solid copper wire with a maximum length of 1.5 m (5 ft). Attach the wire to the earth ground of the facility's power system. For more information about earth ground connections, refer to the KnowledgeBase document, *Grounding for Test and Measurement Devices*, by going to `ni.com/info` and entering the Info Code `emcground`.

Note If you use shielded cabling to connect to a C Series module with a plastic connector, you must attach the cable shield to the chassis grounding terminal using 1.31 mm^2 (16 AWG) or larger wire. Use shorter wire for better EMC performance.

CPU eXpansion Module (CXM) Connector

In the future, the CXM connector will enable you to connect additional industry-standard I/O to the cDAQ controller.

CFast SSD Module

The CFast SSD module is the solid state hard drive of the cDAQ controller.

Cables and Accessories

Table 1-10 contains information about cables and accessories available for the cDAQ controller. For a complete list of cDAQ controller accessories and ordering information, refer to the pricing section of the NI cDAQ-913*x* product page at ni.com.

Table 1-10. Cables and Accessories

Accessory	Part Number
NI PS-15 power supply (24 VDC, 5 A, 100-120/200-240 VAC input)	781093-01
NI PS-10 desktop DC power supply (24 VDC, 5 A, 100-120/200-240 VAC input)	782698-01
NI desktop mount kit	781988-01
NI panel mount kit	781919-01
NI DIN rail mount kit	781987-01
NI rack mount kit with DIN rail	781989-01
NI 9910 sliding rack mount kit with DIN rail	779102-01
CAT-5E Ethernet cable, shielded (2, 5, and 10 m lengths)	151733-02, 151733-05, 151733-10
Industrial USB extension with retention cable (0.5 and 2 m lengths)	152166-*xx*
DIN rail-mountable screw terminal adapter (COM 2 termination resistor connection)	778674-01
Cable adapters for 10-position modular jacks (1, 2, and 3 m lengths)	182845-01, 182845-02, 182845-03
MXI-Express cables (1, 3, and 7 m lengths)	779500-01, 779500-03, 779500-07

Table 1-10. Cables and Accessories (Continued)

Accessory	Part Number
Keyboard and mouse	779660-01
USB CD/DVD drive	778492-01
Flat panel touch screen	779560-01
Flat panel monitors	779559-01, 781002-01

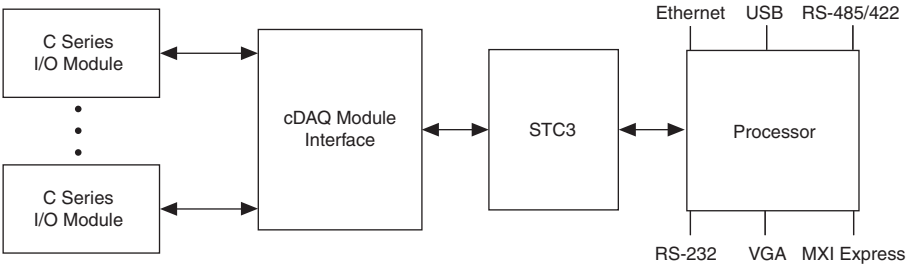
Caution To ensure the specified EMC performance, operate this product only with shielded cables and accessories.

Go to ni.com/info and enter Info Code exswh5 for up-to-date information about supported NI devices for the cDAQ controller.

Using the cDAQ Controller

The cDAQ controller consists of four parts—C Series module(s), the cDAQ module interface, the STC3, and the processor board—as shown in Figure 1-21. These components digitize signals, perform D/A conversions to generate analog output signals, measure and control digital I/O signals, and provide signal conditioning.

Figure 1-21. Block Diagram



C Series Module

National Instruments C Series modules provide built-in signal conditioning and screw terminal, spring terminal, BNC, D-SUB, or RJ-50 connectors. A wide variety of I/O types are available, allowing you to customize the cDAQ controller to meet your application needs.

C Series modules are hot-swappable and automatically detected by the cDAQ controller. I/O channels are accessible using the NI-DAQmx driver software.

Because the modules contain built-in signal conditioning for extended voltage ranges or industrial signal types, you can usually make your wiring connections directly from the C Series

modules to your sensors/actuators. C Series modules can sometimes provide isolation from channel-to-earth ground and channel-to-channel.

For more information about which C Series modules are compatible with the cDAQ controller, refer to the *C Series Support in NI-DAQmx* document by going to `ni.com/info` and entering the Info Code `rdcdaq`.

Parallel versus Serial DIO Modules

Digital I/O module capabilities are determined by the type of digital signals that the module is capable of measuring or generating.

- Serial digital I/O modules are designed for signals that change slowly and are accessed by either software-timed or hardware-timed reads and writes.
- Parallel digital I/O modules are for signals that change rapidly and are updated by either software-timed or hardware-timed reads and writes.

For more information about digital I/O modules, refer to Chapter 4, *Digital Input/Output and PFI*.

cDAQ Module Interface

The cDAQ module interface manages data transfers between the STC3 and the C Series I/O modules. The interface also handles autodetection, signal routing, and synchronization.

STC3

The STC3 features independent high-speed data streams; flexible AI, AO, and DIO sample timing; triggering; PFI signals for multi-device synchronization; flexible counter/timers with hardware gating; digital waveform acquisition and generation; and static DIO.

- **AI, AO, and DIO Sample Timing**—The STC3 contains advanced AI, AO, and DIO timing engines. A wide range of timing and synchronization signals are available through the PFI lines. Refer to the following sections for more information about the configuration of these signals:
  - The *Analog Input Timing Signals* section of Chapter 2, *Analog Input*
  - The *Analog Output Timing Signals* section of Chapter 3, *Analog Output*
  - The *Digital Input Timing Signals* section of Chapter 4, *Digital Input/Output and PFI*
  - The *Digital Output Timing Signals* section of Chapter 4, *Digital Input/Output and PFI*
- **Triggering Modes**—The cDAQ controller supports different trigger modes, such as start trigger, reference trigger, and pause trigger with analog, digital, or software sources. Refer to the following sections for more information:
  - The *Analog Input Triggering Signals* section of Chapter 2, *Analog Input*
  - The *Analog Output Triggering Signals* section of Chapter 3, *Analog Output*

  - The *Digital Input Triggering Signals* section of Chapter 4, *Digital Input/Output and PFI*
  - The *Digital Output Triggering Signals* section of Chapter 4, *Digital Input/Output and PFI*

- **Independent Data Streams**—The cDAQ controller supports seven independent high-speed data streams, which allow for up to seven simultaneous hardware-timed tasks, such as analog input, analog output, buffered counter/timers, and hardware-timed digital input/output.
- **PFI Signals**—The PFI signals provide access to advanced features such as triggering, synchronization, and counter/timers. You can also enable a programmable debouncing filter on each PFI signal that, when enabled, samples the input on each rising edge of a filter clock. PFI signals are available through parallel digital input and output modules installed in up to two controller slots. Refer to the *PFI* section of Chapter 4, *Digital Input/Output and PFI*, for more information.
- **Flexible Counter/Timers**—The cDAQ controller includes four general-purpose 32-bit counter/timers that can be used to count edges, measure pulse-widths, measure periods and frequencies, and perform position measurements (encoding). In addition, the counter/timers can generate pulses, pulse trains, and square waves with adjustable frequencies. You can access the counter inputs and outputs using parallel digital I/O modules installed in up to two slots. Refer to Chapter 5, *Counters*, for more information.

Processor and Ports

Refer to the specifications document for your cDAQ controller for information about the processors on the cDAQ controller. Refer to the *cDAQ Controller Features* section for information about using the various ports on the cDAQ controller.

2

Analog Input

To perform analog input measurements, insert a supported analog input C Series module into any slot on the cDAQ controller. The measurement specifications, such as number of channels, channel configuration, sample rate, and gain, are determined by the type of C Series module used. For more information and wiring diagrams, refer to the documentation included with your C Series modules.

The cDAQ controller has three AI timing engines, which means that three analog input tasks can be running at a time on a controller. An analog input task can include channels from multiple analog input modules. However, channels from a single module cannot be used in multiple tasks.

Multiple timing engines allow the cDAQ controller to run up to three analog input tasks simultaneously, each using independent timing and triggering configurations. The three AI timing engines are ai, te0, and te1.

Analog Input Triggering Signals

A trigger is a signal that causes an action, such as starting or stopping the acquisition of data. When you configure a trigger, you must decide how you want to produce the trigger and the action you want the trigger to cause. The cDAQ controller supports internal software triggering, external digital triggering, and analog triggering.

Three triggers are available: Start Trigger, Reference Trigger, and Pause Trigger. An analog or digital trigger can initiate these three trigger actions. Up to two C Series parallel digital input modules can be used in any controller slot to supply a digital trigger. To find your module triggering options, refer to the documentation included with your C Series modules. For more information about using digital modules for triggering, refer to Chapter 4, *Digital Input/Output and PFI*.

Refer to the *AI Start Trigger Signal*, *AI Reference Trigger Signal*, and *AI Pause Trigger Signal* sections for more information about the analog input trigger signals.

Analog Input Timing Signals

The cDAQ controller features the following analog input timing signals:

- *AI Sample Clock Signal**
- *AI Sample Clock Timebase Signal*
- *AI Start Trigger Signal**

- *AI Reference Trigger Signal**
- *AI Pause Trigger Signal**

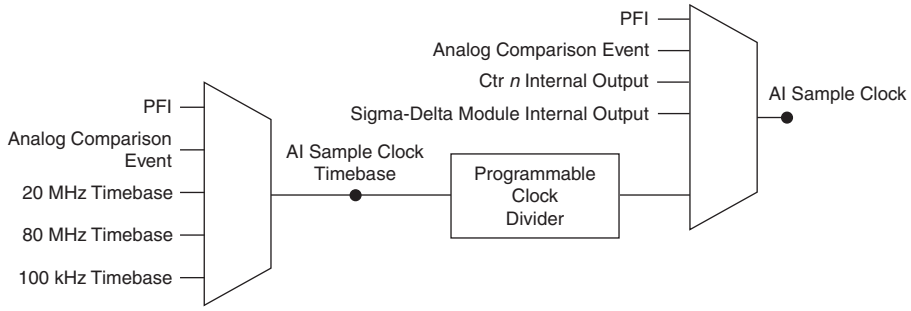
Signals with an * support digital filtering. Refer to the *PFI Filters* section of Chapter 4, *Digital Input/Output and PFI*, for more information.

Refer to the *AI Convert Clock Signal Behavior For Analog Input Modules* section for AI Convert Clock signals and the cDAQ controller.

AI Sample Clock Signal

A sample consists of one reading from each channel in the AI task. Sample Clock signals the start of a sample of all analog input channels in the task. Sample Clock can be generated from external or internal sources as shown in Figure 2-1.

Figure 2-1. AI Sample Clock Timing Options



Routing the Sample Clock to an Output Terminal

You can route Sample Clock to any output PFI terminal. Sample Clock is an active high pulse by default.

AI Sample Clock Timebase Signal

The AI Sample Clock Timebase signal is divided down to provide a source for Sample Clock. AI Sample Clock Timebase can be generated from external or internal sources. AI Sample Clock Timebase is not available as an output from the controller.

AI Convert Clock Signal Behavior For Analog Input Modules

Refer to the *Scanned Modules*, *Simultaneous Sample-and-Hold Modules*, *Sigma-Delta Modules*, and *Slow Sample Rate Modules* sections for information about the AI Convert Clock signal and C Series analog input modules.

Scanned Modules

Scanned C Series analog input modules contain a single A/D converter and a multiplexer to select between multiple input channels. When the cDAQ Module Interface receives a Sample Clock pulse, it begins generating a Convert Clock for each scanned module in the current task. Each Convert Clock signals the acquisition of a single channel from that module. The Convert Clock rate depends on the module being used, the number of channels used on that module, and the system Sample Clock rate.

The driver chooses the fastest conversion rate possible based on the speed of the A/D converter for each module and adds 10 µs of padding between each channel to allow for adequate settling time. This scheme enables the channels to approximate simultaneous sampling. If the AI Sample Clock rate is too fast to allow for 10 µs of padding, NI-DAQmx selects a conversion rate that spaces the AI Convert Clock pulses evenly throughout the sample. NI-DAQmx uses the same amount of padding for all the modules in the task. To explicitly specify the conversion rate, use the **ActiveDevs** and **AI Convert Clock Rate** properties using the **DAQmx Timing** property node or functions.

Simultaneous Sample-and-Hold Modules

Simultaneous sample-and-hold (SSH) C Series analog input modules contain multiple A/D converters or circuitry that allows all the input channels to be sampled at the same time. These modules sample their inputs on every Sample Clock pulse.

Sigma-Delta Modules

Sigma-delta C Series analog input modules function much like SSH modules, but use A/D converters that require a high-frequency oversample clock to produce accurate, synchronized data. Some sigma-delta modules in the cDAQ controller automatically share a single oversample clock to synchronize data from all the modules that support an external oversample clock timebase when they all share the same task. (DSA modules are an example). The cDAQ controller supports a maximum of two synchronization pulse signals configured for your system. This limits the system to two tasks with different oversample clock timebases.

The oversample clock is used as the AI Sample Clock Timebase. While most modules supply a common oversample clock frequency (12.8 MHz), some modules, such as the NI 9234, supply a different frequency. When sigma-delta modules with different oversample clock frequencies are used in an analog input task, the AI Sample Clock Timebase can use any of the available frequencies; by default, the fastest available is used. The sampling rate of all modules in the system is an integer divisor of the frequency of the AI Sample Clock Timebase.

When one or more sigma-delta modules are in an analog input task, the sigma-delta modules also provide the signal used as the AI Sample Clock. This signal is used to cause A/D conversion for other modules in the system, just as the AI Sample Clock does when a sigma-delta module is not being used.

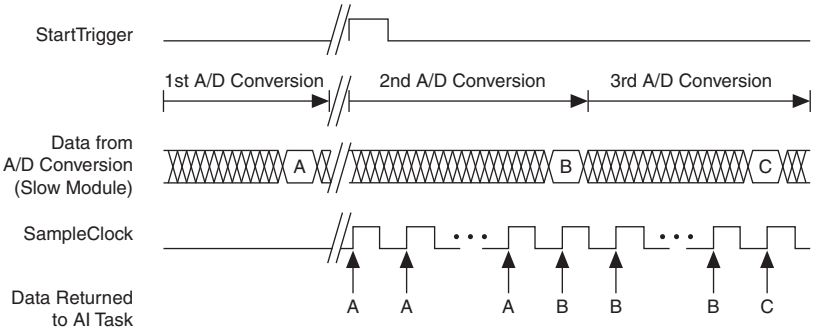
When sigma-delta modules are in an AI task, the controller automatically issues a synchronization pulse to each sigma-delta modules that resets their ADCs at the same time.

Because of the filtering used in sigma-delta A/D converters, these modules usually exhibit a fixed input delay relative to non-sigma-delta modules in the system. This input delay is specified in the C Series module documentation.

Slow Sample Rate Modules

Some C Series analog input modules are specifically designed for measuring signals that vary slowly, such as temperature. Because of their slow rate, it is not appropriate for these modules to constrain the AI Sample Clock to operate at or slower than their maximum rate. When using such a module in the cDAQ controller, the maximum Sample Clock rate can run faster than the maximum rate for the module. When operating at a rate faster than these slow rate modules can support, the slow rate module returns the same point repeatedly, until a new conversion completes. In a hardware-timed task, the first point is acquired when the task is committed. The second point is acquired after the start trigger as shown in Figure 2-2.

Figure 2-2. Sample Clock Timing Example



For example, if running an AI task at 1 kHz using a module with a maximum rate of 10 Hz, the slow module returns 100 samples of the first point, followed by 100 samples of the second point, etc. Other modules in the task will return 1,000 new data points per second, which is normal. When performing a single-point acquisition, no points are repeated. To avoid this behavior, use multiple AI timing engines, and assign slow sample rate modules to a task with a rate at or slower than their maximum rate.

Refer to the *C Series Support in NI-DAQmx* document by going to `ni.com/info` and entering the Info Code `rdcdaq`.

AI Start Trigger Signal

Use the Start Trigger signal to begin a measurement acquisition. A measurement acquisition consists of one or more samples. If you do not use triggers, begin a measurement with a software command. Once the acquisition begins, configure the acquisition to stop in one of the following ways:

- When a certain number of points has been sampled (in finite mode)
- After a hardware reference trigger (in finite mode)
- With a software command (in continuous mode)

An acquisition that uses a start trigger (but not a reference trigger) is sometimes referred to as a posttriggered acquisition. That is, samples are measured only after the trigger.

When you are using an internal sample clock, you can specify a default delay from the start trigger to the first sample.

Using a Digital Source

To use the Start Trigger signal with a digital source, specify a source and a rising or falling edge. Use the following signals as the source:

- Any PFI terminal
- Counter *n* Internal Output

The source also can be one of several other internal signals on your cDAQ controller. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information.

Using an Analog Source

Some C Series modules can generate a trigger based on an analog signal. In NI-DAQmx, this is called the Analog Comparison Event. When you use an analog trigger source for Start Trigger, the acquisition begins on the first rising edge of the Analog Comparison Event signal.



Note Depending on the C Series module capabilities, you may need two modules to utilize analog triggering.

Routing AI Start Trigger to an Output Terminal

You can route the Start Trigger signal to any output PFI terminal. The output is an active high pulse.

AI Reference Trigger Signal

Use Reference Trigger to stop a measurement acquisition. To use a reference trigger, specify a buffer of finite size and a number of pretrigger samples (samples that occur before the reference trigger). The number of posttrigger samples (samples that occur after the reference trigger) desired is the buffer size minus the number of pretrigger samples.

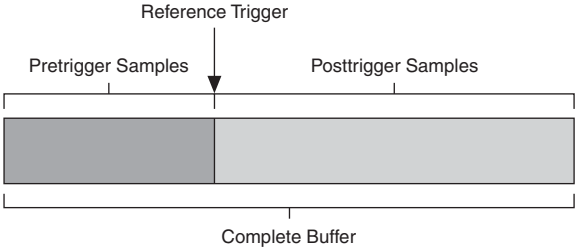
Once the acquisition begins, the cDAQ controller writes samples to the buffer. After the cDAQ controller captures the specified number of pretrigger samples, the cDAQ controller begins to look for the reference trigger condition. If the reference trigger condition occurs before the cDAQ controller captures the specified number of pretrigger samples, the controller ignores the condition.

If the buffer becomes full, the cDAQ controller continuously discards the oldest samples in the buffer to make space for the next sample. This data can be accessed (with some limitations) before the cDAQ controller discards it. Refer to the KnowledgeBase document, *Can a*

Pretriggered Acquisition be Continuous?, for more information. To access this KnowledgeBase, go to ni.com/info and enter the Info Code rdcanq.

When the reference trigger occurs, the cDAQ controller continues to write samples to the buffer until the buffer contains the number of posttrigger samples desired. Figure 2-3 shows the final buffer.

Figure 2-3. Reference Trigger Final Buffer



Using a Digital Source

To use Reference Trigger with a digital source, specify a source and a rising or falling edge. Either PFI or one of several internal signals on the cDAQ controller can provide the source. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information.

Using an Analog Source

Some C Series modules can generate a trigger based on an analog signal. In NI-DAQmx, this is called the Analog Comparison Event.

When you use an analog trigger source, the acquisition stops on the first rising or falling edge of the Analog Comparison Event signal, depending on the trigger properties.

Note Depending on the C Series module capabilities, you may need two modules to utilize analog triggering.

Routing the Reference Trigger Signal to an Output Terminal

You can route Reference Trigger to any output PFI terminal. Reference Trigger is active high by default.

AI Pause Trigger Signal

You can use the Pause Trigger to pause and resume a measurement acquisition. The internal sample clock pauses while the external trigger signal is active and resumes when the signal is inactive. You can program the active level of the pause trigger to be high or low.

Using a Digital Source

To use the Pause Trigger, specify a source and a polarity. The source can be either from PFI or one of several other internal signals on your cDAQ controller. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information.

Using an Analog Source

Some C Series modules can generate a trigger based on an analog signal. In NI-DAQmx, this is called the Analog Comparison Event.

When you use an analog trigger source, the internal sample clock pauses when the Analog Comparison Event signal is low and resumes when the signal goes high (or vice versa).

Note Depending on the C Series module capabilities, you may need two modules to utilize analog triggering.

Note Pause triggers are only sensitive to the level of the source, not the edge.

Getting Started with AI Applications in Software

You can use the cDAQ controller in the following analog input applications:

- Single-point acquisition
- Finite acquisition
- Continuous acquisition

For more information about programming analog input applications and triggers in software, refer to the *NI-DAQmx Help* or the *LabVIEW Help* for more information.

3

Analog Output

To generate analog output, insert an analog output C Series module in any slot on the cDAQ controller. The generation specifications, such as the number of channels, channel configuration, update rate, and output range, are determined by the type of C Series module used. For more information, refer to the documentation included with your C Series module(s).

On a single analog output C Series module, you can assign any number of channels to either a hardware-timed task or a software-timed (single-point) task. However, you cannot assign some channels to a hardware-timed task and other channels (on the same module) to a software-timed task.

Any hardware-timed task or software-timed task can have channels from multiple modules in the same controller.

Analog Output Data Generation Methods

When performing an analog output operation, you either can perform software-timed or hardware-timed generations. Hardware-timed generations must be buffered.

Software-Timed Generations

With a software-timed generation, software controls the rate at which data is generated. Software sends a separate command to the hardware to initiate each DAC conversion. In NI-DAQmx, software-timed generations are referred to as on-demand timing. Software-timed generations are also referred to as immediate or static operations. They are typically used for writing out a single value, such as a constant DC voltage.

The following considerations apply to software-timed generations:

- If any AO channel on a module is used in a hardware-timed (waveform) task, no channels on that module can be used in a software-timed task
- You can configure software-timed generations to simultaneously update
- Only one simultaneous update task can run at a time
- A hardware-timed AO task and a simultaneous update AO task cannot run at the same time

Hardware-Timed Generations

With a hardware-timed generation, a digital hardware signal controls the rate of the generation. This signal can be generated internally on the controller or provided externally.

Hardware-timed generations have several advantages over software-timed acquisitions:

- The time between samples can be much shorter
- The timing between samples is deterministic
- Hardware-timed acquisitions can use hardware triggering

Hardware-timed AO operations on the cDAQ controller must be buffered.

Buffered Analog Output

A buffer is a temporary storage in computer memory for generated samples. In a buffered generation, data is moved from a host buffer to the cDAQ controller onboard FIFO before it is written to the C Series modules.

One property of buffered I/O operations is sample mode. The sample mode can be either finite or continuous:

- **Finite**—Finite sample mode generation refers to the generation of a specific, predetermined number of data samples. After the specified number of samples is written out, the generation stops.
- **Continuous**—Continuous generation refers to the generation of an unspecified number of samples. Instead of generating a set number of data samples and stopping, a continuous generation continues until you stop the operation. There are three different continuous generation modes that control how the data is written. These modes are regeneration, onboard regeneration, and non-regeneration:
  - In regeneration mode, you define a buffer in host memory. The data from the buffer is continually downloaded to the FIFO to be written out. New data can be written to the host buffer at any time without disrupting the output. There is no limitation on the number of waveform channels supported by regeneration mode.
  - With onboard regeneration, the entire buffer is downloaded to the FIFO and regenerated from there. After the data is downloaded, new data cannot be written to the FIFO. To use onboard regeneration, the entire buffer must fit within the FIFO size. The advantage of using onboard regeneration is that it does not require communication with the main host memory once the operation is started, which prevents problems that may occur due to excessive bus traffic or operating system latency. There is a limit of 16 waveform channels for onboard regeneration.
  - With non-regeneration, old data is not repeated. New data must continually be written to the buffer. If the program does not write new data to the buffer at a fast enough rate to keep up with the generation, the buffer underflows and causes an error. There is no limitation on the number of waveform channels supported by non-regeneration.

Analog Output Triggering Signals

Analog output supports two different triggering actions: AO Start Trigger and AO Pause Trigger.

An analog or digital trigger can initiate these actions. Up to two C Series parallel digital input modules can be used in any controller slot to supply a digital trigger. An analog trigger can be supplied by some C Series analog modules.

Refer to the *AO Start Trigger Signal* and *AO Pause Trigger Signal* sections for more information about the analog output trigger signals.

Analog Output Timing Signals

The cDAQ controller features the following AO (waveform generation) timing signals:

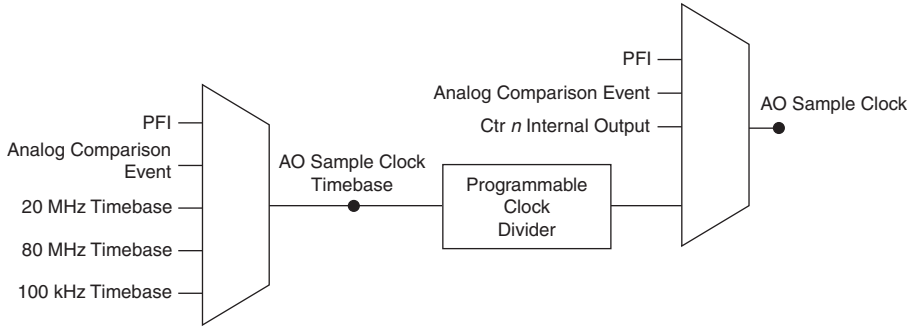
- *AO Sample Clock Signal**
- *AO Sample Clock Timebase Signal*
- *AO Start Trigger Signal**
- *AO Pause Trigger Signal**

Signals with an * support digital filtering. Refer to the *PFI Filters* section of Chapter 4, *Digital Input/Output and PFI*, for more information.

AO Sample Clock Signal

The AO sample clock (ao/SampleClock) signals when all the analog output channels in the task update. AO Sample Clock can be generated from external or internal sources as shown in Figure 3-1.

Figure 3-1. Analog Output Timing Options



Routing AO Sample Clock to an Output Terminal

You can route AO Sample Clock to any output PFI terminal. AO Sample Clock is active high by default.

AO Sample Clock Timebase Signal

The AO Sample Clock Timebase (ao/SampleClockTimebase) signal is divided down to provide a source for AO Sample Clock. AO Sample Clock Timebase can be generated from external or internal sources, and is not available as an output from the controller.

AO Start Trigger Signal

Use the AO Start Trigger (ao/StartTrigger) signal to initiate a waveform generation. If you do not use triggers, you can begin a generation with a software command. If you are using an internal sample clock, you can specify a delay from the start trigger to the first sample. For more information, refer to the *NI-DAQmx Help*.

Using a Digital Source

To use AO Start Trigger, specify a source and a rising or falling edge. The source can be one of the following signals:

- A pulse initiated by host software
- Any PFI terminal
- AI Reference Trigger
- AI Start Trigger

The source also can be one of several internal signals on the cDAQ controller. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information.

You also can specify whether the waveform generation begins on the rising edge or falling edge of AO Start Trigger.

Using an Analog Source

Some C Series modules can generate a trigger based on an analog signal. In NI-DAQmx, this is called the Analog Comparison Event, depending on the trigger properties.

When you use an analog trigger source, the waveform generation begins on the first rising or falling edge of the Analog Comparison Event signal, depending on the trigger properties. The analog trigger circuit must be configured by a simultaneously running analog input task.



Note Depending on the C Series module capabilities, you may need two modules to utilize analog triggering.

Routing AO Start Trigger Signal to an Output Terminal

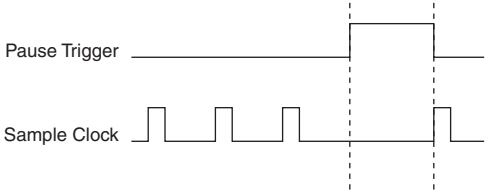
You can route AO Start Trigger to any output PFI terminal. The output is an active high pulse.

AO Pause Trigger Signal

Use the AO Pause Trigger signal (ao/PauseTrigger) to mask off samples in a DAQ sequence. When AO Pause Trigger is active, no samples occur, but AO Pause Trigger does not stop a sample that is in progress. The pause does not take effect until the beginning of the next sample.

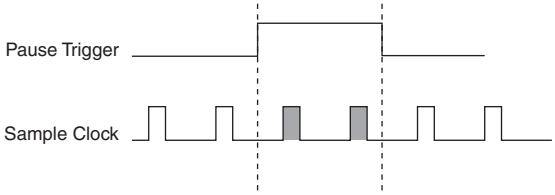
When you generate analog output signals, the generation pauses as soon as the pause trigger is asserted. If the source of the sample clock is the onboard clock, the generation resumes as soon as the pause trigger is deasserted, as shown in Figure 3-2.

Figure 3-2. AO Pause Trigger with the Onboard Clock Source



If you are using any signal other than the onboard clock as the source of the sample clock, the generation resumes as soon as the pause trigger is deasserted and another edge of the sample clock is received, as shown in Figure 3-3.

Figure 3-3. AO Pause Trigger with Other Signal Source



Using a Digital Source

To use AO Pause Trigger, specify a source and a polarity. The source can be a PFI signal or one of several other internal signals on the cDAQ controller.

You also can specify whether the samples are paused when AO Pause Trigger is at a logic high or low level. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information.

Using an Analog Source

Some C Series modules can generate a trigger based on an analog signal. In NI-DAQmx, this is called the Analog Comparison Event, depending on the trigger properties.

When you use an analog trigger source, the samples are paused when the Analog Comparison Event signal is at a high or low level, depending on the trigger properties. The analog trigger circuit must be configured by a simultaneously running analog input task.

Note Depending on the C Series module capabilities, you may need two modules to utilize analog triggering.

Minimizing Glitches on the Output Signal

When you use a DAC to generate a waveform, you may observe glitches on the output signal. These glitches are normal; when a DAC switches from one voltage to another, it produces glitches due to released charges. The largest glitches occur when the most significant bit of the DAC code changes. You can build a lowpass deglitching filter to remove some of these glitches, depending on the frequency and nature of the output signal. Go to `ni.com/support` for more information about minimizing glitches.

Getting Started with AO Applications in Software

You can use the cDAQ controller in the following analog output applications:

- Single-point (on-demand) generation
- Finite generation
- Continuous generation
- Waveform generation

For more information about programming analog output applications and triggers in software, refer the *LabVIEW Help* or to the *NI-DAQmx Help*.

4

Digital Input/Output and PFI

This chapter describes the digital input/output (DIO) and Programmable Function Interface (PFI) functionality available on the cDAQ controller. Refer to the *Digital Input/Output* and *PFI* sections.

Digital Input/Output

To use digital I/O, insert a digital I/O C Series module into any slot on the cDAQ controller. The I/O specifications, such as number of lines, logic levels, update rate, and line direction, are determined by the type of C Series module used. For more information, refer to the documentation included with your C Series module(s).

Serial DIO versus Parallel DIO Modules

Serial digital I/O modules have more than eight lines of digital input/output. They can be used in any controller slot and can perform the following tasks:

- Software-timed and hardware-timed digital input/output tasks

Parallel digital I/O modules can be used in any controller slot and can perform the following tasks:

- Software-timed and hardware-timed digital input/output tasks
- Counter/timer tasks (can be used in up to two slots)
- Accessing PFI signal tasks (can be used in up to two slots)
- Filter digital input signals

Software-timed and hardware-timed digital input/output tasks have the following restrictions:

- You cannot use parallel and serial modules together on the same hardware-timed task.
- You cannot use serial modules for triggering.
- You cannot do both static and timed tasks at the same time on a single serial module.
- You can only do hardware timing in one direction at a time on a serial bidirectional module.

To determine the capability of digital I/O modules supported by the cDAQ controller, refer to the *C Series Support in NI-DAQmx* document by going to `ni.com/info` and entering the Info Code `rdcdaq`.

Static DIO

Each of the DIO lines can be used as a static DI or DO line. You can use static DIO lines to monitor or control digital signals on some C Series modules. Each DIO line can be individually configured as a digital input (DI) or digital output (DO), if the C Series module being used allows such configuration.

All samples of static DI lines and updates of static DO lines are software-timed.

Digital Input

You can acquire digital waveforms using either parallel or serial digital modules.
The DI waveform acquisition FIFO stores the digital samples. The cDAQ controller samples the DIO lines on each rising or falling edge of the DI Sample Clock signal.

Digital Input Triggering Signals

A trigger is a signal that causes an action, such as starting or stopping the acquisition of data. When you configure a trigger, you must decide how you want to produce the trigger and the action you want the trigger to cause. The cDAQ controller supports three types of digital triggering: internal software digital triggering, external digital triggering, and internal digital triggering.

Three triggers are available: Start Trigger, Reference Trigger, and Pause Trigger. An analog or digital trigger can initiate these three trigger actions. Up to two C Series parallel digital input modules can be used in any controller slot to supply a digital trigger. To find your module triggering options, refer to the documentation included with your C Series modules. For more information about using analog modules for triggering, refer to the *Analog Input Triggering Signals* section of Chapter 2, *Analog Input*, and the *Analog Output Triggering Signals* section of Chapter 3, *Analog Output*.

Refer to the *DI Start Trigger Signal*, *DI Reference Trigger Signal*, and *DI Pause Trigger Signal* sections for more information about the digital input trigger signals.

Digital Input Timing Signals

The cDAQ controller features the following digital input timing signals:

- *DI Sample Clock Signal**
- *DI Sample Clock Timebase Signal*
- *DI Start Trigger Signal**
- *DI Reference Trigger Signal**
- *DI Pause Trigger Signal**

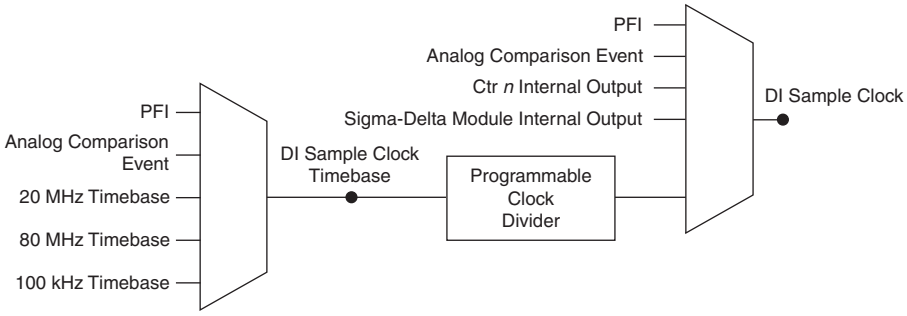
Signals with an * support digital filtering. Refer to the *PFI Filters* section for more information.

DI Sample Clock Signal

Use the DI Sample Clock (di/SampleClock) signal to sample digital I/O on any slot using parallel digital modules, and store the result in the DI waveform acquisition FIFO. If the cDAQ controller receives a DI Sample Clock signal when the FIFO is full, it reports an overflow error to the host software.

A sample consists of one reading from each channel in the DI task. DI Sample Clock signals the start of a sample of all digital input channels in the task. DI Sample Clock can be generated from external or internal sources as shown in Figure 4-1.

Figure 4-1. DI Sample Clock Timing Options



Routing DI Sample Clock to an Output Terminal

You can route DI Sample Clock to any output PFI terminal.

DI Sample Clock Timebase Signal

The DI Sample Clock Timebase (di/SampleClockTimebase) signal is divided down to provide a source for DI Sample Clock. DI Sample Clock Timebase can be generated from external or internal sources. DI Sample Clock Timebase is not available as an output from the controller.

Using an Internal Source

To use DI Sample Clock with an internal source, specify the signal source and the polarity of the signal. Use the following signals as the source:

- AI Sample Clock
- AO Sample Clock
- Counter *n* Internal Output
- Frequency Output
- DI Change Detection Output

Several other internal signals can be routed to DI Sample Clock. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information.

Using an External Source

You can route the following signals as DI Sample Clock:

- Any PFI terminal
- Analog Comparison Event (an analog trigger)

You can sample data on the rising or falling edge of DI Sample Clock.

Routing DI Sample Clock to an Output Terminal

You can route DI Sample Clock to any output PFI terminal. The PFI circuitry inverts the polarity of DI Sample Clock before driving the PFI terminal.

DI Start Trigger Signal

Use the DI Start Trigger (di/StartTrigger) signal to begin a measurement acquisition. A measurement acquisition consists of one or more samples. If you do not use triggers, begin a measurement with a software command. Once the acquisition begins, configure the acquisition to stop in one of the following ways:

- When a certain number of points has been sampled (in finite mode)
- After a hardware reference trigger (in finite mode)
- With a software command (in continuous mode)

An acquisition that uses a start trigger (but not a reference trigger) is sometimes referred to as a posttriggered acquisition. That is, samples are measured only after the trigger.

When you are using an internal sample clock, you can specify a delay from the start trigger to the first sample.

Using a Digital Source

To use DI Start Trigger with a digital source, specify a source and a rising or falling edge. Use the following signals as the source:

- Any PFI terminal
- Counter *n* Internal Output

The source also can be one of several other internal signals on the cDAQ controller. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information.

Using an Analog Source

Some C Series modules can generate a trigger based on an analog signal. In NI-DAQmx, this is called the Analog Comparison Event. When you use an analog trigger source for DI Start Trigger, the acquisition begins on the first rising edge of the Analog Comparison Event signal.



Note Depending on the C Series module capabilities, you may need two modules to utilize analog triggering.

Routing DI Start Trigger to an Output Terminal

You can route DI Start Trigger to any output PFI terminal. The output is an active high pulse.

DI Reference Trigger Signal

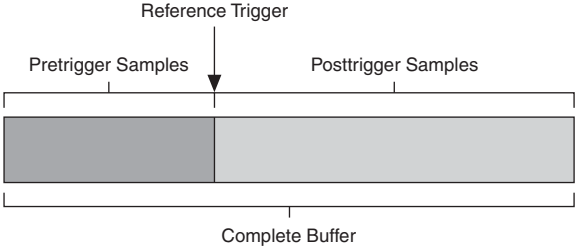
Use a reference trigger (di/ReferenceTrigger) signal to stop a measurement acquisition. To use a reference trigger, specify a buffer of finite size and a number of pretrigger samples (samples that occur before the reference trigger). The number of posttrigger samples (samples that occur after the reference trigger) desired is the buffer size minus the number of pretrigger samples.

Once the acquisition begins, the cDAQ controller writes samples to the buffer. After the cDAQ controller captures the specified number of pretrigger samples, the controller begins to look for the reference trigger condition. If the reference trigger condition occurs before the cDAQ controller captures the specified number of pretrigger samples, the controller ignores the condition.

If the buffer becomes full, the cDAQ controller continuously discards the oldest samples in the buffer to make space for the next sample. This data can be accessed (with some limitations) before the cDAQ controller discards it. Refer to the KnowledgeBase document, *Can a Pretriggered Acquisition be Continuous?*, for more information. To access this KnowledgeBase, go to `ni.com/info` and enter the Info Code `rdcanq`.

When the reference trigger occurs, the cDAQ controller continues to write samples to the buffer until the buffer contains the number of posttrigger samples desired. Figure 4-2 shows the final buffer.

Figure 4-2. Reference Trigger Final Buffer



Using a Digital Source

To use DI Reference Trigger with a digital source, specify a source and a rising or falling edge. Either PFI or one of several internal signals on the cDAQ controller can provide the source. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information.

Using an Analog Source

Some C Series modules can generate a trigger based on an analog signal. In NI-DAQmx, this is called the Analog Comparison Event.

When you use an analog trigger source, the acquisition stops on the first rising or falling edge of the Analog Comparison Event signal, depending on the trigger properties.

Note Depending on the C Series module capabilities, you may need two modules to utilize analog triggering.

Routing DI Reference Trigger Signal to an Output Terminal

You can route DI Reference Trigger to any output PFI terminal. Reference Trigger is active high by default.

DI Pause Trigger Signal

You can use the DI Pause Trigger (di/PauseTrigger) signal to pause and resume a measurement acquisition. The internal sample clock pauses while the external trigger signal is active and resumes when the signal is inactive. You can program the active level of the pause trigger to be high or low.

Using a Digital Source

To use DI Pause Trigger, specify a source and a polarity. The source can be either from PFI or one of several other internal signals on your cDAQ controller. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information.

Using an Analog Source

Some C Series modules can generate a trigger based on an analog signal. In NI-DAQmx, this is called the Analog Comparison Event.

When you use an analog trigger source, the internal sample clock pauses when the Analog Comparison Event signal is low and resumes when the signal goes high (or vice versa).

Note Depending on the C Series module capabilities, you may need two modules to utilize analog triggering.

Note Pause triggers are only sensitive to the level of the source, not the edge.

Digital Input Filters

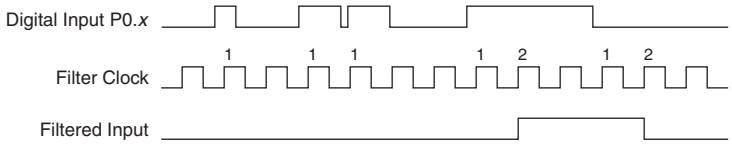
When performing a hardware timed task, you can enable a programmable debouncing filter on the digital input lines of a parallel DIO module. All lines on a module must share the same filter configuration. When the filter is enabled, the controller samples the inputs with a user-configured Filter Clock derived from the controller timebase. This is used to determine whether a pulse is propagated to the rest of the system. However, the filter also introduces jitter onto the input signal.

In NI-DAQmx, the filter is programmed by setting the minimum pulse width, *Tp*[1], that will pass the filter, and is selectable in 25 ns increments. The appropriate Filter Clock is selected by the driver. Pulses of length less than 1/2 *Tp* will be rejected, and the filtering behavior of lengths between 1/2 *Tp* and 1 *Tp* are not defined because they depend on the phase of the Filter Clock relative to the input signal.

Figure 4-3 shows an example of low-to-high transitions of the input signal. High-to-low transitions work similarly.

Assume that an input terminal has been low for a long time. The input terminal then changes from low to high, but glitches several times. When the filter clock has sampled the signal high on consecutive rising edges, the low-to-high transition is propagated to the rest of the circuit.

Figure 4-3. Filter Example



Getting Started with DI Applications in Software

You can use the cDAQ controller in the following digital input applications:

- Single-point acquisition
- Finite acquisition
- Continuous acquisition

For more information about programming digital input applications and triggers in software, refer to the *NI-DAQmx Help* or the *LabVIEW Help* for more information.

Change Detection Event

The Change Detection Event is the signal generated when a change on the rising or falling edge lines is detected by the change detection task.

Routing Change Detection Event to an Output Terminal

You can route ChangeDetectionEvent to any output PFI terminal.

Change Detection Acquisition

You can configure lines on parallel digital modules to detect rising or falling edges. When one or more of these lines sees the edge specified for that line, the cDAQ controller samples all the lines in the task. The rising and falling edge lines do not necessarily have to be in the task.

[1] *Tp* is a nominal value; the accuracy of the controller timebase and I/O distortion will affect this value.

Change detection acquisitions can be buffered or nonbuffered:

- **Nonbuffered Change Detection Acquisition**—In a nonbuffered acquisition, data is transferred from the cDAQ controller directly to a PC buffer.
- **Buffered Change Detection Acquisition**—A buffer is a temporary storage in computer memory for acquired samples. In a buffered acquisition, data is stored in the cDAQ controller onboard FIFO then transferred to a PC buffer. Buffered acquisitions typically allow for much faster transfer rates than nonbuffered acquisitions because data accumulates and is transferred in blocks, rather than one sample at a time.

Digital Output

To generate digital output, insert a digital output C Series module in any slot on the cDAQ controller. The generation specifications, such as the number of channels, channel configuration, update rate, and output range, are determined by the type of C Series module used. For more information, refer to the documentation included with your C Series module(s).

With parallel digital output modules (formerly known as hardware-timed modules), you can do multiple software-timed tasks on a single module, as well as mix hardware-timed and software-timed digital output tasks on a single module. On serial digital output modules, (formerly known as static digital output modules), you cannot mix hardware-timed and software-timed tasks, but you can run multiple software-timed tasks.

You may have a hardware-timed task or a software-timed task include channels from multiple modules, but a hardware-timed task may not include a mix of channels from both parallel and serial modules.

Digital Output Data Generation Methods

When performing a digital output operation, you either can perform software-timed or hardware-timed generations. Hardware-timed generations must be buffered.

Software-Timed Generations

With a software-timed generation, software controls the rate at which data is generated. Software sends a separate command to the hardware to initiate each digital generation. In NI-DAQmx, software-timed generations are referred to as on-demand timing. Software-timed generations are also referred to as immediate or static operations. They are typically used for writing out a single value.

For software-timed generations, if any DO channel on a serial digital module is used in a hardware-timed task, no channels on that module can be used in a software-timed task.

Hardware-Timed Generations

With a hardware-timed generation, a digital hardware signal controls the rate of the generation. This signal can be generated internally on the controller or provided externally.

Hardware-timed generations have several advantages over software-timed acquisitions:

- The time between samples can be much shorter.
- The timing between samples is deterministic.
- Hardware-timed acquisitions can use hardware triggering.

Hardware-timed DO operations on the cDAQ controller must be buffered.

Buffered Digital Output

A buffer is a temporary storage in computer memory for generated samples. In a buffered generation, data is moved from a host buffer to the cDAQ controller onboard FIFO before it is written to the C Series module(s).

One property of buffered I/O operations is sample mode. The sample mode can be either finite or continuous:

- **Finite**—Finite sample mode generation refers to the generation of a specific, predetermined number of data samples. After the specified number of samples is written out, the generation stops.
- **Continuous**—Continuous generation refers to the generation of an unspecified number of samples. Instead of generating a set number of data samples and stopping, a continuous generation continues until you stop the operation. There are three different continuous generation modes that control how the data is written. These modes are regeneration, onboard regeneration, and non-regeneration:
  - In regeneration mode, you define a buffer in host memory. The data from the buffer is continually downloaded to the FIFO to be written out. New data can be written to the host buffer at any time without disrupting the output.
  - With onboard regeneration, the entire buffer is downloaded to the FIFO and regenerated from there. After the data is downloaded, new data cannot be written to the FIFO. To use onboard regeneration, the entire buffer must fit within the FIFO size. The advantage of using onboard regeneration is that it does not require communication with the main host memory once the operation is started, which prevents problems that may occur due to excessive bus traffic or operating system latency.



Note Install parallel DO modules in slots 1 through 4 to maximize accessible FIFO size because using a module in slots 5 through 8 will reduce the accessible FIFO size.

  - With non-regeneration, old data is not repeated. New data must continually be written to the buffer. If the program does not write new data to the buffer at a fast enough rate to keep up with the generation, the buffer underflows and causes an error.

Digital Output Triggering Signals

Digital output supports two different triggering actions: DO Start Trigger and DO Pause Trigger.

A digital or analog trigger can initiate these actions. Any PFI terminal can supply a digital trigger, and some C Series analog modules can supply an analog trigger. For more information, refer to the documentation included with your C Series module(s).

Refer to the *DO Start Trigger Signal* and *DO Pause Trigger Signal* sections for more information about the digital output trigger signals.

Digital Output Timing Signals

The cDAQ controller features the following DO timing signals:

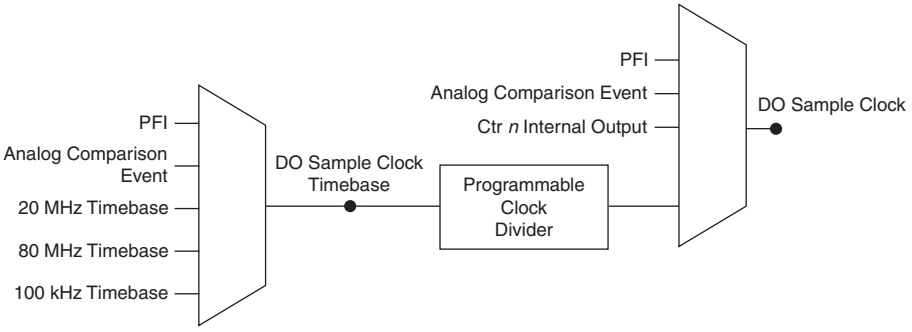
- *DO Sample Clock Signal**
- *DO Sample Clock Timebase Signal*
- *DO Start Trigger Signal**
- *DO Pause Trigger Signal**

Signals with an * support digital filtering. Refer to the *PFI Filters* section for more information.

DO Sample Clock Signal

The DO Sample Clock (do/SampleClock) signals when all the digital output channels in the task update. DO Sample Clock can be generated from external or internal sources as shown in Figure 4-4.

Figure 4-4. Digital Output Timing Options



Routing DO Sample Clock to an Output Terminal

You can route DO Sample Clock to any output PFI terminal. DO Sample Clock is active high by default.

DO Sample Clock Timebase Signal

The DO Sample Clock Timebase (do/SampleClockTimebase) signal is divided down to provide a source for DO Sample Clock. DO Sample Clock Timebase can be generated from external or internal sources, and is not available as an output from the controller.

DO Start Trigger Signal

Use the DO Start Trigger (do/StartTrigger) signal to initiate a waveform generation. If you do not use triggers, you can begin a generation with a software command. If you are using an internal sample clock, you can specify a delay from the start trigger to the first sample. For more information, refer to the *NI-DAQmx Help*.

Using a Digital Source

To use DO Start Trigger, specify a source and a rising or falling edge. The source can be one of the following signals:

- A pulse initiated by host software
- Any PFI terminal
- AI Reference Trigger
- AI Start Trigger

The source also can be one of several internal signals on the cDAQ controller. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information.

You also can specify whether the waveform generation begins on the rising edge or falling edge of DO Start Trigger.

Using an Analog Source

Some C Series modules can generate a trigger based on an analog signal. In NI-DAQmx, this is called the Analog Comparison Event, depending on the trigger properties.

When you use an analog trigger source, the waveform generation begins on the first rising or falling edge of the Analog Comparison Event signal, depending on the trigger properties. The analog trigger circuit must be configured by a simultaneously running analog input task.

Note Depending on the C Series module capabilities, you may need two modules to utilize analog triggering.

Routing DO Start Trigger Signal to an Output Terminal

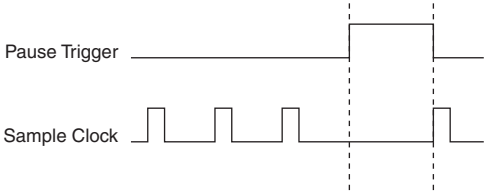
You can route DO Start Trigger to any output PFI terminal. The output is an active high pulse.

DO Pause Trigger Signal

Use the DO Pause Trigger signal (do/PauseTrigger) to mask off samples in a DAQ sequence. When DO Pause Trigger is active, no samples occur, but DO Pause Trigger does not stop a sample that is in progress. The pause does not take effect until the beginning of the next sample.

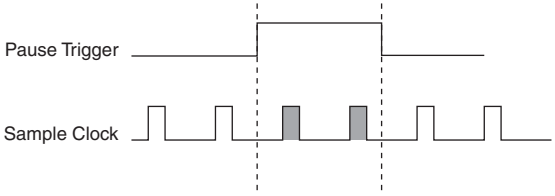
When you generate digital output signals, the generation pauses as soon as the pause trigger is asserted. If the source of the sample clock is the onboard clock, the generation resumes as soon as the pause trigger is deasserted, as shown in Figure 4-5.

Figure 4-5. DO Pause Trigger with the Onboard Clock Source



If you are using any signal other than the onboard clock as the source of the sample clock, the generation resumes as soon as the pause trigger is deasserted and another edge of the sample clock is received, as shown in Figure 4-6.

Figure 4-6. DO Pause Trigger with Other Signal Source



Using a Digital Source

To use DO Pause Trigger, specify a source and a polarity. The source can be a PFI signal or one of several other internal signals on the cDAQ controller.

You also can specify whether the samples are paused when DO Pause Trigger is at a logic high or low level. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information.

Using an Analog Source

Some C Series modules can generate a trigger based on an analog signal. In NI-DAQmx, this is called the Analog Comparison Event, depending on the trigger properties.

When you use an analog trigger source, the samples are paused when the Analog Comparison Event signal is at a high or low level, depending on the trigger properties. The analog trigger circuit must be configured by a simultaneously running analog input task.

Note Depending on the C Series module capabilities, you may need two modules to utilize analog triggering.

Getting Started with DO Applications in Software

You can use the cDAQ controller in the following digital output applications:

- Single-point (on-demand) generation
- Finite generation
- Continuous generation

For more information about programming digital output applications and triggers in software, refer the *LabVIEW Help* or to the *NI-DAQmx Help*.

Digital Input/Output Configuration for NI 9401

When you change the configuration of lines on a NI 9401 digital I/O module between input and output, NI-DAQmx temporarily reserves all of the lines on the module for communication to send the module a line configuration command. For this reason, you must reserve the task in advance through the DAQmx Control Task before any task has started. If another task or route is actively using the module, to avoid interfering with the other task, NI-DAQmx generates an error instead of sending the line configuration command. During the line configuration command, the output lines are maintained without glitching.

PFI

You can configure channels of a parallel digital module as Programmable Function Interface (PFI) terminals. Up to two digital modules can be used to access PFI terminals in a single controller.

You can configure each PFI individually as the following:

- Timing input signal for AI, AO, DI, DO, or counter/timer functions
- Timing output signal from AI, AO, DI, DO, or counter/timer functions

PFI Filters

You can enable a programmable debouncing filter on each PFI signal. When the filter is enabled, the controller samples the inputs with a user-configured Filter Clock derived from the controller timebase. This is used to determine whether a pulse is propagated to the rest of the circuit. However, the filter also introduces jitter onto the PFI signal.

The following is an example of low-to-high transitions of the input signal. High-to-low transitions work similarly.

Assume that an input terminal has been low for a long time. The input terminal then changes from low to high, but glitches several times. When the Filter Clock has sampled the signal high

on *N* consecutive edges, the low-to-high transition is propagated to the rest of the circuit. The value of *N* depends on the filter setting, as shown in Table 4-1.

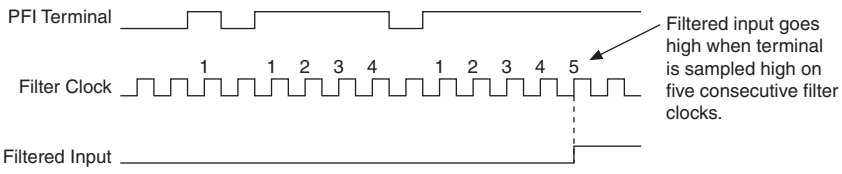
Table 4-1. Selectable PFI Filter Settings

Filter Setting	Filter Clock	Jitter	Min Pulse Width* to Pass	Max Pulse Width* to Not Pass
112.5 ns (short)	80 MHz	12.5 ns	112.5 ns	100 ns
6.4 µs (medium)	80 MHz	12.5 ns	6.4 µs	6.3875 µs
2.56 ms (high)	100 kHz	10 µs	2.56 ms	2.55 ms
Custom	User-configurable	1 Filter Clock period	T_{user}	T_{user} - (1 Filter Clock period)

* Pulse widths are nominal values; the accuracy of the controller timebase and I/O distortion will affect these values.

On powerup, the filters are disabled. Figure 4-7 shows an example of a low-to-high transition on an input that has a custom filter set to $N = 5$.

Figure 4-7. PFI Filter Example

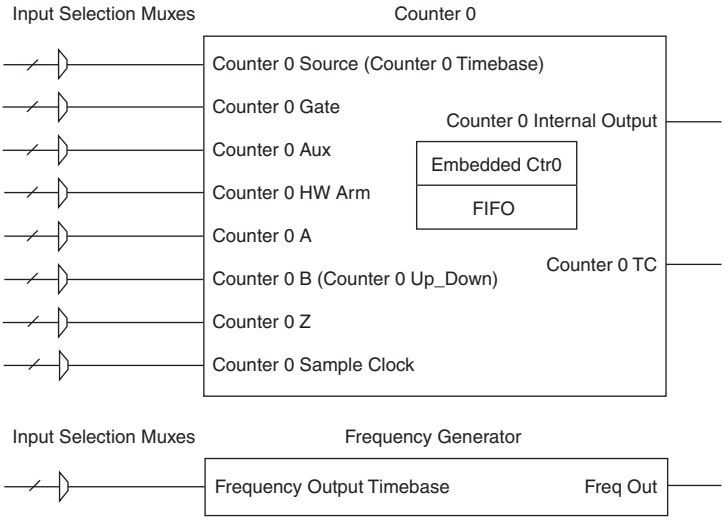


5

Counters

The cDAQ controller has four general-purpose 32-bit counter/timers and one frequency generator. The general-purpose counter/timers can be used for many measurement and pulse generation applications. Figure 5-1 shows the cDAQ controller Counter 0 and the frequency generator. All four counters on the cDAQ controller are identical.

Figure 5-1. Controller Counter 0 and Frequency Generator



Counters have eight input signals, although in most applications only a few inputs are used.

For information about connecting counter signals, refer to the *Default Counter/Timer Routing* section.

Each counter has a FIFO that can be used for buffered acquisition and generation. Each counter also contains an embedded counter (Embedded Ctr*n*) for use in what are traditionally two-counter measurements and generations. The embedded counters cannot be programmed independent of the main counter; signals from the embedded counters are not routable.

Counter Timing Engine

Unlike analog input, analog output, digital input, and digital output, the cDAQ controller counters do not have the ability to divide down a timebase to produce an internal counter sample clock. For sample clocked operations, an external signal must be provided to supply a clock source. The source can be any of the following signals:

- AI Sample Clock
- AI Start Trigger
- AI Reference Trigger
- AO Sample Clock
- DI Sample Clock
- DI Start Trigger
- DO Sample Clock
- CTR *n* Internal Output
- Freq Out
- PFI
- Change Detection Event
- Analog Comparison Event

Not all timed counter operations require a sample clock. For example, a simple buffered pulse width measurement latches in data on each edge of a pulse. For this measurement, the measured signal determines when data is latched in. These operations are referred to as implicit timed operations. However, many of the same measurements can be clocked at an interval with a sample clock. These are referred to as sample clocked operations. Table 5-1 shows the different options for the different measurements.

Table 5-1. Counter Timing Measurements

Measurement	Implicit Timing Support	Sample Clocked Timing Support
Buffered Edge Count	No	Yes
Buffered Pulse Width	Yes	Yes
Buffered Pulse	Yes	Yes
Buffered Semi-Period	Yes	No
Buffered Frequency	Yes	Yes
Buffered Period	Yes	Yes

Table 5-1. Counter Timing Measurements (Continued)

Measurement	Implicit Timing Support	Sample Clocked Timing Support
Buffered Position	No	Yes
Buffered Two-Signal Edge Separation	Yes	Yes

Counter Input Applications

The following sections list the various counter input applications available on the cDAQ controller:

- *Counting Edges*
- *Pulse-Width Measurement*
- *Pulse Measurement*
- *Semi-Period Measurement*
- *Frequency Measurement*
- *Period Measurement*
- *Position Measurement*

Counting Edges

In edge counting applications, the counter counts edges on its Source after the counter is armed. You can configure the counter to count rising or falling edges on its Source input. You also can control the direction of counting (up or down), as described in the *Controlling the Direction of Counting* section. The counter values can be read on demand or with a sample clock.

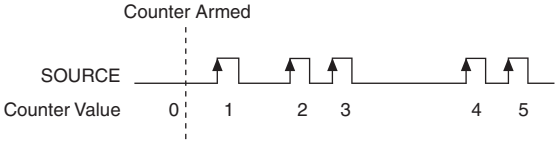
Refer to the following sections for more information about edge counting options:

- *Single Point (On-Demand) Edge Counting*
- *Buffered (Sample Clock) Edge Counting*

Single Point (On-Demand) Edge Counting

With single point (on-demand) edge counting, the counter counts the number of edges on the Source input after the counter is armed. On-demand refers to the fact that software can read the counter contents at any time without disturbing the counting process. Figure 5-2 shows an example of single point edge counting.

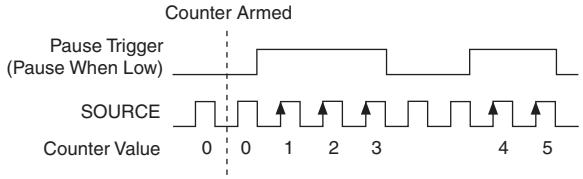
Figure 5-2. Single Point (On-Demand) Edge Counting



You also can use a pause trigger to pause (or gate) the counter. When the pause trigger is active, the counter ignores edges on its Source input. When the pause trigger is inactive, the counter counts edges normally.

You can route the pause trigger to the Gate input of the counter. You can configure the counter to pause counting when the pause trigger is high or when it is low. Figure 5-3 shows an example of on-demand edge counting with a pause trigger.

Figure 5-3. Single Point (On-Demand) Edge Counting with Pause Trigger



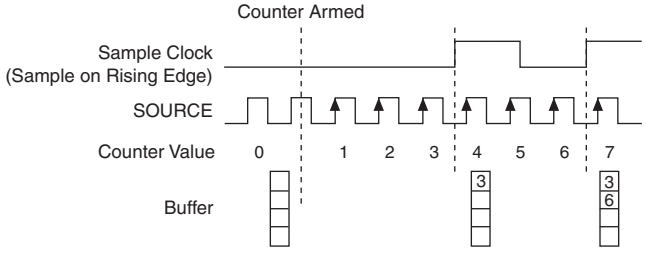
Buffered (Sample Clock) Edge Counting

With buffered edge counting (edge counting using a sample clock), the counter counts the number of edges on the Source input after the counter is armed. The value of the counter is sampled on each active edge of a sample clock and stored in the FIFO. The STC3 transfers the sampled values to host memory using a high-speed data stream.

The count values returned are the cumulative counts since the counter armed event. That is, the sample clock does not reset the counter. You can configure the counter to sample on the rising or falling edge of the sample clock.

Figure 5-4 shows an example of buffered edge counting. Notice that counting begins when the counter is armed, which occurs before the first active edge on Sample Clock.

Figure 5-4. Buffered (Sample Clock) Edge Counting



Controlling the Direction of Counting

In edge counting applications, the counter can count up or down. You can configure the counter to do the following:

- Always count up
- Always count down

- Count up when the Counter 0 B input is high; count down when it is low

For information about connecting counter signals, refer to the *Default Counter/Timer Routing* section.

Pulse-Width Measurement

In pulse-width measurements, the counter measures the width of a pulse on its Gate input signal. You can configure the counter to measure the width of high pulses or low pulses on the Gate signal.

You can route an internal or external periodic clock signal (with a known period) to the Source input of the counter. The counter counts the number of rising (or falling) edges on the Source signal while the pulse on the Gate signal is active.

You can calculate the pulse width by multiplying the period of the Source signal by the number of edges returned by the counter.

A pulse-width measurement will be accurate even if the counter is armed while a pulse train is in progress. If a counter is armed while the pulse is in the active state, it will wait for the next transition to the active state to begin the measurement.

Refer to the following sections for more information about cDAQ controller pulse-width measurement options:

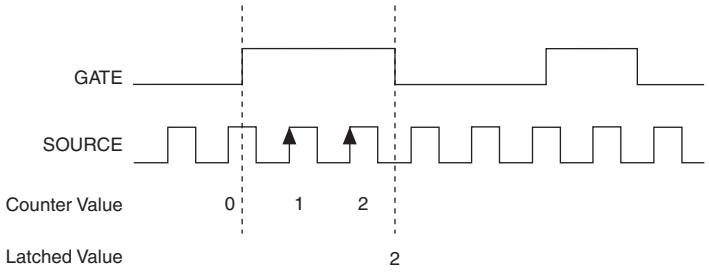
- *Single Pulse-Width Measurement*
- *Implicit Buffered Pulse-Width Measurement*
- *Sample Clocked Buffered Pulse-Width Measurement*

Single Pulse-Width Measurement

With single pulse-width measurement, the counter counts the number of edges on the Source input while the Gate input remains active. When the Gate input goes inactive, the counter stores the count in the FIFO and ignores other edges on the Gate and Source inputs. Software then reads the stored count.

Figure 5-5 shows an example of a single pulse-width measurement.

Figure 5-5. Single Pulse-Width Measurement



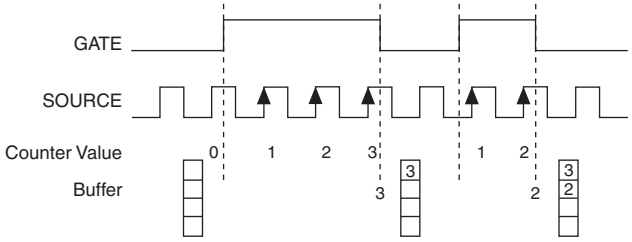
Implicit Buffered Pulse-Width Measurement

An implicit buffered pulse-width measurement is similar to single pulse-width measurement, but buffered pulse-width measurement takes measurements over multiple pulses.

The counter counts the number of edges on the Source input while the Gate input remains active. On each trailing edge of the Gate signal, the counter stores the count in the counter FIFO. The STC3 transfers the sampled values to host memory using a high-speed data stream.

Figure 5-6 shows an example of an implicit buffered pulse-width measurement.

Figure 5-6. Implicit Buffered Pulse-Width Measurement



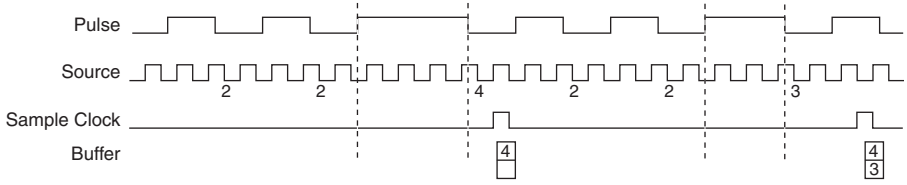
Sample Clocked Buffered Pulse-Width Measurement

A sample clocked buffered pulse-width measurement is similar to single pulse-width measurement, but buffered pulse-width measurement takes measurements over multiple pulses correlated to a sample clock.

The counter counts the number of edges on the Source input while the Gate input remains active. On each sample clock edge, the counter stores the count in the FIFO of the last pulse width to complete. The STC3 transfers the sampled values to host memory using a high-speed data stream.

Figure 5-7 shows an example of a sample clocked buffered pulse-width measurement.

Figure 5-7. Sample Clocked Buffered Pulse-Width Measurement



Note If a pulse does not occur between sample clocks, an overrun error occurs.

For information about connecting counter signals, refer to the *Default Counter/Timer Routing* section.

Pulse Measurement

In pulse measurements, the counter measures the high and low time of a pulse on its Gate input signal after the counter is armed. A pulse is defined in terms of its high and low time, high and low ticks or frequency and duty cycle. This is similar to the pulse-width measurement, except that the inactive pulse is measured as well.

You can route an internal or external periodic clock signal (with a known period) to the Source input of the counter. The counter counts the number of rising (or falling) edges occurring on the Source input between two edges of the Gate signal.

You can calculate the high and low time of the Gate input by multiplying the period of the Source signal by the number of edges returned by the counter.

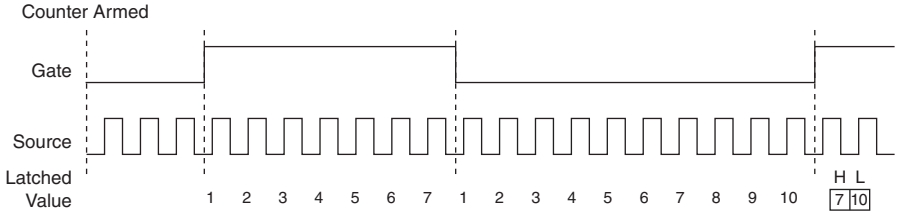
Refer to the following sections for more information about cDAQ controller pulse measurement options:

- *Single Pulse Measurement*
- *Implicit Buffered Pulse Measurement*
- *Sample Clocked Buffered Pulse Measurement*

Single Pulse Measurement

Single (on-demand) pulse measurement is equivalent to two single pulse-width measurements on the high (H) and low (L) ticks of a pulse, as shown in Figure 5-8.

Figure 5-8. Single (On-Demand) Pulse Measurement



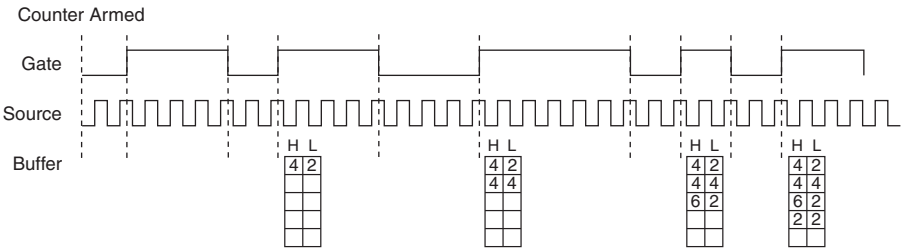
Implicit Buffered Pulse Measurement

In an implicit buffered pulse measurement, on each edge of the Gate signal, the counter stores the count in the FIFO. The STC3 transfers the sampled values to host memory using a high-speed data stream.

The counter begins counting when it is armed. The arm usually occurs between edges on the Gate input but the counting does not start until the desired edge. You can select whether to read the high pulse or low pulse first using the **StartingEdge** property in NI-DAQmx.

Figure 5-9 shows an example of an implicit buffered pulse measurement.

Figure 5-9. Implicit Buffered Pulse Measurement



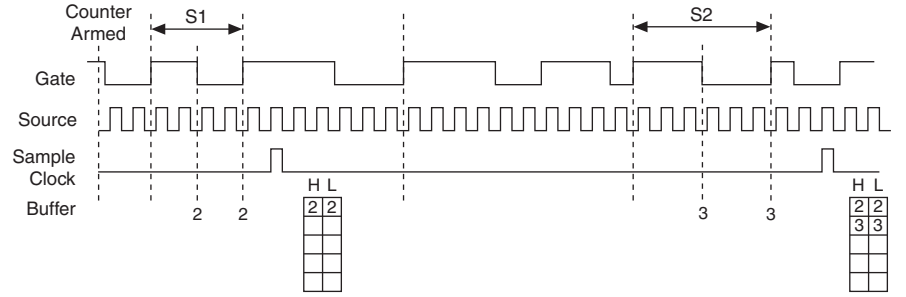
Sample Clocked Buffered Pulse Measurement

A sample clocked buffered pulse measurement is similar to single pulse measurement, but a buffered pulse measurement takes measurements over multiple pulses correlated to a sample clock.

The counter performs a pulse measurement on the Gate. On each sample clock edge, the counter stores the high and low ticks in the FIFO of the last pulse to complete. The STC3 transfers the sampled values to host memory using a high-speed data stream.

Figure 5-10 shows an example of a sample clocked buffered pulse measurement.

Figure 5-10. Sample Clocked Buffered Pulse Measurement



Note If a pulse does not occur between sample clocks, an overrun error occurs.

For information about connecting counter signals, refer to the *Default Counter/Timer Routing* section.

Semi-Period Measurement

In semi-period measurements, the counter measures a semi-period on its Gate input signal after the counter is armed. A semi-period is the time between any two consecutive edges on the Gate input.

You can route an internal or external periodic clock signal (with a known period) to the Source input of the counter. The counter counts the number of rising (or falling) edges occurring on the Source input between two edges of the Gate signal.

You can calculate the semi-period of the Gate input by multiplying the period of the Source signal by the number of edges returned by the counter.

Refer to the following sections for more information about semi-period measurement options:

- *Single Semi-Period Measurement*
- *Implicit Buffered Semi-Period Measurement*

Refer to the *Pulse versus Semi-Period Measurements* section for information about the differences between semi-period measurement and pulse measurement.

Single Semi-Period Measurement

Single semi-period measurement is equivalent to single pulse-width measurement.

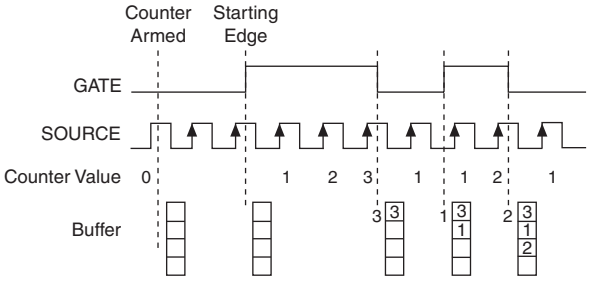
Implicit Buffered Semi-Period Measurement

In implicit buffered semi-period measurements, on each edge of the Gate signal, the counter stores the count in the FIFO. The STC3 transfers the sampled values to host memory using a high-speed data stream.

The counter begins counting when it is armed. The arm usually occurs between edges on the Gate input. You can select whether to read the first active low or active high semi period using the **CI.SemiPeriod.StartingEdge** property in NI-DAQmx.

Figure 5-11 shows an example of an implicit buffered semi-period measurement.

Figure 5-11. Implicit Buffered Semi-Period Measurement



For information about connecting counter signals, refer to the *Default Counter/Timer Routing* section.

Pulse versus Semi-Period Measurements

In hardware, pulse measurement and semi-period are the same measurement. Both measure the high and low times of a pulse. The functional difference between the two measurements is how the data is returned. In a semi-period measurement, each high or low time is considered one point of data and returned in units of seconds or ticks. In a pulse measurement, each pair of high and low times is considered one point of data and returned as a paired sample in units of frequency and duty cycle, high and low time or high and low ticks. When reading data, 10 points in a semi-period measurement will get an array of five high times and five low times. When you read 10 points in a pulse measurement, you get an array of 10 pairs of high and low times.

Also, pulse measurements support sample clock timing while semi-period measurements do not.

Frequency Measurement

You can use the counters to measure frequency in several different ways. Refer to the following sections for information about cDAQ controller frequency measurement options:

- *Low Frequency with One Counter*
- *High Frequency with Two Counters*
- *Large Range of Frequencies with Two Counters*
- *Sample Clocked Buffered Frequency Measurement*

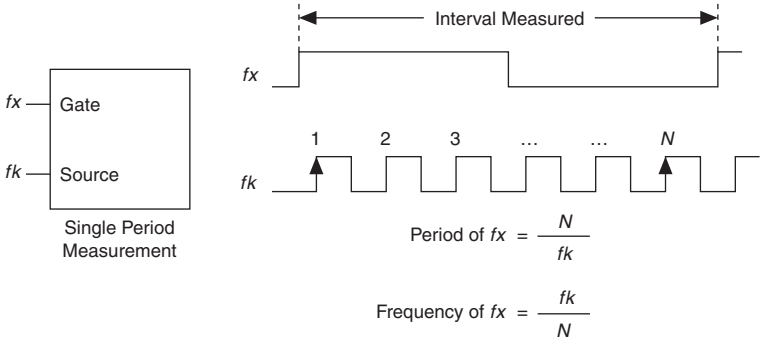
Low Frequency with One Counter

For low frequency measurements with one counter, you measure one period of your signal using a known timebase.

You can route the signal to measure (*fx*) to the Gate of a counter. You can route a known timebase (*fk*) to the Source of the counter. The known timebase can be an onboard timebase, such as 80 MHz Timebase, 20 MHz Timebase, or 100 kHz Timebase, or any other signal with a known rate.

You can configure the counter to measure one period of the gate signal. The frequency of *fx* is the inverse of the period. Figure 5-12 illustrates this method.

Figure 5-12. Low Frequency with One Counter



High Frequency with Two Counters

For high frequency measurements with two counters, you measure one pulse of a known width using your signal and derive the frequency of your signal from the result.

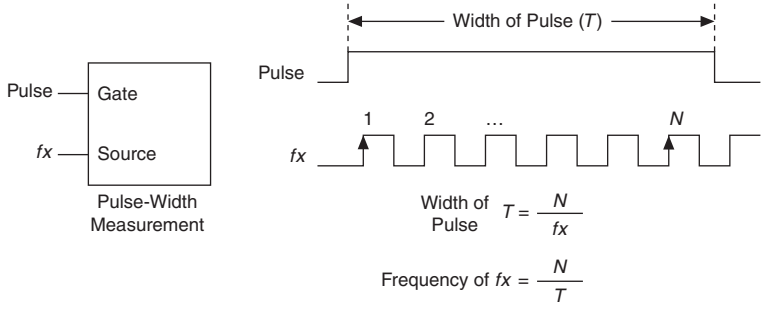
Note Counter 0 is always paired with Counter 1. Counter 2 is always paired with Counter 3.

In this method, you route a pulse of known duration (*T*) to the Gate of a counter. You can generate the pulse using a second counter. You also can generate the pulse externally and connect it to a PFI terminal. You only need to use one counter if you generate the pulse externally.

Route the signal to measure (*fx*) to the Source of the counter. Configure the counter for a single pulse-width measurement. If you measure the width of pulse *T* to be *N* periods of *fx*, the frequency of *fx* is *N*/*T*.

Figure 5-13 illustrates this method. Another option is to measure the width of a known period instead of a known pulse.

Figure 5-13. High Frequency with Two Counters



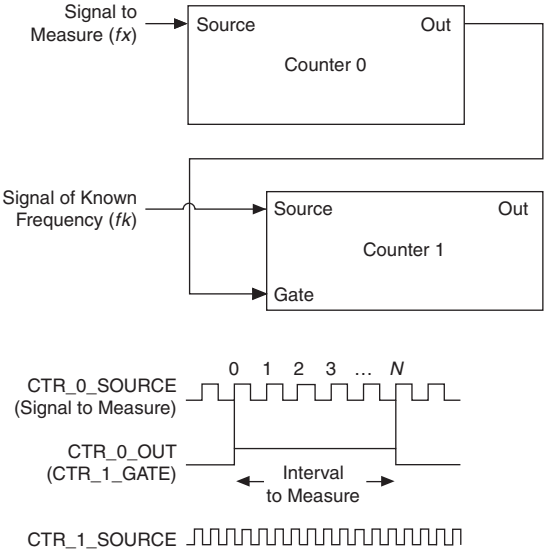
Large Range of Frequencies with Two Counters

By using two counters, you can accurately measure a signal that might be high or low frequency. This technique is called reciprocal frequency measurement. When measuring a large range of frequencies with two counters, you generate a long pulse using the signal to measure. You then measure the long pulse with a known timebase. The cDAQ controller can measure this long pulse more accurately than the faster input signal.

Note Counter 0 is always paired with Counter 1. Counter 2 is always paired with Counter 3.

You can route the signal to measure to the Source input of Counter 0, as shown in Figure 5-14. Assume this signal to measure has frequency *fx*. NI-DAQmx automatically configures Counter 0 to generate a single pulse that is the width of *N* periods of the source input signal.

Figure 5-14. Large Range of Frequencies with Two Counters



Next, route the Counter 0 Internal Output signal to the Gate input of Counter 1. You can route a signal of known frequency (*fk*) to the Counter 1 Source input. Configure Counter 1 to perform a single pulse-width measurement. Suppose the result is that the pulse width is *J* periods of the *fk* clock.

From Counter 0, the length of the pulse is *N*/*fx*. From Counter 1, the length of the same pulse is *J*/*fk*. Therefore, the frequency of *fx* is given by $fx = fk * (N/J)$.

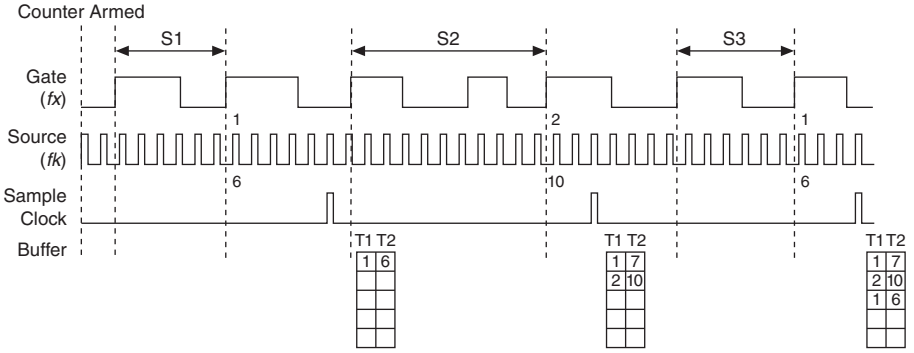
Sample Clocked Buffered Frequency Measurement

Sample clocked buffered point frequency measurements can either be a single frequency measurement or an average between sample clocks. Use **CI.Freq.EnableAveraging** to set the behavior. For buffered frequency, the default is True.

A sample clocked buffered frequency measurement with **CI.Freq.EnableAveraging** set to True uses the embedded counter and a sample clock to perform a frequency measurement. For each sample clock period, the embedded counter counts the signal to measure (*fx*) and the primary counter counts the internal time-base of a known frequency (*fk*). Suppose T1 is the number of ticks of the unknown signal counted between sample clocks and T2 is the number of ticks counted of the known timebase as shown in Figure 5-15. The frequency measured is:

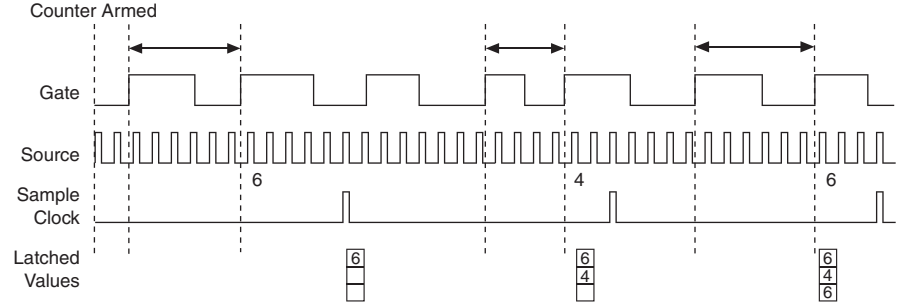
$$fx = fk * (T1/T2)$$

Figure 5-15. Sample Clocked Buffered Frequency Measurement (Averaging)



When **CI.Freq.EnableAveraging** is set to false, the frequency measurement returns the frequency of the pulse just before the sample clock. This single measurement is a single frequency measurement and is not an average between clocks as shown in Figure 5-16.

Figure 5-16. Sample Clocked Buffered Frequency Measurement (Non-Averaging)



With sample clocked frequency measurements, ensure that the frequency to measure is twice as fast as the sample clock to prevent a measurement overflow.

Choosing a Method for Measuring Frequency

The best method to measure frequency depends on several factors including the expected frequency of the signal to measure, the desired accuracy, how many counters are available, and how long the measurement can take. For all frequency measurement methods, assume the following:

fx	is the frequency to be measured if no error
fk	is the known source or gate frequency
measurement time (*T*)	is the time it takes to measure a single sample
Divide down (*N*)	is the integer to divide down measured frequency, only used in large range two counters
fs	is the sample clock rate, only used in sample clocked frequency measurements

Here is how these variables apply to each method, summarized in Table 5-2.

- **One counter**—With one counter measurements, a known timebase is used for the source frequency (*fk*). The measurement time is the period of the frequency to be measured, or 1/*fx*.
- **Two counter high frequency**—With the two counter high frequency method, the second counter provides a known measurement time. The gate frequency equals 1/*measurement time*.
- **Two counter large range**—The two counter larger range measurement is the same as a one counter measurement, but now the user has an integer divide down of the signal. An internal timebase is still used for the source frequency (*fk*), but the divide down means that the measurement time is the period of the divided down signal, or *N*/*fx* where *N* is the divide down.
- **Sample clocked**—For sample clocked frequency measurements, a known timebase is counted for the source frequency (*fk*). The measurement time is the period of the sample clock (*fs*).

Table 5-2. Frequency Measurement Methods

Variable	Sample Clocked	One Counter	Two Counter	
			High Frequency	Large Range
fk	Known timebase	Known timebase	$\frac{1}{\text{gating period}}$	Known timebase
Measurement time	$\frac{1}{fs}$	$\frac{1}{fx}$	gating period	$\frac{N}{fx}$
Max. frequency error	$fx \times \frac{fx}{fk \times \left\lfloor \frac{fx}{fs} - 1 \right\rfloor}$	$fx \times \frac{fx}{fk - fx}$	*fk*	$fx \times \frac{fx}{N \times fk - fx}$
Max. error %	$\frac{fx}{fk \times \left\lfloor \frac{fx}{fs} - 1 \right\rfloor}$	$\frac{fx}{fk - fx}$	$\frac{fk}{fx}$	$\frac{fx}{N \times fk - fx}$
Note: Accuracy equations do not take clock stability into account. Refer to the specifications document for your cDAQ controller for information about clock stability.				

Which Method Is Best?

This depends on the frequency to be measured, the rate at which you want to monitor the frequency and the accuracy you desire. Take for example, measuring a 50 kHz signal. Assuming that the measurement times for the sample clocked (with averaging) and two counter frequency measurements are configured the same, Table 5-3 summarizes the results.

Table 5-3. 50 kHz Frequency Measurement Methods

Variable	Sample Clocked	One Counter	Two Counter	
			High Frequency	Large Range
fx	50,000	50,000	50,000	50,000
fk	80 M	80 M	1,000	80 M
Measurement time (*mS*)	1	.02	1	1
N	—	—	—	50

Table 5-3. 50 kHz Frequency Measurement Methods (Continued)

Variable	Sample Clocked	One Counter	Two Counter	
			High Frequency	Large Range
Max. frequency error (Hz)	.638	31.27	1,000	.625
Max. error %	.00128	.0625	2	.00125

From this, you can see that while the measurement time for one counter is shorter, the accuracy is best in the sample clocked and two counter large range measurements. For another example, Table 5-4 shows the results for 5 MHz.

Table 5-4. 5 MHz Frequency Measurement Methods

Variable	Sample Clocked	One Counter	Two Counter	
			High Frequency	Large Range
fx	5 M	5 M	5 M	5 M
fk	80 M	80 M	1,000	80 M
Measurement time (*mS*)	1	.0002	1	1
N	—	—	—	5,000
Max. Frequency error (Hz)	62.51	333 k	1,000	62.50
Max. Error %	.00125	6.67	.02	.00125

Again the measurement time for the one counter measurement is lowest but the accuracy is lower. Note that the accuracy and measurement time of the sample clocked and two counter large range are almost the same. The advantage of the sample clocked method is that even when the frequency to measure changes, the measurement time does not and error percentage varies little. For example, if you configured a large range two counter measurement to use a divide down of 50 for a 50 k signal, then you would get the accuracy measurement time and accuracy listed in Table 5-3. But if your signal ramped up to 5 M, then with a divide down of 50, your measurement time is 0.01 ms, but your error is now 0.125%. The error with a sample clocked frequency measurement is not as dependent on the measured frequency so at 50 k and 5 M with a measurement time of 1 ms the error percentage is still close to 0.00125%. One of the disadvantages of a sample clocked frequency measurement is that the frequency to be measured

must be at least twice the sample clock rate to ensure that a full period of the frequency to be measured occurs between sample clocks.

- Low frequency measurements with one counter is a good method for many applications. However, the accuracy of the measurement decreases as the frequency increases.
- High frequency measurements with two counters is accurate for high frequency signals. However, the accuracy decreases as the frequency of the signal to measure decreases. At very low frequencies, this method may be too inaccurate for your application. Another disadvantage of this method is that it requires two counters (if you cannot provide an external signal of known width). An advantage of high frequency measurements with two counters is that the measurement completes in a known amount of time.
- Measuring a large range of frequencies with two counters measures high and low frequency signals accurately. However, it requires two counters, and it has a variable sample time and variable error % dependent on the input signal.

Table 5-5 summarizes some of the differences in methods of measuring frequency.

Table 5-5. Frequency Measurement Method Comparison

Method	Number of Counters Used	Number of Measurements Returned	Measures High Frequency Signals Accurately	Measures Low Frequency Signals Accurately
Low frequency with one counter	1	1	Poor	Good
High frequency with two counters	1 or 2	1	Good	Poor
Large range of frequencies with two counters	2	1	Good	Good
Sample clocked (averaged)	1	1	Good	Good

For information about connecting counter signals, refer to the *Default Counter/Timer Routing* section.

Period Measurement

In period measurements, the counter measures a period on its Gate input signal after the counter is armed. You can configure the counter to measure the period between two rising edges or two falling edges of the Gate input signal.

You can route an internal or external periodic clock signal (with a known period) to the Source input of the counter. The counter counts the number of rising (or falling) edges occurring on the Source input between the two active edges of the Gate signal.

You can calculate the period of the Gate input by multiplying the period of the Source signal by the number of edges returned by the counter.

Period measurements return the inverse results of frequency measurements. Refer to the *Frequency Measurement* section for more information.

Position Measurement

You can use the counters to perform position measurements with quadrature encoders or two-pulse encoders. You can measure angular position with X1, X2, and X4 angular encoders. Linear position can be measured with two-pulse encoders. You can choose to do either a single point (on-demand) position measurement or a buffered (sample clock) position measurement. You must arm a counter to begin position measurements.

Refer to the following sections for more information about the cDAQ controller position measurement options:

- *Measurements Using Quadrature Encoders*
- *Measurements Using Two Pulse Encoders*
- *Buffered (Sample Clock) Position Measurement*

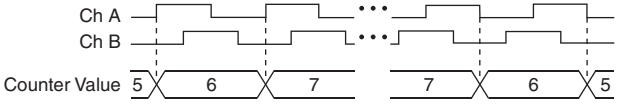
Measurements Using Quadrature Encoders

The counters can perform measurements of quadrature encoders that use X1, X2, or X4 encoding. A quadrature encoder can have up to three channels—channels A, B, and Z.

- **X1 Encoding**—When channel A leads channel B in a quadrature cycle, the counter increments. When channel B leads channel A in a quadrature cycle, the counter decrements. The amount of increments and decrements per cycle depends on the type of encoding—X1, X2, or X4.

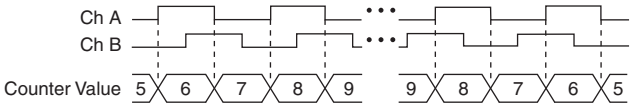
  Figure 5-17 shows a quadrature cycle and the resulting increments and decrements for X1 encoding. When channel A leads channel B, the increment occurs on the rising edge of channel A. When channel B leads channel A, the decrement occurs on the falling edge of channel A.

Figure 5-17. X1 Encoding



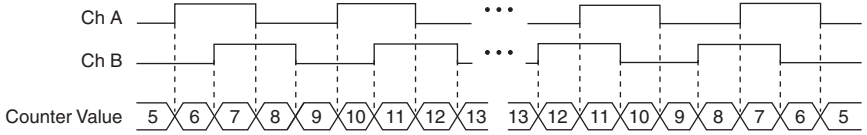
- **X2 Encoding**—The same behavior holds for X2 encoding except the counter increments or decrements on each edge of channel A, depending on which channel leads the other. Each cycle results in two increments or decrements, as shown in Figure 5-18.

Figure 5-18. X2 Encoding



- **X4 Encoding**—Similarly, the counter increments or decrements on each edge of channels A and B for X4 encoding. Whether the counter increments or decrements depends on which channel leads the other. Each cycle results in four increments or decrements, as shown in Figure 5-19.

Figure 5-19. X4 Encoding



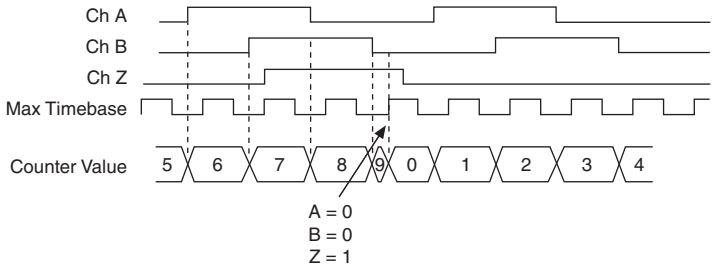
Channel Z Behavior

Some quadrature encoders have a third channel, channel Z, which is also referred to as the index channel. A high level on channel Z causes the counter to be reloaded with a specified value in a specified phase of the quadrature cycle. You can program this reload to occur in any one of the four phases in a quadrature cycle.

Channel Z behavior—when it goes high and how long it stays high—differs with quadrature encoder designs. You must refer to the documentation for your quadrature encoder to obtain timing of channel Z with respect to channels A and B. You must then ensure that channel Z is high during at least a portion of the phase you specify for reload. For instance, in Figure 5-20, channel Z is never high when channel A is high and channel B is low. Thus, the reload must occur in some other phase.

In Figure 5-20, the reload phase is when both channel A and channel B are low. The reload occurs when this phase is true and channel Z is high. Incrementing and decrementing takes priority over reloading. Thus, when the channel B goes low to enter the reload phase, the increment occurs first. The reload occurs within one maximum timebase period after the reload phase becomes true. After the reload occurs, the counter continues to count as before. The figure illustrates channel Z reload with X4 decoding.

Figure 5-20. Channel Z Reload with X4 Decoding

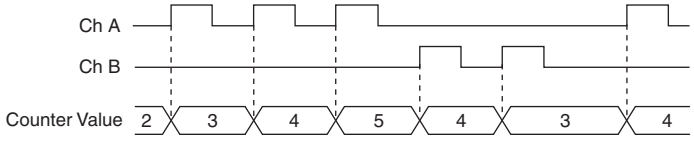


Measurements Using Two Pulse Encoders

The counter supports two pulse encoders that have two channels—channels A and B.

The counter increments on each rising edge of channel A. The counter decrements on each rising edge of channel B, as shown in Figure 5-21.

Figure 5-21. Measurements Using Two Pulse Encoders



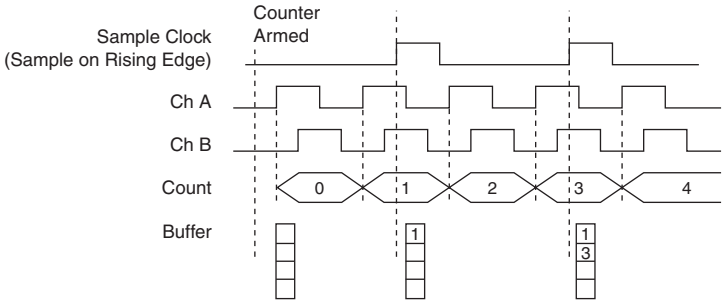
For information about connecting counter signals, refer to the *Default Counter/Timer Routing* section.

Buffered (Sample Clock) Position Measurement

With buffered position measurement (position measurement using a sample clock), the counter increments based on the encoding used after the counter is armed. The value of the counter is sampled on each active edge of a sample clock. The STC3 transfers the sampled values to host memory using a high-speed data stream. The count values returned are the cumulative counts since the counter armed event; that is, the sample clock does not reset the counter. You can route the counter sample clock to the Gate input of the counter. You can configure the counter to sample on the rising or falling edge of the sample clock.

Figure 5-22 shows an example of a buffered X1 position measurement.

Figure 5-22. Buffered Position Measurement



Two-Signal Edge-Separation Measurement

Two-signal edge-separation measurement is similar to pulse-width measurement, except that there are two measurement signals—Aux and Gate. An active edge on the Aux input starts the counting and an active edge on the Gate input stops the counting. You must arm a counter to begin a two edge separation measurement.

After the counter has been armed and an active edge occurs on the Aux input, the counter counts the number of rising (or falling) edges on the Source. The counter ignores additional edges on the Aux input.

The counter stops counting upon receiving an active edge on the Gate input. The counter stores the count in the FIFO.

You can configure the rising or falling edge of the Aux input to be the active edge. You can configure the rising or falling edge of the Gate input to be the active edge.

Use this type of measurement to count events or measure the time that occurs between edges on two signals. This type of measurement is sometimes referred to as start/stop trigger measurement, second gate measurement, or A-to-B measurement.

Refer to the following sections for more information about the cDAQ controller edge-separation measurement options:

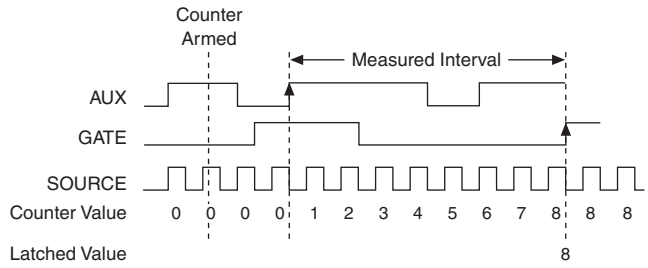
- *Single Two-Signal Edge-Separation Measurement*
- *Implicit Buffered Two-Signal Edge-Separation Measurement*
- *Sample Clocked Buffered Two-Signal Separation Measurement*

Single Two-Signal Edge-Separation Measurement

With single two-signal edge-separation measurement, the counter counts the number of rising (or falling) edges on the Source input occurring between an active edge of the Gate signal and an active edge of the Aux signal. The counter then stores the count in the FIFO and ignores other edges on its inputs. Software then reads the stored count.

Figure 5-23 shows an example of a single two-signal edge-separation measurement.

Figure 5-23. Single Two-Signal Edge-Separation Measurement



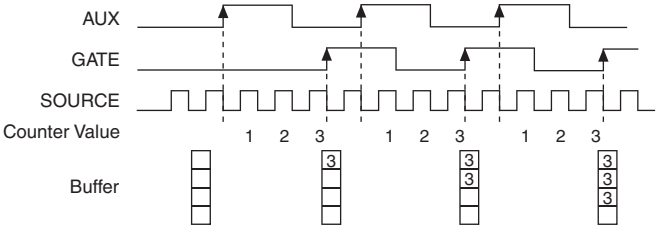
Implicit Buffered Two-Signal Edge-Separation Measurement

Implicit buffered and single two-signal edge-separation measurements are similar, but implicit buffered measurement measures multiple intervals.

The counter counts the number of rising (or falling) edges on the Source input occurring between an active edge of the Gate signal and an active edge of the Aux signal. The counter then stores the count in the FIFO. On the next active edge of the Gate signal, the counter begins another measurement. The STC3 transfers the sampled values to host memory using a high-speed data stream.

Figure 5-24 shows an example of an implicit buffered two-signal edge-separation measurement.

Figure 5-24. Implicit Buffered Two-Signal Edge-Separation Measurement

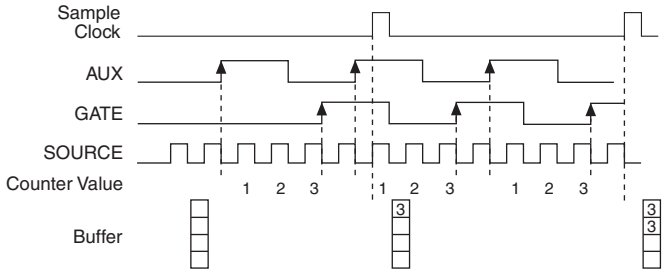


Sample Clocked Buffered Two-Signal Separation Measurement

A sample clocked buffered two-signal separation measurement is similar to single two-signal separation measurement, but buffered two-signal separation measurement takes measurements over multiple intervals correlated to a sample clock. The counter counts the number of rising (or falling) edges on the Source input occurring between an active edge of the Gate signal and an active edge of the Aux signal. The counter then stores the count in the FIFO on a sample clock edge. On the next active edge of the Gate signal, the counter begins another measurement. The STC3 transfers the sampled values to host memory using a high-speed data stream.

Figure 5-25 shows an example of a sample clocked buffered two-signal separation measurement.

Figure 5-25. Sample Clocked Buffered Two-Signal Separation Measurement



Note If an active edge on the Gate and an active edge on the Aux does not occur between sample clocks, an overrun error occurs.

For information about connecting counter signals, refer to the *Default Counter/Timer Routing* section.

Counter Output Applications

The following sections list the various counter output applications available on the cDAQ controller:

- *Simple Pulse Generation*
- *Pulse Train Generation*
- *Frequency Generation*
- *Frequency Division*
- *Pulse Generation for ETS*

Simple Pulse Generation

Refer to the following sections for more information about the cDAQ controller simple pulse generation options:

- *Single Pulse Generation*
- *Single Pulse Generation with Start Trigger*

Single Pulse Generation

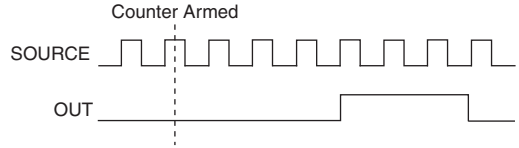
The counter can output a single pulse. The pulse appears on the Counter *n* Internal Output signal of the counter.

You can specify a delay from when the counter is armed to the beginning of the pulse. The delay is measured in terms of a number of active edges of the Source input.

You can specify a pulse width. The pulse width is also measured in terms of a number of active edges of the Source input. You also can specify the active edge of the Source input (rising or falling).

Figure 5-26 shows a generation of a pulse with a pulse delay of four and a pulse width of three (using the rising edge of Source).

Figure 5-26. Single Pulse Generation



Single Pulse Generation with Start Trigger

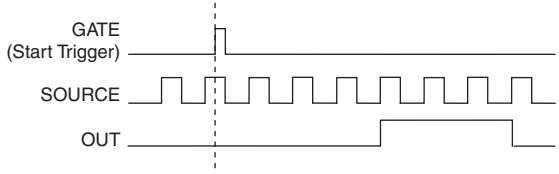
The counter can output a single pulse in response to one pulse on a hardware Start Trigger signal. The pulse appears on the Counter *n* Internal Output signal of the counter.

You can specify a delay from the Start Trigger to the beginning of the pulse. You also can specify the pulse width. The delay is measured in terms of a number of active edges of the Source input.

You can specify a pulse width. The pulse width is also measured in terms of a number of active edges of the Source input. You can also specify the active edge of the Source input (rising and falling).

Figure 5-27 shows a generation of a pulse with a pulse delay of four and a pulse width of three (using the rising edge of Source).

Figure 5-27. Single Pulse Generation with Start Trigger



Pulse Train Generation

Refer to the following sections for more information about the cDAQ controller pulse train generation options:

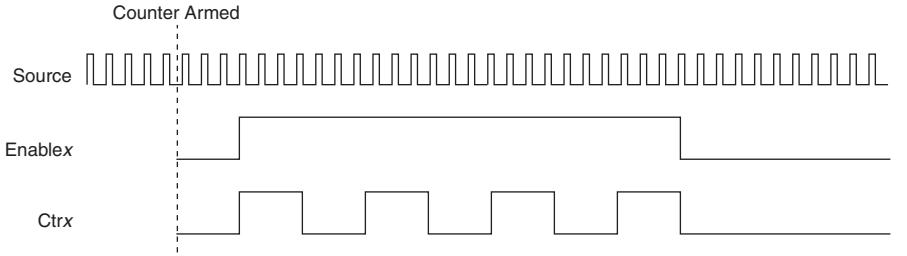
- *Finite Pulse Train Generation*
- *Retriggerable Pulse or Pulse Train Generation*
- *Continuous Pulse Train Generation*
- *Buffered Pulse Train Generation*
- *Finite Implicit Buffered Pulse Train Generation*

- *Continuous Buffered Implicit Pulse Train Generation*
- *Finite Buffered Sample Clocked Pulse Train Generation*
- *Continuous Buffered Sample Clocked Pulse Train Generation*

Finite Pulse Train Generation

This function generates a train of pulses with programmable frequency and duty cycle for a predetermined number of pulses. With cDAQ controller counters, the primary counter generates the specified pulse train and the embedded counter counts the pulses generated by the primary counter. When the embedded counter reaches the specified tick count, it generates a trigger that stops the primary counter generation.

Figure 5-28. Finite Pulse Train Generation: Four Ticks Initial Delay, Four Pulses



Retriggerable Pulse or Pulse Train Generation

The counter can output a single pulse or multiple pulses in response to each pulse on a hardware Start Trigger signal. The generated pulses appear on the Counter *n* Internal Output signal of the counter.

You can route the Start Trigger signal to the Gate input of the counter. You can specify a delay from the Start Trigger to the beginning of each pulse. You also can specify the pulse width. The delay and pulse width are measured in terms of a number of active edges of the Source input. The initial delay can be applied to only the first trigger or to all triggers using the **CO.EnableInitialDelayOnRetrigger** property. The default for a single pulse is True, while the default for finite pulse trains is False.

The counter ignores the Gate input while a pulse generation is in progress. After the pulse generation is finished, the counter waits for another Start Trigger signal to begin another pulse generation. For retriggered pulse generation, pause triggers are not allowed since the pause trigger also uses the gate input.

Figure 5-29 shows a generation of two pulses with a pulse delay of five and a pulse width of three (using the rising edge of Source) with **CO.EnableInitialDelayOnRetrigge**r set to the default True.

Figure 5-29. Retriggerable Single Pulse Generation with Initial Delay on Retrigger

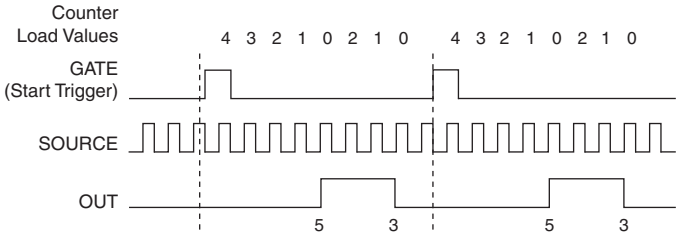
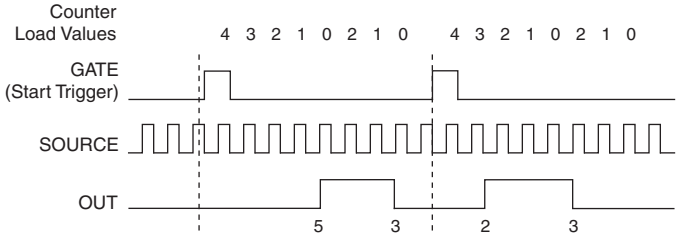


Figure 5-30 shows the same pulse train with **CO.EnableInitialDelayOnRetrigger** set to the default False.

Figure 5-30. Retriggerable Single Pulse Generation False



Note The minimum time between the trigger and the first active edge is two ticks of the source.

For information about connecting counter signals, refer to the *Default Counter/Timer Routing* section.

Continuous Pulse Train Generation

This function generates a train of pulses with programmable frequency and duty cycle. The pulses appear on the Counter *n* Internal Output signal of the counter.

You can specify a delay from when the counter is armed to the beginning of the pulse train. The delay is measured in terms of a number of active edges of the Source input.

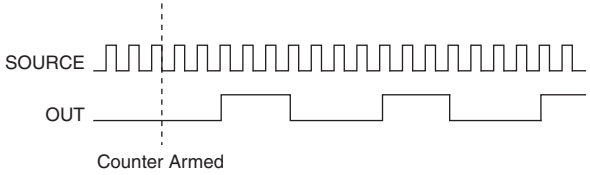
You specify the high and low pulse widths of the output signal. The pulse widths are also measured in terms of a number of active edges of the Source input. You also can specify the active edge of the Source input (rising or falling).

The counter can begin the pulse train generation as soon as the counter is armed, or in response to a hardware Start Trigger. You can route the Start Trigger to the Gate input of the counter.

You also can use the Gate input of the counter as a Pause Trigger (if it is not used as a Start Trigger). The counter pauses pulse generation when the Pause Trigger is active.

Figure 5-31 shows a continuous pulse train generation (using the rising edge of Source).

Figure 5-31. Continuous Pulse Train Generation



Continuous pulse train generation is sometimes called frequency division. If the high and low pulse widths of the output signal are *M* and *N* periods, then the frequency of the Counter *n* Internal Output signal is equal to the frequency of the Source input divided by *M* + *N*.

For information about connecting counter signals, refer to the *Default Counter/Timer Routing* section.

Buffered Pulse Train Generation

The cDAQ controller counters can use the FIFO to perform a buffered pulse train generation. This pulse train can use implicit timing or sample clock timing. When using implicit timing, the pulse idle time and active time changes with each sample you write. With sample clocked timing, each sample you write updates the idle time and active time of your generation on each sample clock edge. Idle time and active time can also be defined in terms of frequency and duty cycle or idle ticks and active ticks.

Note On buffered implicit pulse trains the pulse specifications in the DAQmx Create Counter Output Channel are ignored so that you generate the number of pulses defined in the multipoint write. On buffered sample clock pulse trains the pulse specifications in the DAQmx Create Counter Output Channel are generated after the counters starts and before the first sample clock so that you generate the number of updates defined in the multipoint write.

Finite Implicit Buffered Pulse Train Generation

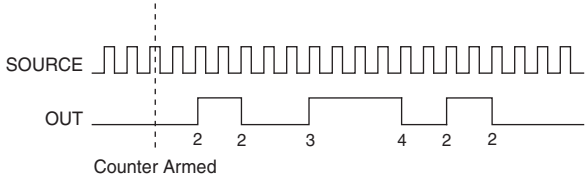
This function generates a predetermined number of pulses with variable idle and active times. Each point you write generates a single pulse. The number of pairs of idle and active times (pulse specifications) you write determines the number of pulses generated. All points are generated back to back to create a user defined pulse train.

Table 5-6 and Figure 5-32 detail a finite implicit generation of three samples.

Table 5-6. Finite Implicit Buffered Pulse Train Generation

Sample	Idle Ticks	Active Ticks
1	2	2
2	3	4
3	2	2

Figure 5-32. Finite Implicit Buffered Pulse Train Generation



Continuous Buffered Implicit Pulse Train Generation

This function generates a continuous train of pulses with variable idle and active times. Instead of generating a set number of data samples and stopping, a continuous generation continues until you stop the operation. Each point you write generates a single pulse. All points are generated back to back to create a user defined pulse train.

Finite Buffered Sample Clocked Pulse Train Generation

This function generates a predetermined number of pulse train updates. Each point you write defines pulse specifications that are updated with each sample clock. When a sample clock occurs, the current pulse (idle followed by active) finishes generation and the next pulse updates with the next sample specifications.

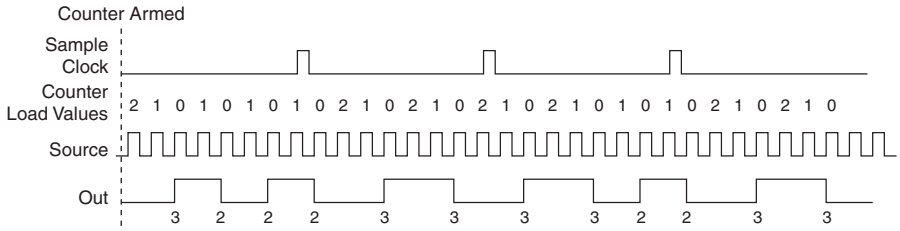
Note When the last sample is generated, the pulse train continues to generate with these specifications until the task is stopped.

Table 5-7 and Figure 5-33 detail a finite sample clocked generation of three samples where the pulse specifications from the create channel are two ticks idle, two ticks active, and three ticks initial delay.

Table 5-7. Finite Buffered Sample Clocked Pulse Train Generation

Sample	Idle Ticks	Active Ticks
1	3	3
2	2	2
3	3	3

Figure 5-33. Finite Buffered Sample Clocked Pulse Train Generation



There are several different methods of continuous generation that control what data is written. These methods are regeneration, FIFO regeneration, and non-regeneration modes.

Regeneration is the repetition of the data that is already in the buffer.

Standard regeneration is when data from the PC buffer is continually downloaded to the FIFO to be written out. New data can be written to the PC buffer at any time without disrupting the output. With FIFO regeneration, the entire buffer is downloaded to the FIFO and regenerated from there. Once the data is downloaded, new data cannot be written to the FIFO. To use FIFO regeneration, the entire buffer must fit within the FIFO size. The advantage of using FIFO regeneration is that it does not require communication with the main host memory once the operation is started, thereby preventing any problems that may occur due to excessive bus traffic.

With non-regeneration, old data is not repeated. New data must be continually written to the buffer. If the program does not write new data to the buffer at a fast enough rate to keep up with the generation, the buffer underflows and causes an error.

Continuous Buffered Sample Clocked Pulse Train Generation

This function generates a continuous train of pulses with variable idle and active times. Instead of generating a set number of data samples and stopping, a continuous generation continues until you stop the operation. Each point you write specifies pulse specifications that are updated with each sample clock. When a sample clock occurs, the current pulse finishes generation and the next pulse uses the next sample specifications.

Frequency Generation

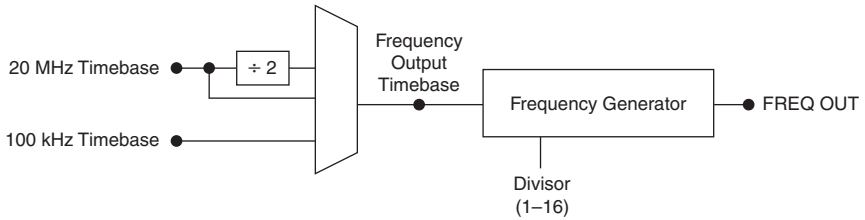
You can generate a frequency by using a counter in pulse train generation mode or by using the frequency generator circuit, as described in the *Using the Frequency Generator* section.

Using the Frequency Generator

The frequency generator can output a square wave at many different frequencies. The frequency generator is independent of the four general-purpose 32-bit counter/timer modules on the cDAQ controller.

Figure 5-34 shows a block diagram of the frequency generator.

Figure 5-34. Frequency Generator Block Diagram

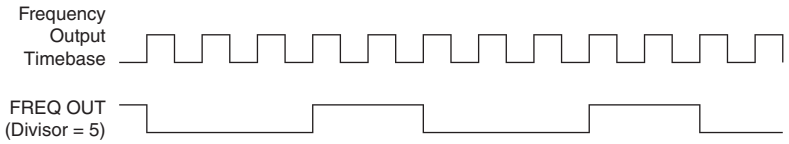


The frequency generator generates the Frequency Output signal. The Frequency Output signal is the Frequency Output Timebase divided by a number you select from 1 to 16. The Frequency Output Timebase can be either the 20 MHz Timebase, the 20 MHz Timebase divided by 2, or the 100 kHz Timebase.

The duty cycle of Frequency Output is 50% if the divider is either 1 or an even number. For an odd divider, suppose the divider is set to D. In this case, Frequency Output is low for (D + 1)/2 cycles and high for (D - 1)/2 cycles of the Frequency Output Timebase.

Figure 5-35 shows the output waveform of the frequency generator when the divider is set to 5.

Figure 5-35. Frequency Generator Output Waveform



Frequency Output can be routed out to any PFI terminal. All PFI terminals are set to high-impedance at startup. The FREQ OUT signal also can be routed to many internal timing signals.

In software, program the frequency generator as you would program one of the counters for pulse train generation.

For information about connecting counter signals, refer to the *Default Counter/Timer Routing* section.

Frequency Division

The counters can generate a signal with a frequency that is a fraction of an input signal. This function is equivalent to continuous pulse train generation. Refer to the *Continuous Pulse Train Generation* section for detailed information.

For information about connecting counter signals, refer to the *Default Counter/Timer Routing* section.

Pulse Generation for ETS

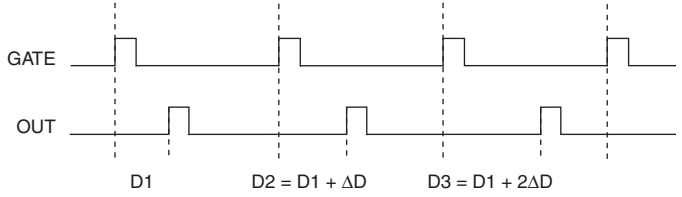
In the equivalent time sampling (ETS) application, the counter produces a pulse on the output a specified delay after an active edge on Gate. After each active edge on Gate, the counter cumulatively increments the delay between the Gate and the pulse on the output by a specified amount. Thus, the delay between the Gate and the pulse produced successively increases.

The increase in the delay value can be between 0 and 255. For instance, if you specify the increment to be 10, the delay between the active Gate edge and the pulse on the output increases by 10 every time a new pulse is generated.

Suppose you program your counter to generate pulses with a delay of 100 and pulse width of 200 each time it receives a trigger. Furthermore, suppose you specify the delay increment to be 10. On the first trigger, your pulse delay will be 100, on the second it will be 110, on the third it will be 120; the process will repeat in this manner until the counter is disarmed. The counter ignores any Gate edge that is received while the pulse triggered by the previous Gate edge is in progress.

The waveform thus produced at the counter's output can be used to provide timing for undersampling applications where a digitizing system can sample repetitive waveforms that are higher in frequency than the Nyquist frequency of the system. Figure 5-36 shows an example of pulse generation for ETS; the delay from the trigger to the pulse increases after each subsequent Gate active edge.

Figure 5-36. Pulse Generation for ETS



For information about connecting counter signals, refer to the *Default Counter/Timer Routing* section.

Counter Timing Signals

The cDAQ controller features the following counter timing signals:

- *Counter n Source Signal*
- *Counter n Gate Signal*
- *Counter n Aux Signal*
- *Counter n A Signal*
- *Counter n B Signal*
- *Counter n Z Signal*
- *Counter n Up_Down Signal*
- *Counter n HW Arm Signal*
- *Counter n Sample Clock Signal*
- *Counter n Internal Output Signal*
- *Counter n TC Signal*
- *Frequency Output Signal*

In this section, *n* refers to the cDAQ controller Counter 0, 1, 2, or 3. For example, Counter *n* Source refers to four signals—Counter 0 Source (the source input to Counter 0), Counter 1 Source (the source input to Counter 1), Counter 2 Source (the source input to Counter 2), or Counter 3 Source (the source input to Counter 3).

Note All counter timing signals can be filtered. Refer to the *PFI Filters* section of Chapter 4, *Digital Input/Output and PFI*, for more information.

Counter *n* Source Signal

The selected edge of the Counter *n* Source signal increments and decrements the counter value depending on the application the counter is performing. Table 5-8 lists how this terminal is used in various applications.

Table 5-8. Counter Applications and Counter *n* Source

Application	Purpose of Source Terminal
Pulse Generation	Counter Timebase
One Counter Time Measurements	Counter Timebase
Two Counter Time Measurements	Input Terminal
Non-Buffered Edge Counting	Input Terminal

Table 5-8. Counter Applications and Counter *n* Source (Continued)

Application	Purpose of Source Terminal
Buffered Edge Counting	Input Terminal
Two-Edge Separation	Counter Timebase

Routing a Signal to Counter *n* Source

Each counter has independent input selectors for the Counter *n* Source signal. Any of the following signals can be routed to the Counter *n* Source input:

- 80 MHz Timebase
- 20 MHz Timebase
- 100 kHz Timebase
- Any PFI terminal
- Analog Comparison Event
- Change Detection Event

In addition, TC or Gate from a counter can be routed to a different counter source.

Some of these options may not be available in some driver software. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information about available routing options.

Routing Counter *n* Source to an Output Terminal

You can route Counter *n* Source out to any PFI terminal.

Counter *n* Gate Signal

The Counter *n* Gate signal can perform many different operations depending on the application including starting and stopping the counter, and saving the counter contents.

Routing a Signal to Counter *n* Gate

Each counter has independent input selectors for the Counter *n* Gate signal. Any of the following signals can be routed to the Counter *n* Gate input:

- Any PFI terminal
- AI Reference Trigger
- AI Start Trigger
- AO Sample Clock
- DI Sample Clock
- DI Reference Trigger
- DO Sample Clock

- Change Detection Event
- Analog Comparison Event

In addition, a counter's Internal Output or Source can be routed to a different counter's gate.

Some of these options may not be available in some driver software. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information about available routing options.

Routing Counter *n* Gate to an Output Terminal

You can route Counter *n* Gate out to any PFI terminal.

Counter *n* Aux Signal

The Counter *n* Aux signal indicates the first edge in a two-signal edge-separation measurement.

Routing a Signal to Counter *n* Aux

Each counter has independent input selectors for the Counter *n* Aux signal. Any of the following signals can be routed to the Counter *n* Aux input:

- Any PFI terminal
- AI Reference Trigger
- AI Start Trigger
- Analog Comparison Event
- Change Detection Event

In addition, a counter's Internal Output, Gate or Source can be routed to a different counter's Aux. A counter's own gate can also be routed to its Aux input.

Some of these options may not be available in some driver software. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information about available routing options.

Counter *n* A, Counter *n* B, and Counter *n* Z Signals

Counter *n* B can control the direction of counting in edge counting applications. Use the A, B, and Z inputs to each counter when measuring quadrature encoders or measuring two pulse encoders.

Routing Signals to A, B, and Z Counter Inputs

Each counter has independent input selectors for each of the A, B, and Z inputs. Any of the following signals can be routed to each input:

- Any PFI terminal
- Analog Comparison Event

Routing Counter *n* Z Signal to an Output Terminal

You can route Counter *n* Z out to any PFI terminal.

Counter *n* Up_Down Signal

Counter *n* Up_Down is another name for the Counter *n* B signal.

Counter *n* HW Arm Signal

The Counter *n* HW Arm signal enables a counter to begin an input or output function.

To begin any counter input or output function, you must first enable, or arm, the counter. In some applications, such as a buffered edge count, the counter begins counting when it is armed. In other applications, such as single pulse-width measurement, the counter begins waiting for the Gate signal when it is armed. Counter output operations can use the arm signal in addition to a start trigger.

Software can arm a counter or configure counters to be armed on a hardware signal. Software calls this hardware signal the Arm Start Trigger. Internally, software routes the Arm Start Trigger to the Counter *n* HW Arm input of the counter.

Routing Signals to Counter *n* HW Arm Input

Any of the following signals can be routed to the Counter *n* HW Arm input:

- Any PFI terminal
- AI Reference Trigger
- AI Start Trigger
- Analog Comparison Event
- Change Detection Event

A counter's Internal Output can be routed to a different counter's HW Arm.

Some of these options may not be available in some driver software. Refer to the *Device Routing in MAX* topic in the *NI-DAQmx Help* or the *LabVIEW Help* for more information about available routing options.

Counter *n* Sample Clock Signal

Use the Counter *n* Sample Clock (Ctr*n*SampleClock) signal to perform sample clocked acquisitions and generations.

You can specify an internal or external source for Counter *n* Sample Clock. You also can specify whether the measurement sample begins on the rising edge or falling edge of Counter *n* Sample Clock.

If the cDAQ controller receives a Counter *n* Sample Clock when the FIFO is full, it reports an overflow error to the host software.

Using an Internal Source

To use Counter *n* Sample Clock with an internal source, specify the signal source and the polarity of the signal. The source can be any of the following signals:

- DI Sample Clock
- DO Sample Clock
- AI Sample Clock (ai/SampleClock, te0/SampleClock, te1/SampleClock)
- AI Convert Clock
- AO Sample Clock
- DI Change Detection output

Several other internal signals can be routed to Counter *n* Sample Clock through internal routes. Refer to *Device Routing in MAX* in the *NI-DAQmx Help* or the *LabVIEW Help* for more information.

Using an External Source

You can route any of the following signals as Counter *n* Sample Clock:

- Any PFI terminal
- Analog Comparison Event

You can sample data on the rising or falling edge of Counter *n* Sample Clock.

Routing Counter *n* Sample Clock to an Output Terminal

You can route Counter *n* Sample Clock out to any PFI terminal. The PFI circuitry inverts the polarity of Counter n Sample Clock before driving the PFI terminal.

Counter *n* Internal Output and Counter *n* TC Signals

The Counter *n* Internal Output signal changes in response to Counter *n* TC.

The two software-selectable output options are pulse output on TC and toggle output on TC. The output polarity is software-selectable for both options.

With pulse or pulse train generation tasks, the counter drives the pulse(s) on the Counter *n* Internal Output signal. The Counter *n* Internal Output signal can be internally routed to be a counter/timer input or an “external” source for AI, AO, DI, or DO timing signals.

Routing Counter *n* Internal Output to an Output Terminal

You can route Counter *n* Internal Output to any PFI terminal.

Frequency Output Signal

The Frequency Output (FREQ OUT) signal is the output of the frequency output generator.

Routing Frequency Output to a Terminal

You can route Frequency Output to any PFI terminal.

Default Counter/Timer Routing

Counter/timer signals are available to parallel digital I/O C Series modules. To determine the signal routing options for modules installed in your system, refer to the **Device Routes** tab in MAX.

You can use these defaults or select other sources and destinations for the counter/timer signals in NI-DAQmx. Refer to *Connecting Counter Signals* in the *NI-DAQmx Help* or the *LabVIEW Help* for more information about how to connect your signals for common counter measurements and generations. Refer to *Physical Channels* in the *NI-DAQmx Help* or the *LabVIEW Help* for a list of default PFI lines for counter functions.

Counter Triggering

Counters support three different triggering actions:

- **Arm Start Trigger**—To begin any counter input or output function, you must first enable, or arm, the counter. Software can arm a counter or configure counters to be armed on a hardware signal. Software calls this hardware signal the Arm Start Trigger. Internally, software routes the Arm Start Trigger to the Counter *n* HW Arm input of the counter.

  For counter output operations, you can use it in addition to the start and pause triggers. For counter input operations, you can use the arm start trigger to have start trigger-like behavior. The arm start trigger can be used for synchronizing multiple counter input and output tasks.

  When using an arm start trigger, the arm start trigger source is routed to the Counter *n* HW Arm signal.
- **Start Trigger**—For counter output operations, a start trigger can be configured to begin a finite or continuous pulse generation. Once a continuous generation has triggered, the pulses continue to generate until you stop the operation in software. For finite generations, the specified number of pulses is generated and the generation stops unless you use the retriggerable attribute. When you use this attribute, subsequent start triggers cause the generation to restart.

  When using a start trigger, the start trigger source is routed to the Counter *n* Gate signal input of the counter. Counter input operations can use the arm start trigger to have start trigger-like behavior.
- **Pause Trigger**—You can use pause triggers in edge counting and continuous pulse generation applications. For edge counting acquisitions, the counter stops counting edges while the external trigger signal is low and resumes when the signal goes high or vice versa. For continuous pulse generations, the counter stops generating pulses while the external trigger signal is low and resumes when the signal goes high or vice versa.

  When using a pause trigger, the pause trigger source is routed to the Counter *n* Gate signal input of the counter.

Other Counter Features

The following sections list the other counter features available on the cDAQ controller.

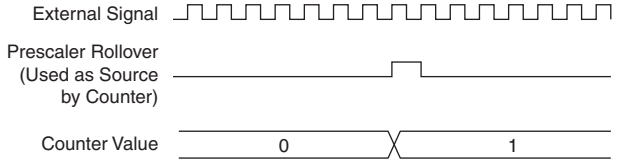
Cascading Counters

You can internally route the Counter n Internal Output and Counter n TC signals of each counter to the Gate inputs of the other counter. By cascading two counters together, you can effectively create a 64-bit counter. By cascading counters, you also can enable other applications. For example, to improve the accuracy of frequency measurements, use reciprocal frequency measurement, as described in the *Large Range of Frequencies with Two Counters* section.

Prescaling

Prescaling allows the counter to count a signal that is faster than the maximum timebase of the counter. The cDAQ controller offers 8X and 2X prescaling on each counter (prescaling can be disabled). Each prescaler consists of a small, simple counter that counts to eight (or two) and rolls over. This counter can run faster than the larger counters, which simply count the rollovers of this smaller counter. Thus, the prescaler acts as a frequency divider on the Source and puts out a frequency that is one-eighth (or one-half) of what it is accepting as shown in Figure 5-37.

Figure 5-37. Prescaling



Prescaling is intended to be used for frequency measurement where the measurement is made on a continuous, repetitive signal. The prescaling counter cannot be read; therefore, you cannot determine how many edges have occurred since the previous rollover. Prescaling can be used for event counting provided it is acceptable to have an error of up to seven (or one) ticks. Prescaling can be used when the counter Source is an external signal. Prescaling is not available if the counter Source is one of the internal timebases (80MHzTimebase, 20MHzTimebase, or 100kHzTimebase).

Synchronization Modes

The 32-bit counter counts up or down synchronously with the Source signal. The Gate signal and other counter inputs are asynchronous to the Source signal, so the cDAQ controller synchronizes these signals before presenting them to the internal counter.

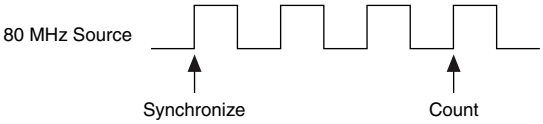
Depending on how you configure your controller, the cDAQ controller uses one of two synchronization methods:

- *80 MHz Source Mode*
- *External or Internal Source Less than 20 MHz*

80 MHz Source Mode

In 80 MHz source mode, the controller synchronizes signals on the rising edge of the source, and counts on the third rising edge of the source. Edges are pipelined so no counts are lost, as shown in Figure 5-38.

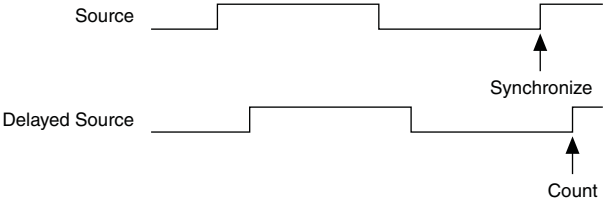
Figure 5-38. 80 MHz Source Mode



External or Internal Source Less than 20 MHz

With an external or internal source less than 20 MHz, the module generates a delayed Source signal by delaying the Source signal by several nanoseconds. The controller synchronizes signals on the rising edge of the delayed Source signal, and counts on the following rising edge of the source, as shown in Figure 5-39.

Figure 5-39. External or Internal Source Less than 20 MHz



6

Digital Routing and Clock Generation

This chapter describes the digital routing and clock routing circuitry on the cDAQ controller. Refer to the *Digital Routing* and *Clock Routing* sections.

Digital Routing

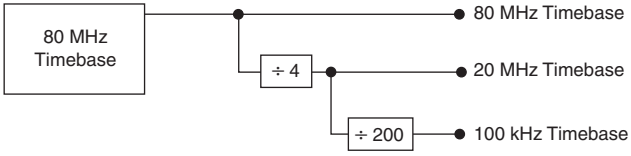
The digital routing circuitry has the following functions:

- Manages the flow of data between the bus interface and the acquisition/generation sub-systems (analog input, analog output, digital I/O, and the counters). The digital routing circuitry uses FIFOs (if present) in each sub-system to ensure efficient data movement.
- Routes timing and control signals. The acquisition/generation sub-systems use these signals to manage acquisitions and generations. These signals can come from the following sources:
  - Your C Series modules
  - User input through the PFI terminals using parallel digital C Series modules
- Routes and generates the main clock signals for the cDAQ controller. To determine the signal routing options for C Series module(s) installed in the cDAQ controller, refer to the **Device Routes** tab in MAX.

Clock Routing

Figure 6-1 shows the clock routing circuitry of the cDAQ controller.

Figure 6-1. Clock Routing Circuitry



80 MHz Timebase

You can use the 80 MHz Timebase as the Source input to the 32-bit general-purpose counter/timers.

20 MHz Timebase

The 20 MHz Timebase normally generates many of the AI and AO timing signals. It can function as the Source input to the 32-bit general-purpose counter/timers.

The 20 MHz Timebase is generated by dividing down the 80 MHz Timebase, as shown in Figure 6-1.

100 kHz Timebase

You can use the 100 kHz Timebase to generate many of the AI and AO timing signals. It can also function as the Source input to the 32-bit general-purpose counter/timers.

The 100 kHz Timebase is generated by dividing down the 20 MHz Timebase by 200, as shown in Figure 6-1.

A

Controller Operating System and Configuration

This appendix covers the following topics regarding the NI cDAQ-9138/9139 integrated controller configurations:

- *Power-On Self Test (POST) Warning Messages*
- *Restoring the Hard Drive to Factory Default Condition (Windows Only)*
- *Installing an Operating System*
- *Using the BIOS Setup Utility to Change Configuration Settings*
- *Resetting the BIOS Settings*

Power-On Self Test (POST) Warning Messages

The cDAQ controller POST displays warning messages for specific issues onscreen. You can use the CONSOLE OUT DIP switch to send these warning messages through the RS-232 serial port.

Note When a warning message is displayed, 10 additional seconds are added to the POST to give the user time to read the warning.

The POST can display the following warning messages:

- **First Boot Detected**—This warning is displayed at the first boot of the system after updating the BIOS firmware. This warning indicates that the BIOS settings have the default values.
- **BIOS Reset Detected**—This warning is displayed when the CMOS reset button has been pushed. This warning indicates that the BIOS settings have the default values.
- **CMOS Battery Is Dead**—This warning is displayed when the CMOS battery is dead and must be replaced. The BIOS settings are preserved even when the CMOS battery is dead, but that the system will boot very slowly because the BIOS cannot optimize boot time by saving specific system information to CMOS.
- **Front Panel Switches Set to Reserved State**—This warning is displayed when the CMOS battery is dead and the DIP switches are configured to reset the CMOS and BIOS settings, as shown in the *Resetting the System CMOS and BIOS Settings* section of Chapter 1, *Getting Started with the cDAQ Controller*. This warning indicates that the BIOS settings have the default values.

- **Warning: Recovering from CPU Overtemp**—This warning indicates that the thermal protection features of the cDAQ controller shut down the system because of a high CPU temperature.
- **Warning: Recovering from Ambient Overtemp**—This warning indicates that the thermal protection features of the cDAQ controller shut down the system because of a high ambient temperature.

Restoring the Hard Drive to Factory Default Condition (Windows Only)

(NI cDAQ-9138/9139 for Windows) You can restore the hard drive of the cDAQ controller to factory default condition either from a recovery partition on the hard drive or from the *NI Embedded Controller OEM Re-Installation DVD* shipped with the cDAQ controller.

In order to use the hard-drive recovery partition, you must press and hold <F4>, which allows you to enter the Acronis Recovery utility. In order to use the recovery DVD, you must connect an external DVD-ROM drive to one of the USB ports of the cDAQ controller. For more information about restoring the hard drive to factory default condition, go to `ni.com/info` and enter the Info Code `hdrecovery913x`.

Note Restoring the hard drive to factory default condition erases the contents of the hard drive. Back up any files you want to keep before restoring the hard drive.

Installing an Operating System

The cDAQ controller is shipped with an operating system installed. You can use an external CD/DVD-ROM drive, connected to one of the USB ports, to install a different operating system such as Windows Embedded Standard 7 (WES7). For more information about installing an operating system on the NI cDAQ-9138/9139, go to `ni.com/info` and enter the Info Code `hdrecovery913x`.

Using the BIOS Setup Utility to Change Configuration Settings

The cDAQ controller is shipped with configuration settings that work well for most applications. However, if your application requires different settings, you can use the BIOS setup utility to change settings. You can also use the BIOS setup utility to enable special controller functions. This section includes the following topics:

- *Launching the BIOS Setup Utility*
- *Main Setup Menu*
- *Advanced Setup Menu*
- *LabVIEW RT Options Setup Menu*

- *Boot Setup Menu*
- *Security Menu*
- *Save & Exit Menu*

Changing BIOS settings can cause incorrect controller behavior, including failure to boot. In general, do *not* change a setting unless you are absolutely sure what the setting does. Refer to the *Resetting the System CMOS and BIOS Settings* section of Chapter 1, *Getting Started with the cDAQ Controller*, for information about restoring the default configuration settings.

Launching the BIOS Setup Utility

Complete the following steps to launch the BIOS setup utility:

1. Connect a VGA monitor to the video (VGA) port on the cDAQ controller.
2. Connect a USB keyboard to one of the USB ports of the cDAQ controller.
3. Power on or reboot the cDAQ controller.
4. Hold down either the <F10> key or the <Del> key until the message **`Please select boot device:`** appears onscreen.
5. Use the Down Arrow key to select **`Enter Setup`** and press <Enter>. The setup utility loads after a short delay.

The **Main** setup menu is displayed when you first enter the BIOS setup utility.

The Main setup menu is displayed when you first enter the BIOS setup utility. Use the keys listed in Table A-1 to navigate through the BIOS setup utility.

Table A-1. BIOS Setup Utility Keyboard Navigation

Key(s)	Function(s)
Left Arrow, Right Arrow	Move between the different setup menus. If you are in a submenu, these keys have no effect, and you must press <Esc> to leave the submenu first. (To use the arrows on the numeric keypad, you must disable Num Lock.)
Up Arrow, Down Arrow	Move between the options within a setup menu. (To use the arrows on the numeric keypad, you must disable Num Lock.)
<Enter>	Either enters a submenu or displays all available settings for a highlighted configuration option.
<Esc>	Returns to the parent menu of a submenu. At the top-level menus, this key serves as a shortcut to the Exit menu.
<+>, <->	Cycle between all available settings for a selected configuration option.
<Tab>	Selects time and date fields.

Table A-1. BIOS Setup Utility Keyboard Navigation (Continued)

Key(s)	Function(s)
<F9>	Loads the optimal default values for all BIOS configuration settings. The optimal default values are the same as the shipping configuration default values.
<F10>	Saves settings and exits the BIOS setup utility.

Main Setup Menu

The most commonly accessed and modified BIOS settings are in the **Main** setup menu. The **Main** setup menu reports the following configuration information:

- **BIOS Version and Build Date**—These values indicate the version of the controller BIOS and the date on which the BIOS was built.
- **Processor Type, Processor Base Frequency, and Processor Core**—These values indicate the type of processor used in the controller, the speed of the processor, and the number of processor cores.
- **Total Memory**—This value indicates the size of system RAM detected by the BIOS.

The **Main** setup menu also includes the following settings:

- **System Date**—This setting controls the date, which is stored in a battery-backed real-time clock. Most operating systems also include a way to change this setting. Use <+> and <-> in conjunction with <Enter> and <Tab> to change these values.
- **System Time**—This setting controls the time of day, which is stored in a battery-backed real-time clock. Most operating systems also include a way to change this setting. Use <+> and <-> in conjunction with <Enter> and <Tab> to change these values.

Advanced Setup Menu

This menu contains BIOS settings that normally do not require modification. If you have specific problems such as unbootable disks or resource conflicts, you may need to examine these settings.

Caution Changing settings in this menu may result in an unstable or unbootable controller. If this happens, follow the procedures outlined in the *Resetting the System CMOS and BIOS Settings* section of Chapter 1, *Getting Started with the cDAQ Controller*, to restore BIOS settings to the factory defaults.

The **Advanced** setup menu includes the following settings and submenus:

- *SATA Configuration Submenu*—Use this setting to access the SATA Configuration submenu.
- *CPU Configuration Submenu*—Use this setting to access the CPU Configuration submenu.

- *Video Configuration Submenu*—Use this setting to access the Video Configuration submenu.
- *Power/Wake Configuration Submenu*—Use this setting to access the Power/Wake Configuration submenu.
- *USB Configuration Submenu*—Use this setting to access the USB Configuration submenu.
- *Intel AMT Configuration Submenu*—**(NI cDAQ-9139)** Use this setting to access the AMT Configuration submenu.
- *Serial Port Configuration Submenu*—Use this setting to access the Serial Port Configuration submenu.
- *Serial Port Console Redirection Submenu*—Use this setting to access the Serial Port Console Redirection submenu.

SATA Configuration Submenu

Use this submenu to apply alternate settings to the hard disk drive (HDD) interfaces. Normally, you do not need to modify these settings, as the factory default settings provide the most compatible and optimal configuration possible.

- **SATA Mode Selection**—This setting determines whether AHCI mode is enabled or disabled for the SATA port. Some operating systems, do not support AHCI mode. You can use this setting to disable AHCI mode and enable IDE mode so that non-compatible OSes function correctly. The default value is AHCI.
- **Onboard Storage**—This item displays the onboard drive detected in the system.

CPU Configuration Submenu

Use this submenu to apply alternate settings to the CPU. Normally, you do not need to modify these settings, as the factory default settings provide the most compatible and optimal configuration possible.

- **Hyper-Threading—(NI cDAQ-9139)** This setting enables or disables Intel Hyper-Threading technology. The default value is **Disabled** if the boot OS is LabVIEW Real-Time and **Enabled** for other boot OSes. Enabling Hyper-Threading increases performance for some applications by adding virtual CPU cores. Hyper-Threading can cause control algorithms to behave less deterministically.
- **Enabled CPU Cores**—This setting selects the number of active CPU cores for the processor. Valid values are 2 and 1. The default value is **2**.
- **Turbo Boost—(NI cDAQ-9139)** This setting enables or disables Intel Turbo Boost technology. The default value is **Disabled** if the boot OS is LabVIEW Real-Time and **Enabled** for other boot OSes. Enabling Turbo Boost allows CPU cores to run at higher than their base frequency for short durations, while other cores are idle. Enabling Turbo Boost can cause control algorithms to behave less deterministically.
- **Hardware Prefetcher**—This setting enables or disables CPU cache hardware prefetching. The default value is enabled.
- **Adjacent Cache Line Prefetch**—This setting enables or disables prefetching of adjacent cache lines from memory to the CPU cache. The default value is enabled.

Video Configuration Submenu

Use this submenu to apply alternate settings to the video configuration. Normally, you do not need to modify these settings, as the factory default settings provide the most compatible and optimal configuration possible.

- **Primary Display**—This setting specifies which video adapter the BIOS uses as the primary adapter if more than one adapter is present. To use an external video adapter as the primary graphics adapter, choose **Add-in Board Video**. The default value is **Onboard Video**.

Power/Wake Configuration Submenu

Use this submenu to apply alternate configurations to the power and wake features of the chipset and controller. Normally, you do not need to modify these settings, as the factory default settings provide the most compatible and optimal configuration possible.

- **DC Power Behavior**—This setting specifies the power state that the controller should go to when DC power is applied to the system. Valid values are **Stay Off** and **Turn On**. The default is **Stay Off**. When set to **Stay Off**, the controller will go to the soft off power state after when DC power is applied. When set to **Turn On**, the controller will power on when DC power is applied.
- **Power Button Off Behavior**—This setting specifies how the system responds to the power button. Valid options are **Normal** and **Disabled**. The default value is **Normal**. If the value is **Normal**, the system responds to the power button as defined by the OS. If the value is **Disabled**, pressing the power button has no effect when the system is on. When the system is in the soft off state, pushing the power button always powers on the system.
- **Ring Indicator Wake**—This setting enables or disables the ability to wake a powered-off system using the Ring Indicator pin of the RS-232 Serial Port. The default value is **Disabled**. Refer to the *RS-232 Serial Port* section of Chapter 1, *Getting Started with the cDAQ Controller*, for more information.

USB Configuration Submenu

Use this submenu to apply alternate configurations to the USB ports. Normally, you do not need to modify these settings, as the factory default settings provide the most compatible and optimal configuration possible.

- **USB Devices**—This item lists the total number of devices detected in the system, categorized by device type.
- **Legacy USB Support**—This setting specifies whether or not legacy USB support is enabled. Legacy USB support refers to the ability to use a USB keyboard and mouse during system boot or in a legacy operating system such as DOS. The default value is **Disabled** when booting LabVIEW Real-Time, **Enabled** when booting other OSes.
- **Overcurrent Reporting**—This setting enables or disables OS notification of USB overcurrent events. The default value is **Disabled**. Hardware overcurrent protection is always active and cannot be disabled.

- **Transfer Timeout**—This setting specifies the number of seconds the POST waits for a USB mass storage device to complete a transaction. The default is **20** seconds.
- **Device Reset Timeout**—This setting specifies the number of seconds the POST waits for a USB mass storage device to start. The default is **20** seconds.
- **Device Power-Up Delay**—This setting specifies the maximum amount of time a device can take to properly report itself during the POST. The default value is **Auto**. Alternatively, a **Manual** override setting can be used to support very slow USB devices.

In addition, the following option is available for each detected device if a USB mass storage device is present:

- **Emulation Type**—This setting specifies how the BIOS presents the USB mass storage device to the system. This option can be used to present a USB mass storage device as a floppy, Zip, hard disk, or CD-ROM drive. The default is **Auto**, which allows the BIOS to treat small USB flash disk drives as floppy drives and larger USB flash disk drives as hard disk drives.

Intel AMT Configuration Submenu

(NI cDAQ-9139) Use this submenu to enable or disable the Intel Active Management Technology feature.

Note Intel Active Management Technology is disabled by default. For information on how to enable, configure, and disable AMT, go to `ni.com/info` and enter the Info Code `intelamt`.

- **Management Engine Setup Prompt**—This setting enables the Intel Management Engine Setup prompt during the POST. If this setting is enabled, pressing <Ctrl-P> during the POST starts the ME Setup utility. The default value is **Disabled**.
- **Unconfigure Management Engine**—This setting enables the prompt during the POST to unconfigure the Management Engine on the next boot. The default value is **Disabled**.
- **USB-Based Configuration**—This setting enables searching USB drives for AMT configuration files. If such files are found, the user is prompted during the POST to perform configuration using the information stored on the USB drive. The default value is **Disabled**.

Serial Port Configuration Submenu

Use this submenu to view the serial port configuration and enable or disable the onboard serial ports. Normally, you do not need to modify these settings, as the factory default settings provide the most compatible and optimal configuration possible.

- **COM 1 (RS-232)**—This setting enables or disables the onboard RS-232 serial port. The default value is **Enabled**.
- **Device Settings**—This item displays the current base address and interrupt request level (IRQ) information for the onboard RS-232 serial port.

- **COM 2 (RS-485/422)**—This setting enables or disables the onboard RS-485/422 serial port. The default value is **Enabled**.
- **Device Settings**—This item displays the current base address and interrupt request level (IRQ) information for the onboard RS-485/422 serial port.

Serial Port Console Redirection Submenu

Use this submenu to access configuration information related to console redirection.

- **COM1 Console Redirection**—This item displays the current state of COM1 (RS-232) console redirection based on the state of the CONSOLE OUT switch. Refer to the *Console Redirection Settings Submenu* section for more information.
- **Console Redirection Settings**—Use this setting to access the **Console Redirection Settings** submenu. This setting is enabled only if COM1 Console Redirection is enabled. Refer to the *Console Redirection Settings Submenu* section for more information.

Console Redirection Settings Submenu

Use this submenu to apply alternate configurations to the serial port related to console redirection. Normally, you do not need to modify these settings, as the factory default settings provide the most compatible and optimal configuration possible.

- **Terminal Type**—This setting selects the terminal emulation type. Valid values are **ANSI**, **VT100**, **VT100+**, and **VT-UTF8**. The default value is **ANSI**.
- **Bits Per Second**—This setting selects the serial port transmission speed (baud rate). Valid values are **9600**, **19200**, **57600**, and **115200**. The default value is **9600**.
- **Data Bits**—This setting selects the number of data bits per byte. Valid values are **7** and **8**. The default value is **8**.
- **Parity**—This setting selects the parity bit type which can help detect some types of transmission errors. Valid values are **None**, **Even**, **Odd**, **Mark** (Always Send 1), and **Space** (Always Send 0). The default value is **None**.
- **Stop Bits**—This setting selects the number of stop bits. Valid values are **1** and **2**. The default value is **1**.
- **Flow Control**—This setting enables flow control to help prevent data loss from buffer overflows. Valid values are **None** and **Hardware RTS/CTS**. The default value is **None**.
- **Recorder Mode**—This setting selects whether or not terminal display formatting characters are transmitted with the screen text. When **Recorder Mode** is **Enabled**, only the text characters are transmitted. The default value is **Disabled**.
- **100x31 Resolution**—This setting enables extended terminal resolution. The default value is **Disabled**.
- **Legacy OS Redirection**—This setting selects the resolution (rows and columns) used for Legacy OS Redirection. Valid values are **80x24** and **80x25**. The default value is **80x24**.

LabVIEW RT Options Setup Menu

(NI cDAQ-9138/9139 for LabVIEW Real-Time) Use this menu to configure boot options for LabVIEW RT if it is installed on the controller. If you are not using LabVIEW RT, you should leave these settings at default.

Note The following settings temporarily override the behavior of the DIP switches. Refer to the *DIP Switches* section of Chapter 1, *Getting Started with the cDAQ Controller*, for more information about the DIP switches.

- **Change Boot Config on Next Boot**—This setting temporarily overrides the combined state of the LABVIEW RT and SAFE MODE switches. This setting selects whether the controller should boot LabVIEW RT, LabVIEW RT Safe Mode, or an installed OS such as Windows. The default is **No**.
- **Reset IP Address on Next Boot**— This setting temporarily overrides the state of the IP RESET switch. The default is **No**.
- **Disable Startup VI on Next Boot**— This setting temporarily overrides the state of the NO APP switch. The default is **No**.
- *LabVIEW RT Configuration Overrides Submenu*—Use this setting to access the LabVIEW RT Configuration Overrides submenu.

LabVIEW RT Configuration Overrides Submenu

(NI cDAQ-9138/9139 for LabVIEW Real-Time) Use this submenu to override specific settings optimized for using LabVIEW RT. Normally, you do not need to modify these settings, as the factory default settings provide the most compatible and optimal configuration possible.

Note When booting LabVIEW RT, certain options are automatically set to minimize system jitter and optimize LabVIEW RT performance. These settings can be manually overridden using the menu options described below but may result in an increase in overall system jitter, so care should be taken when enabling this setting on a Real Time system.

- **CPU Hyper Threading**—**(NI cDAQ-9139 for LabVIEW Real-Time)** This setting allows overriding the optimal configuration for Intel Hyper-Threading technology when booting LabVIEW RT. Refer to the *CPU Configuration Submenu* section for more information. The default value is **Use RT Default**.
- **CPU Turbo Boost**—**(NI cDAQ-9139 for LabVIEW Real-Time)** This setting allows overriding the optimal configuration for Intel Turbo Boost technology when booting LabVIEW RT. Refer to the *CPU Configuration Submenu* section for more information. The default value is **Use RT Default**.

Boot Setup Menu

Use this menu to configure settings related to the boot process and boot device priority.

- *Boot Settings Configuration Submenu*—Use this setting to access the Boot Settings Configuration submenu.
- **SCSI Drive Boot**—This setting specifies whether or not boot support is enabled for legacy mass storage devices, such as SCSI drives. When enabled, legacy mass storage controllers with boot support will be displayed in the **Boot Option Priorities** menu. The default value is **Enabled**.
- **PXE Network Boot**—This setting specifies whether or not the PXE network boot agent is enabled. When enabled, the Intel Boot Agent will be displayed in the **Boot Option Priorities** menu, allowing you to boot from a PXE server on the local subnet. Note that the Intel Boot Agent device names are preceded by **IBA GE Slot 00c9 v1310** in the **Boot Option Priorities** menu. The system must be restarted for this setting to take effect. The default value is **Disabled**.
- **Boot Option Priorities**—When the DISABLE RT switch is set, these settings specify the order in which the BIOS checks for bootable devices, including the local hard disk drive, removable devices such as USB flash disk drives or USB CD-ROM drives, or the PXE network boot agent. The BIOS will first attempt to boot from the device associated with **1st Boot Device**, followed by **2nd Boot Device**, and **3rd Boot Device**. If multiple boot devices are not present, the BIOS setup utility will not display all of these configuration options. To select a boot device, press <Enter> on the desired configuration option and select a boot device from the resulting menu. You can also disable certain boot devices by selecting **Disabled**.
- When the DISABLE RT switch is not set, the only detectable boot options are **LabVIEW RT** and **LabVIEW RT Safe Mode**.

Note Only one device of a given type is shown in this list. If more than one device of the same type exists, use the *Device BBS Priorities* submenus to re-order the priority of devices of the same type.

The following submenus are displayed if one or more bootable devices of the corresponding type is present:

- *Hard Drive BBS Priorities Submenu*—Use this setting to access the Hard Drive BBS Priorities submenu to re-order or disable bootable hard drive devices.
- *CD/DVD ROM Drive BBS Priorities Submenu*—Use this setting to access the CD/DVD ROM Drive BBS Priorities submenu to re-order or disable bootable CD/DVD ROM drive devices.
- *Floppy Drive BBS Priorities Submenu*—Use this setting to access the Floppy Drive BBS Priorities submenu to re-order or disable bootable floppy drive devices.
- *Network Device BBS Priorities Submenu*—Use this setting to access the Network Device BBS Priorities submenu to re-order or disable bootable network devices.

Boot Settings Configuration Submenu

Use this submenu to apply alternate configurations to boot settings. Normally, you do not need to modify these settings, as the factory default settings provide the most compatible and optimal configuration.

- **Setup Prompt Timeout**—This setting specifies the amount of time the system waits for a BIOS Setup menu keypress (the <F10> or <Delete> key) in units of a second. The default value is **2** for a delay of 2 seconds.
- **Bootup NumLock State**—This setting specifies the power-on state of the keyboard NumLock setting. The default value is **On**.

Hard Drive BBS Priorities Submenu

Boot Option #1, Boot Option #2, Boot Option #3—These settings specify the boot priority of hard drive devices. The highest priority device is displayed on the main **Boot Option Priorities** list. Optionally, each device can also be **Disabled** if the device should never be used as a boot device.

CD/DVD ROM Drive BBS Priorities Submenu

Boot Option #1, Boot Option #2, Boot Option #3—These settings specify the boot priority of CD/DVD ROM drive devices. The highest priority device is displayed on the main **Boot Option Priorities** list. Optionally, each device can also be **Disabled** if the device should never be used as a boot device.

Floppy Drive BBS Priorities Submenu

Boot Option #1, Boot Option #2, Boot Option #3—These settings specify the boot priority of floppy drive devices. The highest priority device is displayed on the main **Boot Option Priorities** list. Optionally, each device can also be **Disabled** if the device should never be used as a boot device.

Network Device BBS Priorities Submenu

Boot Option #1, Boot Option #2, Boot Option #3—These settings specify the boot priority of network devices. The highest priority device is displayed on the main **Boot Option Priorities** list. Optionally, each device can also be **Disabled** if the device should never be used as a boot device.

Security Menu

Use this menu to enable BIOS security options.

- **Setup Administrator Password**—This setting specifies a password that must be entered to access the BIOS Setup Utility. If only the Administrator's password is set, then this only limits access to the BIOS setup utility and is only asked for when entering the BIOS setup utility. By default, no password is specified.
- **User Password**—This setting specifies a password that must be entered to access the BIOS Setup Utility or to boot the system. If only the User's password is set, then this is a

power-on password and must be entered to boot or enter the BIOS setup utility. In the BIOS setup utility, the User has Administrator rights. By default, no password is specified.

Save & Exit Menu

The **Save & Exit** setup menu includes all available options for exiting, saving, and loading the BIOS default configuration. As an alternative to this screen, press <F9> to load optimal BIOS default settings and <F10> to save changes and exit setup.

The **Exit** setup menu includes the following settings:

- **Save Changes and Reset**—Any changes made to BIOS settings are stored in NVRAM. The setup utility then exits and reboots the controller. The <F10> key can also be used to select this option.
- **Discard Changes and Reset**—Any changes made to BIOS settings during this session of the BIOS setup utility are discarded. The setup utility then exits and reboots the controller. The <Esc> key can also be used to select this option.
- **Save Changes**—Changes made to BIOS settings during this session are committed to NVRAM. The setup utility remains active, allowing further changes.
- **Discard Changes**—Any changes made to BIOS settings during this session of the BIOS setup utility are discarded. The BIOS setup continues to be active.
- **Restore Factory Defaults**—This option restores all BIOS settings to the factory default. This option is useful if the controller exhibits unpredictable behavior due to an incorrect or inappropriate BIOS setting. Notice that any nondefault settings such as boot order, passwords, and so on, are also restored to their factory defaults. The <F9> key can also be used to select this option.
- **Save As User Defaults**—This option saves a copy of the current BIOS settings as the User Defaults. This option is useful for preserving custom BIOS setup configurations.
- **Restore User Defaults**—This option restores all BIOS settings to the user defaults. This option is useful for restoring previously preserved custom BIOS setup configurations.
- **Boot Override**—This option lists all possible bootable devices and allows the user to override the **Boot Option Priorities** list for the current boot. If no changes have been made to the BIOS setup options, the system will continue booting to the selected device without first rebooting. If BIOS setup options have been changed and saved, a reboot will be required and the boot override selection will not be valid.

Resetting the BIOS Settings

Refer to the *Resetting the System CMOS and BIOS Settings* section of Chapter 1, *Getting Started with the cDAQ Controller*, for steps to take to reset the CMOS and BIOS settings to factory default values.

B

Where to Go from Here

This appendix lists where you can find example programs for the cDAQ controller and C Series modules and relevant documentation.

Example Programs

NI-DAQmx software includes example programs to help you get started programming with the cDAQ chassis and C Series modules. Modify example code and save it in an application, or use examples to develop a new application, or add example code to an existing application.

To locate NI software examples, go to `ni.com/info` and enter the Info Code `daqmxexp`. For additional examples, refer to `ni.com/examples`.

To run examples without the device installed, use an NI-DAQmx simulated device. For more information, in Measurement & Automation Explorer (MAX), select **Help»Help Topics» NI-DAQmx»MAX Help for NI-DAQmx** and search for simulated devices.

Related Documentation

Each application software package and driver includes information about writing applications for taking measurements and controlling measurement devices. The following references to documents assume you have NI-DAQmx, LabVIEW 2012 or later, and where applicable, LabVIEW Real-Time 2012 and version 15.1 or later of other NI application software.

NI cDAQ Controller Documentation

The *NI cDAQ-9138/9139 for Windows Quick Start*, packaged with your cDAQ controller preloaded with Windows Embedded Standard 7 software, describes how to set up and install the cDAQ controller and C Series modules, and how to confirm that your device is operating properly.

The *NI cDAQ-9138/9139 for LabVIEW Real-Time Quick Start*, packaged with your cDAQ controller with its hard drive formatted for LabVIEW Real-Time, describes how to set up your host computer, install your NI-DAQmx for Windows software, install the cDAQ controller and C Series modules, and how to confirm that your device is operating properly.

The *NI cDAQ-9138 Specifications* and *NI cDAQ-9139 Specifications* list all specifications for your cDAQ controller. Go to `ni.com/manuals` and search for your cDAQ controller.

The *NI cDAQ-9138 Safety, Environmental, and Regulatory Information* or *NI cDAQ-9139 Safety, Environmental, and Regulatory Information* includes important hazardous locations information, compliance precautions, and connection information for your cDAQ controller. Go to ni.com/manuals and search for your cDAQ controller.

The *NI cDAQ Chassis Calibration Procedure* contains information for calibrating all National Instruments CompactDAQ chassis and controllers. Go to ni.com/manuals and search for your cDAQ controller.

C Series Module Documentation and Specifications

For module specifications, refer to the documentation included with your C Series module or go to ni.com/manuals.

NI-DAQmx

The *NI-DAQmx Readme* lists which devices, ADEs, and NI application software are supported by this version of NI-DAQmx. Select **Start»All Programs»National Instruments»NI-DAQmx»NI-DAQmx Readme**.

The *NI-DAQmx Help* contains API overviews, general information about measurement concepts, key NI-DAQmx concepts, and common applications that are applicable to all programming environments. Select **Start»All Programs»National Instruments»Start»All Programs»National Instruments»NI-DAQmx»NI-DAQmx Help**.

LabVIEW

Refer to ni.com/gettingstarted for more information about LabVIEW.

Use the *LabVIEW Help*, available by selecting **Help»LabVIEW Help** in LabVIEW, to access information about LabVIEW programming concepts, step-by-step instructions for using LabVIEW, and reference information about LabVIEW VIs, functions, palettes, menus, and tools. Refer to the following locations on the **Contents** tab of the *LabVIEW Help* for information about NI-DAQmx:

- **VI and Function Reference»Measurement I/O VIs and Functions»DAQmx - Data Acquisition VIs and Functions**—Describes the LabVIEW NI-DAQmx VIs and functions.
- **Property and Method Reference»NI-DAQmx Properties**—Contains the property reference.
- **Taking Measurements**—Contains the conceptual and how-to information you need to acquire and analyze measurement data in LabVIEW, including common measurements, measurement fundamentals, NI-DAQmx key concepts, and device considerations.

LabVIEW Real-Time

Use the *Getting Started with the LabVIEW Real-Time Module* document to learn how to develop a real-time project and VIs, set up RT targets, and build, debug, and deploy real-time applications. Open the *Getting Started with the LabVIEW Real-Time Module* document by selecting **Start»All Programs»National Instruments»LabVIEW»LabVIEW Manuals** or by navigating to the `labview\manuals` directory and opening `RT_Getting_Started.pdf`.

The *Real-Time Module Concepts* book of the *LabVIEW Help* includes conceptual information about real-time programming techniques, application architectures, and Real-Time Module features you can use to create real-time applications. Refer to the Real-Time Module concepts before attempting to create a deterministic real-time application.

.NET Languages without NI Application Software

With the Microsoft .NET Framework, you can use NI-DAQmx to create applications using Visual C# and Visual Basic .NET without Measurement Studio. Refer to the *NI-DAQmx Readme* for specific versions supported.

Training Courses

If you need more help getting started developing an application with NI products, NI offers training courses. To enroll in a course or obtain a detailed course outline, refer to `ni.com/training`.

Technical Support on the Web

For additional support, refer to `ni.com/support` or `ni.com/examples`.

Note You can download these documents at `ni.com/manuals`.

Many DAQ specifications and user guides/manuals are available as PDFs. You must have Adobe Reader 7.0 or later (PDF 1.6 or later) installed to view the PDFs. Refer to the Adobe Systems Incorporated website at `www.adobe.com` to download Adobe Reader. Refer to the National Instruments Product Manuals Library at `ni.com/manuals` for updated documentation resources.

C

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