5 Questions for Choosing the Right Measurement Bus

Select the right bus for your application and be successful from the start.

When you have hundreds of different DAQ devices on a wide variety of buses, selecting the right bus for your application needs may be challenging. Each bus has different advantages and optimizations. To help you decide, ask yourself these five questions.

1 How Much Data Will I Stream Across This Bus?

All PC buses have a limit to the amount of data that you can transfer in a certain period of time. This is the bus bandwidth, which is often specified in megabytes per second (MB/s). The PCI bus, for example, features a theoretical bandwidth of 132 MB/s that is shared among all PCI boards in the computer. Gigabit Ethernet offers 125 MB/s of shared bandwidth across devices on a subnet or network. PCI Express and PXI Express offer dedicated data links that are capable of up to 1 GB/s per device.

When you take waveform measurements, your bus bandwidth must support the speed at which you acquire data. To calculate the minimum required bandwidth, take the number of bytes per sample (rounded up to the next byte), multiply by the sampling speed, and then multiply by the number of channels.

For example, a 16-bit (2-byte) device sampling at 4 MS/s on four channels requires the following bandwidth:

$$\frac{2\ \text{bytes}}{\text{S}} \times \frac{4\ \text{MS}}{\text{sec}} \times 4\ \text{channels} = 32\ \text{MB/s}$$

Note that the actual observed system bandwidth will be lower than the theoretical bus limits. It depends on the number of devices in a system and any additional bus traffic from overhead.

2 What Are My Single-Point I/O Requirements?

Applications that require single-point reads and writes often depend on I/O values that are updated immediately and consistently. Bus latency is the time delay between when a driver software function is called and the actual hardware value of the I/O is updated. Depending on the bus you choose, this delay can range from less than a microsecond to a few milliseconds.

Another important factor in single-point I/O applications is determinism, which is a measure of how consistently I/O can execute on time. Buses that always have the same latency when communicating with I/O are more deterministic than buses with varied responsiveness.

Latency and determinism are important for control applications because they directly impact the reliability of the control loop. Therefore, when implementing closed-loop control applications, you should avoid buses such as wireless, Ethernet, or USB that are high in latency with poor determinism. In general, internal buses such as PCI Express and PXI Express are better for low-latency single-point I/O applications.

3 Do I Need to Synchronize Multiple Devices?

Many measurement systems have complex synchronization needs, whether you're synchronizing hundreds of input channels or multiple types of instruments. The simplest way to synchronize measurements across multiple devices is to share a sample clock and a trigger. Many DAQ devices offer programmable digital lines for importing and exporting both clocks and triggers.

Certain buses, such as PCI and PCI Express, work with the real-time system integration (RTSI) bus, on which you can cable multiple boards in a desktop system directly together inside the case to make synchronization as easy as possible. This removes the need for additional wiring through the front connector and simplifies I/O connectivity.

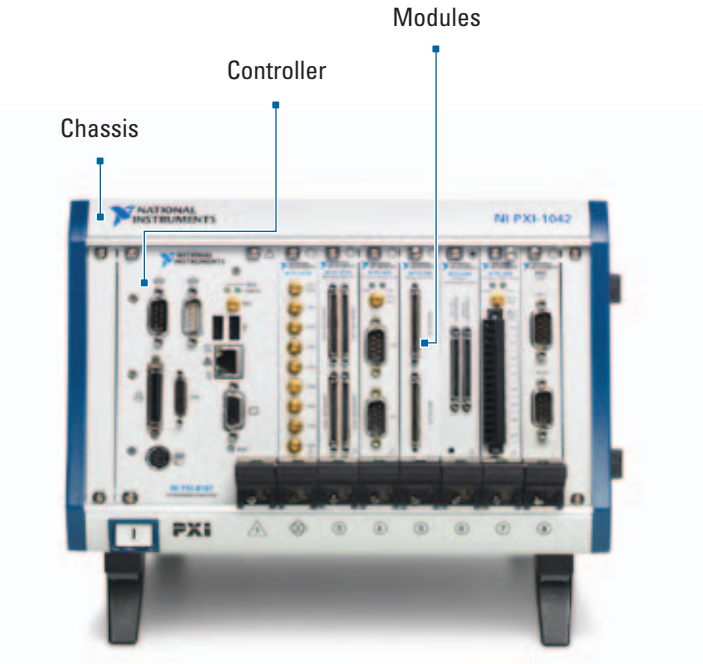

Figure 1. *The PXI platform is the best option for multidevice synchronization.*

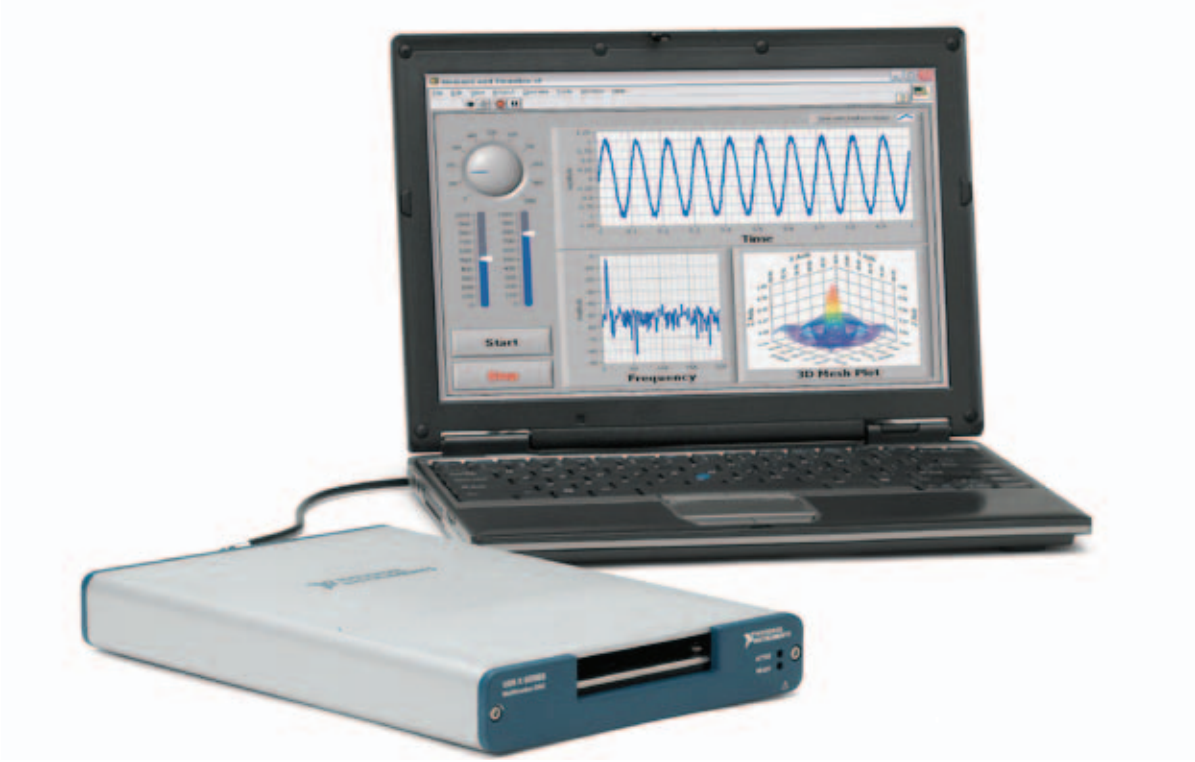

Figure 2. *Portable USB DAQ devices can quickly connect to laptop computers.*

The best bus option for synchronizing multiple devices is the PXI platform, including PXI and PXI Express. This open standard was designed specifically for high-performance synchronization and triggering, with several different options for synchronizing I/O modules within the same chassis or multiple chassis.

4 How Portable Do I Need This System to Be?

Portability is important for many applications. External buses like USB and Ethernet are particularly effective for portable DAQ systems because of their quick hardware installation and compatibility with laptop computers. Bus-powered USB devices offer additional convenience because they are powered from the USB port and do not require a separate power supply. Wireless data transfer buses are another good option because the measurement hardware itself becomes portable while the computer can remain stationary.

5 How Far Will My Measurements Be From My Computer?

The distance between the measurements you need and the computer's location can drastically vary from application to application. To achieve the best signal integrity and measurement accuracy, place your DAQ hardware as close to the signal source as possible. Running cables across long distances is costly and can result in noisy signals. A solution to this problem is to use a portable computing platform to move the entire system closer to the signal source. Wireless technology can altogether remove the physical connection between the computer and the measurement, so you can take distributed measurements and send the data back to a central location.

Based on these five questions, you can use NI's selection guide for the most common DAQ buses to choose the right option for your application.

Figure 3. *Wi-Fi DAQ devices eliminate the wires between measurement hardware and the host PC.*

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To download the Complete Guide to Building a Measurement System, including a selection guide for the most common buses, visit ni.com/newsletter/measurementguide.