

# CompactDAQ System Build Guide

The CompactDAQ system is ideal for medium-channel-count DAQ applications that require accurate measurements from multiple sensors, signals, and networks. This guide includes a comprehensive list of components and considerations to successfully deploy a CompactDAQ system and meet your application requirements.



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## How to Use This Guide

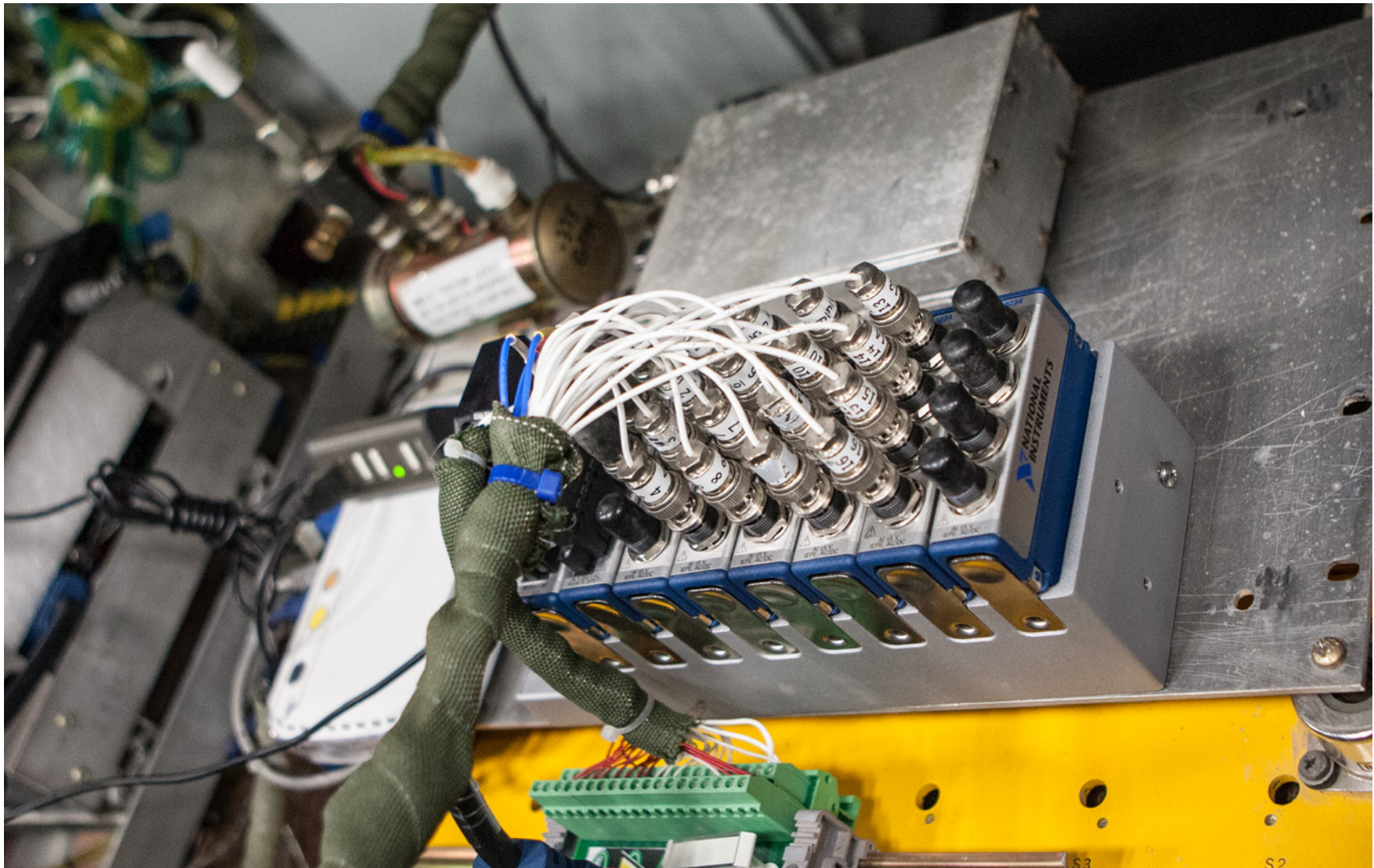
- A** **Advisor:** Turn your application specifications into a valid solution and list of products.
- V** **Video:** Watch technical demonstrations to further understand the content addressed.
- M** **User Manual:** Read the in-depth product manual or user guide for the hardware you are considering.
- P** **White Paper:** Read technical content that focuses on a specific topic area.
- D** **PDF Document:** Review detailed information on a printable, web hosted PDF document.
- E** **Engineer:** Speak to an NI engineer about your system requirements.
- W** **Web Site:** Explore varied resources hosted on [ni.com](http://ni.com).

\* To enjoy the full functionality of this interactive PDF, download and make sure the latest version of [Acrobat Reader](#) is installed.



# NI Components for CompactDAQ Systems

To meet your application-specific DAQ requirements, NI provides a variety of CompactDAQ products and options from module and chassis options to wiring, connectivity, synchronization, and more.



# Assembling Your CompactDAQ Hardware

## Chassis and Controller Options

CompactDAQ chassis control the timing, synchronization, and data transfer between the modules and an external or built-in computer. The I/O modules and the programming experience are common between all CompactDAQ chassis options, so you can change your system deployment without reinvesting in other parts of your design.

CompactDAQ features a variety of connectivity and module capacity options:

### Chassis

Connectivity	Module Capacity
USB	1, 4, or 8
Ethernet	1, 4, or 8
802.11 (wireless)	1

### Controller

Processor	Module Capacity
1.33 GHz dual-core Intel Atom	4 or 8
1.06 GHz dual-core Intel Celeron	8
1.33 GHz dual-core Intel i7	8

## Module Options

By specifying your module mix to include exactly the right combination of signal conditioned I/O, you can ensure accurate measurements and direct sensor connectivity without the lengthy process of custom design or expensive pure-universal options.

CompactDAQ is compatible with over 60 I/O modules for the sensor and signal types listed below:

### Analog Input

- Voltage
- Current
- Universal
- Thermocouple
- RTD
- Strain/bridge based
- Acceleration and sound

### Analog Output

- Voltage
- Current

### Digital I/O

- Input
- Output
- Input/output
- Relays

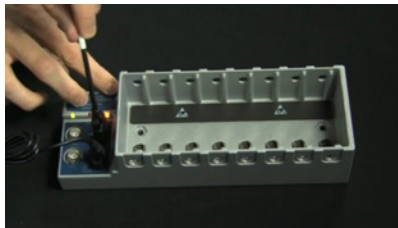
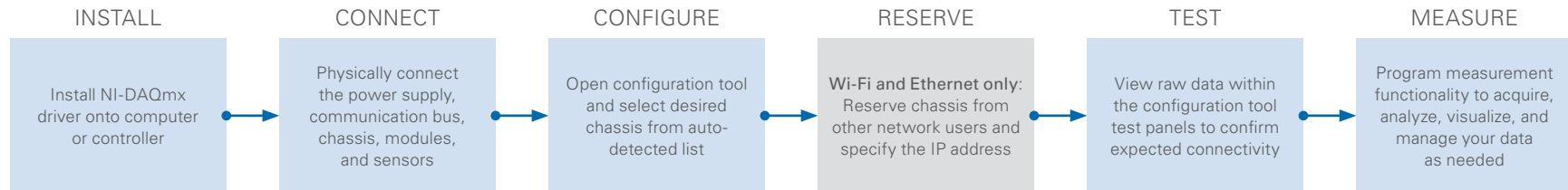
### Bus

- CAN
- LIN



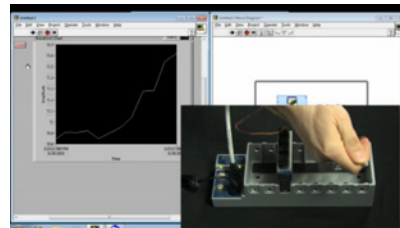
# Out-of-Box Hardware Setup Experience

Getting to your first measurement using CompactDAQ is a straightforward process. The form factor you choose for your application can produce slight process variations, but, in general, the configuration for any device that uses the NI-DAQmx driver follows the same simple steps.



## USB Systems

CompactDAQ USB chassis provide the plug-and-play simplicity of USB to sensor and electrical measurements. Watch this introductory video to learn how to set up your system, from unpacking your hardware and software to taking your first measurement.



## Ethernet Systems

To make networking more accessible to the non-IT professional, CompactDAQ Ethernet chassis use the zero configuration networking (zeroconf) standard. Watch this introductory video to walk through the setup process.



## Wireless Systems

With simple network configuration and 802.11 WiFi connectivity, CompactDAQ wireless chassis make it easier than ever to take your measurement system to the sensor. Watch this introductory video for the step-by-step setup process.



## Integrated Controllers

CompactDAQ controllers integrate processing with the option to run Windows Embedded Standard 7 or a real-time OS preloaded with the required software for configuration and setup. Watch this introductory video to see the setup process for each option.



# Sensor Connectivity

You have a lot of different options when it comes to choosing your connectivity. Choosing between a BNC, D-SUB, screw terminal, RJ50, LEMO, spring terminals, and other connectivity options to achieve the best performance can be difficult. Your measurement type requirements, the locking mechanism you need, the ruggedness of the connector, and the ease of connection/disconnection help you determine the appropriate connector for your application.



## BNC

This miniature quick connect/disconnect connector features two pins and ensures a high-quality connection with just a quarter turn of the coupling nut. It is ideal for single-ended measurements. Since the BNC connector has two pins, it doesn't provide a true differential measurement, which requires three pins.



## D-SUB

Surrounded by a D-shaped metal to ensure the correct connection orientation, a D-SUB connector contains two or more parallel rows of pins or sockets. Its many different sizes are denoted by the number of positions; for example, the DB-25 denotes 25 positions. Widely used for serial communication, the D-SUB connector also works for a variety of measurements because of the available positions.



## Screw Terminal

The wire from the sensor is held by the tightening of a screw in this connector, which offers so many different implementation possibilities that it has become one of the most common connectors. However, a screw terminal connector doesn't provide a quick connect/disconnect solution, so it can be tedious in higher channel count applications.



## RJ50

Similar to the RJ45 except that it uses one more pair of signal wires for a total of 10, the RJ50 connector provides a quick and secure connect/disconnect from CompactDAQ, which is ideal for bridge-based measurements. It can measure Transducer Electronic Data Sheets (TEDS).



## LEMO

This push/pull connector works with several connector standards to offer high-quality connections with a variety of options so you can achieve high measurement quality.



## Spring Terminals

A spring mechanism located inside this connector allows a user to quickly and easily connect bare wires from the sensor simply by compressing the spring with a small screwdriver, inserting the wire and then releasing to lock. Ideal for low channel count, often reconfigured applications, spring connectors can be tedious in higher channel count use cases as they do not provide a quick multi channel connect/disconnect solution.

# Communication

CompactDAQ systems communicate over USB, Ethernet, and wireless buses or are designed as independent controller-based devices. Each bus has different advantages and disadvantages, including trade-offs between bandwidth, latency, ease of synchronization, portability, and measurement distance from a host.

## USB

USB is practical for portable measurements and convenient because connectivity is easy and ubiquitous. After software drivers are installed, the host automatically detects USB devices, which eliminates the need for manual configuration to discover the devices. A USB controller can connect to multiple devices that share a maximum theoretical bandwidth of 60 MB/s under the USB 2.0 standard. Although easy to use, USB devices are not recommended for closed-loop control applications because the bus is inherently latent and nondeterministic.

## Wireless

Wireless is also useful for remote and distributed measurements for which cabling is expensive or impractical, such as structural health monitoring for bridges. Wi-Fi communication using the IEEE 802.11 protocol is widely available and easy to set up by connecting to a hotspot or access point. Wireless has the highest latency of any DAQ bus, so avoid using it with applications that need high-speed control and determinism. Refer to the wireless communication section for more information on other types of wireless communication such as cellular and satellite.

## Ethernet

Ethernet is ideal for remote and distributed measurements, particularly those that extend beyond the reach of a 5 m USB cable. In addition to enabling direct connection to your laptop or PC, Ethernet provides widely available ports throughout offices, labs, and manufacturing facilities to offer additional accessibility options for multiple users. Network bandwidth varies based on the number of other devices connected to the network.

## Stand-Alone

Using a CompactDAQ controller can be beneficial for applications that are remote or mobile such as environmental monitoring or in-vehicle data logging. To run completely independent, CompactDAQ controllers include embedded processing and onboard storage, which eliminates the need for an external PC. Running either a Windows Embedded Standard 7 (WES7) or the LabVIEW Real-Time OS you can run all your measurement, analysis, and logging software, as well as any additional software supported by your choice of OS, directly on the device. There is an additional advantage to integrating the entire signal chain into a single rugged system; the points of failure and sources of error are reduced, this makes CompactDAQ controllers a highly reliable option to collecting important data sets.

# Synchronizing Your Signals

When CompactDAQ applications require precise time correlation between measurement channels, modules, or even chassis, a combination of hardware and the NI-DAQmx API ensures tight synchronization.

## Hardware Synchronization

A CompactDAQ system features three main types of hardware synchronization:

**Single Module:** Most CompactDAQ modules have a simultaneous architecture that ensures the tight phase synchronization of data, which is then automatically synchronized within your task.

**Multi-Module:** CompactDAQ chassis contain seven distinct timing engines specified as 3 x AI, AO, DI, DO, and counters. With these options, you can easily synchronize multiple modules of different types at the same or different sample rates.

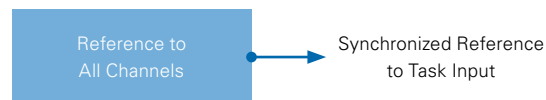
**Multi-Chassis:** You can synchronize channels across any number of chassis into a single task when you link chassis together by slotting in synchronization modules.

## Synchronization Programming Experience

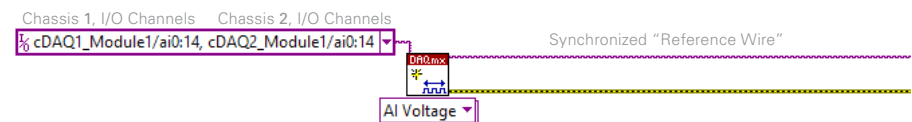
The NI-DAQmx driver automatically handles the synchronization of channels across one or multiple chassis as long as all channels in the task are of the same I/O type. This simplifies your code by making it straightforward to write, debug, and understand.

By connecting multiple CompactDAQ systems using the NI 9469 synchronization module, you can include channels from multiple C Series I/O modules within separate CompactDAQ chassis in the same task, and the NI-DAQmx driver then takes care of the synchronization. The NI 9469 offers synchronization to SAR, Slow-Sampled, Delta Sigma, digital input and output, and analog output modules in differing chassis topologies.

Function Diagram



LabVIEW G Code





# Maintaining Your CompactDAQ System

Often the maintenance of a DAQ system is considered only when a component fails or a result is inaccurate. By planning ahead for repairs, component replacements, and calibration, you can maintain system accuracy with minimum downtime.

## Calibration

Electronic components naturally drift over time, which can cause uncertainty in your measurements. To have confidence in the data you publish and to meet the often strict regulations of the industry you work in, NI provides customized calibration options.

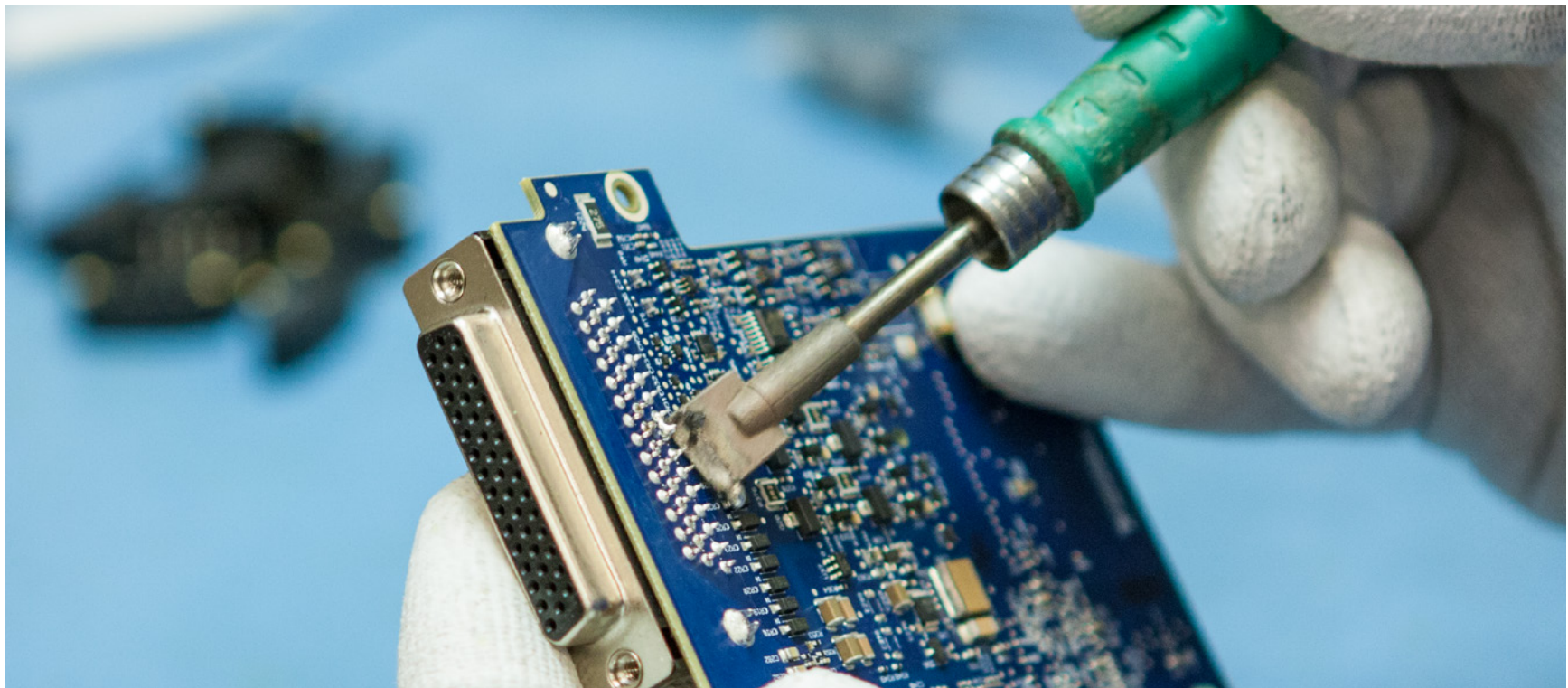
	Traceable Calibration	Compliant Calibration	ISO 17025 Accredited Calibration	Additional Calibration Services
Verification and adjustment of measurement performance using calibration procedures approved by NI	•	•	•	•
Detailed measurement data for all applicable channels	•	•	•	•
Availability at point of sale	•	•	•	•
Calibration performed at ISO 17025 accredited laboratory	–	•	•	•
Evaluation of measurement uncertainty	–	•	•	•
Calculated expanded measurement uncertainty	–	–	•	•
Advanced services—system calibration, on-site calibration, and more	–	–	–	•

# Repair Services

Though you may never need to repair your hardware, NI offers repair services for unexpected breakdowns. Highly trained factory technicians perform these services in a timely manner using only original parts at one of the NI service centers.

When time is at a premium, you can choose one of NI's several repair options to expedite your repair. In addition, NI provides advanced options to give you more information about the nature of the repair. These additional service upgrades including the following:

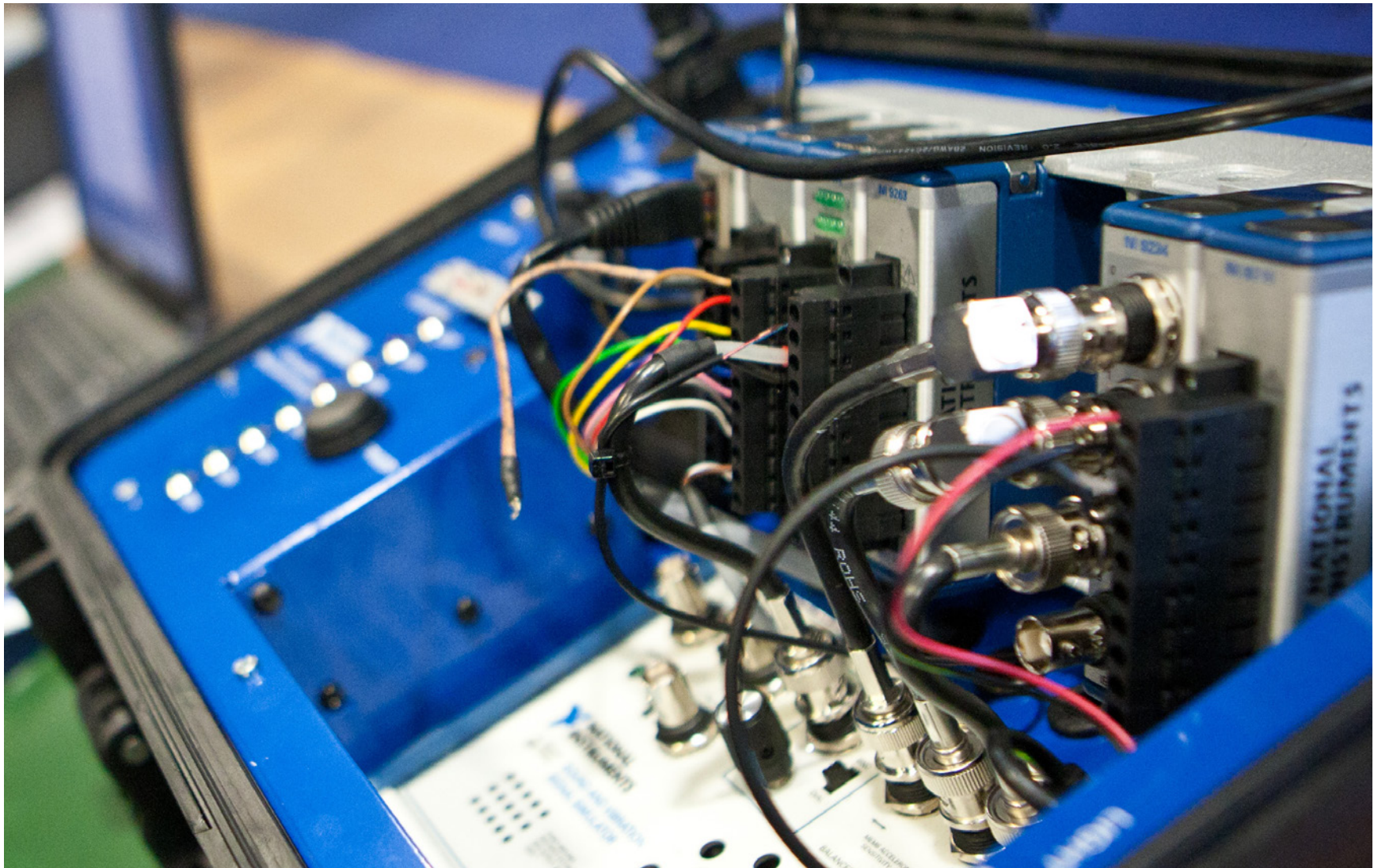
- **Next-on-bench:** Move your product to the front of the line by purchasing this expedited service upgrade.
- **Advanced replacement:** Minimize application downtime with this service. NI ships a replacement immediately so you get a working product as fast as possible, which can save you 10 days of downtime. The advanced replacement service is available only via an NI Service Program.
- **Detailed repair report:** Get a better understanding of what went wrong with more details about the component failure.





# Completing Your CompactDAQ System

A DAQ system consists of more than just the DAQ hardware. You often need peripheral components like batteries, Wi-Fi routers, touch screens, and enclosures to complete your system to meet your application-specific requirements.



# Powering Your System

## Desktop or Industrial Power Supply

Most applications feature access to grid power. However, your application's environment determines which type of power supply you should select.

**Desktop Power Supply:** Used in a desktop or lab setting, a desktop power supply provides an economical, compact, and reliable power solution.

**Industrial Power Supply:** Recommended for applications deployed into industrial environments, such as factory floors, these power supplies provide a long expected life, generous power reserves, and reliable operation in harsh conditions.

## Battery-Powered Operation

To properly choose a battery for your CompactDAQ system, either as a primary or secondary (back-up) supply, you need to answer three questions:

Do you need a single-use or rechargeable option?

How long does the system need to run on battery power?

What are your current and future budgets for batteries?

CompactDAQ requires 9 VDC to 30 VDC power to operate, so Alkaline, NiMH, and Li-Ion batteries are all viable options and have been deployed successfully. No one battery pack can solve every remote or portable power application. With some planning, however, you can choose a custom battery solution for your DAQ applications.

## Redundant Power Supplies

Most applications do not require redundancy, but if the cost of failure is high enough, you may consider adding it. When using CompactDAQ systems with an onboard controller, you can implement dual power supplies. V1 (usually mains) operates in normal running conditions, but if this supply drops below 9 V in a blackout or brownout situation, the CompactDAQ system automatically and seamlessly switches to its auxiliary power supply (V2), which is often a battery. You can use this to ensure continued operation through short-term power outages or to implement safe shutdown procedures with no loss of data.



# Grounding and Isolation

## Isolation

### Signal Integrity and Accuracy

For a nonisolated instrument, the local ground is the system/earth ground, so the instrument's input range is in a window around earth ground. However, an instrument with channel-to-earth isolation has a measurement range in a window around its isolated-local ground, which can float at a much different voltage than earth ground. This can allow the measurement of several tiny millivolt signals such as thermocouples, each sitting at its own unique common-mode voltage.

### Safety and Instrument Protection

CompactDAQ modules are independently certified to be safe when used within specifications. Most modules feature hazardous location certifications and/or isolation. Each module is categorized into NI-defined isolation levels:

- 60 VDC continuous/1,000  $V_{rms}$  withstand
- 250  $V_{rms}$  continuous/2,300  $V_{rms}$  withstand
- 300  $V_{rms}$  continuous/2,300  $V_{rms}$  withstand

## Field Wiring and Grounding

Measuring analog signals is not always as simple as wiring the signal source leads to the DAQ device. Knowing the nature of the signal source and relevant grounding configurations is required to produce accurate and noise-free measurements.

Signal sources are broadly classified into two types:

- Grounded or ground-referenced signal source
- Ungrounded or nonreferenced (floating) signal source

A grounded signal source is best measured with a differential or nonreferenced measurement system.

In a differential architecture, neither of the inputs is tied to a fixed reference such as earth or building ground. This is useful in rejecting noise including the unwanted noise often introduced in the circuit that makes up the cabling

system as common-mode voltage. One drawback is you need twice the number of input channels as signals in your DAQ system. You can reduce channel requirements by adopting a nonreferenced single-ended (NRSE) architecture for which all channels are measured with respect to a single node usually labeled as AI Sense.

You must provide bias resistors when measuring floating signal sources in DIFF and NRSE configurations. Failure to do so results in erratic or saturated (positive full-scale or negative full-scale) readings.

Find more information on grounding architectures along with details on minimizing noise and balancing your system in the NI field wiring guide.

	Signal Source Type	
	Floating Signal Source (Not Connected to Building Ground)	Grounded Signal Source
Input Configuration	Examples • Thermocouples • Signal Conditioning with Isolated Outputs • Battery Devices	Examples • Plug-in Instruments with Nonisolated Inputs
Differential (DIFF)		
Single-Ended-Ground Referenced (RSE)		<p>NOT RECOMMENDED</p>
Single-Ended-Nonreferenced (NRSE)		

# Wireless Communications

Many applications require wireless communication to remotely access a DAQ system, whether for upgrading software, changing configuration parameters, or streaming, downloading, or viewing data. If your system is installed in a remote location or if you simply want to reduce physical wiring for cost, noise, or aesthetic reasons, you can choose from several wireless standards such as Wi-Fi, 900 MHz, cellular, and satellite. But each of these standards involves trade-offs, including bandwidth, availability, cost, distance, and reliability, that you need to consider during your selection process.

## Types of Wireless



**Wi-Fi**, the most common wireless standard, is readily available in both consumer and industrial-grade routers. It offers the highest bandwidth and cheapest cost, but it generally requires you to build your own infrastructure and limits you to a few hundred meters.



**Cellular communication** uses infrastructure provided by wireless service companies to allow high-bandwidth data to be transmitted from anywhere there is cellular service. This often comes at a high price, though, especially when dealing with data plans.



**900 MHz radios** are limited to the United States, but they offer long-range, low-bandwidth communication over existing infrastructure. This technology is a low-cost way to transmit small amounts of data over long distances in remote locations.



**Satellite communication** is the most expensive option, but it can offer data transmission from virtually anywhere on the planet. You can achieve high bandwidth if you are willing to pay for it, but you are susceptible to rain fade bandwidth loss when there is significant moisture in the air.

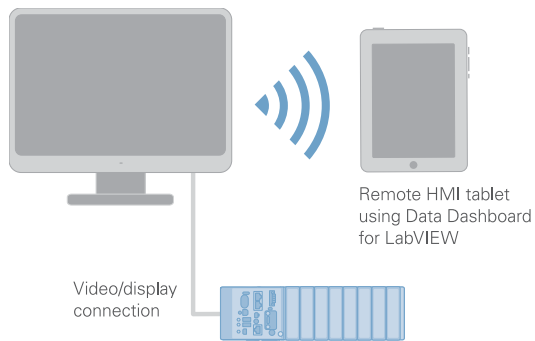
# User Interfaces and HMIs

When you need to build a user interface or integrate a human machine interface (HMI) in a CompactDAQ system, you have several options. Two primary configurations for CompactDAQ systems are:

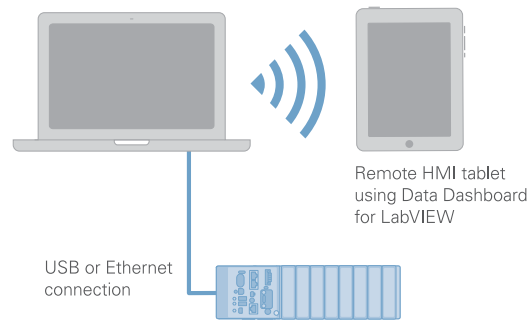
1. A CompactDAQ controller with an embedded PC that you can directly connect to an HMI
2. A USB or Ethernet chassis wired to a host PC/IPC/laptop

For the first configuration, you can wire a traditional display or HMI directly to a CompactDAQ controller that is running a LabVIEW application and use the user interface or front panel within the LabVIEW application as your user interface. For the second configuration, you can create a LabVIEW application to run on the host PC/IPC/laptop and use the user interface or front panel within the application as the user interface.

Additionally, with both configurations, if you need a remote HMI to connect to your CompactDAQ system, you can use the Data Dashboard for LabVIEW. With it, you can create a custom dashboard on iPads or Android tablets to interact with any networked LabVIEW-based system.



**Configuration 1. CompactDAQ Controller Directly Connected to a Local HMI or Display**



**Configuration 2. USB or Ethernet CompactDAQ Chassis Connected to a Host PC/Laptop Running a LabVIEW Application**

# Enclosures

Enclosures can help protect your hardware from exposure to harsh environmental conditions such as extreme temperatures, dirt, dust, water, or soot. Unfortunately, choosing a sealed metal box and mounting the hardware in it can be difficult. You need to consider self-heating from the hardware, airflow, cable management, heating and cooling, connectivity in and out of the enclosure, and clearspace requirements to ensure the hardware performs to its specifications.

## Choosing an Enclosure

Keep in mind the below considerations when choosing and installing an enclosure.

- Enclosure materials such as metals, plastics, and polymers have different insulating, structural integrity, and flammability properties, so you need to account for your CompactDAQ system's environment when selecting your enclosure.
- When choosing the size, be mindful of the clearance requirements of your CompactDAQ chassis, including the modules with backshell connectors installed.
- You can pass signal and communication wires in and out of the enclosure through glands, which is faster but often permanent. Bulkhead connectors offer a more flexible way to send signals in and out of the enclosure.
- Enclosures can include both heating elements for cold environments and cooling systems like Peltier plates or split system air conditioners for hot environments. For less extreme environments, you can directly attach a simple heat sink to the back of the CompactDAQ system to remove heat from the enclosure.

## Sizes and Clearances

To properly choose an enclosure size, you need to know both the sizes and clearances of the equipment you plan to install in the enclosure. Clearance requirements are often mistakenly ignored. This limits the proper airflow around the equipment and derates the temperatures or accuracies your DAQ system can operate to.

To ensure you are properly choosing and laying out your enclosure, reference your CompactDAQ documentation or the dimensional drawings.

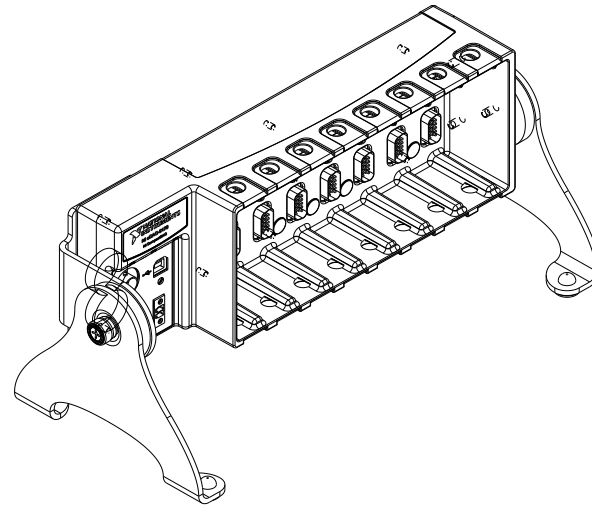


# Mounting

CompactDAQ systems feature built-in mounting holes you can use to secure the hardware in place. Mounting provides convenient and secure placement, but it also can affect the measurement quality of your DAQ system. Different mounting configurations can reduce the maximum ambient temperature under which you can maintain the typical accuracy of certain I/O modules.

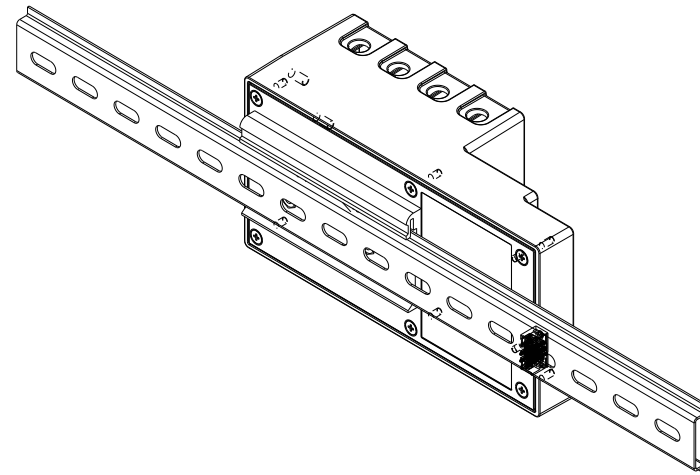
## Desktop Mount

Use the desktop mount kit for easy access to modules for interactive desk or lab use. This is available for all multislot chassis and controller variations.



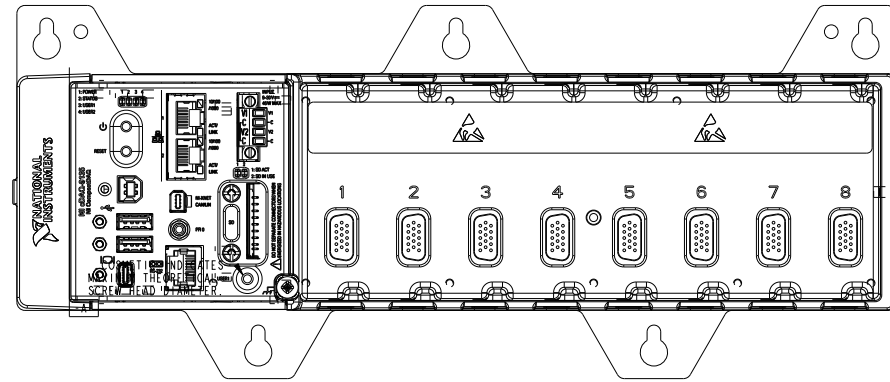
## DIN Rail Mount

Use the DIN rail mount kit to attach your CompactDAQ system to any standard 35 mm DIN rail.



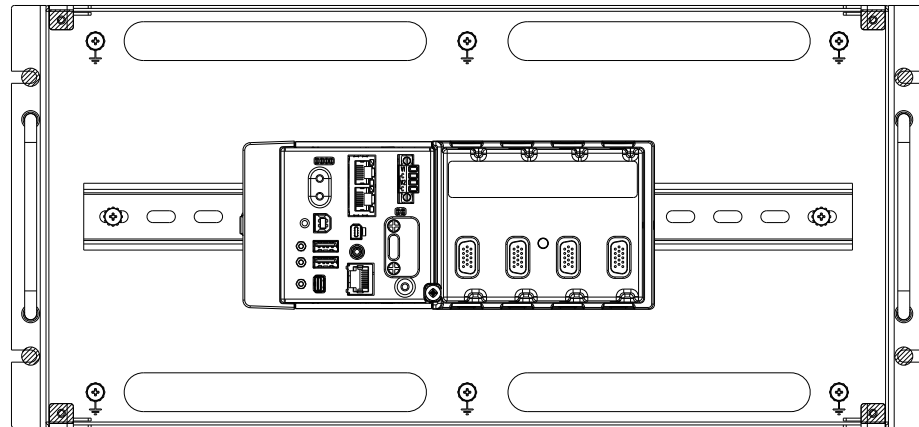
## Panel Mount

Use the panel mount kit to securely mount your CompactDAQ system to a wall or flat surface. Panel mounting is recommended for high shock and vibration applications.



## Rack Mount

Use the rack mount kit to install your CompactDAQ system into a standard 19 in. rack. You can place the chassis or controller in an enclosure that slides into the rack or attach the hardware without an enclosure to DIN rails that slide along the side rails of the rack.



# Next Steps and Additional Resources

Each unique application will have individual specifications, needs and deployment requirements. For assistance configuring a system or to ask further questions about how to ensure CompactDAQ meets your exact requirements, please contact one of our engineers.

## [Speak to an NI Engineer about your system requirements](#)

Map your specifications document to NI hardware and software options.

## [Configure a Complete CompactDAQ System with the Online Product Advisor](#)

Walk through selecting I/O modules and chassis based on your measurement needs.

Already have an idea of which CompactDAQ products will meet your application needs?

Review the CompactDAQ user manuals for an in-depth study of product features, analog & digital timing specifications, counters, and environmental requirements.